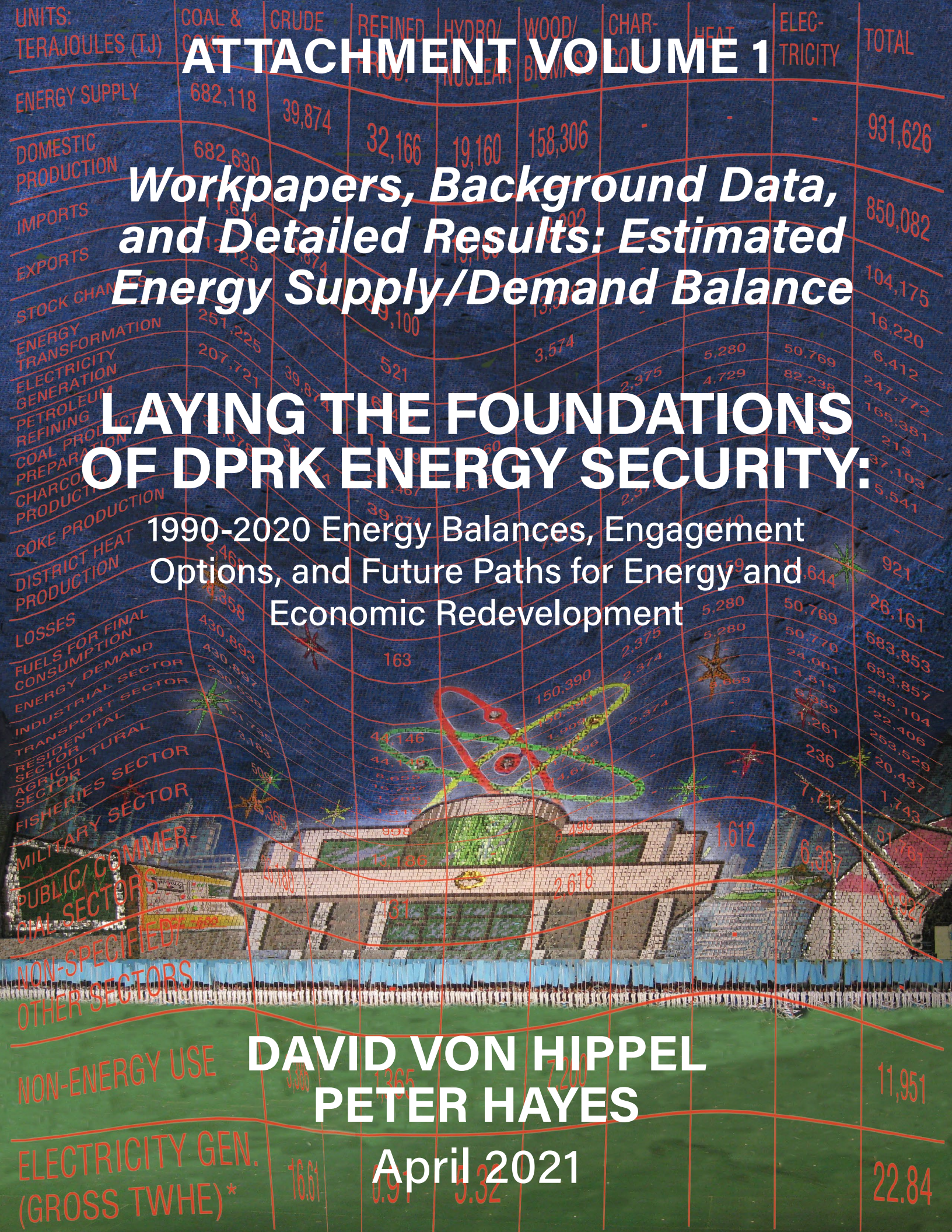
ATTACHMENT VOLUME 1

Workpapers, Background Data, and Detailed Results: Estimated Energy Supply/Demand Balance

LAYING THE FOUNDATIONS OF DPRK ENERGY SECURITY:

1990-2020 Energy Balances, Engagement Options, and Future Paths for Energy and Economic Redevelopment



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PETER HAYES

April 2021

The Nautilus Institute
for Security and Sustainability

LAYING THE FOUNDATIONS OF DPRK ENERGY SECURITY: 1990-2020 ENERGY BALANCES, ENGAGEMENT OPTIONS, AND FUTURE PATHS FOR ENERGY AND ECONOMIC REDEVELOPMENT

ATTACHMENT VOLUME 1

WORKPAPERS, BACKGROUND DATA, AND DETAILED RESULTS: ESTIMATED ENERGY SUPPLY/DEMAND BALANCES

Prepared by David F. von Hippel and Peter Hayes
The Nautilus Institute for Security and Sustainability

April 26, 2021

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ATTACHMENT 1

WORKPAPERS, BACKGROUND DATA, AND DETAILED RESULTS:

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES FOR THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK) AND RELATED ENERGY SECTOR AND POLLUTANT EMISSIONS ANALYSES

CONTENTS:

ATTACHMENT 1

Detailed, Petroleum Product, and Summary Energy Balances

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1990

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	1,325,571	110,742	26,622	78,075	161,941	(0)	-	-	1,702,951
Domestic Production	1,301,288	-		78,075	149,909				1,529,272
Imports	68,392	110,742	26,622		12,183				217,938
Exports	44,108				151	0		-	44,259
Inputs to International Marine Bunkers									-
Stock Changes									-
ENERGY TRANSFORMATION	(377,571)	(110,742)	82,762	(78,075)	(9,920)	2,976	9,251	120,464	(360,855)
Electricity Generation	(294,926)		(21,947)	(76,641)			7,884	165,600	(220,030)
Petroleum Refining		(110,742)	110,742					(593)	(593)
Coal Production/Preparation	(63,092)							(8,544)	(71,636)
Charcoal Production					(9,920)	2,976			(6,944)
Coke Production									-
District Heat Production	(3,417)		(73)	(1,433)			2,916		(2,008)
Other Transformation									-
Own Use			(5,960)					(12,408)	(18,368)
Losses	(16,136)						(1,549)	(23,592)	(41,277)
FUELS FOR FINAL CONSUMPTION	948,000	-	109,384	-	152,021	2,976	9,251	120,464	1,342,096
ENERGY DEMAND	948,009	-	109,384	-	152,021	2,973	9,251	120,467	1,342,105
INDUSTRIAL SECTOR	671,661	-	28,393	-	5,626	-	-	70,242	775,923
Iron and Steel	324,615							17,388	342,003
Cement	68,139		7,571					4,356	80,065
Fertilizers	23,994		4,573					18,891	47,458
Other Chemicals	11,203							6,616	17,819
Pulp and Paper	4,026				4,026			932	8,985
Other Metals	23,720							4,126	27,846
Other Minerals	-		12,600					396	12,996
Textiles	29,385							2,497	31,882
Building Materials	61,980							189	62,169
Non-specified Industry	124,600		3,650		1,600			14,850	144,700
TRANSPORT SECTOR	-	-	37,896	-	1,672	-	-	11,470	51,039
Road			32,571		1,672				34,243
Rail	-		1,949					10,870	12,819
Water	-		1,253						1,253
Air			1,123						1,123
Non-Specified			1,000					600	1,600
RESIDENTIAL SECTOR	189,274	-	6,600	-	86,140	2,973	6,134	10,718	301,840
Urban	129,155		6,256			1,814	6,134	7,420	150,780
Rural	60,119		344		86,140	1,159		3,298	151,060
AGRICULTURAL SECTOR	9,750	-	5,005	-	44,950	-	-	2,572	62,277
Field Operations			2,619					907	3,526
Processing/Other	9,750		2,386		44,950			1,664	58,750
FISHERIES SECTOR	1,132	-	3,137	-	-	-	-	524	4,794
Large Ships	-		2,681						2,681
Collectives/Processing/Other	1,132		456					524	2,112
MILITARY SECTOR	29,828	-	16,533	-	-	-	-	14,008	60,369
Trucks and other Transport			6,585						6,585
Armaments			263						263
Air Force			2,648						2,648
Naval Forces			6,937						6,937
Military Manufacturing	890							48	938
Buildings and Other	28,938		100					13,960	42,998
PUBLIC/COMMERCIAL SECTORS	32,646		98		1,632		2,644	10,932	47,952
NON-SPECIFIED/OTHER SECTORS			5,950				473		6,423
NON-ENERGY USE	13,718		5,771		12,000				31,488
Electricity Gen. (Gross TWhe)	23.43		1.28	21.29					46.00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1996

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	682,118	39,874	32,166	19,160	158,306	-	-	-	931,626
Domestic Production	682,630	-		19,160	148,292				850,082
Imports	11,614	39,874	39,100		13,588	-			104,175
Exports	12,125		521		3,574	-		-	16,220
Inputs to International Marine Bunkers									-
Stock Changes			6,412						6,412
ENERGY TRANSFORMATION	(251,225)	(39,874)	11,979	(19,160)	(7,916)	2,375	5,280	50,769	(247,772)
Electricity Generation	(207,721)		(25,467)	(19,160)			4,729	82,238	(165,381)
Petroleum Refining		(39,874)	39,874					(213)	(213)
Coal Production/Preparation	(32,678)							(4,425)	(37,103)
Charcoal Production					(7,916)	2,375			(5,541)
Coke Production									-
District Heat Production	(2,468)		(163)				1,710		(921)
Other Transformation									-
Own Use			(2,266)					(10,186)	(12,452)
Losses	(8,358)						(1,159)	(16,644)	(26,161)
FUELS FOR FINAL CONSUMPTION	430,893	-	44,146	-	150,390	2,375	5,280	50,769	683,853
ENERGY DEMAND	430,897	-	44,146	-	150,390	2,374	5,280	50,770	683,857
INDUSTRIAL SECTOR	250,538	-	8,655	-	1,909	-	-	24,001	285,104
Iron and Steel	124,977							6,694	131,671
Cement	29,981		3,331					1,917	35,229
Fertilizers	6,515		1,129					5,130	12,774
Other Chemicals	3,697		-					2,183	5,880
Pulp and Paper	1,329				1,329			308	2,965
Other Metals	7,828							1,362	9,189
Other Minerals	832		3,326					131	4,289
Textiles	9,697							824	10,521
Building Materials	20,453							62	20,516
Non-specified Industry	45,230		869		581			5,391	52,070
TRANSPORT SECTOR	-	-	16,707	-	884	-	-	4,815	22,406
Road			14,528		884				15,412
Rail	-		779					4,815	5,595
Water	-		501						501
Air			899						899
Non-Specified			-					-	-
RESIDENTIAL SECTOR	121,735	-	1,785	-	117,606	2,374	3,669	6,359	253,529
Urban	92,747		1,649		15,135	1,455	3,669	4,685	119,340
Rural	28,988		136		102,471	919		1,674	134,189
AGRICULTURAL SECTOR	3,183	-	1,319	-	14,674	-	-	1,261	20,437
Field Operations			690					717	1,408
Processing/Other	3,183		629		14,674			543	19,029
FISHERIES SECTOR	509	-	998	-	-	-	-	236	1,743
Large Ships	-		804						804
Collectives/Processing/Other	509		193					236	939
MILITARY SECTOR	25,365	-	13,186	-	5,498	-	-	7,711	51,761
Trucks and other Transport			5,734						5,734
Armaments			211						211
Air Force			1,886						1,886
Naval Forces			5,261						5,261
Military Manufacturing	623		-					33	657
Buildings and Other	24,742		95		5,498			7,678	38,013
PUBLIC/COMMERCIAL SECTORS	26,180		131		2,618		1,612	6,387	36,927
NON-SPECIFIED/OTHER SECTORS			-				-		-
NON-ENERGY USE	3,386		1,365		7,200				11,951
Electricity Gen. (Gross TWhe)*	16.61		0.91	5.32					22.84

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2000

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	338,806	16,877	40,010	37,705	160,477	3	-	(82)	593,796
Domestic Production	336,168	298		37,705	150,543				524,715
Imports	11,952	16,579	41,778		12,450	3		-	82,762
Exports	9,314		3,013		2,517	0		82	14,926
Inputs to International Marine Bunkers									-
Stock Changes			(1,245)						(1,245)
ENERGY TRANSFORMATION	(52,861)	(16,877)	(721)	(37,705)	(6,051)	1,815	2,645	30,857	(78,898)
Electricity Generation	(31,665)		(16,206)	(37,705)			2,451	47,746	(35,379)
Petroleum Refining		(16,877)	16,877					(99)	(99)
Coal Production/Preparation	(16,093)							(2,179)	(18,272)
Charcoal Production					(6,051)	1,815			(4,236)
Coke Production									-
District Heat Production	(988)		(391)				855		(524)
Other Transformation									-
Own Use			(1,001)					(1,903)	(2,904)
Losses	(4,116)						(661)	(12,708)	(17,485)
FUELS FOR FINAL CONSUMPTION	285,945	-	39,289	-	154,425	1,818	2,645	30,775	514,898
ENERGY DEMAND	285,944	-	39,290	-	154,426	1,818	2,645	30,774	514,897
INDUSTRIAL SECTOR	149,673	-	11,726	-	1,153	-		12,828	175,380
Iron and Steel	67,382							3,609	70,991
Cement	19,096		7,024					1,503	27,623
Fertilizers	2,070		343					1,629	4,042
Other Chemicals	2,325		-					1,373	3,699
Pulp and Paper	836				836			194	1,865
Other Metals	4,924							857	5,780
Other Minerals	869		3,478					137	4,484
Textiles	6,100							518	6,618
Building Materials	21,383							65	21,448
Non-specified Industry	24,689		882		317			2,942	28,831
TRANSPORT SECTOR	-	-	8,395	-	504	-	-	3,237	12,135
Road			6,548		504				7,052
Rail	-		585					3,237	3,821
Water	-		476						476
Air			786						786
Non-Specified			-					-	-
RESIDENTIAL SECTOR	95,055	-	2,079	-	121,601	1,818	1,826	2,856	225,235
Urban	73,246		1,924		19,021	1,117	1,826	2,421	99,555
Rural	21,808		156		102,580	701		435	125,680
AGRICULTURAL SECTOR	2,827	-	968	-	14,663	-	-	979	19,437
Field Operations			507					526	1,033
Processing/Other	2,827		461		14,663			452	18,404
FISHERIES SECTOR	423	-	828	-	-	-	-	196	1,447
Large Ships	-		668						668
Collectives/Processing/Other	423		161					196	779
MILITARY SECTOR	21,308	-	11,094	-	7,379	-	-	7,420	47,202
Trucks and other Transport			4,064						4,064
Armaments			148						148
Air Force			1,367						1,367
Naval Forces			5,430						5,430
Military Manufacturing	401		-					21	422
Buildings and Other	20,908		85		7,379			7,399	35,771
PUBLIC/COMMERCIAL SECTORS	15,629		78		3,126		820	3,258	22,911
NON-SPECIFIED/OTHER SECTORS			-				-		-
NON-ENERGY USE	1,029		4,121		6,000				11,150
Electricity Gen. (Gross TWhe)*	2.64		0.15	10.47					13.26

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2005

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	390,916	22,568	23,403	44,008	187,209	(10)	-	(60)	668,034
Domestic Production	434,409	298		44,008	182,194				660,909
Imports	36,405	22,270	23,383		7,014	1		265	89,338
Exports	79,898		188		1,999	11		325	82,420
Inputs to International Marine Bunkers									-
Stock Changes			(207)						(207)
ENERGY TRANSFORMATION	(112,260)	(22,568)	12,764	(44,008)	(6,150)	1,845	4,311	37,677	(128,388)
Electricity Generation	(84,246)		(8,409)	(42,575)			3,763	59,598	(71,869)
Petroleum Refining		(22,568)	22,568					(133)	(133)
Coal Production/Preparation	(20,795)							(2,816)	(23,612)
Charcoal Production					(6,150)	1,845			(4,305)
Coke Production									-
District Heat Production	(1,900)		(71)	(1,433)			1,695		(1,709)
Other Transformation									-
Own Use			(1,324)					(3,508)	(4,832)
Losses	(5,319)						(1,146)	(15,463)	(21,928)
FUELS FOR FINAL CONSUMPTION	278,657	-	36,167	-	181,059	1,835	4,311	37,617	539,646
ENERGY DEMAND	278,654	-	36,166	-	181,058	1,836	4,311	37,618	539,643
INDUSTRIAL SECTOR	150,376	-	8,640	-	1,085	-		14,679	174,780
Iron and Steel	52,717							2,824	55,541
Cement	23,566		3,568					1,561	28,695
Fertilizers	3,010		512					2,370	5,892
Other Chemicals	2,265							1,338	3,602
Pulp and Paper	814				814			188	1,816
Other Metals	15,940							2,773	18,713
Other Minerals	3,528		3,528					222	7,278
Textiles	6,582							559	7,142
Building Materials	20,825							64	20,889
Non-specified Industry	21,128		1,032		271			2,780	25,212
TRANSPORT SECTOR	-	-	11,216	-	816	-	-	3,532	15,565
Road			8,958		816				9,774
Rail	-		935					3,532	4,468
Water	-		526						526
Air			797						797
Non-Specified			-					-	-
RESIDENTIAL SECTOR	84,886	-	2,169	-	134,550	1,836	2,442	3,891	229,773
Urban	67,806		2,016		24,739	1,132	2,442	3,403	101,538
Rural	17,079		153		109,810	704		488	128,235
AGRICULTURAL SECTOR	5,282	-	1,164	-	25,784	-	-	1,410	33,641
Field Operations			609					508	1,117
Processing/Other	5,282		555		25,784			902	32,523
FISHERIES SECTOR	453	-	924	-	-	-	-	210	1,586
Large Ships	-		751						751
Collectives/Processing/Other	453		173					210	836
MILITARY SECTOR	19,615	-	11,253	-	7,871	-	-	8,746	47,486
Trucks and other Transport			3,524						3,524
Armaments			129						129
Air Force			2,002						2,002
Naval Forces			5,513						5,513
Military Manufacturing	401		-					21	422
Buildings and Other	19,215		85		7,871			8,725	35,896
PUBLIC/COMMERCIAL SECTORS	16,506		165		4,952		1,396	5,150	28,169
NON-SPECIFIED/OTHER SECTORS			-				473		473
NON-ENERGY USE	1,536		635		6,000				8,171
Electricity Gen. (Gross TWhe)*	5.15		0.26	11.15					16.55

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2008

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	378,844	22,812	25,671	42,575	204,349	1	-	357	674,608
Domestic Production	426,842	298		42,575	199,729				669,443
Imports	18,558	22,514	29,658		6,024	1		874	77,629
Exports	66,556		3,987		1,403	0		517	72,464
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(107,170)	(22,812)	8,615	(42,575)	(5,873)	1,762	4,213	39,529	(124,309)
Electricity Generation	(79,895)		(12,701)	(42,575)			4,234	62,036	(68,901)
Petroleum Refining		(22,812)	22,812					(134)	(134)
Coal Production/Preparation	(20,433)							(2,767)	(23,200)
Charcoal Production					(5,873)	1,762			(4,111)
Coke Production									-
District Heat Production	(1,615)		(158)				1,100		(674)
Other Transformation									-
Own Use			(1,338)					(3,493)	(4,831)
Losses	(5,226)						(1,120)	(16,112)	(22,458)
FUELS FOR FINAL CONSUMPTION	271,674	-	34,286	-	198,476	1,763	4,213	39,887	550,299
ENERGY DEMAND	271,674	-	34,285	-	198,476	1,762	4,213	39,885	550,295
INDUSTRIAL SECTOR	155,101	-	7,349	-	1,013	-		15,239	178,702
Iron and Steel	51,776							2,773	54,549
Cement	30,144		3,168					1,917	35,229
Fertilizers	2,872		498					2,261	5,632
Other Chemicals	2,095							1,237	3,332
Pulp and Paper	753				753			174	1,680
Other Metals	16,177							2,814	18,991
Other Minerals	4,108		3,099					227	7,434
Textiles	6,465							549	7,014
Building Materials	20,453							62	20,516
Non-specified Industry	20,257		584		260			3,224	24,325
TRANSPORT SECTOR	-	-	12,274	-	843	-	-	4,185	17,303
Road			10,384		843				11,226
Rail	-		604					4,185	4,790
Water	-		414						414
Air			873						873
Non-Specified			-					-	-
RESIDENTIAL SECTOR	74,302	-	2,100	-	153,322	1,762	2,818	4,675	238,979
Urban	61,212		1,916		34,093	1,089	2,818	4,050	105,178
Rural	13,090		184		119,228	673		625	133,800
AGRICULTURAL SECTOR	5,094	-	1,008	-	24,864	-	-	1,261	32,227
Field Operations			517					392	909
Processing/Other	5,094		491		24,864			870	31,318
FISHERIES SECTOR	419	-	884	-	-	-	-	194	1,497
Large Ships	-		724						724
Collectives/Processing/Other	419		160					194	773
MILITARY SECTOR	18,415	-	9,830	-	7,379	-	-	9,095	44,720
Trucks and other Transport			3,186						3,186
Armaments			101						101
Air Force			2,234						2,234
Naval Forces			4,227						4,227
Military Manufacturing	401		-					21	422
Buildings and Other	18,014		82		7,379			9,074	34,549
PUBLIC/COMMERCIAL SECTORS	16,850		239		5,055		1,395	5,235	28,775
NON-SPECIFIED/OTHER SECTORS							-		-
NON-ENERGY USE	1,493		600		6,000				8,093
Electricity Gen. (Gross TWhe)	5.12		0.29	11.83					17.23

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2009

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	396,765	22,392	13,334	42,719	205,317	1	-	386	680,914
Domestic Production	484,287	251		42,719	202,014				729,272
Imports	6,543	22,140	13,506		4,769	1		850	47,809
Exports	94,065		172		1,466	-		464	96,167
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(98,867)	(22,392)	14,209	(42,719)	(5,967)	1,790	3,708	37,101	(113,136)
Electricity Generation	(68,017)		(6,833)	(42,719)			3,594	58,453	(55,521)
Petroleum Refining		(22,392)	22,392					(132)	(132)
Coal Production/Preparation	(23,183)							(3,140)	(26,323)
Charcoal Production					(5,967)	1,790			(4,177)
Coke Production									-
District Heat Production	(1,738)		(36)				1,100		(674)
Other Transformation									-
Own Use			(1,314)					(2,802)	(4,116)
Losses	(5,929)						(986)	(15,279)	(22,193)
FUELS FOR FINAL CONSUMPTION	297,899	-	27,543	-	199,350	1,791	3,708	37,488	567,778
ENERGY DEMAND	297,901	-	27,542	-	199,350	1,791	3,708	37,487	567,779
INDUSTRIAL SECTOR	180,677	-	4,653	-	866	-	-	15,322	201,517
Iron and Steel	69,936							3,746	73,682
Cement	43,952		1,585					2,620	48,156
Fertilizers	1,903		330					1,498	3,730
Other Chemicals	1,848							1,092	2,940
Pulp and Paper	664				664			154	1,483
Other Metals	15,916							2,769	18,685
Other Minerals	4,816		2,114					218	7,148
Textiles	5,495							467	5,962
Building Materials	20,453							62	20,516
Non-specified Industry	15,693		625		202			2,696	19,216
TRANSPORT SECTOR	-	-	9,463	-	641	-	-	3,913	14,018
Road			7,871		641				8,512
Rail	-		448					3,913	4,361
Water	-		351						351
Air			793						793
Non-Specified			-					-	-
RESIDENTIAL SECTOR	75,642	-	1,691	-	155,758	1,791	2,427	4,042	241,350
Urban	62,349		1,549		34,685	1,108	2,427	3,524	105,642
Rural	13,292		142		121,072	683		518	135,708
AGRICULTURAL SECTOR	4,839	-	950	-	23,623	-	-	1,185	30,597
Field Operations			518					359	877
Processing/Other	4,839		432		23,623			826	29,721
FISHERIES SECTOR	396	-	820	-	-	-	-	178	1,395
Large Ships	-		670						670
Collectives/Processing/Other	396		150					178	725
MILITARY SECTOR	18,415	-	8,856	-	7,379	-	-	8,142	42,791
Trucks and other Transport			2,984						2,984
Armaments			101						101
Air Force			1,792						1,792
Naval Forces			3,901						3,901
Military Manufacturing	401		-					21	422
Buildings and Other	18,014		78		7,379			8,121	33,592
PUBLIC/COMMERCIAL SECTORS	16,944		330		5,083		1,281	4,705	28,343
NON-SPECIFIED/OTHER SECTORS							-		-
NON-ENERGY USE	989		779		6,000				7,768
Electricity Gen. (Gross TWhe)	4.05		0.32	11.87					16.24

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2010

Prepared By David Von Hippel
Date Last Modified: 3/13/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	383,464	25,309	14,789	42,864	208,309	0	-	507	675,242
Domestic Production	491,714	251		42,864	204,624				739,453
Imports	13,432	25,058	16,459		4,268	0		1,053	60,270
Exports	121,681		1,670		583	0		546	124,480
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(89,126)	(25,309)	16,676	(42,864)	(6,067)	1,820	3,517	36,023	(105,330)
Electricity Generation	(57,667)		(7,118)	(42,864)			3,353	56,540	(47,756)
Petroleum Refining		(25,309)	25,309					(149)	(149)
Coal Production/Preparation	(23,539)							(3,188)	(26,726)
Charcoal Production					(6,067)	1,820			(4,247)
Coke Production									-
District Heat Production	(1,900)		(35)				1,100		(836)
Other Transformation									-
Own Use			(1,480)					(2,395)	(3,875)
Losses	(6,020)						(935)	(14,785)	(21,740)
FUELS FOR FINAL CONSUMPTION	294,338	-	31,465	-	202,242	1,820	3,517	36,530	569,912
ENERGY DEMAND	294,337	-	31,465	-	202,242	1,821	3,517	36,530	569,912
INDUSTRIAL SECTOR	175,522	-	5,688	-	836	-	-	15,204	197,250
Iron and Steel	69,197							3,707	72,904
Cement	43,099		2,278					2,611	47,988
Fertilizers	1,950		338					1,535	3,823
Other Chemicals	1,725							1,019	2,744
Pulp and Paper	642				642			149	1,433
Other Metals	15,133							2,633	17,766
Other Minerals	4,423		2,381					214	7,018
Textiles	5,172		-					439	5,611
Building Materials	19,090		-					58	19,148
Non-specified Industry	15,090		691		194			2,839	18,814
TRANSPORT SECTOR	-	-	10,485	-	712	-	-	3,913	15,111
Road			8,720		712			0	9,432
Rail	-		526					3,913	4,439
Water	-		376						376
Air			863						863
Non-Specified			-					-	-
RESIDENTIAL SECTOR	77,012	-	2,071	-	158,248	1,821	2,294	3,849	245,295
Urban	63,513		1,894		35,291	1,127	2,294	3,366	107,486
Rural	13,499		177		122,957	694		483	137,809
AGRICULTURAL SECTOR	4,907	-	1,031	-	23,955	-	-	1,211	31,105
Field Operations			539					374	913
Processing/Other	4,907		491		23,955			838	30,192
FISHERIES SECTOR	430	-	889	-	-	-	-	183	1,502
Large Ships	-		724						724
Collectives/Processing/Other	430		165					183	778
MILITARY SECTOR	18,415	-	10,018	-	7,379	-	-	7,699	43,512
Trucks and other Transport			3,186						3,186
Armaments			103						103
Air Force			2,100						2,100
Naval Forces			4,553						4,553
Military Manufacturing	401		-					21	422
Buildings and Other	18,014		76		7,379			7,678	33,147
PUBLIC/COMMERCIAL SECTORS	17,037		417		5,111		1,224	4,469	28,258
NON-SPECIFIED/OTHER SECTORS			-				-		-
NON-ENERGY USE	1,014		866		6,000				7,879
Electricity Gen. (Gross TWhe)	3.44		0.36	11.91					15.70

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2014

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR/ SOLAR/ WIND	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	457,195	24,870	20,582	38,999	208,378	-	-	628	750,653
Domestic Production	851,489	251		38,999	205,333				1,096,072
Imports	7,823	24,619	21,708		4,633			1,429	60,212
Exports	402,116		1,126		1,588			801	405,631
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(153,313)	(24,870)	11,128	(38,999)	(6,627)	1,988	3,287	36,726	(170,680)
Electricity Generation	(100,347)		(12,254)	(38,999)			3,036	61,904	(86,660)
Petroleum Refining		(24,870)	24,870					(146)	(146)
Coal Production/Preparation	(40,761)							(5,520)	(46,281)
Charcoal Production					(6,627)	1,988			(4,639)
Coke Production									-
District Heat Production	(1,780)		(33)				1,124		(689)
Other Transformation									-
Own Use			(1,455)					(4,016)	(5,470)
Losses	(10,425)						(874)	(15,496)	(26,795)
FUELS FOR FINAL CONSUMPTION	303,882	-	31,711	-	201,752	1,988	3,287	37,354	579,973
ENERGY DEMAND	303,883	-	31,710	-	201,751	1,988	3,287	37,356	579,975
INDUSTRIAL SECTOR	165,869	-	6,398	-	584	-	-	17,252	190,102
Iron and Steel	66,005							3,536	69,541
Cement	44,330		2,530					2,696	49,557
Fertilizers	5,841		1,031					4,599	11,470
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	13,568							2,360	15,928
Other Minerals	4,484		2,320					214	7,018
Textiles	3,879		-					330	4,208
Building Materials	14,999		-					46	15,045
Non-specified Industry	10,965		516		141			2,569	14,191
TRANSPORT SECTOR	-	-	10,320	-	794	-	-	3,445	14,559
Road			8,610		794			4	9,408
Rail	-		525					3,442	3,967
Water	-		338						338
Air			846						846
Non-Specified			-					-	-
RESIDENTIAL SECTOR	90,615	-	2,186	-	155,810	1,988	1,852	3,165	255,617
Urban	73,032		2,004		34,289	1,234	1,852	2,839	115,250
Rural	17,583		183		121,521	754		326	140,367
AGRICULTURAL SECTOR	5,410	-	983	-	26,410	-	-	1,226	34,029
Field Operations			515					357	871
Processing/Other	5,410		469		26,410			869	33,158
FISHERIES SECTOR	430	-	1,222	-	-	-	-	173	1,825
Large Ships	-		1,048						1,048
Collectives/Processing/Other	430		174					173	777
MILITARY SECTOR	19,144	-	9,522	-	7,130	-	-	8,120	43,916
Trucks and other Transport			3,527						3,527
Armaments			96						96
Air Force			1,899						1,899
Naval Forces			3,923						3,923
Military Manufacturing	427		-					23	450
Buildings and Other	18,717		78		7,130			8,097	34,022
PUBLIC/COMMERCIAL SECTORS	19,322		491		5,024		1,119	3,975	29,930
NON-SPECIFIED/OTHER SECTORS			-				315		315
NON-ENERGY USE	3,092		589		6,000				9,681
Electricity Gen. (Gross TWhe)	5.97		0.66	10.57					17.20

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2015

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR/ SOLAR/ WIND	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	463,146	27,734	25,293	40,496	204,486	-	-	1,314	762,467
Domestic Production	949,915	251		40,496	201,836				1,192,498
Imports	29,620	27,482	25,482		4,790			1,741	89,116
Exports	516,389		190		2,140			427	519,146
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(159,267)	(27,734)	9,407	(40,496)	(6,880)	2,064	3,444	37,028	(182,433)
Electricity Generation	(100,347)		(16,673)	(40,496)			3,211	62,238	(92,067)
Petroleum Refining		(27,734)	27,734					(163)	(163)
Coal Production/Preparation	(45,473)							(6,158)	(51,631)
Charcoal Production					(6,880)	2,064			(4,816)
Coke Production									-
District Heat Production	(1,816)		(36)				1,148		(704)
Other Transformation									-
Own Use			(1,618)					(3,448)	(5,066)
Losses	(11,630)						(915)	(15,441)	(27,986)
FUELS FOR FINAL CONSUMPTION	303,879	-	34,699	-	197,606	2,064	3,444	38,342	580,035
ENERGY DEMAND	303,880	-	34,700	-	197,605	2,063	3,444	38,343	580,036
INDUSTRIAL SECTOR	156,549	-	7,812	-	584	-	-	16,844	181,788
Iron and Steel	58,377							3,127	61,503
Cement	43,254		3,761					2,705	49,720
Fertilizers	5,430		958					4,275	10,663
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	13,568							2,360	15,928
Other Minerals	4,280		2,524					214	7,018
Textiles	3,879		-					330	4,208
Building Materials	14,999		-					46	15,045
Non-specified Industry	10,965		568		141			2,884	14,558
TRANSPORT SECTOR	-	-	10,573	-	812	-	-	4,203	15,587
Road			8,755		812			6	9,573
Rail	-		535					4,196	4,731
Water	-		351						351
Air			932						932
Non-Specified			-					-	-
RESIDENTIAL SECTOR	98,616	-	2,753	-	151,122	2,063	1,943	3,343	259,840
Urban	78,328		2,528		32,981	1,282	1,943	3,012	120,073
Rural	20,289		224		118,141	782		331	139,767
AGRICULTURAL SECTOR	5,581	-	1,042	-	27,243	-	-	1,254	35,119
Field Operations			546					357	902
Processing/Other	5,581		497		27,243			897	34,217
FISHERIES SECTOR	340	-	851	-	-	-	-	157	1,348
Large Ships	-		717						717
Collectives/Processing/Other	340		134					157	631
MILITARY SECTOR	19,622	-	10,310	-	6,771	-	-	8,399	45,103
Trucks and other Transport			3,874						3,874
Armaments			102						102
Air Force			2,310						2,310
Naval Forces			3,944						3,944
Military Manufacturing	436		-					23	460
Buildings and Other	19,186		79		6,771			8,376	34,412
PUBLIC/COMMERCIAL SECTORS	20,297		710		5,074.32		1,186	4,143	31,411
NON-SPECIFIED/OTHER SECTORS			-				315		315
NON-ENERGY USE	2,874		648		6,000				9,522
Electricity Gen. (Gross TWhe)	5.08		0.96	11.25					17.29

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2016

Prepared By David Von Hippel
Date Last Modified: **4/20/2020**

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	476,927	28,282	29,614	42,351	196,968	-	-	(295)	773,848
Domestic Production	1,019,644	251		42,351	194,495				1,256,740
Imports	41,430	28,031	29,634		4,172			307	103,574
Exports	584,146		20		1,699			602	586,466
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(154,503)	(28,282)	7,510	(42,351)	(7,137)	2,141	3,592	38,921	(180,109)
Electricity Generation	(91,391)		(19,615)	(42,351)			3,398	65,340	(84,619)
Petroleum Refining		(28,282)	28,840					(170)	389
Coal Production/Preparation	(48,811)							(6,610)	(55,421)
Charcoal Production					(7,137)	2,141			(4,996)
Coke Production									-
District Heat Production	(1,817)		(35)				1,148		(704)
Other Transformation									-
Own Use			(1,681)					(3,679)	(5,360)
Losses	(12,484)						(955)	(15,960)	(29,398)
FUELS FOR FINAL CONSUMPTION	322,425	-	37,124	-	189,831	2,141	3,592	38,626	593,739
ENERGY DEMAND	322,424	-	37,123	-	189,831	2,141	3,592	38,627	593,737
INDUSTRIAL SECTOR	165,190	-	8,454	-	584	-	-	16,472	190,700
Iron and Steel	65,238							3,494	68,732
Cement	44,481		4,228					2,802	51,511
Fertilizers	6,156		1,096					4,846	12,098
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	13,444							2,339	15,783
Other Minerals	4,230		2,511					212	6,953
Textiles	3,879		-					330	4,208
Building Materials	14,999		-					46	15,045
Non-specified Industry	10,965		619		141			1,500	13,224
TRANSPORT SECTOR	-	-	11,020	-	881	-	-	4,375	16,276
Road			9,115		881			17	10,013
Rail	-		554					4,358	4,912
Water	-		363						363
Air			988						988
Non-Specified			-					-	-
RESIDENTIAL SECTOR	107,093	-	2,993	-	146,422	2,141	2,023	3,508	264,179
Urban	83,880		2,728		31,668	1,331	2,023	3,172	124,801
Rural	23,213		266		114,754	810		336	139,379
AGRICULTURAL SECTOR	5,004	-	1,106	-	24,428	-	-	1,163	31,702
Field Operations			579					359	938
Processing/Other	5,004		527		24,428			804	30,764
FISHERIES SECTOR	430	-	1,463	-	-	-	-	199	2,092
Large Ships	-		1,282						1,282
Collectives/Processing/Other	430		181					199	810
MILITARY SECTOR	20,106	-	10,805	-	6,401	-	-	8,609	45,921
Trucks and other Transport			3,999						3,999
Armaments			111						111
Air Force			2,567						2,567
Naval Forces			4,049						4,049
Military Manufacturing	445		-					24	469
Buildings and Other	19,660		80		6,401			8,585	34,727
PUBLIC/COMMERCIAL SECTORS	21,312		746		5,115		1,254	4,300	32,727
NON-SPECIFIED/OTHER SECTORS			-				315		315
NON-ENERGY USE	3,289		537		6,000				9,826
Electricity Gen. (Gross TWhe)	5.44		1.21	11.50					18.15

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2017

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	459,521	27,731	16,543	38,289	171,700	-	-	(898)	712,886
Domestic Production	566,806	251		38,289	168,898				774,243
Imports	29,480	27,480	16,543		3,794			72	77,368
Exports	136,765		0		991			969	138,726
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(125,611)	(27,731)	14,597	(38,289)	(7,103)	2,131	3,607	36,767	(141,632)
Electricity Generation	(89,592)		(11,499)	(38,289)			3,344	58,789	(77,246)
Petroleum Refining		(27,731)	27,738					(162)	(155)
Coal Production/Preparation	(27,133)							(3,675)	(30,808)
Charcoal Production					(7,103)	2,131			(4,972)
Coke Production									-
District Heat Production	(1,946)		(24)				1,222		(749)
Other Transformation									-
Own Use			(1,618)					(3,551)	(5,169)
Losses	(6,939)						(959)	(14,635)	(22,533)
FUELS FOR FINAL CONSUMPTION	333,910	-	31,140	-	164,597	2,131	3,607	35,869	571,255
ENERGY DEMAND	333,910	-	31,140	-	164,598	2,130	3,607	35,870	571,254
INDUSTRIAL SECTOR	157,796	-	4,229	-	592	-	-	14,266	176,883
Iron and Steel	58,972							3,159	62,130
Cement	45,605		1,930					2,735	50,269
Fertilizers	4,215		744					3,318	8,276
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	12,785							2,224	15,009
Other Minerals	4,899		1,225					192	6,316
Textiles	3,556		-					302	3,858
Building Materials	14,317		-					44	14,361
Non-specified Industry	11,650		331		150			1,388	13,519
TRANSPORT SECTOR	-	-	10,044	-	836	-	-	3,808	14,688
Road			8,317		836			41	9,193
Rail	-		516					3,767	4,283
Water	-		338						338
Air			873						873
Non-Specified			-					-	-
RESIDENTIAL SECTOR	125,722	-	3,023	-	123,108	2,130	2,025	3,553	259,560
Urban	95,433		2,748		25,401	1,325	2,025	3,212	130,143
Rural	30,289		275		97,706	805		341	129,417
AGRICULTURAL SECTOR	4,574	-	887	-	22,330	-	-	1,073	28,865
Field Operations			464					338	802
Processing/Other	4,574		423		22,330			735	28,062
FISHERIES SECTOR	408	-	1,404	-	-	-	-	210	2,021
Large Ships	-		1,232						1,232
Collectives/Processing/Other	408		172					210	789
MILITARY SECTOR	20,355	-	9,391	-	6,482	-	-	8,679	44,907
Trucks and other Transport			4,035						4,035
Armaments			85						85
Air Force			2,119						2,119
Naval Forces			3,072						3,072
Military Manufacturing	445		-					24	469
Buildings and Other	19,909		80		6,482			8,655	35,127
PUBLIC/COMMERCIAL SECTORS	22,825		872		5,249.69		1,266	4,281	34,494
NON-SPECIFIED/OTHER SECTORS			-				315		315
NON-ENERGY USE	2,231		1,290		6,000				9,521
Electricity Gen. (Gross TWhe)	5.29		0.67	10.37					16.33

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2018

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	449,406	30,705	13,020	38,928	165,253	-	-	(605)	696,708
Domestic Production	531,112	251		38,928	161,383				731,674
Imports	301	30,454	13,027		4,085			401	48,267
Exports	82,006		7		214			1,006	83,233
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(106,873)	(30,705)	17,092	(38,928)	(7,212)	2,164	3,785	35,428	(125,250)
Electricity Generation	(73,012)		(11,790)	(38,928)			3,569	56,003	(64,158)
Petroleum Refining		(30,705)	30,705					(179)	(179)
Coal Production/Preparation	(25,425)							(3,443)	(28,868)
Charcoal Production					(7,212)	2,164			(5,048)
Coke Production									-
District Heat Production	(1,934)		(37)				1,222		(749)
Other Transformation									-
Own Use			(1,786)					(2,936)	(4,723)
Losses	(6,502)						(1,006)	(14,017)	(21,525)
FUELS FOR FINAL CONSUMPTION	342,534	-	30,112	-	158,042	2,164	3,785	34,823	571,458
ENERGY DEMAND	342,534	-	30,112	-	158,042	2,163	3,785	34,822	571,457
INDUSTRIAL SECTOR	154,873	-	4,161	-	654	-	-	12,995	172,682
Iron and Steel	55,184							2,956	58,140
Cement	42,164		2,186					2,552	46,902
Fertilizers	2,359		416					1,857	4,632
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	12,785							2,224	15,009
Other Minerals	4,899		1,225					192	6,316
Textiles	3,556		-					302	3,858
Building Materials	15,681		-					48	15,729
Non-specified Industry	16,447		333		211			1,960	18,952
TRANSPORT SECTOR	-	-	9,668	-	792	-	-	3,656	14,117
Road			7,984		792			50	8,827
Rail	-		491					3,606	4,097
Water	-		320						320
Air			873						873
Non-Specified			-					-	-
RESIDENTIAL SECTOR	136,783	-	3,371	-	117,314	2,163	2,169	3,837	265,637
Urban	103,341		3,060		23,242	1,346	2,169	3,481	136,640
Rural	33,442		311		94,072	817		356	128,997
AGRICULTURAL SECTOR	4,370	-	757	-	21,331	-	-	1,014	27,471
Field Operations			396					312	708
Processing/Other	4,370		361		21,331			702	26,763
FISHERIES SECTOR	285	-	1,032	-	-	-	-	147	1,464
Large Ships	-		910						910
Collectives/Processing/Other	285		122					147	554
MILITARY SECTOR	20,852	-	9,078	-	6,644	-	-	8,819	45,393
Trucks and other Transport			4,035						4,035
Armaments			85						85
Air Force			2,015						2,015
Naval Forces			2,867						2,867
Military Manufacturing	445		-					24	469
Buildings and Other	20,407		76		6,644			8,795	35,922
PUBLIC/COMMERCIAL SECTORS	24,122		965		5,307		1,300	4,355	36,049
NON-SPECIFIED/OTHER SECTORS			-				315		315
NON-ENERGY USE	1,248		1,080		6,000				8,329
Electricity Gen. (Gross TWhe)	4.34		0.67	10.55					15.56

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2019

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	456,851	30,705	14,048	38,392	164,524	-	-	(834)	703,686
Domestic Production	619,098	251		38,392	160,907				818,649
Imports	301	30,454	14,127		3,616			172	48,670
Exports	162,548		79		-			1,006	163,633
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(112,177)	(30,705)	16,178	(38,392)	(7,321)	2,196	3,359	35,428	(131,435)
Electricity Generation	(73,027)		(12,705)	(38,392)			3,030	56,674	(64,419)
Petroleum Refining		(30,705)	30,705					(179)	(179)
Coal Production/Preparation	(29,637)							(4,014)	(33,650)
Charcoal Production					(7,321)	2,196			(5,125)
Coke Production									-
District Heat Production	(1,934)		(36)				1,222		(749)
Other Transformation									-
Own Use			(1,786)					(2,937)	(4,724)
Losses	(7,580)						(893)	(14,117)	(22,589)
FUELS FOR FINAL CONSUMPTION	344,674	-	30,226	-	157,203	2,196	3,359	34,594	572,251
ENERGY DEMAND	344,674	-	30,226	-	157,203	2,196	3,359	34,593	572,251
INDUSTRIAL SECTOR	154,886	-	4,147	-	654	-	-	12,995	172,682
Iron and Steel	55,184							2,956	58,140
Cement	42,177		2,173					2,552	46,902
Fertilizers	2,359		416					1,857	4,632
Other Chemicals	1,356							801	2,156
Pulp and Paper	443				443			103	988
Other Metals	12,785							2,224	15,009
Other Minerals	4,899		1,225					192	6,316
Textiles	3,556		-					302	3,858
Building Materials	15,681		-					48	15,729
Non-specified Industry	16,447		333		211			1,960	18,952
TRANSPORT SECTOR	-	-	9,662	-	785	-	-	3,661	14,109
Road			7,988		785			55	8,828
Rail	-		496					3,606	4,103
Water	-		320						320
Air			858						858
Non-Specified			-					-	-
RESIDENTIAL SECTOR	139,060	-	3,300	-	119,048	2,196	2,037	3,659	269,300
Urban	105,137		2,998		23,621	1,368	2,037	3,308	138,469
Rural	33,924		301		95,427	828		351	130,831
AGRICULTURAL SECTOR	3,826	-	749	-	18,678	-	-	927	24,180
Field Operations			396					312	708
Processing/Other	3,826		353		18,678			615	23,472
FISHERIES SECTOR	285	-	1,032	-	-	-	-	147	1,464
Large Ships	-		910						910
Collectives/Processing/Other	285		122					147	554
MILITARY SECTOR	20,852	-	9,272	-	6,644	-	-	8,819	45,587
Trucks and other Transport			4,035						4,035
Armaments			85						85
Air Force			2,209						2,209
Naval Forces			2,867						2,867
Military Manufacturing	445		-					24	469
Buildings and Other	20,407		76		6,644			8,795	35,922
PUBLIC/COMMERCIAL SECTORS	24,515		981		5,393		1,321	4,387	36,597
NON-SPECIFIED/OTHER SECTORS			-				-		-
NON-ENERGY USE	1,248		1,083		6,000				8,331
Electricity Gen. (Gross TWhe)	4.34		0.74	10.66					15.74

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2020

Prepared By David Von Hippel
Date Last Modified: 8/26/2020

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	378,623	32,196	6,629	39,155	163,652	-	-	(834)	619,421
Domestic Production	460,509	251		39,155	161,844				661,758
Imports	120	31,945	6,629		1,808			172	40,674
Exports	82,006		-		-			1,006	83,012
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(72,547)	(32,196)	17,511	(39,155)	(7,435)	2,231	4,639	32,846	(94,106)
Electricity Generation	(42,949)		(12,758)	(39,155)			4,650	50,560	(39,652)
Petroleum Refining		(32,196)	32,196					(188)	(188)
Coal Production/Preparation	(22,045)							(2,985)	(25,030)
Charcoal Production					(7,435)	2,231			(5,205)
Coke Production									-
District Heat Production	(1,915)		(55)				1,222		(749)
Other Transformation									-
Own Use			(1,871)					(1,796)	(3,667)
Losses	(5,638)						(1,233)	(12,745)	(19,616)
FUELS FOR FINAL CONSUMPTION	306,076	-	24,141	-	156,217	2,231	4,639	32,012	525,315
ENERGY DEMAND	306,075	-	24,141	-	156,217	2,231	4,639	32,013	525,316
INDUSTRIAL SECTOR	125,183	-	4,498	-	566	-	-	10,180	140,427
Iron and Steel	47,069							2,521	49,590
Cement	32,188		2,986					2,024	37,198
Fertilizers	1,179		208					928	2,316
Other Chemicals	986							582	1,568
Pulp and Paper	354				354			82	791
Other Metals	9,654							1,679	11,333
Other Minerals	3,810		953					150	4,912
Textiles	2,586		-					220	2,806
Building Materials	10,908		-					33	10,942
Non-specified Industry	16,447		351		211			1,960	18,970
TRANSPORT SECTOR	-	-	7,233	-	582	-	-	3,663	11,478
Road			6,111		582			57	6,750
Rail	-		374					3,606	3,980
Water	-		200						200
Air			547						547
Non-Specified			-					-	-
RESIDENTIAL SECTOR	141,394	-	3,437	-	120,823	2,231	3,528	6,406	277,818
Urban	106,977		3,127		24,009	1,390	3,528	5,796	144,827
Rural	34,417		310		96,814	840		610	132,991
AGRICULTURAL SECTOR	3,629	-	741	-	17,713	-	-	895	22,977
Field Operations			396					312	708
Processing/Other	3,629		344		17,713			583	22,269
FISHERIES SECTOR	257	-	929	-	-	-	-	132	1,318
Large Ships	-		819						819
Collectives/Processing/Other	257		110					132	499
MILITARY SECTOR	17,308	-	5,731	-	6,644	-	-	7,575	37,258
Trucks and other Transport			2,409						2,409
Armaments			47						47
Air Force			1,653						1,653
Naval Forces			1,556						1,556
Military Manufacturing	223		-					12	235
Buildings and Other	17,085		65		6,644			7,564	31,358
PUBLIC/COMMERCIAL SECTORS	17,682		707		3,890		953	3,161	26,393
NON-SPECIFIED/OTHER SECTORS			-				158		158
NON-ENERGY USE	624		866		6,000				7,490
Electricity Gen. (Gross TWhe)	2.58		0.72	10.74					14.04

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1990:
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	110,742	5,275	12,962	6,224	2,160	-		137,364
Domestic Production	-							-
Imports	110,742	5,275	12,962	6,224	2,160			137,364
Exports								-
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(110,742)	25,332	19,357	16,583	8,849	11,560	1,080	(27,980)
Electricity Generation				(21,947)				(21,947)
Petroleum Refining	(110,742)	25,332	19,357	38,603	8,849	17,521	1,080	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(73)				(73)
Other Transformation								-
Own Use						(5,960)		(5,960)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	30,607	32,319	22,807	11,009	11,560	1,080	109,384
ENERGY DEMAND	-	30,606	32,317	22,807	11,008	11,566	1,080	109,384
INDUSTRIAL SECTOR	-	-	3,050	21,685	-	3,658	-	28,393
Iron and Steel								-
Cement				7,571				7,571
Fertilizers				915		3,658		4,573
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				12,600				12,600
Textiles								-
Building Materials								
Non-specified Industry			3,050	600				3,650
TRANSPORT SECTOR	-	23,220	12,926	627	399	-	724	37,896
Road		23,220	9,351					32,571
Rail			1,949					1,949
Water			627	627				1,253
Air					399		724	1,123
Non-Specified			1,000					1,000
RESIDENTIAL SECTOR	-	-	-	-	4,473	2,127	-	6,600
Urban					4,129	2,127		6,256
Rural					344			344
AGRICULTURAL SECTOR	-	-	5,005	-	-	-	-	5,005
Field Operations			2,619					2,619
Processing/Other			2,386					2,386
FISHERIES SECTOR	-	-	2,777	360	-	-	-	3,137
Large Ships			2,547	134				2,681
Collectives/Processing/Other			230	226				456
MILITARY SECTOR	-	7,386	6,859	134	1,798	-	356	16,533
Trucks and other Transport		6,476	109					6,585
Armaments		45	218					263
Air Force		494			1,798		356	2,648
Naval Forces		371	6,432	134				6,937
Military Manufacturing								-
Buildings and Other			100					100
PUBLIC/COMMERCIAL SECTORS					88	10		98
NON-SPECIFIED/OTHER SECTORS		-	1,700		4,250			5,950
NON-ENERGY USE						5,771		5,771

SUMMARY AND COMPARISON OF RESULTS: PETROLEUM REFINING BY PRODUCT

	1990 Production Data from Jang, 1994 *(Note 1)*				1990 Production from Balance *(Note 2)*			
					Oil for Magnesite as Heavy		Oil for Magnesite as Crude	
Product	Production kte/yr	Conversion te/toe	Production ktoe/yr	Fraction of Total	Production ktoe/yr	Fraction of Total	Production ktoe/yr	Fraction of Total
Gasoline	950	1.07	1,017	33%	605	23%	605	26%
Diesel	1000	1.035	1,035	34%	463	17%	463	20%
Heavy Oil	650	0.96	624	20%	923	35%	621	26%
Kerosene/Jet Fuel	210	1.045	219	7%	211	8%	211	9%
Other Products	165	0.96	158	5%	445	17%	445	19%
TOTAL			3,053	100%	2,647	100%	2,346	100%

	Oil for Carbide as Feedstock	
Product	Production ktoe/yr	Fraction of Total
Gasoline	605	22.87%
Diesel	463	17.48%
Heavy Oil	621	23.48%
Kerosene/Jet Fuel	211	7.99%
Other Products	445	16.80%
Petrochem Feedstocks	301	11.38%
TOTAL	2,647	100.00%

Notes:

1 *Young Sik Jang, North Korean Energy Economics, Korea Development Institute, 1994 (pp. 54, 64)*

2 *The "Oil for Magnesite as Heavy" columns in this table present production as estimated in the refined products balance, which assumes that oil used in magnesite production is heavy or residual oil. It is possible that crude oil is input to the magnesite (and/or fertilizer) production process without previous refining. If this is the case (for magnesite), the refined products balance would be as shown in the second pair of columns.*

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1996:
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	39,874	8,545	5,185	18,422	518	(504)	-	72,041
Domestic Production	-							-
Imports	39,874	8,545	5,185	24,834	518	17		78,974
Exports				-		521		521
Inputs to International Marine Bunkers								-
Stock Changes		-	-	6,412				6,412
ENERGY TRANSFORMATION	(39,874)	8,183	8,090	(10,852)	1,618	4,070	871	(27,895)
Electricity Generation				(25,450)		(17)		(25,467)
Petroleum Refining	(39,874)	8,183	8,090	14,760	1,618	6,352	871	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(163)				(163)
Other Transformation								-
Own Use						(2,266)		(2,266)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	16,728	13,275	7,570	2,136	3,565	871	44,146
ENERGY DEMAND	-	16,729	13,274	7,570	2,137	3,565	871	44,146
INDUSTRIAL SECTOR	-	-	671	7,081	-	903	-	8,655
Iron and Steel								-
Cement				3,331				3,331
Fertilizers				226		903		1,129
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,326				3,326
Textiles								-
Building Materials								
Non-specified Industry			671	198				869
TRANSPORT SECTOR	-	10,378	5,180	251	320	-	579	16,707
Road		10,378	4,150					14,528
Rail			779					779
Water			251	251				501
Air					320		579	899
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	553	1,232	-	1,785
Urban					430	1,218		1,649
Rural					123	14		136
AGRICULTURAL SECTOR	-	-	1,319	-	-	-	-	1,319
Field Operations			690					690
Processing/Other			629					629
FISHERIES SECTOR	-	-	856	142	-	-	-	998
Large Ships			764	40				804
Collectives/Processing/Other			92	102				193
MILITARY SECTOR	-	6,352	5,248	96	1,199	-	292	13,186
Trucks and other Transport		5,639	95					5,734
Armaments		36	174					211
Air Force		395			1,199		292	1,886
Naval Forces		281	4,884	96				5,261
Military Manufacturing								-
Buildings and Other			95					95
PUBLIC/COMMERCIAL SECTORS					65	65		131
NON-SPECIFIED/OTHER SECTORS			-		-			-
NON-ENERGY USE						1,365		1,365

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ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2000
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	16,877	4,791	8,221	20,809	951	5,239	-	56,887
Domestic Production	298							298
Imports	16,579	4,791	8,221	22,391	951	5,424		58,357
Exports				2,827		186		3,013
Inputs to International Marine Bunkers								-
Stock Changes		-		(1,245)	-			(1,245)
ENERGY TRANSFORMATION	(16,877)	3,191	3,431	(9,538)	694	845	654	(17,598)
Electricity Generation				(15,435)		(771)		(16,206)
Petroleum Refining	(16,877)	3,191	3,431	6,288	694	2,618	654	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(391)				(391)
Other Transformation								-
Own Use						(1,001)		(1,001)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	7,983	11,652	11,271	1,645	6,084	654	39,289
ENERGY DEMAND	-	7,984	11,651	11,270	1,645	6,086	654	39,290
INDUSTRIAL SECTOR	-	-	633	10,819	-	274	-	11,726
Iron and Steel								-
Cement				7,024				7,024
Fertilizers				69		274		343
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,478				3,478
Textiles								-
Building Materials								
Non-specified Industry			633	249				882
TRANSPORT SECTOR	-	3,350	4,020	238	354	-	433	8,395
Road		3,350	3,198					6,548
Rail			585					585
Water			238	238				476
Air					354		433	786
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	428	1,651	-	2,079
Urban					344	1,579		1,924
Rural					84	72		156
AGRICULTURAL SECTOR	-	-	968	-	-	-	-	968
Field Operations			507					507
Processing/Other			461					461
FISHERIES SECTOR	-	-	710	118	-	-	-	828
Large Ships			634	33				668
Collectives/Processing/Other			76	85				161
MILITARY SECTOR	-	4,634	5,320	95	824	-	222	11,094
Trucks and other Transport		3,997	67					4,064
Armaments		25	122					148
Air Force		321			824		222	1,367
Naval Forces		290	5,045	95				5,430
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					39	39		78
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						4,121		4,121

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2005
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	22,568	1,840	12,741	5,678	2,031	1,114	-	45,971
Domestic Production	298							298
Imports	22,270	1,840	12,741	5,470	2,031	1,301		45,653
Exports				-		188		188
Inputs to International Marine Bunkers								-
Stock Changes				(207)				(207)
ENERGY TRANSFORMATION	(22,568)	4,682	3,196	2,196	925	1,309	455	(9,804)
Electricity Generation			(1,390)	(6,128)		(891)		(8,409)
Petroleum Refining	(22,568)	4,682	4,586	8,395	925	3,524	455	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(71)				(71)
Other Transformation								-
Own Use						(1,324)		(1,324)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	6,522	15,937	7,874	2,956	2,422	455	36,167
ENERGY DEMAND	-	6,524	15,937	7,875	2,955	2,420	455	36,166
INDUSTRIAL SECTOR	-	-	844	7,387	-	410	-	8,640
Iron and Steel								-
Cement				3,568				3,568
Fertilizers				102		410		512
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,528				3,528
Textiles								-
Building Materials								
Non-specified Industry			844	188				1,032
TRANSPORT SECTOR	-	2,395	7,761	263	611	-	185	11,216
Road		2,395	6,563					8,958
Rail			935					935
Water			263	263				526
Air					611		185	797
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	909	1,260	-	2,169
Urban					806	1,210		2,016
Rural					102	50		153
AGRICULTURAL SECTOR	-	-	1,164	-	-	-	-	1,164
Field Operations			609					609
Collectives/Processing/Other			555					555
FISHERIES SECTOR	-	-	796	128	-	-	-	924
Large Ships			713	38				751
Processing/Other			82	91				173
MILITARY SECTOR	-	4,128	5,372	97	1,386	-	270	11,253
Trucks and other Transport		3,466	58					3,524
Armaments		22	107					129
Air Force		346			1,386		270	2,002
Naval Forces		295	5,122	97				5,513
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					50	116		165
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						635		635

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2008
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	22,812	5,089	8,745	9,401	2,184	252	-	48,483
Domestic Production	298							298
Imports	22,514	5,089	8,745	13,253	2,184	388		52,172
Exports				3,852		136		3,987
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(22,812)	4,682	2,747	(2,454)	935	2,225	479	(14,197)
Electricity Generation		(32)	(1,889)	(10,781)		-		(12,701)
Petroleum Refining	(22,812)	4,714	4,635	8,485	935	3,563	479	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(158)				(158)
Other Transformation								-
Own Use						(1,338)		(1,338)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,771	11,492	6,947	3,119	2,477	479	34,286
ENERGY DEMAND	-	9,770	11,494	6,947	3,119	2,476	479	34,285
INDUSTRIAL SECTOR	-	-	403	6,548	-	398	-	7,349
Iron and Steel								-
Cement				3,168				3,168
Fertilizers				100		398		498
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,099				3,099
Textiles								-
Building Materials								
Non-specified Industry			403	182				584
TRANSPORT SECTOR	-	6,022	5,172	207	684	-	189	12,274
Road		6,022	4,362					10,384
Rail			604					604
Water			207	207				414
Air					684		189	873
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	802	1,298	-	2,100
Urban					702	1,214		1,916
Rural					100	84		184
AGRICULTURAL SECTOR	-	-	1,008	-	-	-	-	1,008
Field Operations			517					517
Processing/Other			491					491
FISHERIES SECTOR	-	-	764	120	-	-	-	884
Large Ships			688	36				724
Collectives/Processing/Other			76	84				160
MILITARY SECTOR	-	3,747	4,147	72	1,573	-	290	9,830
Trucks and other Transport		3,133	53					3,186
Armaments		17	84					101
Air Force		371			1,573		290	2,234
Naval Forces		226	3,929	72				4,227
Military Manufacturing								-
Buildings and Other			82					82
PUBLIC/COMMERCIAL SECTORS					60	179		239
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						600		600

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2009
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	22,392	3,479	7,790	353	1,522	190	-	35,726
Domestic Production	251							251
Imports	22,140	3,479	7,790	395	1,522	320		35,647
Exports		-	-	42		130		172
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(22,392)	4,542	2,171	3,928	918	2,181	469	(8,183)
Electricity Generation		(87)	(2,380)	(4,366)		(1)		(6,833)
Petroleum Refining	(22,392)	4,629	4,550	8,329	918	3,496	469	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(36)				(36)
Other Transformation								-
Own Use						(1,314)		(1,314)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	8,021	9,961	4,281	2,440	2,372	469	27,543
ENERGY DEMAND	-	8,022	9,962	4,281	2,439	2,370	469	27,542
INDUSTRIAL SECTOR	-	-	463	3,926	-	264	-	4,653
Iron and Steel								-
Cement				1,585				1,585
Fertilizers				66		264		330
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,114				2,114
Textiles								-
Building Materials								
Non-specified Industry			463	162				625
TRANSPORT SECTOR	-	4,491	4,004	175	621	-	172	9,463
Road		4,491	3,381					7,871
Rail			448					448
Water			175	175				351
Air					621		172	793
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	645	1,046	-	1,691
Urban					568	981		1,549
Rural					77	65		142
AGRICULTURAL SECTOR	-	-	950	-	-	-	-	950
Field Operations			518					518
Processing/Other			432					432
FISHERIES SECTOR	-	-	708	113	-	-	-	820
Large Ships			637	33				670
Collectives/Processing/Other			71	79				150
MILITARY SECTOR	-	3,531	3,836	67	1,124	-	297	8,856
Trucks and other Transport		2,935	49					2,984
Armaments		17	84					101
Air Force		371			1,124		297	1,792
Naval Forces		208	3,625	67				3,901
Military Manufacturing								-
Buildings and Other			78					78
PUBLIC/COMMERCIAL SECTORS					50	281		330
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						779		779

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2010
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	25,309	3,649	9,523	(426)	1,741	302	-	40,099
Domestic Production	251							251
Imports	25,058	3,649	9,955	684	1,741	430		41,517
Exports			432	1,110		128		1,670
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(25,309)	5,199	1,585	5,728	1,218	2,466	480	(8,634)
Electricity Generation		(135)	(3,428)	(3,546)		(10)		(7,118)
Petroleum Refining	(25,309)	5,333	5,013	9,310	1,218	3,956	480	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(35)				(35)
Other Transformation								-
Own Use						(1,480)		(1,480)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	8,848	11,107	5,302	2,959	2,768	480	31,465
ENERGY DEMAND	-	8,849	11,107	5,302	2,958	2,769	480	31,465
INDUSTRIAL SECTOR	-	-	503	4,915	-	270	-	5,688
Iron and Steel								-
Cement				2,278				2,278
Fertilizers				68		270		338
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,381				2,381
Textiles								-
Building Materials								
Non-specified Industry			503	188				691
TRANSPORT SECTOR	-	5,074	4,360	188	717	-	146	10,485
Road		5,074	3,645					8,720
Rail			526					526
Water			188	188				376
Air					717		146	863
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	793	1,278	-	2,071
Urban					699	1,195		1,894
Rural					94	83		177
AGRICULTURAL SECTOR	-	-	1,031	-	-	-	-	1,031
Field Operations			539					539
Processing/Other			491					491
FISHERIES SECTOR	-	-	766	122	-	-	-	889
Large Ships			688	36				724
Collectives/Processing/Other			79	86				165
MILITARY SECTOR	-	3,775	4,447	77	1,386	-	334	10,018
Trucks and other Transport		3,133	53					3,186
Armaments		18	85					103
Air Force		381			1,386		334	2,100
Naval Forces		243	4,233	77				4,553
Military Manufacturing								-
Buildings and Other			76					76
PUBLIC/COMMERCIAL SECTORS					63	355		417
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						866		866

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2014
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 4/2/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	24,870	4,916	12,844	349	1,593	880	-	45,453
Domestic Production	251							251
Imports	24,619	4,916	13,695	349	1,593	1,155		46,327
Exports			851	-		275		1,126
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(24,870)	4,218	(2,225)	5,264	1,019	2,367	485	(13,742)
Electricity Generation		(957)	(7,279)	(3,949)		(69)		(12,254)
Petroleum Refining	(24,870)	5,175	5,053	9,247	1,019	3,891	485	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(33)				(33)
Other Transformation								-
Own Use						(1,455)		(1,455)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,134	10,618	5,614	2,612	3,247	485	31,711
ENERGY DEMAND	-	9,135	10,617	5,614	2,613	3,246	485	31,710
INDUSTRIAL SECTOR	-	-	336	5,238	-	825	-	6,398
Iron and Steel								-
Cement				2,530				2,530
Fertilizers				206		825		1,031
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,320				2,320
Textiles								-
Building Materials								
Non-specified Industry			336	181				516
TRANSPORT SECTOR	-	4,942	4,362	169	703	-	143	10,320
Road		4,942	3,668					8,610
Rail			525					525
Water			169	169				338
Air					703		143	846
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	780	1,406	-	2,186
Urban					683	1,321		2,004
Rural					97	86		183
AGRICULTURAL SECTOR	-	-	983	-	-	-	-	983
Field Operations			515					515
Processing/Other			469					469
FISHERIES SECTOR	-	-	1,084	138	-	-	-	1,222
Large Ships			996	52				1,048
Collectives/Processing/Other			88	86				174
MILITARY SECTOR	-	4,192	3,852	69	1,066	-	342	9,522
Trucks and other Transport		3,480	47					3,527
Armaments		13	83					96
Air Force		490			1,066		342	1,899
Naval Forces		210	3,644	69				3,923
Military Manufacturing								-
Buildings and Other			78					78
PUBLIC/COMMERCIAL SECTORS					64	427		491
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						589		589

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2015
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 4/2/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	27,734	6,670	14,943	464	2,118	1,097	-	53,026
Domestic Production	251							251
Imports	27,482	6,670	14,943	464	2,118	1,287		52,965
Exports			-	-		190		190
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(27,734)	2,926	(4,426)	6,509	1,135	2,721	541	(18,327)
Electricity Generation		(2,844)	(10,060)	(3,762)		(8)		(16,673)
Petroleum Refining	(27,734)	5,769	5,634	10,307	1,135	4,347	541	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(36)				(36)
Other Transformation								-
Own Use						(1,618)		(1,618)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,596	10,517	6,974	3,253	3,819	541	34,699
ENERGY DEMAND	-	9,596	10,518	6,974	3,252	3,819	541	34,700
INDUSTRIAL SECTOR	-	-	419	6,626	-	766	-	7,812
Iron and Steel								-
Cement				3,761				3,761
Fertilizers				192		766		958
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,524				2,524
Textiles								-
Building Materials								
Non-specified Industry			419	149				568
TRANSPORT SECTOR	-	5,041	4,424	175	789	-	143	10,573
Road		5,041	3,714					8,755
Rail			535					535
Water			175	175				351
Air					789		143	932
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	974	1,779	-	2,753
Urban					855	1,674		2,528
Rural					119	106		224
AGRICULTURAL SECTOR	-	-	1,042	-	-	-	-	1,042
Field Operations			546					546
Processing/Other			497					497
FISHERIES SECTOR	-	-	748	104	-	-	-	851
Large Ships			681	36				717
Collectives/Processing/Other			66	68				134
MILITARY SECTOR	-	4,555	3,884	69	1,404	-	398	10,310
Trucks and other Transport		3,822	52					3,874
Armaments		14	88					102
Air Force		508			1,404		398	2,310
Naval Forces		211	3,665	69				3,944
Military Manufacturing								-
Buildings and Other			79					79
PUBLIC/COMMERCIAL SECTORS					85	625		710
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						648		648

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2016
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 4/2/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	28,282	6,434	19,004	527	2,452	1,198	-	57,896
Domestic Production	251							251
Imports	28,031	6,434	19,004	537	2,452	1,207		57,665
Exports			-	10		9		20
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(28,282)	3,357	(7,363)	6,982	1,180	2,816	537	(20,772)
Electricity Generation		(2,667)	(13,221)	(3,699)		(27)		(19,615)
Petroleum Refining	(28,282)	6,025	5,859	10,717	1,180	4,523	537	558
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(35)				(35)
Other Transformation								-
Own Use						(1,681)		(1,681)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,791	11,641	7,509	3,632	4,014	537	37,124
ENERGY DEMAND	-	9,792	11,640	7,510	3,631	4,013	537	37,123
INDUSTRIAL SECTOR	-	-	470	7,107	-	877	-	8,454
Iron and Steel								-
Cement				4,228				4,228
Fertilizers				219		877		1,096
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,511				2,511
Textiles								-
Building Materials								
Non-specified Industry			470	149				619
TRANSPORT SECTOR	-	5,090	4,761	182	843	-	144	11,020
Road		5,090	4,025					9,115
Rail			554					554
Water			182	182				363
Air					843		144	988
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	1,058	1,936	-	2,993
Urban					908	1,819		2,728
Rural					149	116		266
AGRICULTURAL SECTOR	-	-	1,106	-	-	-	-	1,106
Field Operations			579					579
Processing/Other			527					527
FISHERIES SECTOR	-	-	1,313	150	-	-	-	1,463
Large Ships			1,218	64				1,282
Collectives/Processing/Other			95	86				181
MILITARY SECTOR	-	4,702	3,991	71	1,648	-	393	10,805
Trucks and other Transport		3,945	54					3,999
Armaments		15	96					111
Air Force		526			1,648		393	2,567
Naval Forces		216	3,762	71				4,049
Military Manufacturing								-
Buildings and Other			80					80
PUBLIC/COMMERCIAL SECTORS					82	664		746
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						537		537

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2017
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 4/2/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	27,731	4,077	9,778	157	1,363	1,169	-	44,274
Domestic Production	251							251
Imports	27,480	4,077	9,778	157	1,363	1,169		44,023
Exports			-	-		0		0
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(27,731)	5,629	(300)	3,605	1,302	3,863	499	(13,134)
Electricity Generation		(2,982)	(6,768)	(1,735)		(14)		(11,499)
Petroleum Refining	(27,731)	8,610	6,468	5,364	1,302	5,495	499	7
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(24)				(24)
Other Transformation								-
Own Use						(1,618)		(1,618)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,706	9,478	3,761	2,664	5,032	499	31,140
ENERGY DEMAND	-	9,707	9,478	3,762	2,664	5,031	499	31,140
INDUSTRIAL SECTOR	-	-	235	3,399	-	595	-	4,229
Iron and Steel								-
Cement				1,930				1,930
Fertilizers				149		595		744
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				1,225				1,225
Textiles								-
Building Materials								
Non-specified Industry			235	96				331
TRANSPORT SECTOR	-	4,973	4,028	169	746	-	128	10,044
Road		4,973	3,343					8,317
Rail			516					516
Water			169	169				338
Air					746		128	873
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	679	2,344	-	3,023
Urban					582	2,165		2,748
Rural					96	179		275
AGRICULTURAL SECTOR	-	-	887	-	-	-	-	887
Field Operations			464					464
Processing/Other			423					423
FISHERIES SECTOR	-	-	1,261	143	-	-	-	1,404
Large Ships			1,171	62				1,232
Collectives/Processing/Other			91	82				172
MILITARY SECTOR	-	4,733	3,066	50	1,170	-	371	9,391
Trucks and other Transport		3,980	55					4,035
Armaments		12	74					85
Air Force		578			1,170		371	2,119
Naval Forces		164	2,858	50				3,072
Military Manufacturing								-
Buildings and Other			80					80
PUBLIC/COMMERCIAL SECTORS					70	802		872
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						1,290		1,290

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2018
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 5/5/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	30,705	2,879	8,263	30	785	1,064	-	43,725
Domestic Production	251							251
Imports	30,454	2,879	8,263	30	785	1,071		43,481
Exports			-	-		7		7
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(30,705)	6,571	423	3,872	1,441	4,302	482	(13,614)
Electricity Generation		(3,041)	(6,740)	(2,004)		(6)		(11,790)
Petroleum Refining	(30,705)	9,612	7,163	5,913	1,441	6,095	482	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(37)				(37)
Other Transformation								-
Own Use						(1,786)		(1,786)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,450	8,686	3,902	2,225	5,366	482	30,112
ENERGY DEMAND	-	9,449	8,687	3,902	2,225	5,366	482	30,112
INDUSTRIAL SECTOR	-	-	235	3,593	-	333	-	4,161
Iron and Steel								-
Cement				2,186				2,186
Fertilizers				83		333		416
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				1,225				1,225
Textiles								-
Building Materials								
Non-specified Industry			235	98				333
TRANSPORT SECTOR	-	4,741	3,894	160	746	-	128	9,668
Road		4,741	3,244					7,984
Rail			491					491
Water			160	160				320
Air					746		128	873
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	325	3,046	-	3,371
Urban					269	2,791		3,060
Rural					56	255		311
AGRICULTURAL SECTOR	-	-	757	-	-	-	-	757
Field Operations			396					396
Processing/Other			361					361
FISHERIES SECTOR	-	-	930	103	-	-	-	1,032
Large Ships			865	45				910
Collectives/Processing/Other			65	57				122
MILITARY SECTOR	-	4,709	2,872	47	1,097	-	354	9,078
Trucks and other Transport		3,980	55					4,035
Armaments		12	74					85
Air Force		564			1,097		354	2,015
Naval Forces		153	2,667	47				2,867
Military Manufacturing								-
Buildings and Other			76					76
PUBLIC/COMMERCIAL SECTORS					58	907		965
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						1,080		1,080

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2019
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 6/22/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	30,705	2,679	9,432	2	864	1,071	-	44,753
Domestic Production	251							251
Imports	30,454	2,679	9,432	80	864	1,071		44,581
Exports			-	79		0		79
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(30,705)	6,557	(518)	3,887	1,441	4,302	508	(14,528)
Electricity Generation		(3,029)	(7,681)	(1,989)		(6)		(12,705)
Petroleum Refining	(30,705)	9,586	7,163	5,913	1,441	6,095	508	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(36)				(36)
Other Transformation								-
Own Use						(1,786)		(1,786)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	9,237	8,914	3,889	2,305	5,373	508	30,226
ENERGY DEMAND	-	9,237	8,914	3,889	2,305	5,373	508	30,226
INDUSTRIAL SECTOR	-	-	235	3,580	-	333	-	4,147
Iron and Steel								-
Cement				2,173				2,173
Fertilizers				83		333		416
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				1,225				1,225
Textiles								-
Building Materials								
Non-specified Industry			235	98				333
TRANSPORT SECTOR	-	4,515	4,129	160	739	-	119	9,662
Road		4,515	3,473					7,988
Rail			496					496
Water			160	160				320
Air					739		119	858
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	264	3,036	-	3,300
Urban					210	2,788		2,998
Rural					54	247		301
AGRICULTURAL SECTOR	-	-	749	-	-	-	-	749
Field Operations			396					396
Processing/Other			353					353
FISHERIES SECTOR	-	-	930	103	-	-	-	1,032
Large Ships			865	45				910
Collectives/Processing/Other			65	57				122
MILITARY SECTOR	-	4,722	2,872	47	1,243	-	389	9,272
Trucks and other Transport		3,980	55					4,035
Armaments		12	74					85
Air Force		578			1,243		389	2,209
Naval Forces		153	2,667	47				2,867
Military Manufacturing								-
Buildings and Other			76					76
PUBLIC/COMMERCIAL SECTORS					59	922		981
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						1,083		1,083

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2020
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 6/22/2020

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	32,196	381	5,797	30	43	379	-	38,825
Domestic Production	251							251
Imports	31,945	381	5,797	30	43	379		38,574
Exports			-	-		-		-
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(32,196)	6,327	509	4,284	1,511	4,519	361	(14,685)
Electricity Generation		(3,900)	(7,002)	(1,850)		(6)		(12,758)
Petroleum Refining	(32,196)	10,228	7,512	6,189	1,511	6,396	361	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(55)				(55)
Other Transformation								-
Own Use						(1,871)		(1,871)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	6,708	6,306	4,314	1,554	4,898	361	24,141
ENERGY DEMAND	-	6,709	6,305	4,315	1,554	4,897	361	24,141
INDUSTRIAL SECTOR	-	-	235	4,097	-	166	-	4,498
Iron and Steel								-
Cement				2,986				2,986
Fertilizers				42		166		208
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				953				953
Textiles								-
Building Materials								
Non-specified Industry			235	117				351
TRANSPORT SECTOR	-	3,679	2,907	100	471	-	76	7,233
Road		3,679	2,432					6,111
Rail			374					374
Water			100	100				200
Air					471		76	547
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	243	3,193	-	3,437
Urban					188	2,939		3,127
Rural					56	254		310
AGRICULTURAL SECTOR	-	-	741	-	-	-	-	741
Field Operations			396					396
Processing/Other			344					344
FISHERIES SECTOR	-	-	837	92	-	-	-	929
Large Ships			778	41				819
Collectives/Processing/Other			58	51				110
MILITARY SECTOR	-	3,030	1,587	25	804	-	285	5,731
Trucks and other Transport		2,376	33					2,409
Armaments		6	41					47
Air Force		564			804		285	1,653
Naval Forces		83	1,448	25				1,556
Military Manufacturing								-
Buildings and Other			65					65
PUBLIC/COMMERCIAL SECTORS					35	672		707
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						866		866

NAUTILUS INSTITUTE

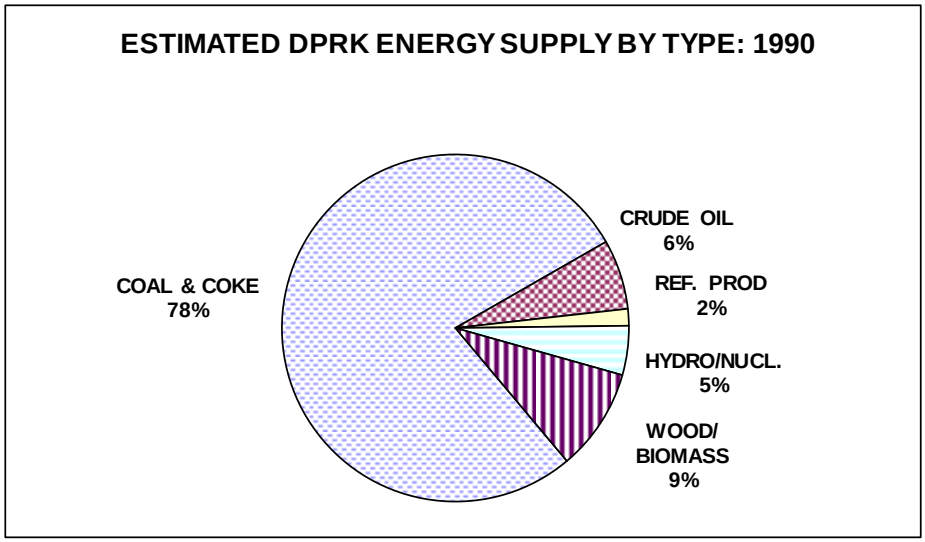
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

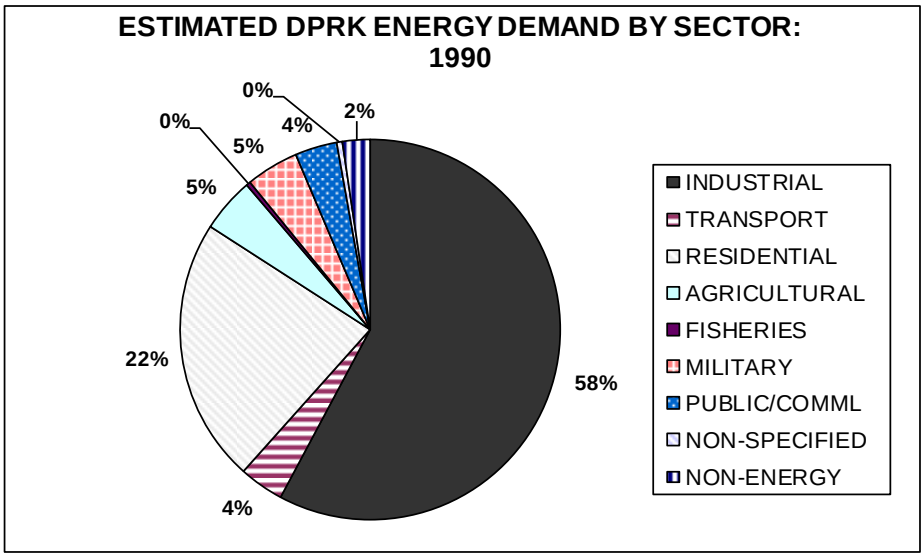
2020 UPDATE

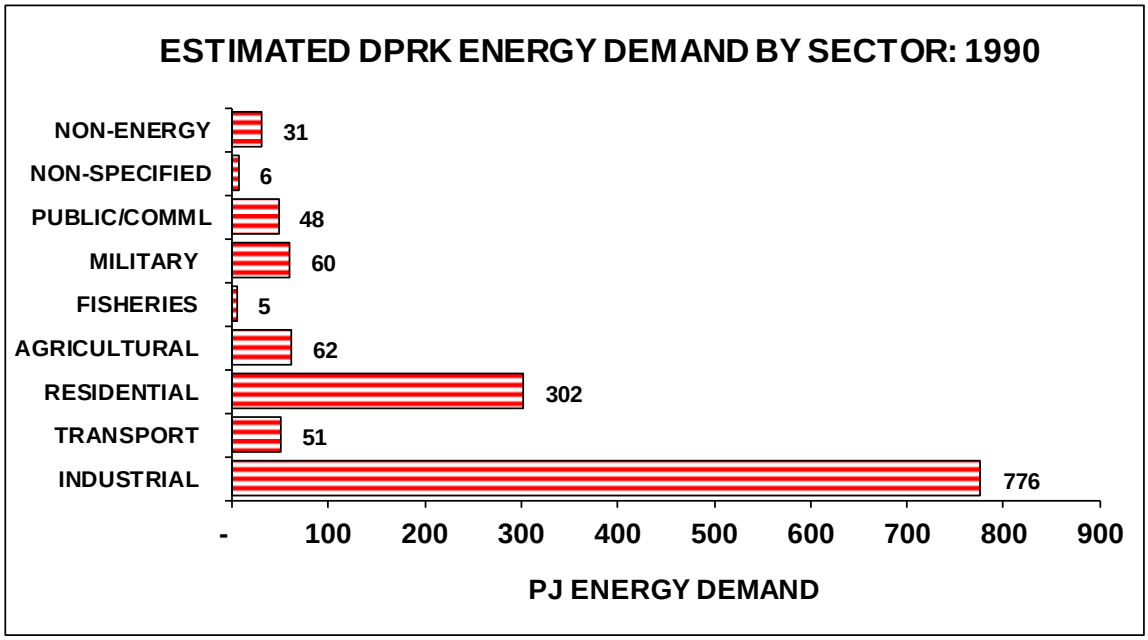
ESTIMATED SUMMARY ENERGY BALANCE FOR 1990

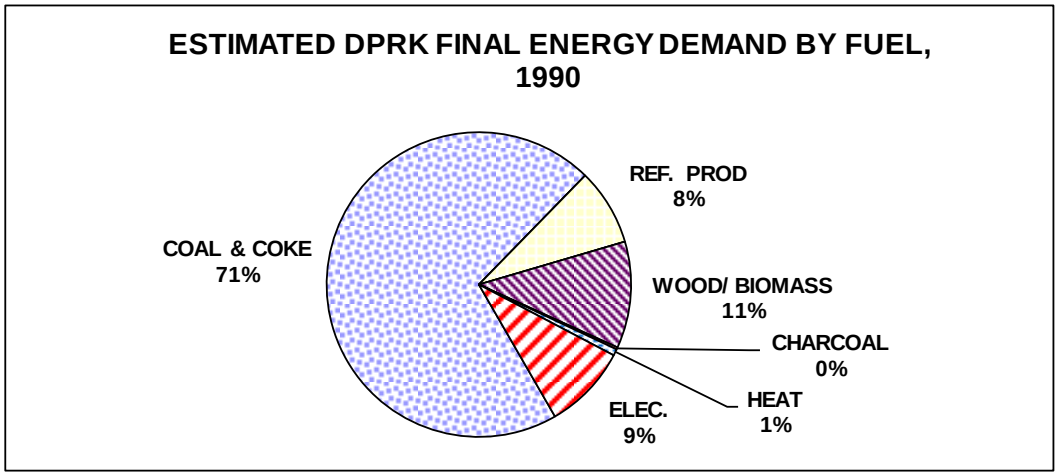
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

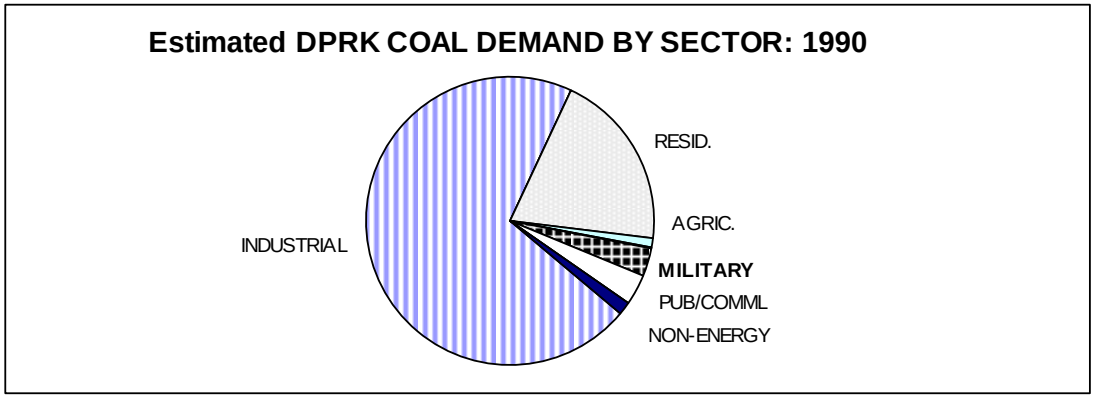
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	1,326	111	27	78	162	(0)	-	-	1,703
Domestic Production	1,301	-		78	150				1,529
Imports	68	111	27		12				218
Exports	44				0	0		-	44
Stock Changes									
ENERGY TRANSF.	(378)	(111)	83	(78)	(10)	3	9	120	(361)
Electricity Generation	(295)		(22)	(77)			8	166	(220)
Petroleum Refining		(111)	111					(1)	(1)
Coal Prod./Prep.	(63)							(9)	(72)
Charcoal Production					(10)	3			(7)
District Heat Production	(3)		(0)	(1)			3		(2)
Own Use			(6)					(12)	(18)
Losses	(16)						(2)	(24)	(41)
FUELS FOR FINAL CONS.	948.00	-	109.38	-	152.02	2.98	9.25	120.46	1,342
ENERGY DEMAND	948.01	-	109.38	-	152.02	2.97	9.25	120.47	1,342
INDUSTRIAL	672	-	28	-	6	-	-	70	776
TRANSPORT	-	-	38	-	2	-	-	11	51
RESIDENTIAL	189	-	7	-	86	3	6	11	302
AGRICULTURAL	10	-	5	-	45	-	-	3	62
FISHERIES	1	-	3	-	-	-	-	1	5
MILITARY	30	-	17	-	-	-	-	14	60
PUBLIC/COMML	33	-	0	-	2	-	3	11	48
NON-SPECIFIED			6	-			0		6
NON-ENERGY	14		6		12				31
Elect. Gen. (Gr. TWhe)	23.43		1.28	21.29					46.00

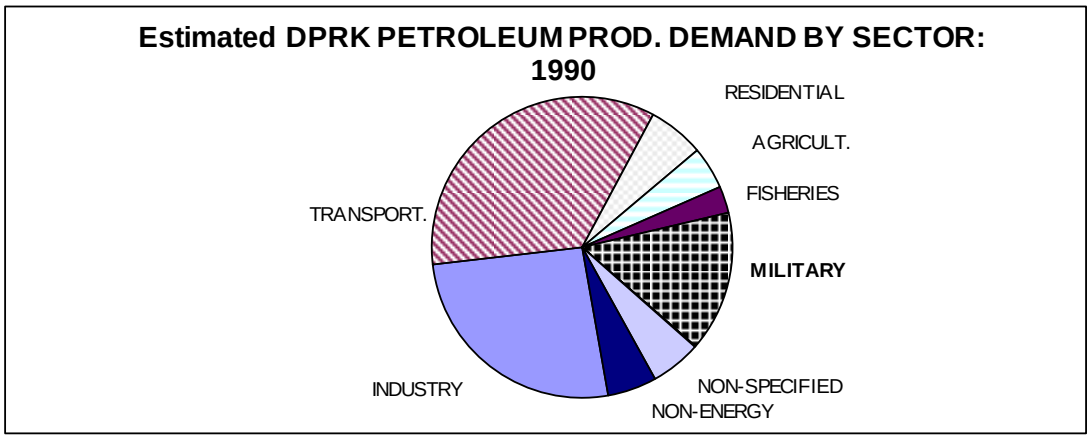

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1990
CRUDE OIL 6%
REF. PROD 2%
HYDRO/NUCL. 5%
WOOD/ BIOMASS 9%
COAL & COKE 78%

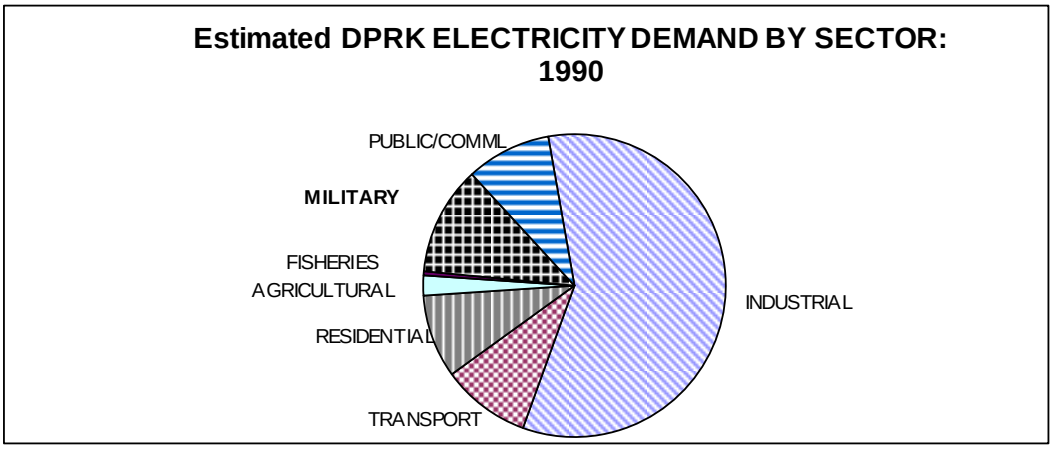

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
0%
2%
4%
0%
5%
5%
22%
58%
4%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY 31
NON-SPECIFIED 6
PUBLIC/COMML 48
MILITARY 60
FISHERIES 5
AGRICULTURAL 62
RESIDENTIAL 302
TRANSPORT 51
INDUSTRIAL 776
- 100 200 300 400 500 600 700 800 900
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 1990
REF. PROD 8%
WOOD/ BIOMASS 11%
CHARCOAL 0%
HEAT 1%
ELEC. 9%
COAL & COKE 71%


Estimated DPRK COAL DEMAND BY SECTOR: 1990
RESID.
AGRIC.
MILITARY
PUB/COMML
NON-ENERGY
INDUSTRIAL


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 1990
RESIDENTIAL
AGRICULT.
FISHERIES
MILITARY
NON-SPECIFIED
NON-ENERGY
INDUSTRY
TRANSPORT.


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1990
PUBLIC/COMML
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

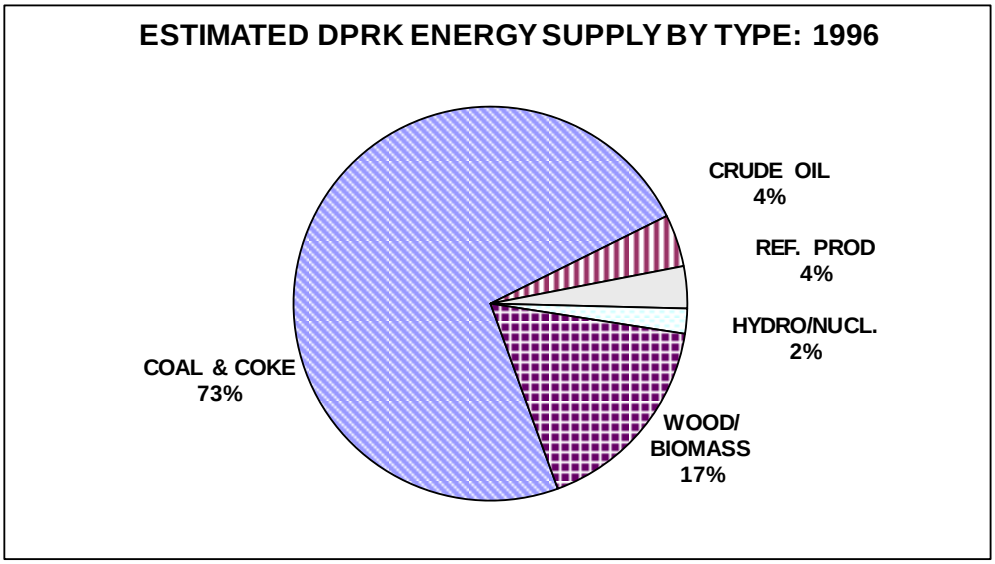
2020 UPDATE

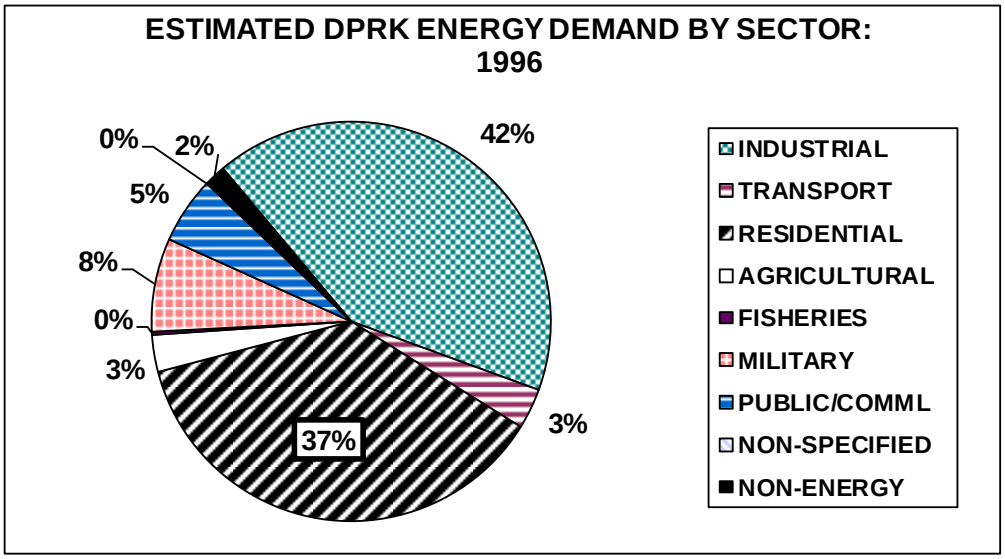
ESTIMATED SUMMARY ENERGY BALANCE FOR 1996

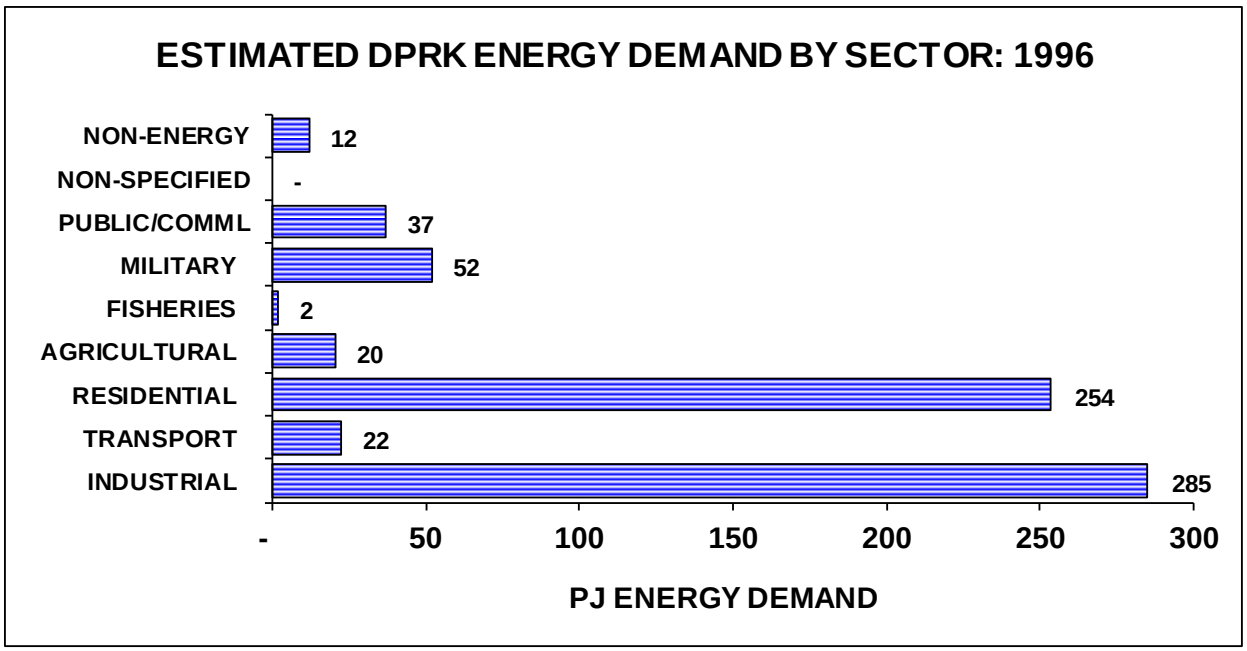
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

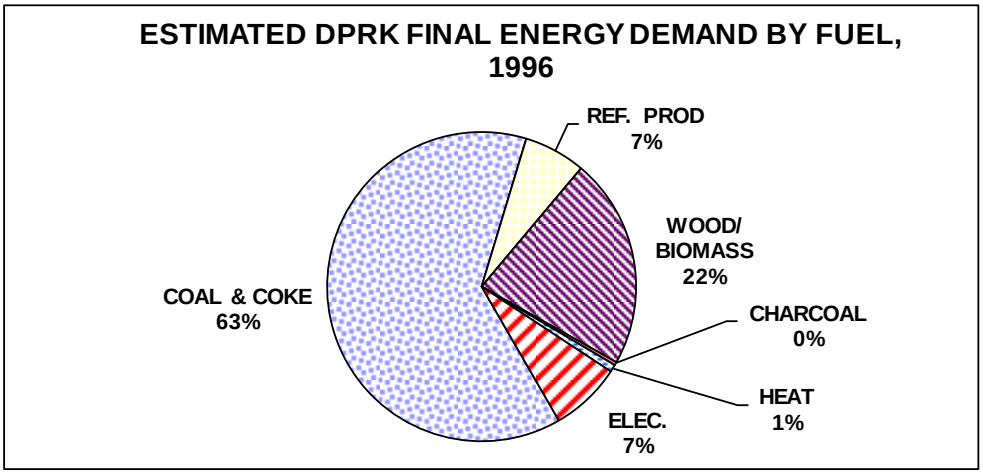
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	682	40	32	19	158	-	-	-	932
Domestic Production	683	-	-	19	148	-		-	850
Imports	12	40	39	-	14	-		-	104
Exports	12	-	1	-	4	-		-	16
Stock Changes	-	-	6	-	-	-		-	6
ENERGY TRANSF.	(251)	(40)	12	(19)	(8)	2	5	51	(248)
Electricity Generation	(208)	-	(25)	(19)	-	-	5	82	(165)
Petroleum Refining	-	(40)	40	-	-	-		(0)	(0)
Coal Prod./Prep.	(33)	-	-	-	-	-		(4)	(37)
Charcoal Production	-	-	-	-	(8)	2		-	(6)
District Heat Production	(2)		(0)				2		(1)
Own Use	-	-	(2)	-	-	-		(10)	(12)
Losses	(8)	-	-	-	-	-	(1)	(17)	(26)
FUELS FOR FINAL CONS.	431	-	44	-	150	2	5	51	684
ENERGY DEMAND	431	-	44	-	150	2	5	51	684
INDUSTRIAL	251	-	9	-	2	-	-	24	285
TRANSPORT	-	-	17	-	1	-	-	5	22
RESIDENTIAL	122	-	2	-	118	2	4	6	254
AGRICULTURAL	3	-	1	-	15	-	-	1	20
FISHERIES	1	-	1	-	-	-	-	0	2
MILITARY	25	-	13	-	5	-	-	8	52
PUBLIC/COMML	26	-	0	-	3	-	2	6	37
NON-SPECIFIED			-	-					-
NON-ENERGY	3		1		7				12
									-
Elect. Gen. (Gr. TWhe)*	16.61	-	0.91	5.32	-	-		-	22.84

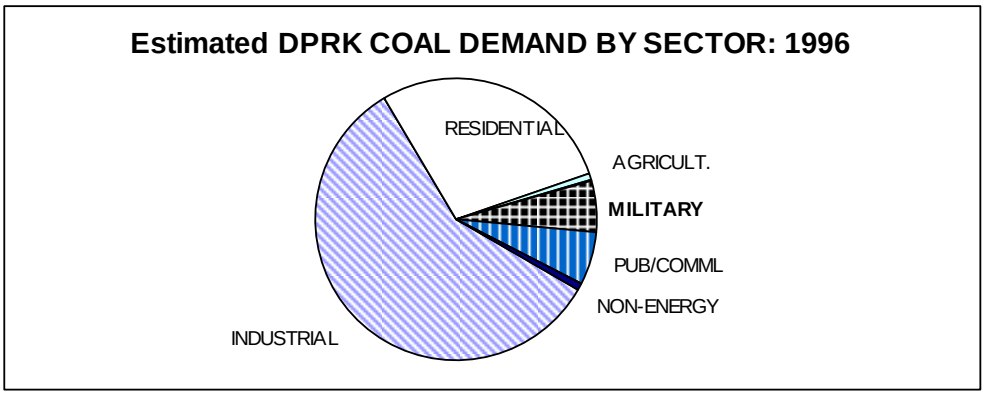
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

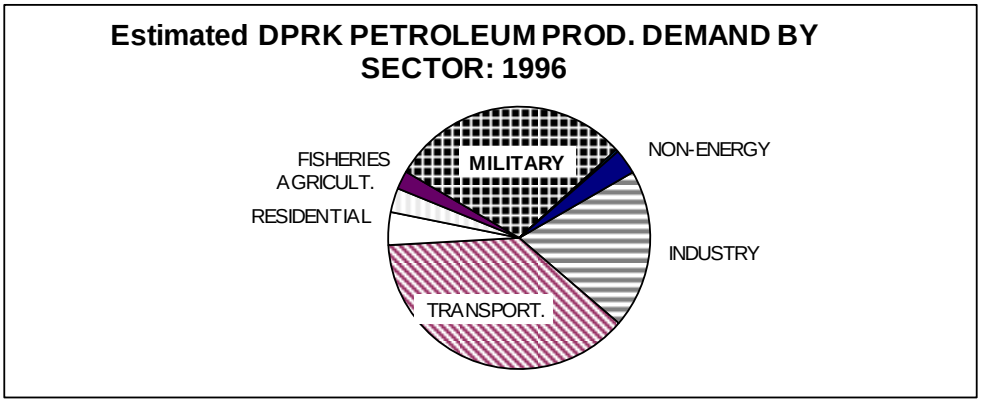

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1996
CRUDE OIL 4%
REF. PROD 4%
HYDRO/NUCL. 2%
WOOD/ BIOMASS 17%
COAL & COKE 73%

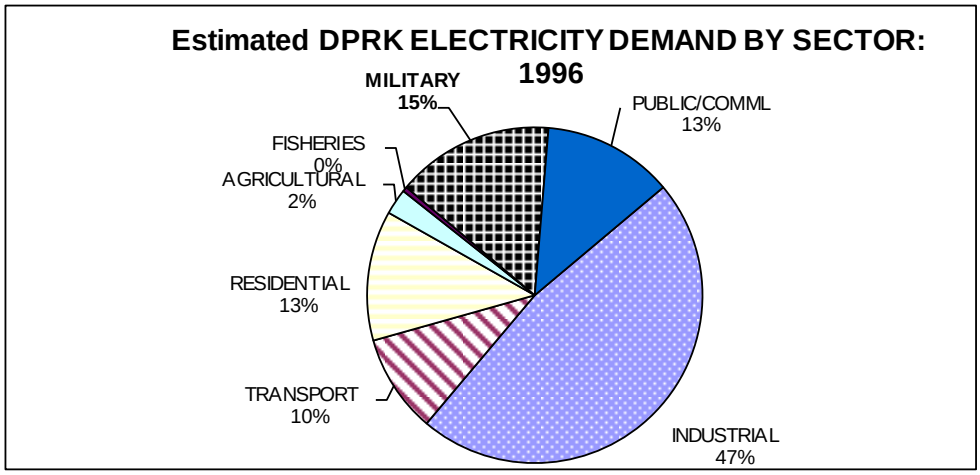

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
0%
2%
42%
5%
8%
0%
3%
37%
3%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
NON-ENERGY 12
NON-SPECIFIED -
PUBLIC/COMML 37
MILITARY 52
FISHERIES 2
AGRICULTURAL 20
RESIDENTIAL 254
TRANSPORT 22
INDUSTRIAL 285
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 1996
REF. PROD 7%
WOOD/ BIOMASS 22%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 63%


Estimated DPRK COAL DEMAND BY SECTOR: 1996
RESIDENTIAL
AGRICULT.
MILITARY
PUB/COMML
NON-ENERGY
INDUSTRIAL


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 1996
FISHERIES
AGRICULT.
MILITARY
NON-ENERGY
RESIDENTIAL
INDUSTRY
TRANSPORT.


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1996
MILITARY 15%
PUBLIC/COMML 13%
FISHERIES 0%
AGRICULTURAL 2%
RESIDENTIAL 13%
TRANSPORT 10%
INDUSTRIAL 47%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

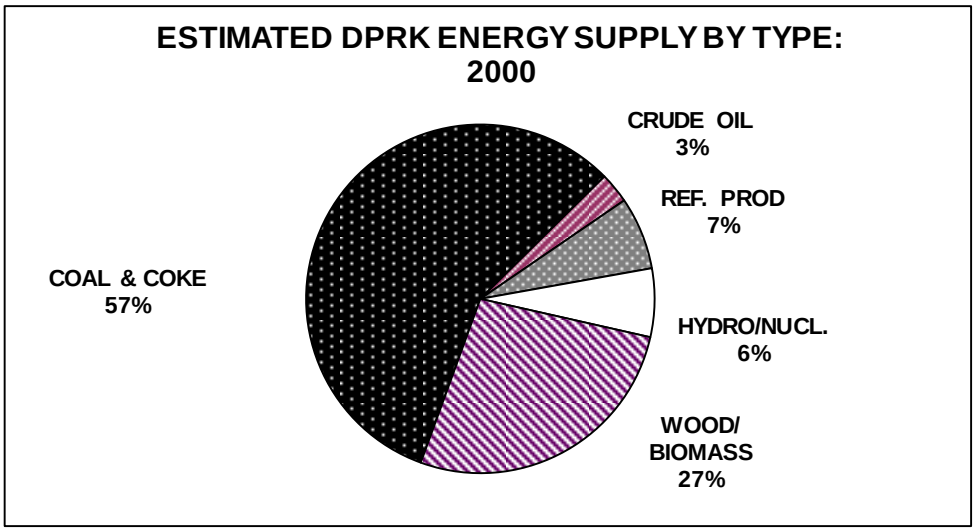
2020 UPDATE

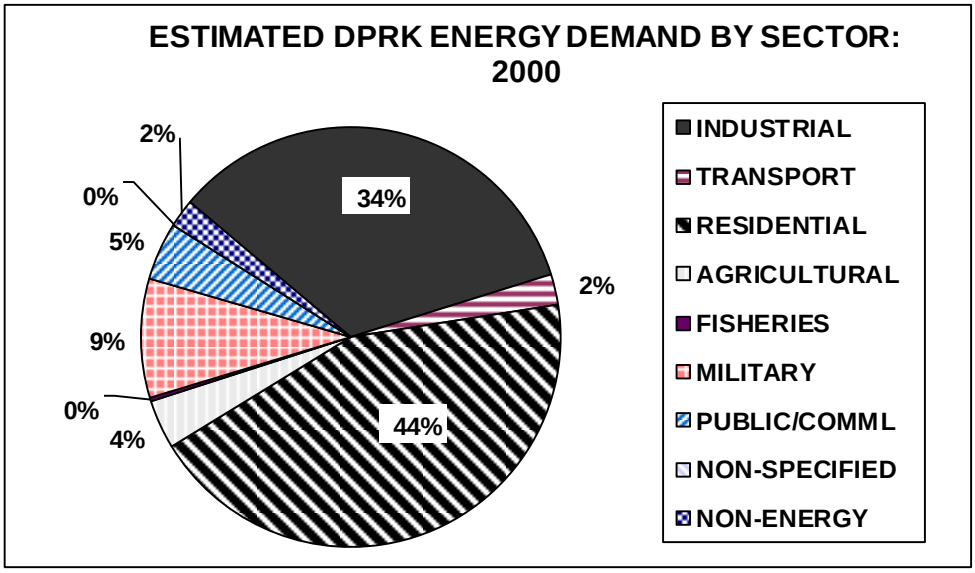
ESTIMATED SUMMARY ENERGY BALANCE FOR 2000

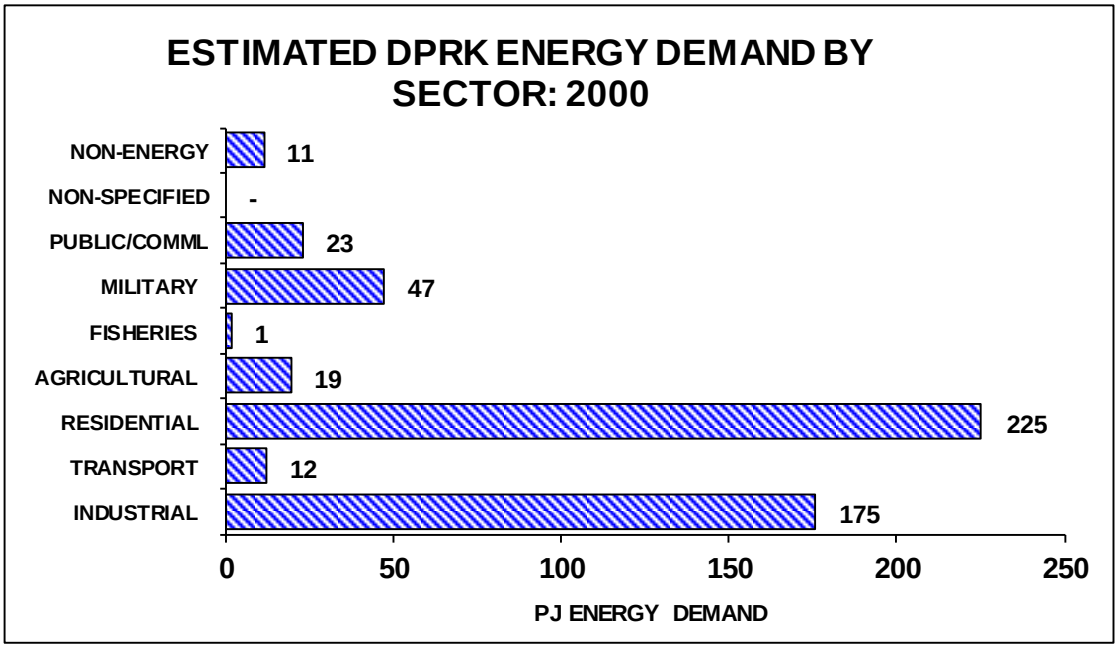
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

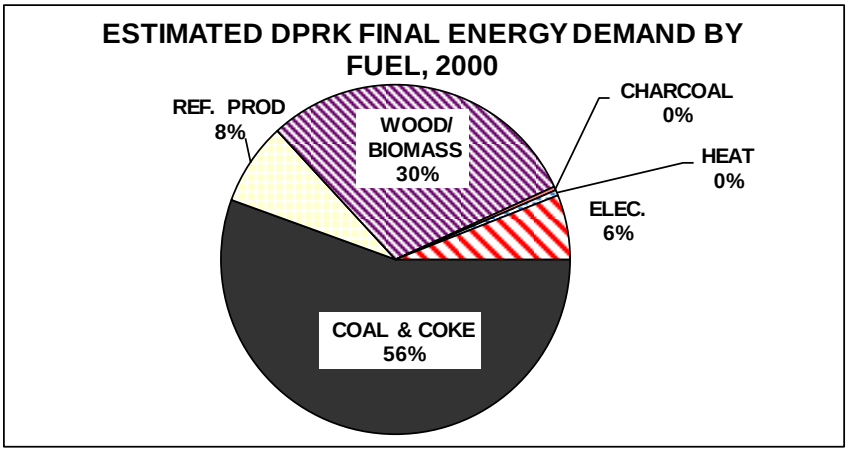
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	339	17	40	38	160	0	-	(0)	594
Domestic Production	336	0	-	38	151	-		-	525
Imports	12	17	42	-	12	0		-	83
Exports	9	-	3	-	3	0		0	15
Stock Changes	-	-	(1)	-	-	-		-	(1)
ENERGY TRANSF.	(53)	(17)	(1)	(38)	(6)	2	3	31	(79)
Electricity Generation	(32)	-	(16)	(38)	-	-	2	48	(35)
Petroleum Refining	-	(17)	17	-	-	-		(0)	(0)
Coal Prod./Prep.	(16)	-	-	-	-	-		(2)	(18)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(1)		(0)				1		(1)
Own Use	-	-	(1)	-	-	-		(2)	(3)
Losses	(4)	-	-	-	-	-	(1)	(13)	(17)
FUELS FOR FINAL CONS.	286	-	39	-	154	2	3	31	515
ENERGY DEMAND	286	-	39	-	154	2	3	31	515
INDUSTRIAL	150	-	12	-	1	-	-	13	175
TRANSPORT	-	-	8	-	1	-	-	3	12
RESIDENTIAL	95	-	2	-	122	2	2	3	225
AGRICULTURAL	3	-	1	-	15	-	-	1	19
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	21	-	11	-	7	-	-	7	47
PUBLIC/COMML	16	-	0	-	3	-	1	3	23
NON-SPECIFIED			-	-					-
NON-ENERGY	1		4		6				11
Elect. Gen. (Gr. TWhe)*	2.64	-	0.15	10.47	-	-		-	13.26

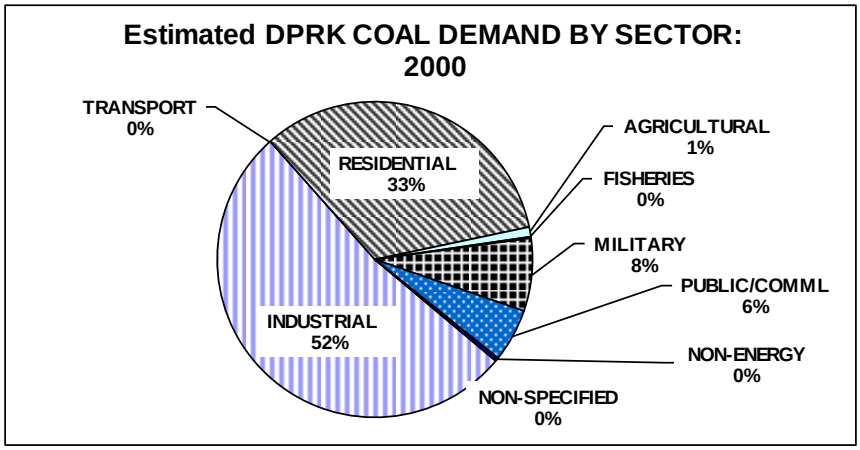
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

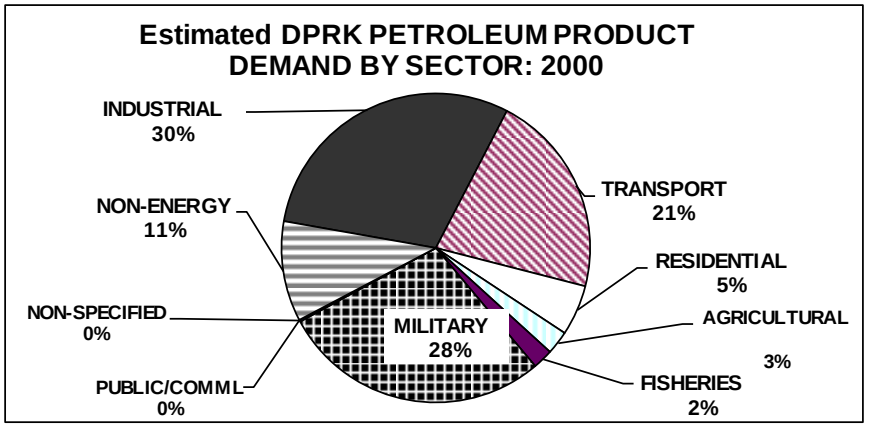

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2000
CRUDE OIL 3%
REF. PROD 7%
HYDRO/NUCL. 6%
WOOD/ BIOMASS 27%
COAL & COKE 57%

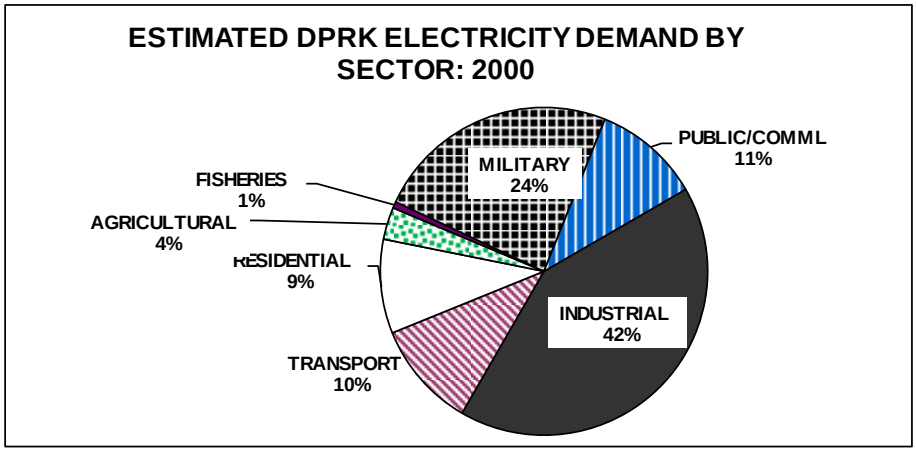

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
2%
0%
5%
9%
0%
4%
34%
2%
44%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
NON-ENERGY 11
NON-SPECIFIED -
PUBLIC/COMML 23
MILITARY 47
FISHERIES 1
AGRICULTURAL 19
RESIDENTIAL 225
TRANSPORT 12
INDUSTRIAL 175
0
50
100
150
200
250
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2000
REF. PROD 8%
WOOD/ BIOMASS 30%
CHARCOAL 0%
HEAT 0%
ELEC. 6%
COAL & COKE 56%


Estimated DPRK COAL DEMAND BY SECTOR: 2000
TRANSPORT 0%
RESIDENTIAL 33%
AGRICULTURAL 1%
FISHERIES 0%
MILITARY 8%
PUBLIC/COMML 6%
INDUSTRIAL 52%
NON-ENERGY 0%
NON-SPECIFIED 0%


Estimated DPRK PETROLEUM PRODUCT DEMAND BY SECTOR: 2000
INDUSTRIAL 30%
TRANSPORT 21%
NON-ENERGY 11%
RESIDENTIAL 5%
NON-SPECIFIED 0%
MILITARY 28%
AGRICULTURAL 3%
PUBLIC/COMML 0%
FISHERIES 2%


ESTIMATED DPRK ELECTRICITY DEMAND BY SECTOR: 2000
PUBLIC/COMML 11%
MILITARY 24%
FISHERIES 1%
AGRICULTURAL 4%
RESIDENTIAL 9%
INDUSTRIAL 42%
TRANSPORT 10%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

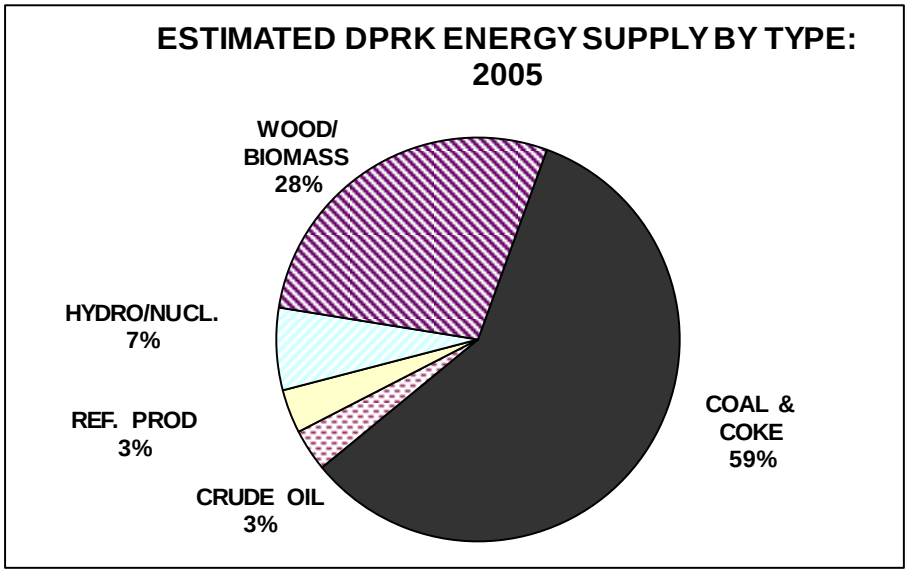
2020 UPDATE

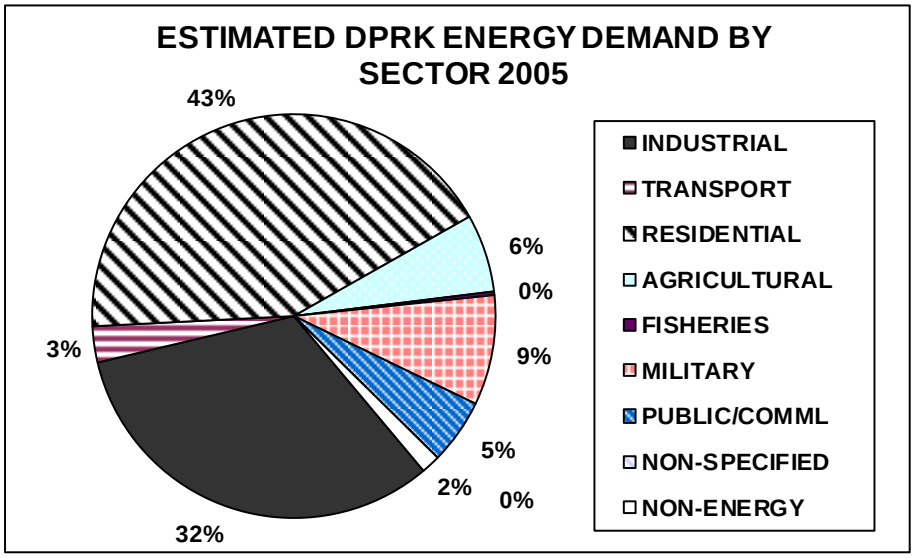
ESTIMATED SUMMARY ENERGY BALANCE FOR 2005

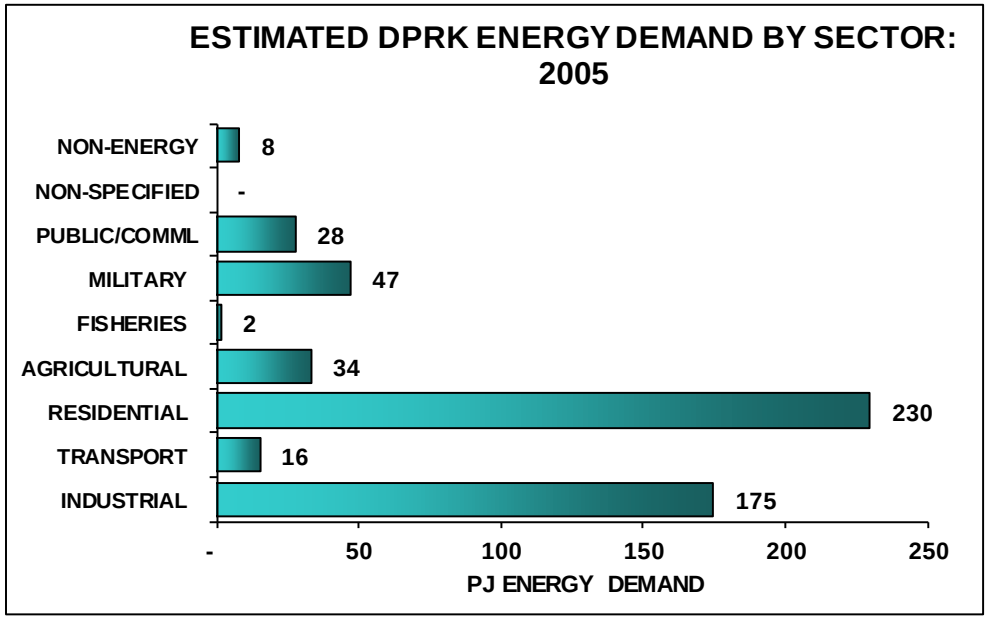
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

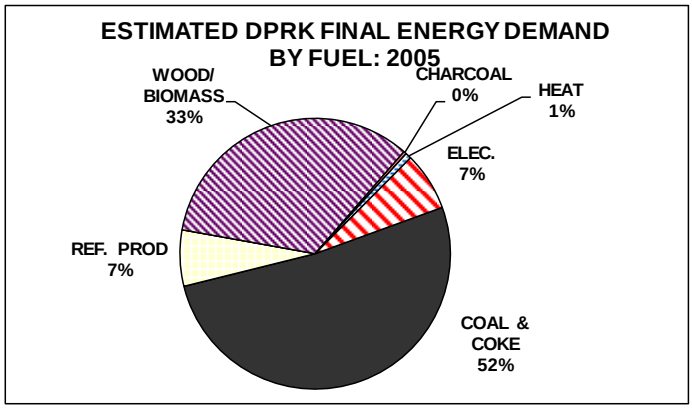
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	391	23	23	44	187	(0)	-	(0)	668
Domestic Production	434	0	-	44	182	-		-	661
Imports	36	22	23	-	7	0		0	89
Exports	80	-	0	-	2	0		0	82
Stock Changes	-	-	(0)	-	-	-		-	(0)
ENERGY TRANSF.	(112)	(23)	13	(43)	(6)	2	4	38	(127)
Electricity Generation	(84)	-	(8)	(43)	-	-	4	60	(72)
Petroleum Refining	-	(23)	23	-	-	-		(0)	(0)
Coal Prod./Prep.	(21)	-	-	-	-	-		(3)	(24)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(2)		(0)				2		(0)
Own Use	-	-	(1)	-	-	-		(4)	(5)
Losses	(5)	-	-	-	-	-	(1)	(15)	(22)
FUELS FOR FINAL CONS.	279	-	36	1	181	2	4	38	541
ENERGY DEMAND	279	-	36	-	181	2	4	38	539
INDUSTRIAL	150	-	9	-	1	-	-	15	175
TRANSPORT	-	-	11	-	1	-	-	4	16
RESIDENTIAL	85	-	2	-	135	2	2	4	230
AGRICULTURAL	5	-	1	-	26	-	-	1	34
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	20	-	11	-	8	-	-	9	47
PUBLIC/COMML	17	-	0	-	5	-	1	5	28
NON-SPECIFIED			-	-					-
NON-ENERGY	2		1		6				8
Elect. Gen. (Gr. TWhe)	5.15	-	0.26	11.15	-	-		-	16.55

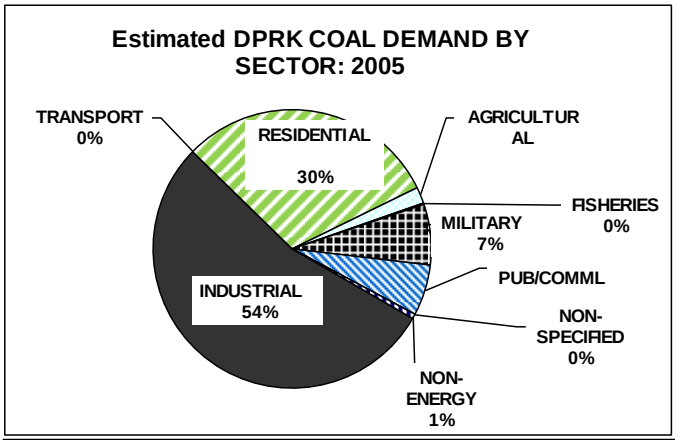
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

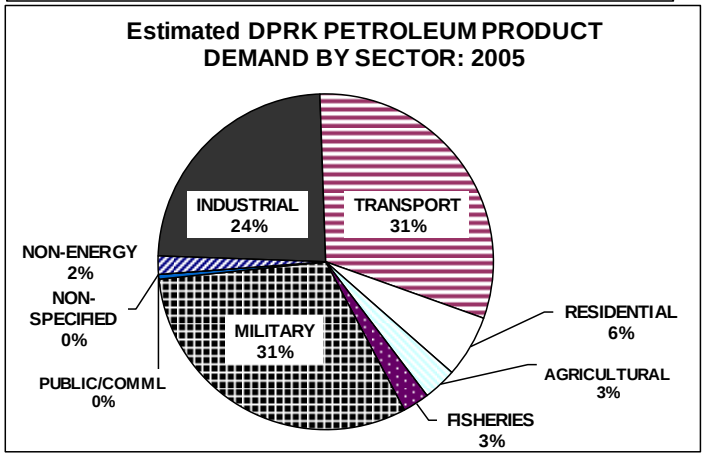

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2005
WOOD/ BIOMASS 28%
HYDRO/NUCL. 7%
REF. PROD 3%
CRUDE OIL 3%
COAL & COKE 59%

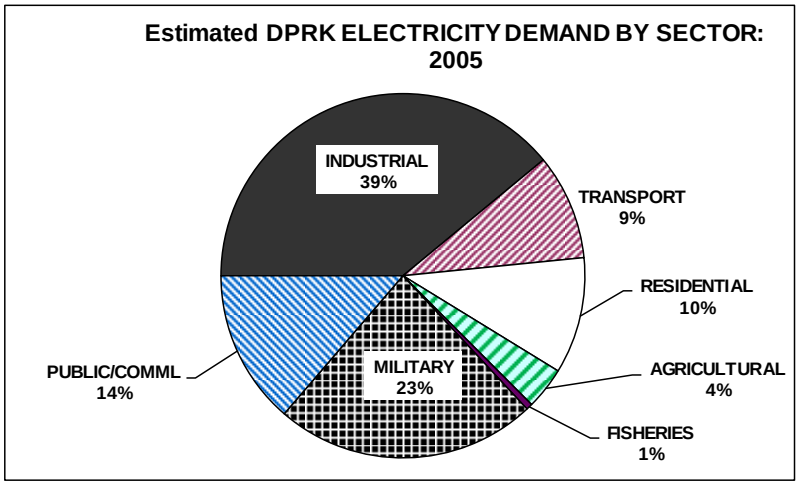

ESTIMATED DPRK ENERGY DEMAND BY SECTOR 2005
43%
6%
0%
9%
5%
0%
2%
3%
32%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2005
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 28
MILITARY 47
FISHERIES 2
AGRICULTURAL 34
RESIDENTIAL 230
TRANSPORT 16
INDUSTRIAL 175
- 50 100 150 200 250
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL: 2005
WOOD/ BIOMASS 33%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
REF. PROD 7%
COAL & COKE 52%


Estimated DPRK COAL DEMAND BY SECTOR: 2005
TRANSPORT 0%
RESIDENTIAL 30%
AGRICULTURAL
FISHERIES 0%
MILITARY 7%
PUB/COMML
INDUSTRIAL 54%
NON-SPECIFIED 0%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PRODUCT DEMAND BY SECTOR: 2005
INDUSTRIAL 24%
TRANSPORT 31%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 31%
RESIDENTIAL 6%
AGRICULTURAL 3%
PUBLIC/COMML 0%
FISHERIES 3%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2005
INDUSTRIAL 39%
TRANSPORT 9%
RESIDENTIAL 10%
PUBLIC/COMML 14%
MILITARY 23%
AGRICULTURAL 4%
FISHERIES 1%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

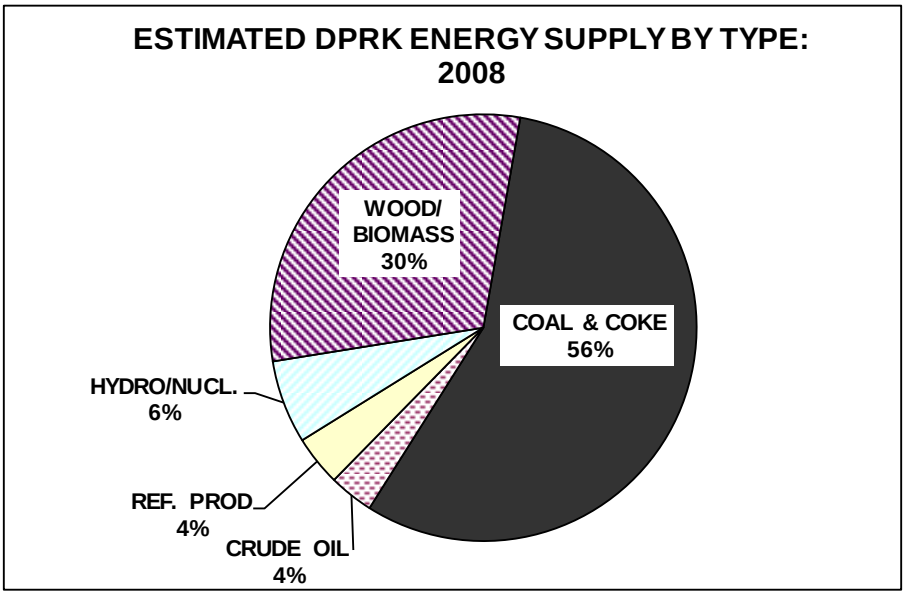
2020 UPDATE

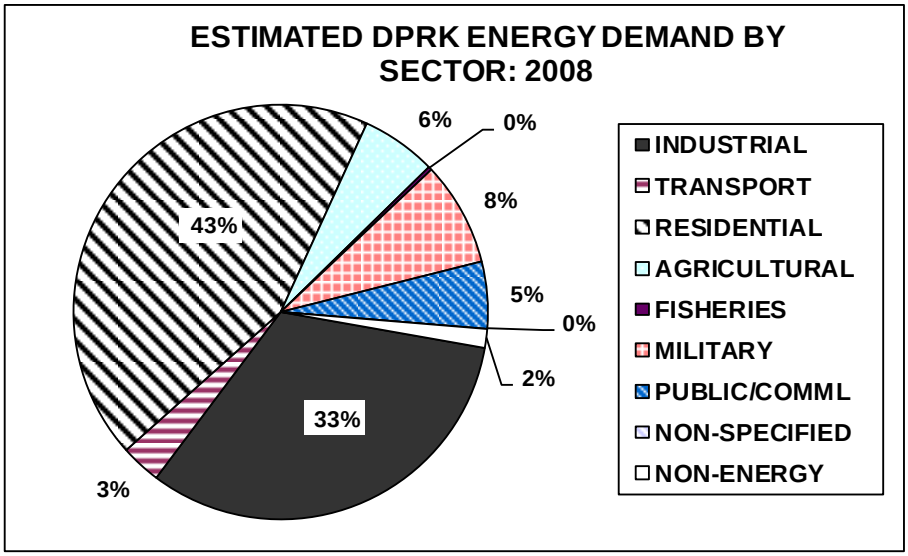
ESTIMATED SUMMARY ENERGY BALANCE FOR 2008

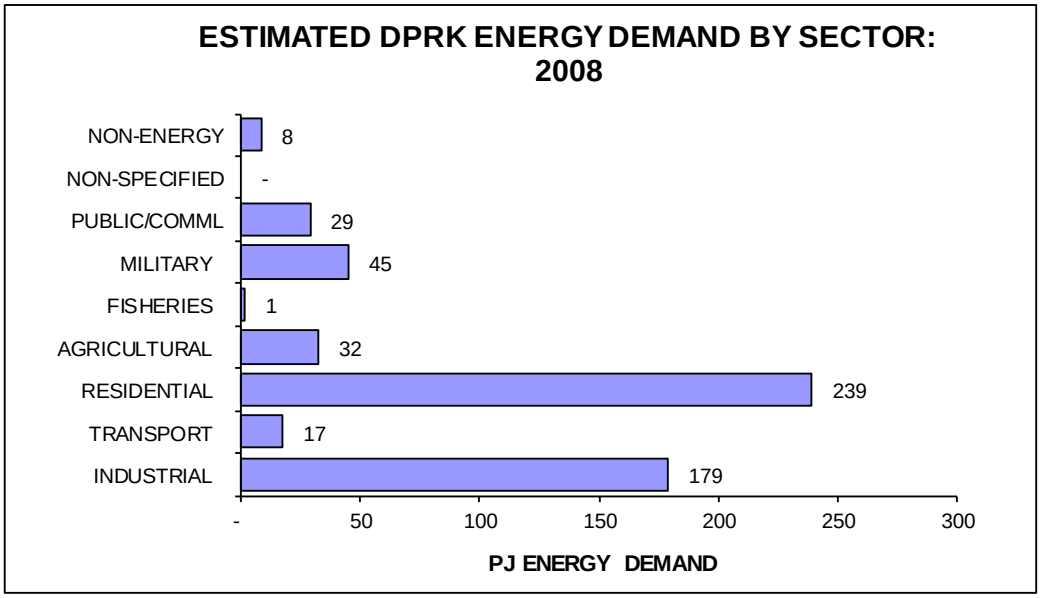
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

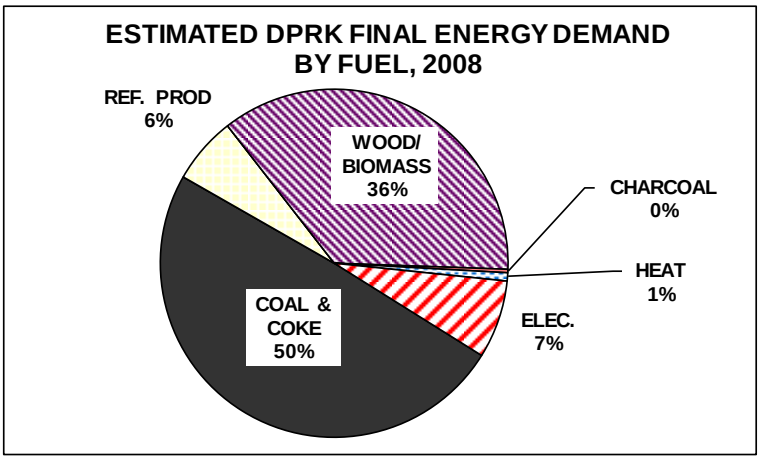
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	379	23	26	43	204	0	-	0	675
Domestic Production	427	0	-	43	200	-		-	669
Imports	19	23	30	-	6	0		1	78
Exports	67	-	4	-	1	0		1	72
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(107)	(23)	9	(43)	(6)	2	4	40	(124)
Electricity Generation	(80)	-	(13)	(43)	-	-	4	62	(69)
Petroleum Refining	-	(23)	23	-	-	-		(0)	(0)
Coal Prod./Prep.	(20)	-	-	-	-	-		(3)	(23)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(2)		(0)				1		(1)
Own Use	-	-	(1)	-	-	-		(3)	(5)
Losses	(5)	-	-	-	-	-	(1)	(16)	(22)
FUELS FOR FINAL CONS.	272	-	34	-	198	2	4	40	550
ENERGY DEMAND	272	-	34	-	198	2	4	40	550
INDUSTRIAL	155	-	7	-	1	-	-	15	179
TRANSPORT	-	-	12	-	1	-	-	4	17
RESIDENTIAL	74	-	2	-	153	2	3	5	239
AGRICULTURAL	5	-	1	-	25	-	-	1	32
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	18	-	10	-	7	-	-	9	45
PUBLIC/COMML	17	-	0	-	5	-	1	5	29
NON-SPECIFIED			-	-					-
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	5.12	-	0.29	11.83	-	-		-	17.23

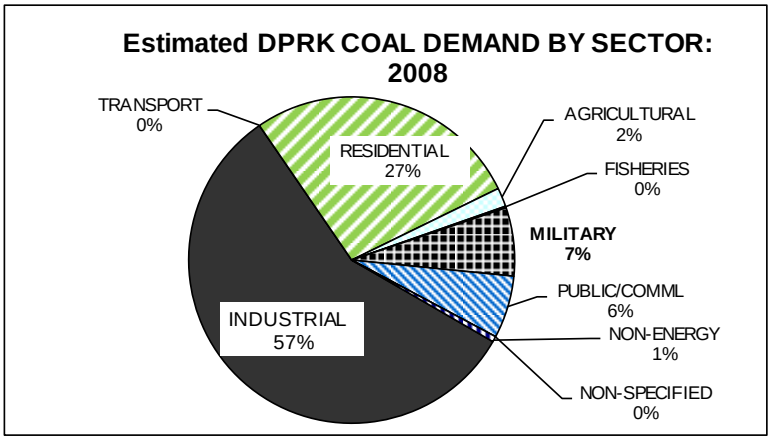
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

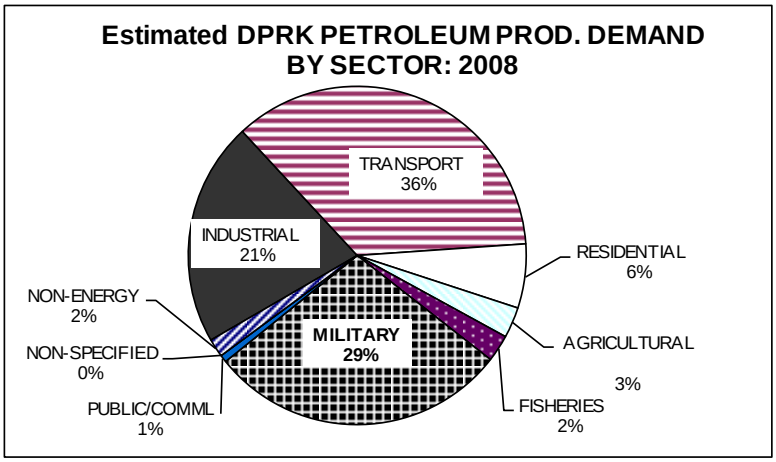

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2008
WOOD/ BIOMASS 30%
COAL & COKE 56%
HYDRO/NUCL. 6%
REF. PROD 4%
CRUDE OIL 4%

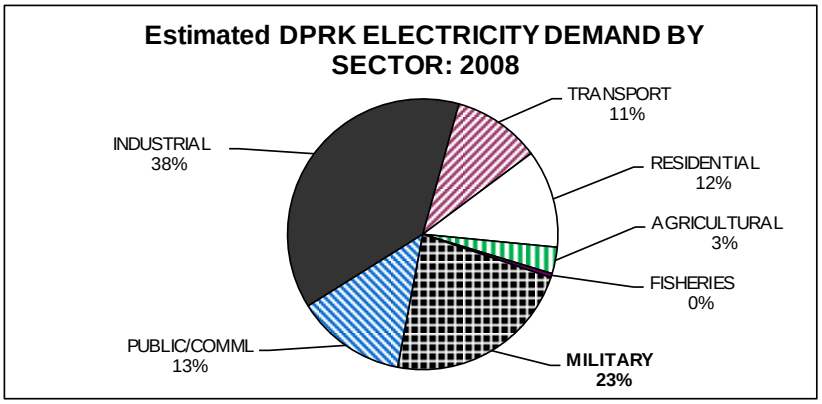

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2008
6%
0%
8%
43%
5%
0%
2%
33%
3%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2008
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 29
MILITARY 45
FISHERIES 1
AGRICULTURAL 32
RESIDENTIAL 239
TRANSPORT 17
INDUSTRIAL 179
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2008
REF. PROD 6%
WOOD/ BIOMASS 36%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 50%


Estimated DPRK COAL DEMAND BY SECTOR: 2008
TRANSPORT 0%
RESIDENTIAL 27%
AGRICULTURAL 2%
FISHERIES 0%
MILITARY 7%
PUBLIC/COMML 6%
NON-ENERGY 1%
NON-SPECIFIED 0%
INDUSTRIAL 57%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2008
TRANSPORT 36%
INDUSTRIAL 21%
RESIDENTIAL 6%
NON-ENERGY 2%
AGRICULTURAL 3%
NON-SPECIFIED 0%
MILITARY 29%
PUBLIC/COMML 1%
FISHERIES 2%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2008
TRANSPORT 11%
INDUSTRIAL 38%
RESIDENTIAL 12%
AGRICULTURAL 3%
FISHERIES 0%
PUBLIC/COMML 13%
MILITARY 23%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

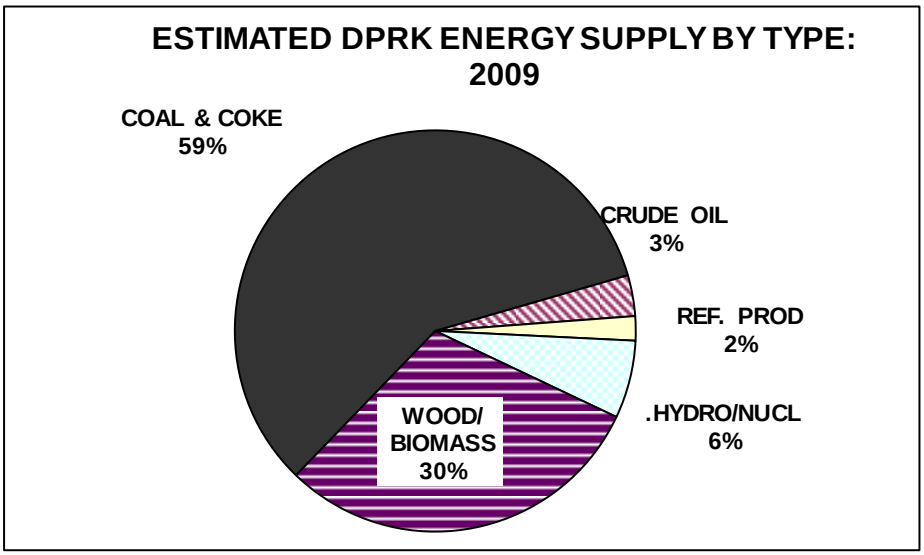
2020 UPDATE

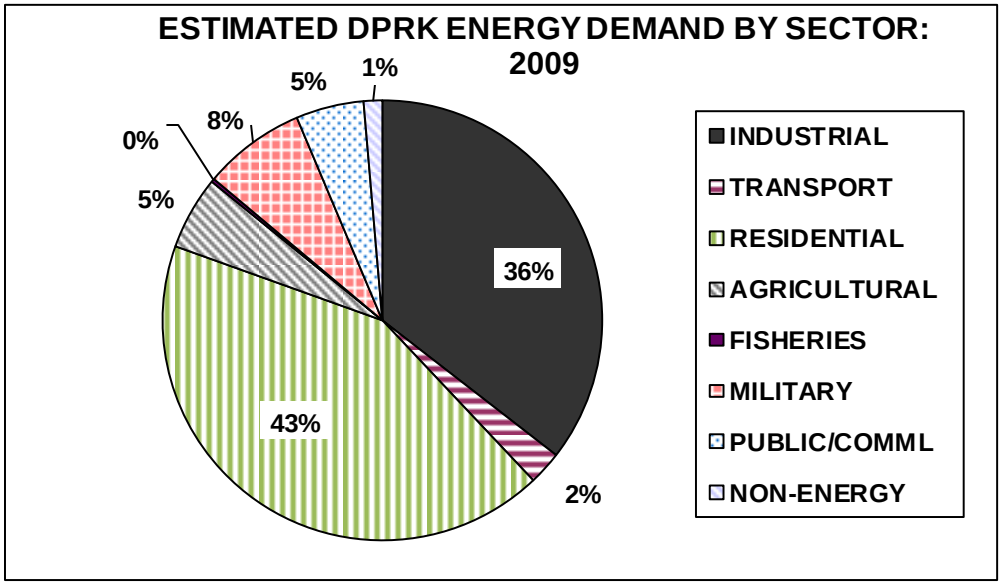
ESTIMATED SUMMARY ENERGY BALANCE FOR 2009

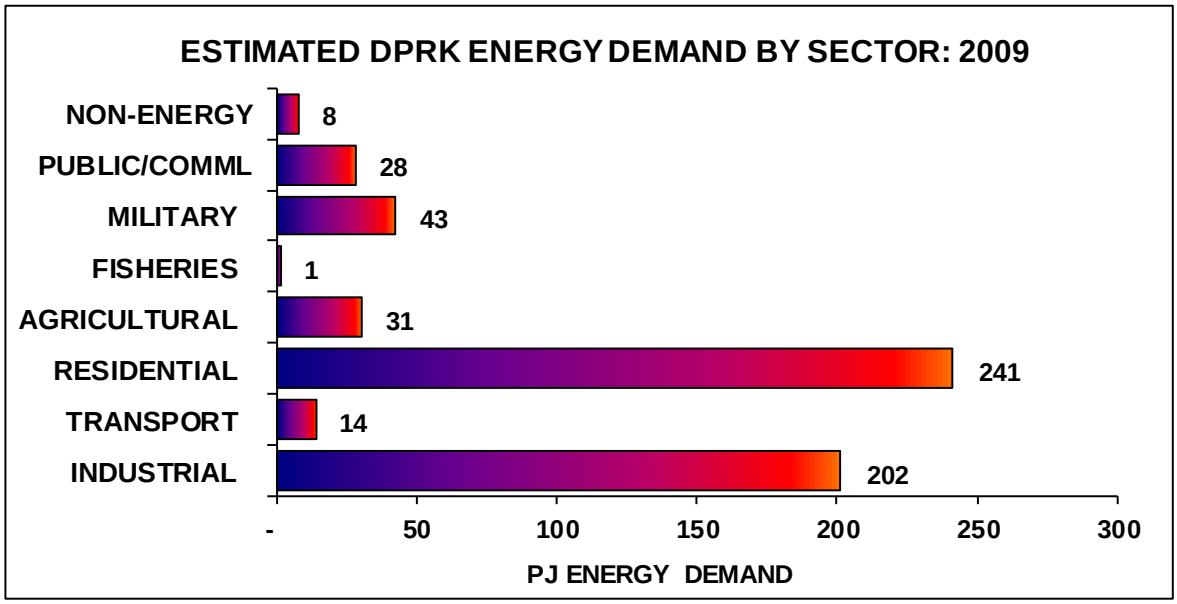
Prepared By David Von Hippel
Date Last Modified: 3/11/2020

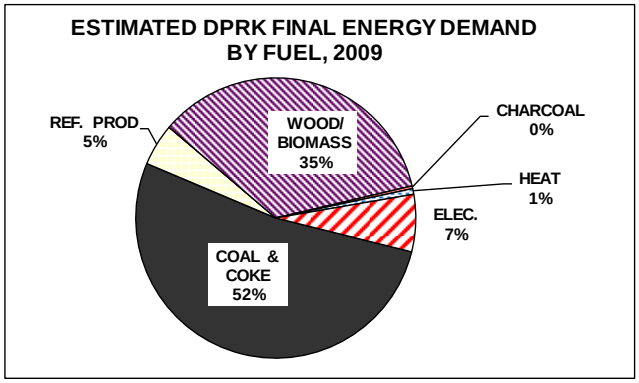
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	397	22	13	43	205	0	-	0	681
Domestic Production	484	0	-	43	202	-		-	729
Imports	7	22	14	-	5	0		1	48
Exports	94	-	0	-	1	-		0	96
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(99)	(22)	14	(43)	(6)	2	4	37	(113)
Electricity Generation	(68)	-	(7)	(43)	-	-	4	58	(56)
Petroleum Refining	-	(22)	22	-	-	-		(0)	(0)
Coal Prod./Prep.	(23)	-	-	-	-	-		(3)	(26)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(2)		(0)				1		(1)
Own Use	-	-	(1)	-	-	-		(3)	(4)
Losses	(6)	-	-	-	-	-	(1)	(15)	(22)
FUELS FOR FINAL CONS.	298	-	28	-	199	2	4	37	568
ENERGY DEMAND	298	-	28	-	199	2	4	37	568
INDUSTRIAL	181	-	5	-	1	-	-	15	202
TRANSPORT	-	-	9	-	1	-	-	4	14
RESIDENTIAL	76	-	2	-	156	2	2	4	241
AGRICULTURAL	5	-	1	-	24	-	-	1	31
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	18	-	9	-	7	-	-	8	43
PUBLIC/COMML	17	-	0	-	5	-	1	5	28
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	4.05	-	0.32	11.87	-	-		-	16.24

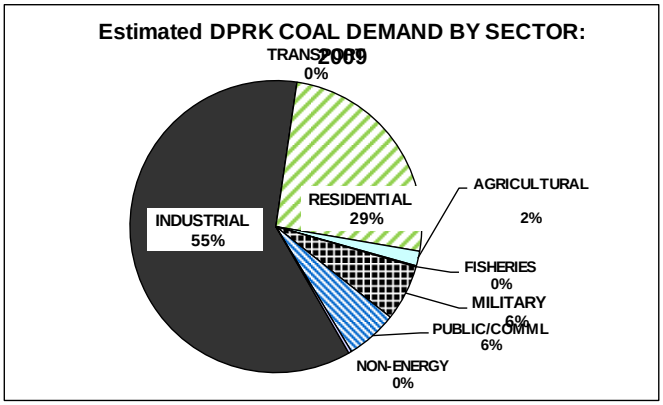
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

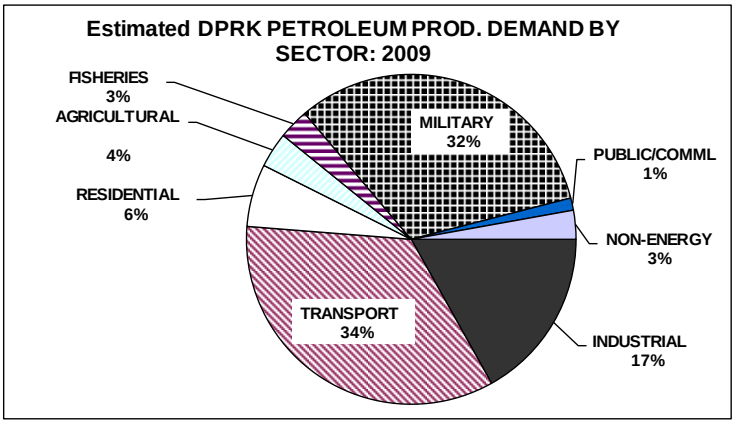

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2009
COAL & COKE 59%
CRUDE OIL 3%
REF. PROD 2%
.HYDRO/NUCL 6%
WOOD/ BIOMASS 30%

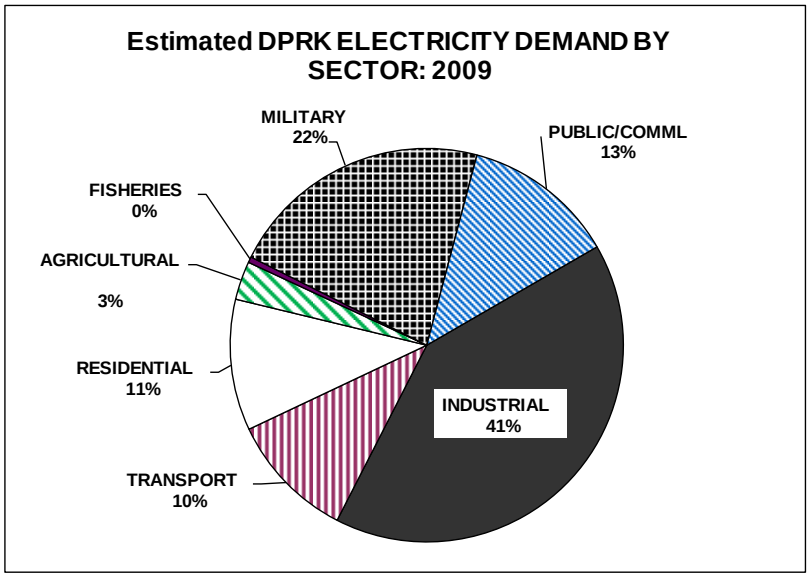

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2009
1%
5%
8%
0%
5%
36%
43%
2%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2009
NON-ENERGY 8
PUBLIC/COMML 28
MILITARY 43
FISHERIES 1
AGRICULTURAL 31
RESIDENTIAL 241
TRANSPORT 14
INDUSTRIAL 202
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2009
REF. PROD 5%
WOOD/ BIOMASS 35%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 52%


Estimated DPRK COAL DEMAND BY SECTOR: 2009
TRANSPORT 0%
RESIDENTIAL 29%
AGRICULTURAL 2%
INDUSTRIAL 55%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
NON-ENERGY 0%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2009
FISHERIES 3%
AGRICULTURAL 4%
RESIDENTIAL 6%
MILITARY 32%
PUBLIC/COMML 1%
NON-ENERGY 3%
TRANSPORT 34%
INDUSTRIAL 17%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2009
MILITARY 22%
PUBLIC/COMML 13%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 11%
INDUSTRIAL 41%
TRANSPORT 10%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

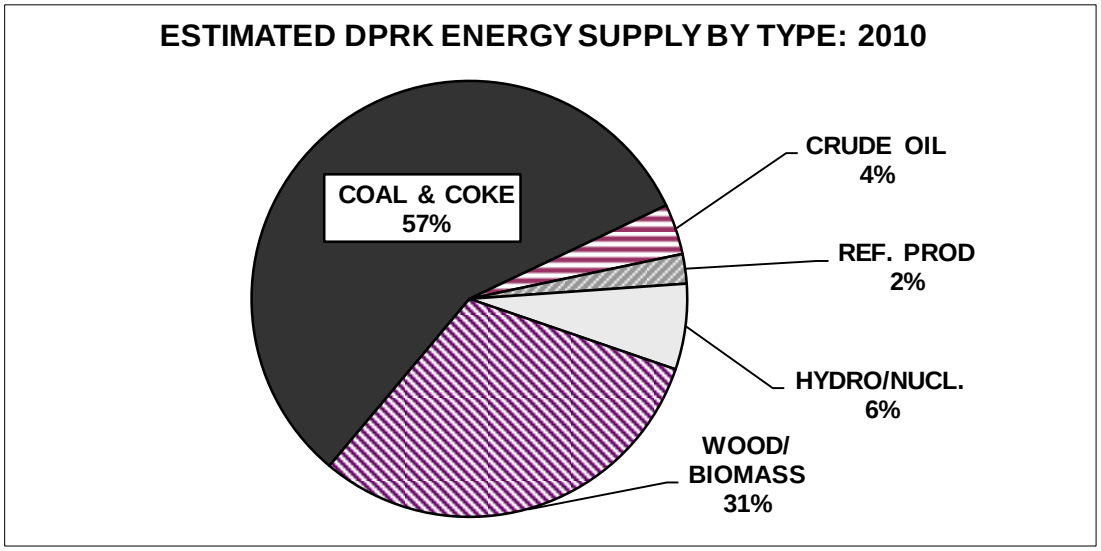
2020 UPDATE

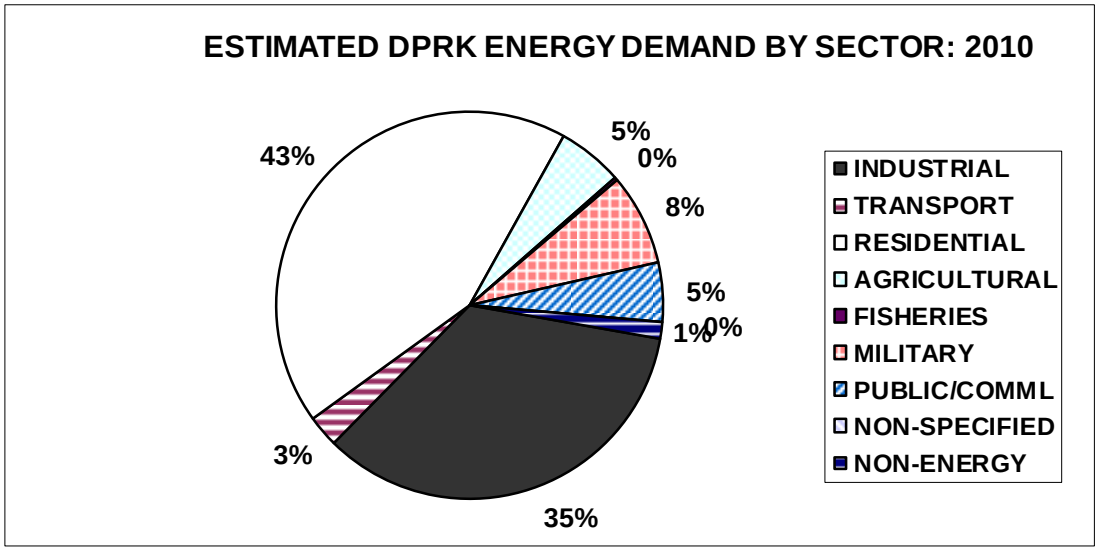
ESTIMATED SUMMARY ENERGY BALANCE FOR 2010

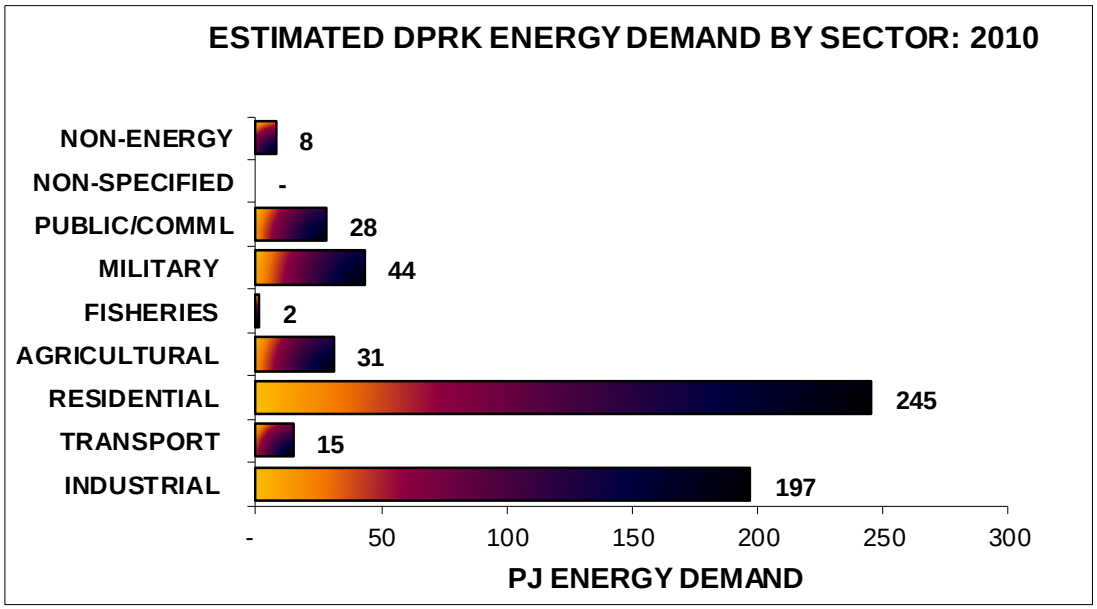
Prepared By David Von Hippel
Date Last Modified: 3/13/2020

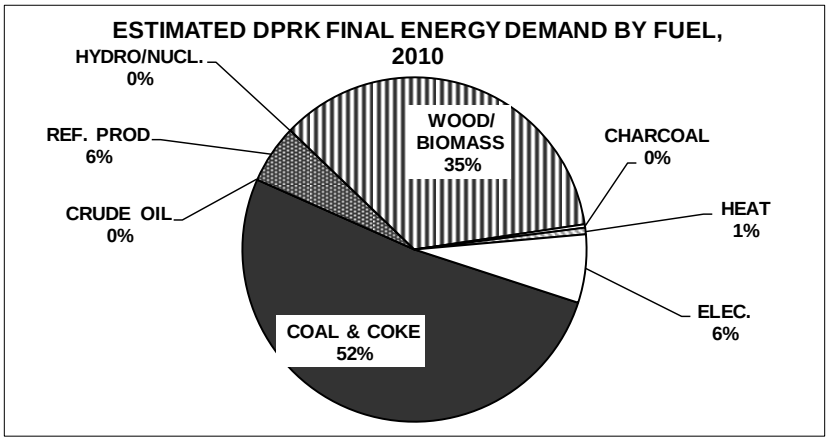
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	383	25	15	43	208	0	-	1	675
Domestic Production	492	0	-	43	205	-		-	739
Imports	13	25	16	-	4	0		1	60
Exports	122	-	2	-	1	0		1	124
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(89)	(25)	17	(43)	(6)	2	4	36	(105)
Electricity Generation	(58)	-	(7)	(43)	-	-	3	57	(48)
Petroleum Refining	-	(25)	25	-	-	-		(0)	(0)
Coal Prod./Prep.	(24)	-	-	-	-	-		(3)	(27)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(1)	-	-	-		(2)	(4)
Losses	(6)	-	-	-	-	-	(1)	(15)	(22)
FUELS FOR FINAL CONS.	294	-	31	-	202	2	4	37	570
ENERGY DEMAND	294	-	31	-	202	2	4	37	570
INDUSTRIAL	176	-	6	-	1	-	-	15	197
TRANSPORT	-	-	10	-	1	-	-	4	15
RESIDENTIAL	77	-	2	-	158	2	2	4	245
AGRICULTURAL	5	-	1	-	24	-	-	1	31
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	18	-	10	-	7	-	-	8	44
PUBLIC/COMML	17	-	0	-	5	-	1	4	28
NON-SPECIFIED			-						-
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	3.44	-	0.36	11.91	-	-		-	15.70

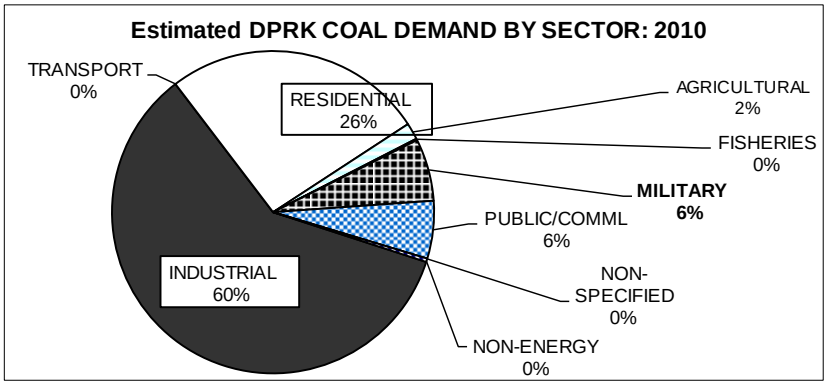
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

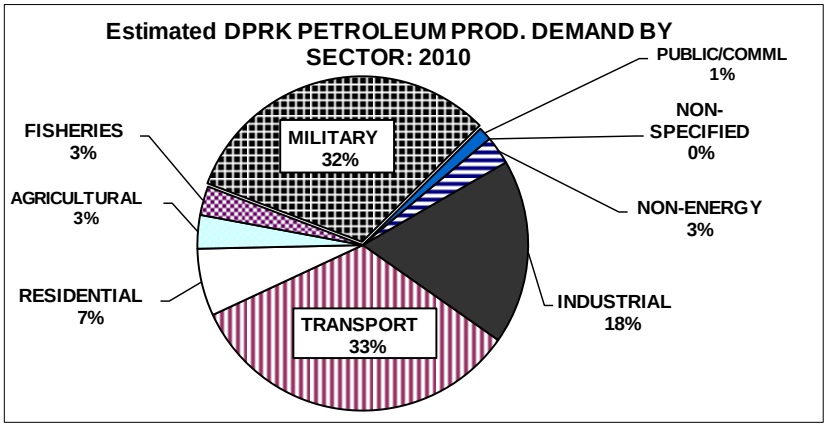

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2010
COAL & COKE 57%
CRUDE OIL 4%
REF. PROD 2%
HYDRO/NUCL. 6%
WOOD/ BIOMASS 31%

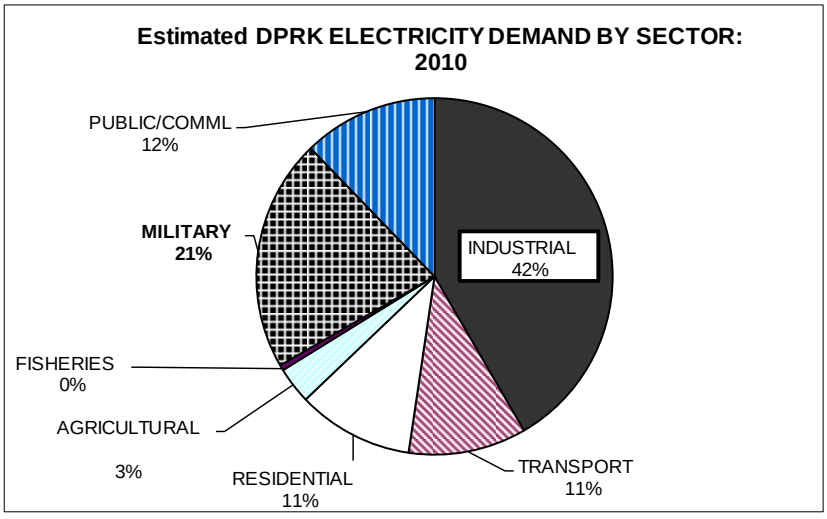

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2010
43%
5%
0%
8%
5%
1%
0%
3%
35%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2010
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 28
MILITARY 44
FISHERIES 2
AGRICULTURAL 31
RESIDENTIAL 245
TRANSPORT 15
INDUSTRIAL 197
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2010
HYDRO/NUCL. 0%
REF. PROD 6%
CRUDE OIL 0%
WOOD/ BIOMASS 35%
CHARCOAL 0%
HEAT 1%
ELEC. 6%
COAL & COKE 52%


Estimated DPRK COAL DEMAND BY SECTOR: 2010
TRANSPORT 0%
RESIDENTIAL 26%
AGRICULTURAL 2%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
NON-ENERGY 0%
INDUSTRIAL 60%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2010
PUBLIC/COMML 1%
NON-SPECIFIED 0%
NON-ENERGY 3%
INDUSTRIAL 18%
TRANSPORT 33%
RESIDENTIAL 7%
AGRICULTURAL 3%
FISHERIES 3%
MILITARY 32%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2010
PUBLIC/COMML 12%
MILITARY 21%
INDUSTRIAL 42%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 11%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

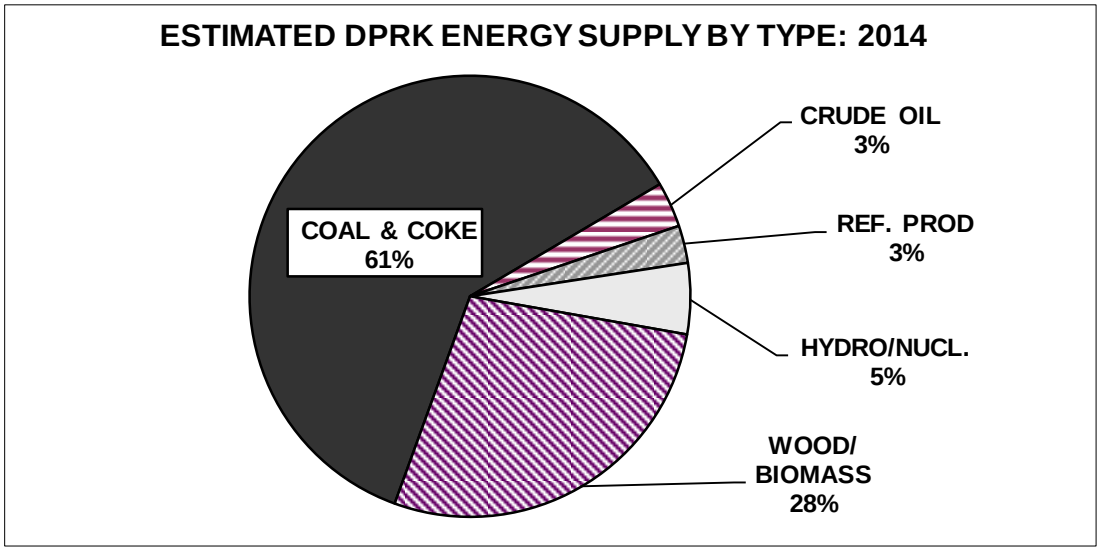
2020 UPDATE

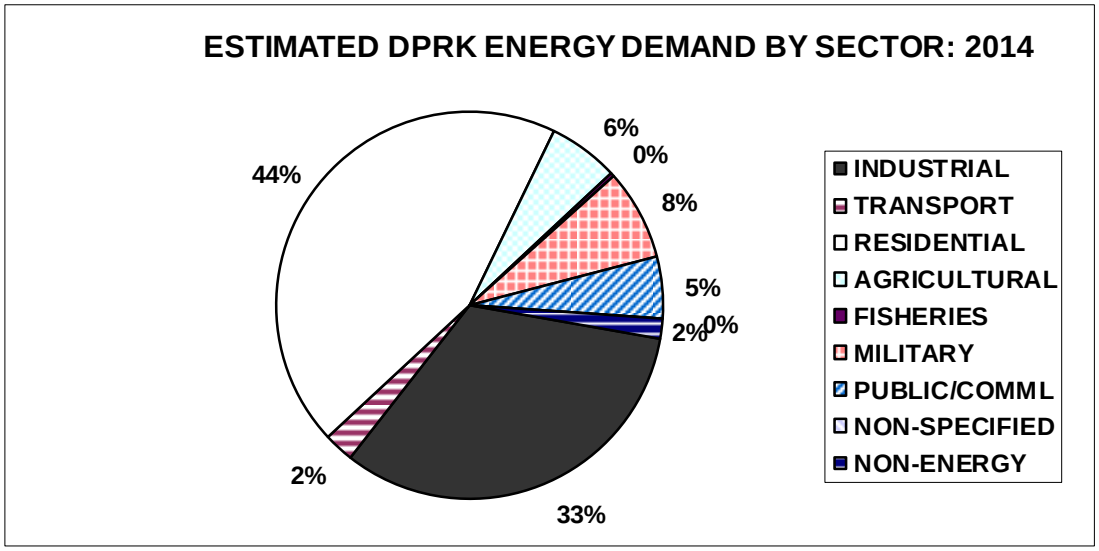
ESTIMATED SUMMARY ENERGY BALANCE FOR 2014

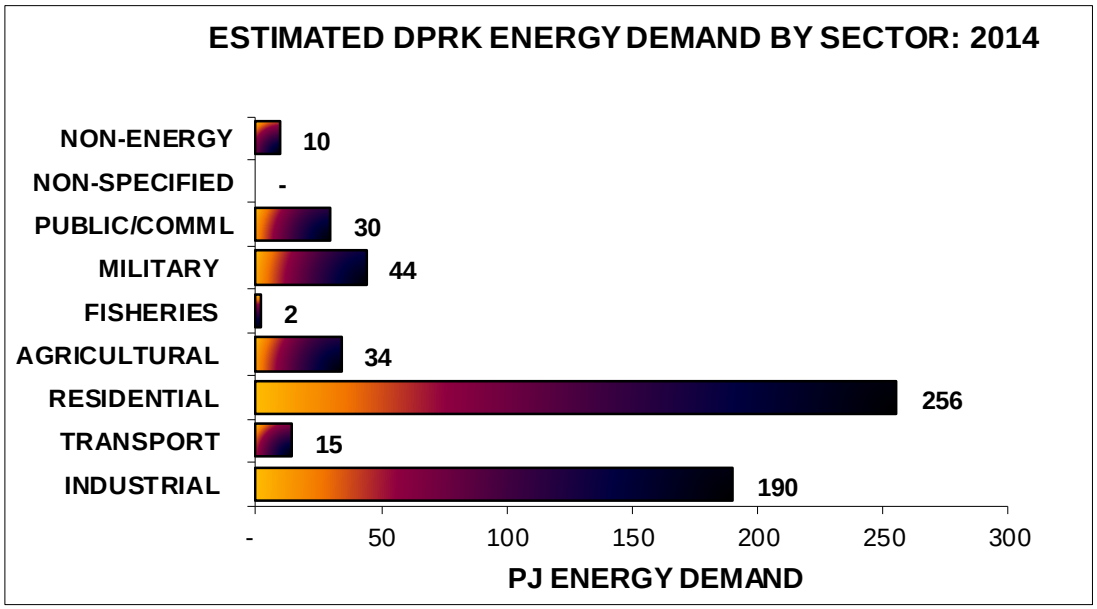
Prepared By David Von Hippel
Date Last Modified: 4/20/2020

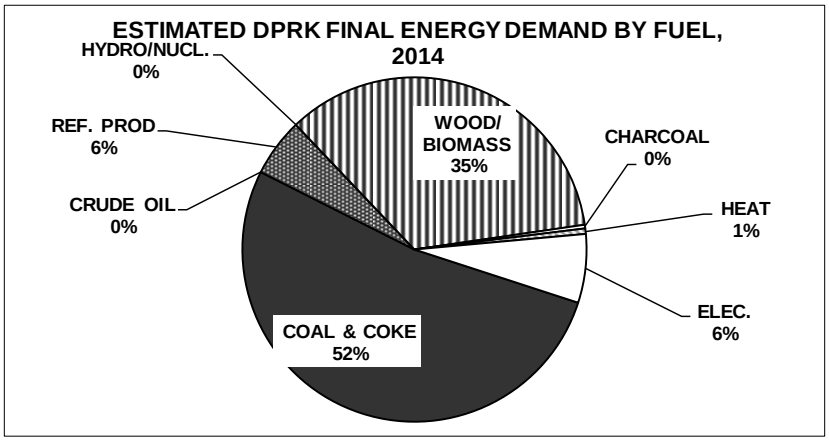
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	457	25	21	39	208	-	-	1	751
Domestic Production	851	0	-	39	205	-		-	1,096
Imports	8	25	22	-	5	-		1	60
Exports	402	-	1	-	2	-		1	406
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(153)	(25)	11	(39)	(7)	2	3	37	(171)
Electricity Generation	(100)	-	(12)	(39)	-	-	3	62	(87)
Petroleum Refining	-	(25)	25	-	-	-		(0)	(0)
Coal Prod./Prep.	(41)	-	-	-	-	-		(6)	(46)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(1)	-	-	-		(4)	(5)
Losses	(10)	-	-	-	-	-	(1)	(15)	(27)
FUELS FOR FINAL CONS.	304	-	32	-	202	2	3	37	580
ENERGY DEMAND	304	-	32	-	202	2	3	37	580
INDUSTRIAL	166	-	6	-	1	-	-	17	190
TRANSPORT	-	-	10	-	1	-	-	3	15
RESIDENTIAL	91	-	2	-	156	2	2	3	256
AGRICULTURAL	5	-	1	-	26	-	-	1	34
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	19	-	10	-	7	-	-	8	44
PUBLIC/COMML	19	-	0	-	5	-	1	4	30
NON-SPECIFIED			-						-
NON-ENERGY	3		1		6				10
Elect. Gen. (Gr. TWhe)	5.97	-	0.66	10.57	-	-		-	17.20

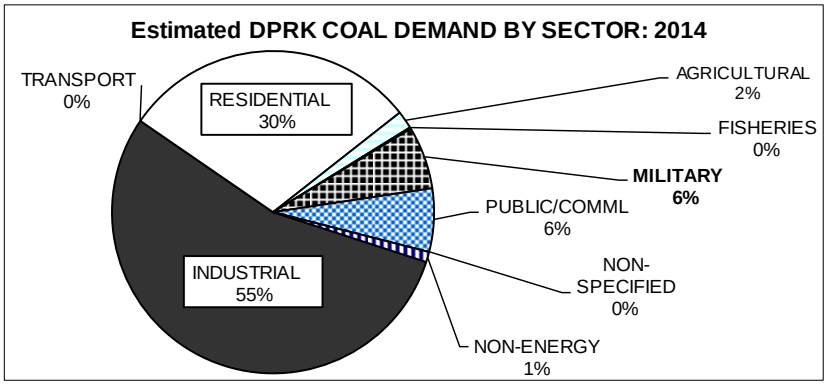
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

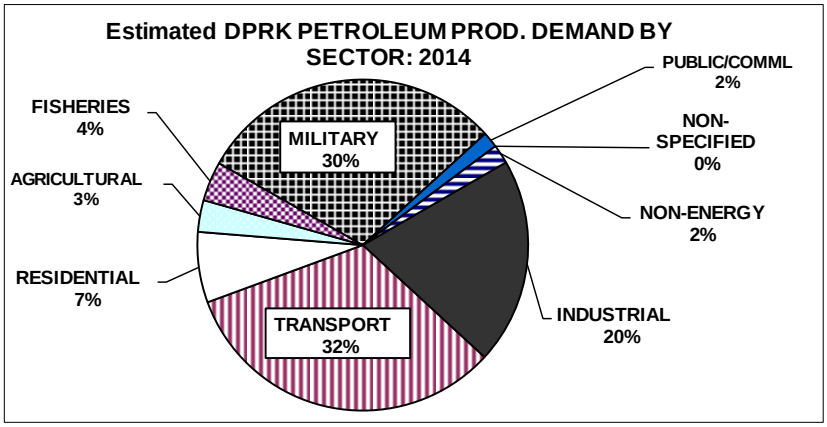

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2014
CRUDE OIL 3%
REF. PROD 3%
HYDRO/NUCL. 5%
WOOD/ BIOMASS 28%
COAL & COKE 61%

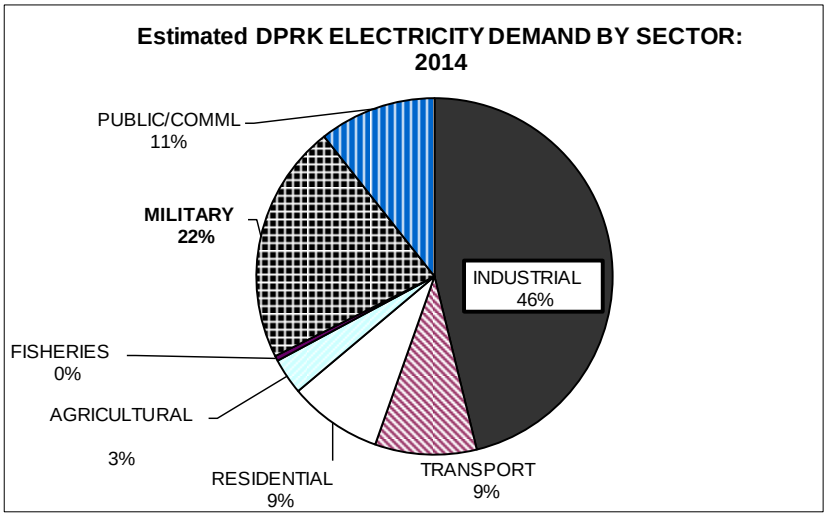

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2014
6%
0%
8%
5%
2%
0%
33%
2%
44%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2014
NON-ENERGY 10
NON-SPECIFIED -
PUBLIC/COMML 30
MILITARY 44
FISHERIES 2
AGRICULTURAL 34
RESIDENTIAL 256
TRANSPORT 15
INDUSTRIAL 190
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2014
HYDRO/NUCL. 0%
REF. PROD 6%
CRUDE OIL 0%
WOOD/ BIOMASS 35%
CHARCOAL 0%
HEAT 1%
ELEC. 6%
COAL & COKE 52%


Estimated DPRK COAL DEMAND BY SECTOR: 2014
TRANSPORT 0%
RESIDENTIAL 30%
AGRICULTURAL 2%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
INDUSTRIAL 55%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2014
PUBLIC/COMML 2%
NON-SPECIFIED 0%
NON-ENERGY 2%
FISHERIES 4%
MILITARY 30%
AGRICULTURAL 3%
RESIDENTIAL 7%
TRANSPORT 32%
INDUSTRIAL 20%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2014
PUBLIC/COMML 11%
MILITARY 22%
INDUSTRIAL 46%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 9%
TRANSPORT 9%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

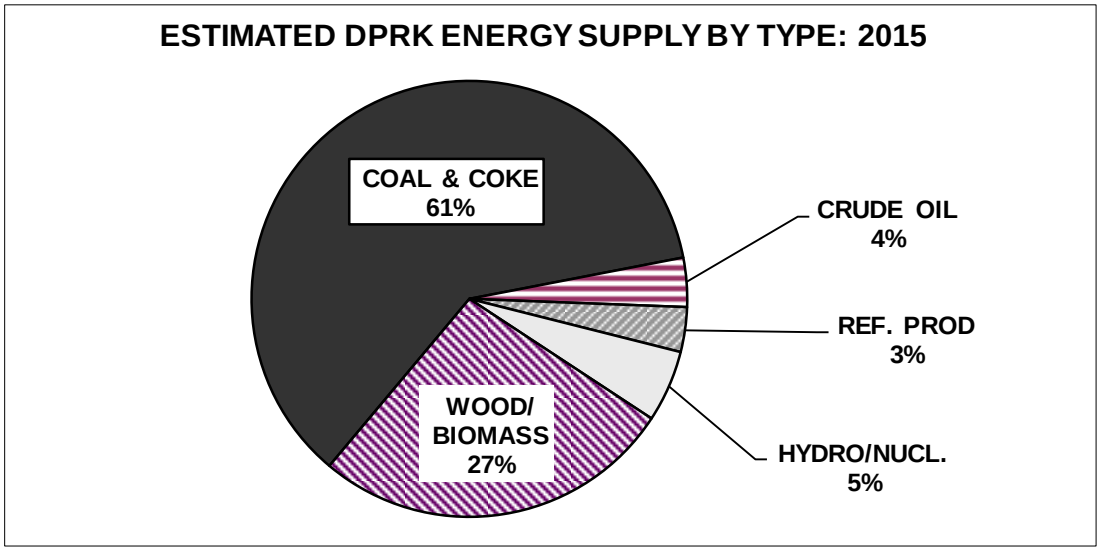
2020 UPDATE

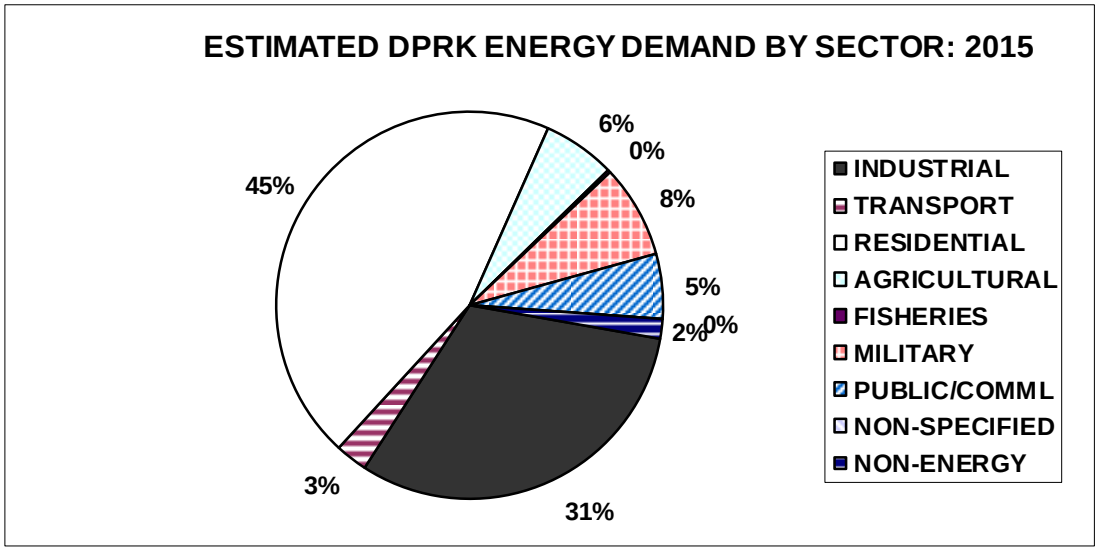
ESTIMATED SUMMARY ENERGY BALANCE FOR 2015

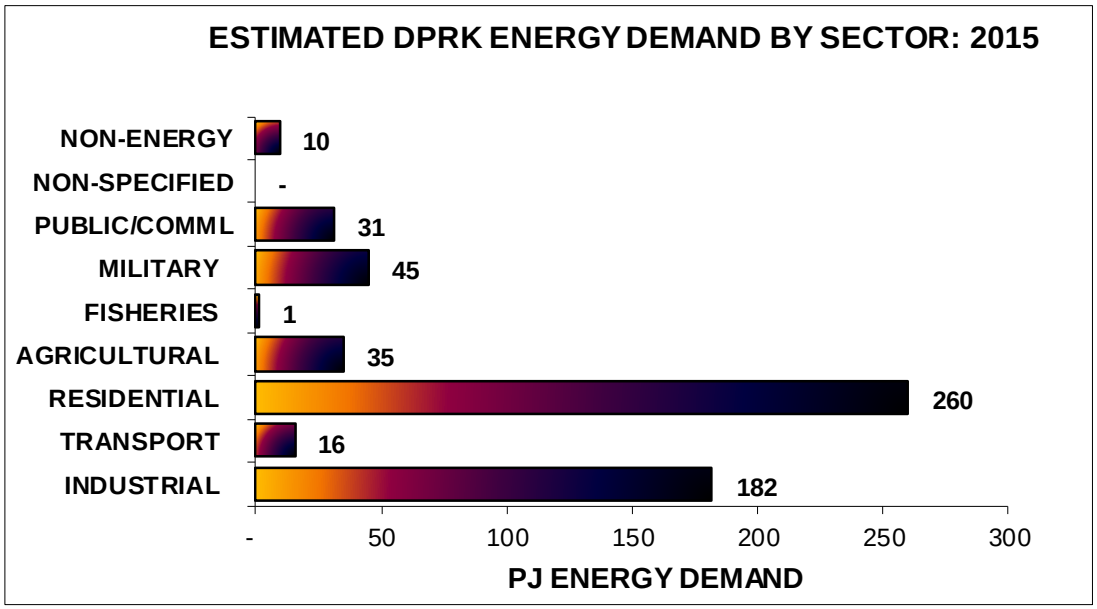
Prepared By David Von Hippel
Date Last Modified: 4/20/2020

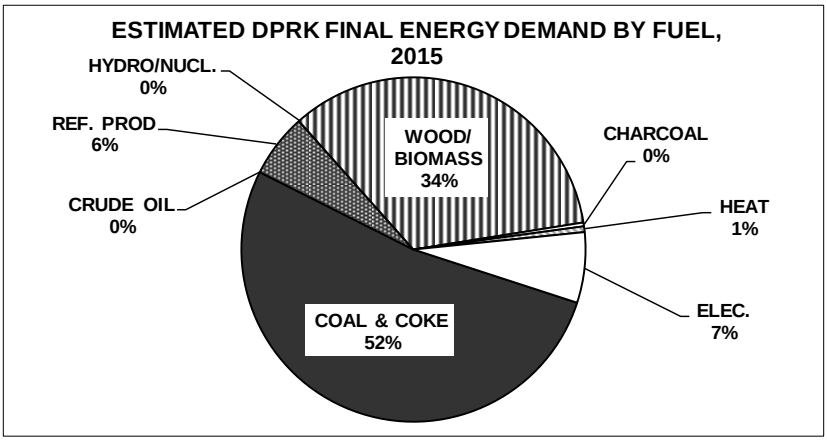
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	463	28	25	40	204	-	-	1	762
Domestic Production	950	0	-	40	202	-		-	1,192
Imports	30	27	25	-	5	-		2	89
Exports	516	-	0	-	2	-		0	519
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(159)	(28)	9	(40)	(7)	2	3	37	(182)
Electricity Generation	(100)	-	(17)	(40)	-	-	3	62	(92)
Petroleum Refining	-	(28)	28	-	-	-		(0)	(0)
Coal Prod./Prep.	(45)	-	-	-	-	-		(6)	(52)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(3)	(5)
Losses	(12)	-	-	-	-	-	(1)	(15)	(28)
FUELS FOR FINAL CONS.	304	-	35	-	198	2	3	38	580
ENERGY DEMAND	304	-	35	-	198	2	3	38	580
INDUSTRIAL	157	-	8	-	1	-	-	17	182
TRANSPORT	-	-	11	-	1	-	-	4	16
RESIDENTIAL	99	-	3	-	151	2	2	3	260
AGRICULTURAL	6	-	1	-	27	-	-	1	35
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	20	-	10	-	7	-	-	8	45
PUBLIC/COMML	20	-	1	-	5	-	1	4	31
NON-SPECIFIED			-						-
NON-ENERGY	3		1		6				10
Elect. Gen. (Gr. TWhe)	5.08	-	0.96	11.25	-	-		-	17.29

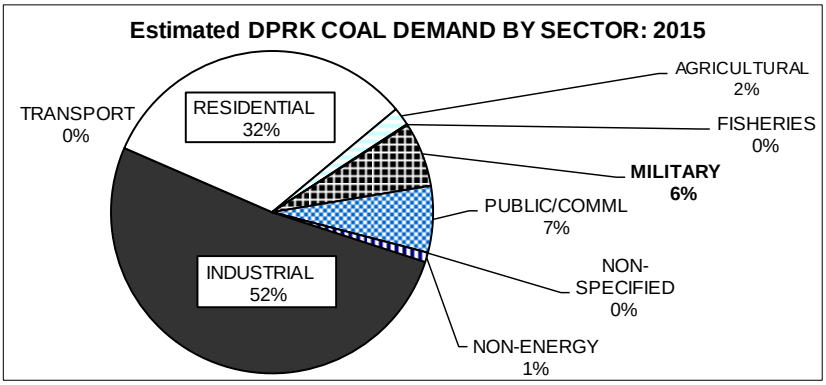
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

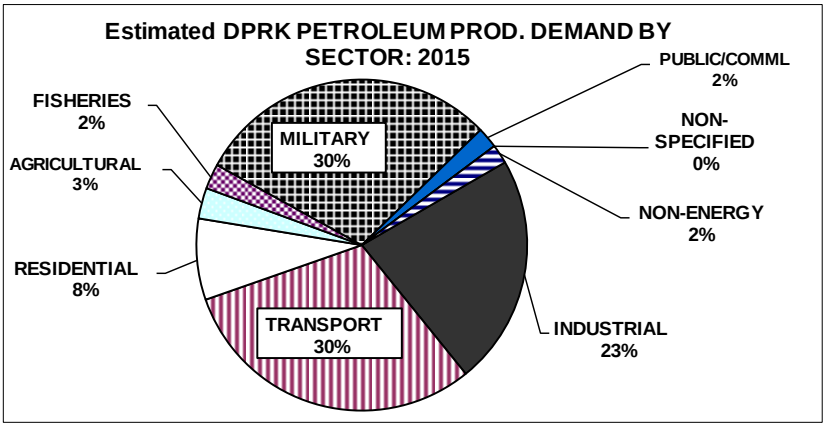

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2015
COAL & COKE
61%
CRUDE OIL
4%
REF. PROD
3%
HYDRO/NUCL.
5%
WOOD/
BIOMASS
27%

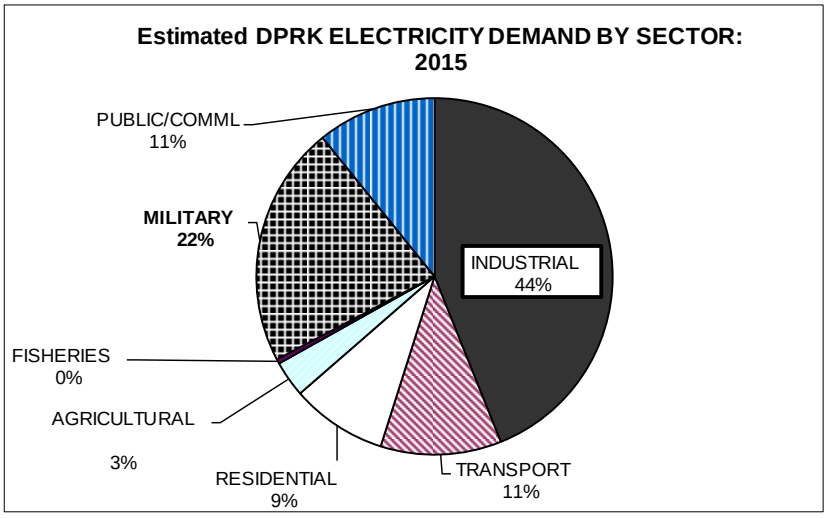

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2015
6%
0%
8%
5%
2%
0%
31%
3%
45%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2015
NON-ENERGY
NON-SPECIFIED
PUBLIC/COMML
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL
10
-
31
45
1
35
260
16
182
-
50
100
150
200
250
300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2015
HYDRO/NUCL. 0%
REF. PROD 6%
CRUDE OIL 0%
WOOD/ BIOMASS 34%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 52%


Estimated DPRK COAL DEMAND BY SECTOR: 2015
TRANSPORT 0%
RESIDENTIAL 32%
AGRICULTURAL 2%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
INDUSTRIAL 52%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2015
FISHERIES 2%
AGRICULTURAL 3%
RESIDENTIAL 8%
MILITARY 30%
TRANSPORT 30%
PUBLIC/COMML 2%
NON-SPECIFIED 0%
NON-ENERGY 2%
INDUSTRIAL 23%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2015
PUBLIC/COMML 11%
MILITARY 22%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 9%
INDUSTRIAL 44%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

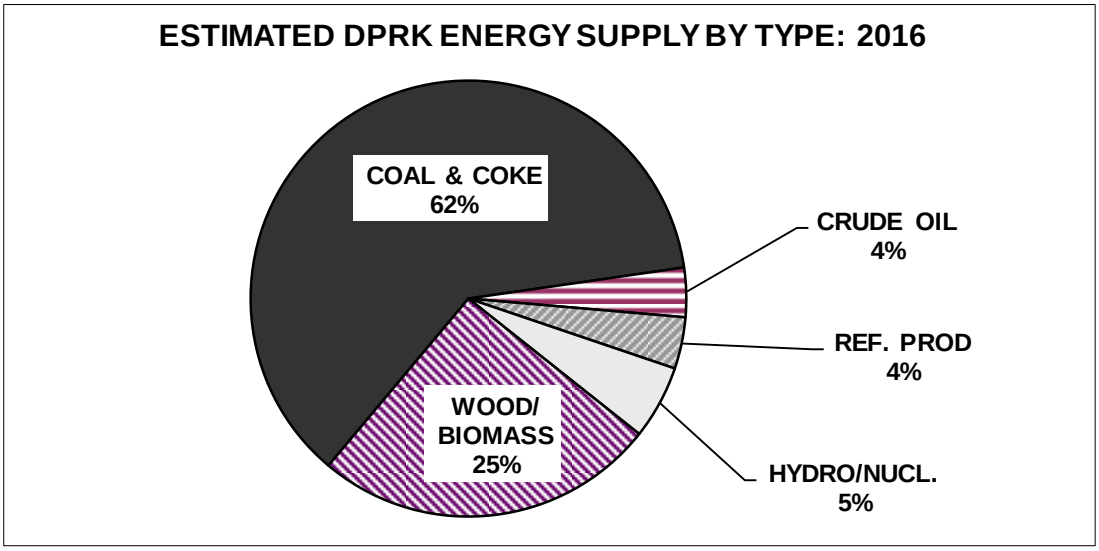
2020 UPDATE

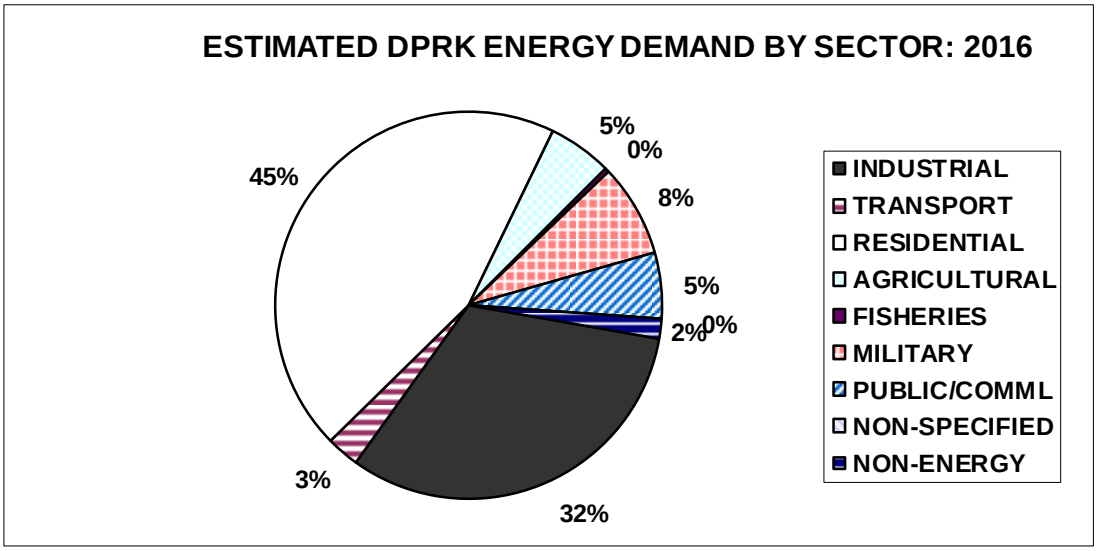
ESTIMATED SUMMARY ENERGY BALANCE FOR 2016

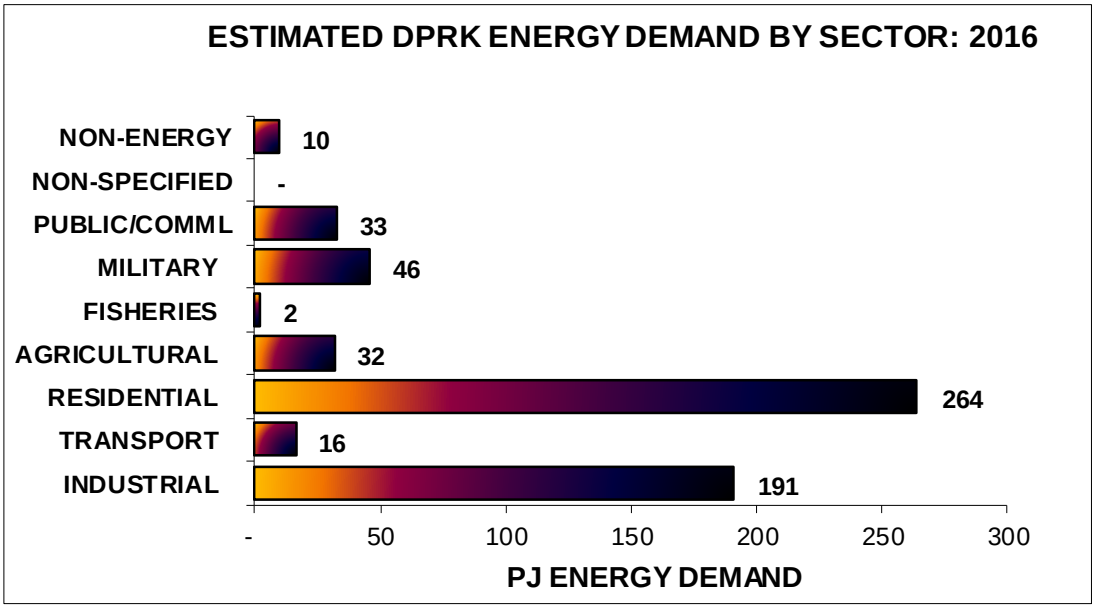
Prepared By David Von Hippel
Date Last Modified: 4/20/2020

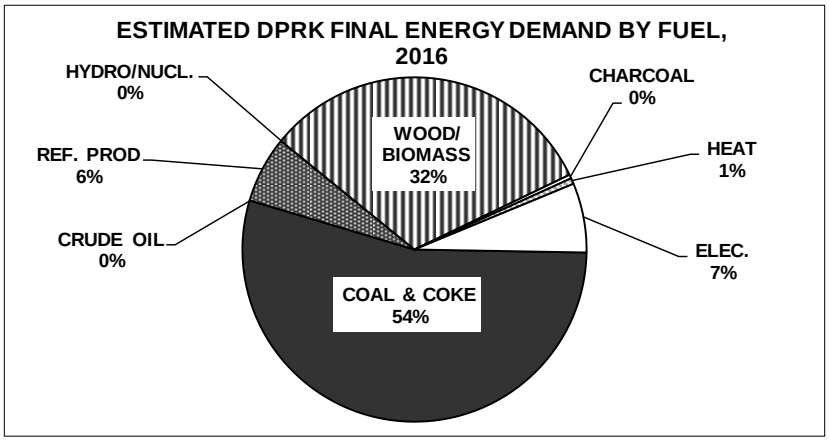
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	477	28	30	42	197	-	-	(0)	774
Domestic Production	1,020	0	-	42	194	-		-	1,257
Imports	41	28	30	-	4	-		0	104
Exports	584	-	0	-	2	-		1	586
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(155)	(28)	8	(42)	(7)	2	4	39	(180)
Electricity Generation	(91)	-	(20)	(42)	-	-	3	65	(85)
Petroleum Refining	-	(28)	29	-	-	-		(0)	0
Coal Prod./Prep.	(49)	-	-	-	-	-		(7)	(55)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(4)	(5)
Losses	(12)	-	-	-	-	-	(1)	(16)	(29)
FUELS FOR FINAL CONS.	322	-	37	-	190	2	4	39	594
ENERGY DEMAND	322	-	37	-	190	2	3	39	593
INDUSTRIAL	165	-	8	-	1	-	-	16	191
TRANSPORT	-	-	11	-	1	-	-	4	16
RESIDENTIAL	107	-	3	-	146	2	2	4	264
AGRICULTURAL	5	-	1	-	24	-	-	1	32
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	20	-	11	-	6	-	-	9	46
PUBLIC/COMML	21	-	1	-	5	-	1	4	33
NON-SPECIFIED			-						-
NON-ENERGY	3		1		6				10
Elect. Gen. (Gr. TWhe)	5.44	-	1.21	11.50	-	-		-	18.15

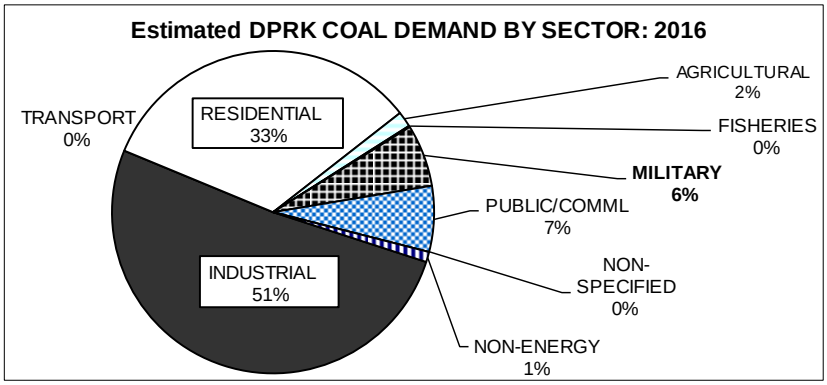
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

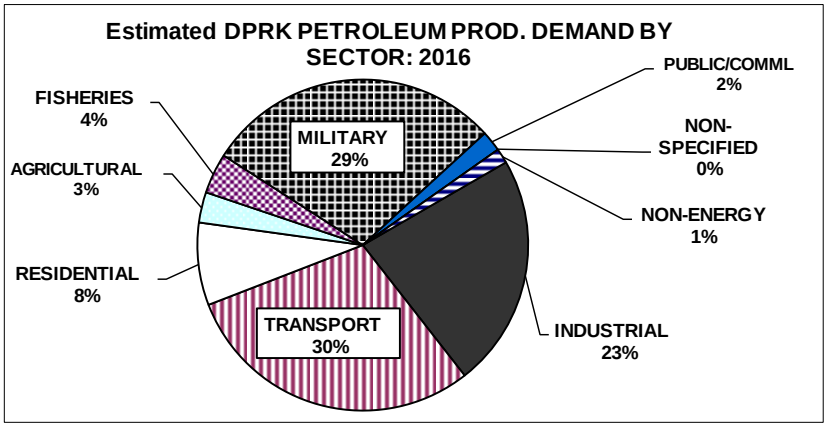

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2016
COAL & COKE 62%
CRUDE OIL 4%
REF. PROD 4%
WOOD/ BIOMASS 25%
HYDRO/NUCL. 5%

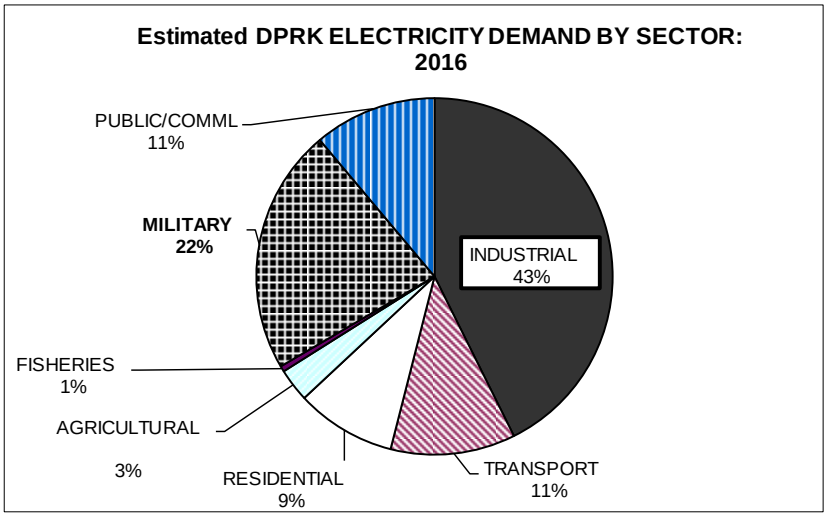

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2016
5%
0%
8%
5%
2%
0%
3%
32%
45%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2016
NON-ENERGY 10
NON-SPECIFIED -
PUBLIC/COMML 33
MILITARY 46
FISHERIES 2
AGRICULTURAL 32
RESIDENTIAL 264
TRANSPORT 16
INDUSTRIAL 191
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2016
HYDRO/NUCL. 0%
CHARCOAL 0%
WOOD/ BIOMASS 32%
REF. PROD 6%
HEAT 1%
CRUDE OIL 0%
ELEC. 7%
COAL & COKE 54%


Estimated DPRK COAL DEMAND BY SECTOR: 2016
AGRICULTURAL 2%
TRANSPORT 0%
RESIDENTIAL 33%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
INDUSTRIAL 51%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2016
PUBLIC/COMML 2%
FISHERIES 4%
MILITARY 29%
NON-SPECIFIED 0%
AGRICULTURAL 3%
NON-ENERGY 1%
RESIDENTIAL 8%
TRANSPORT 30%
INDUSTRIAL 23%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2016
PUBLIC/COMML 11%
MILITARY 22%
INDUSTRIAL 43%
FISHERIES 1%
AGRICULTURAL 3%
RESIDENTIAL 9%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

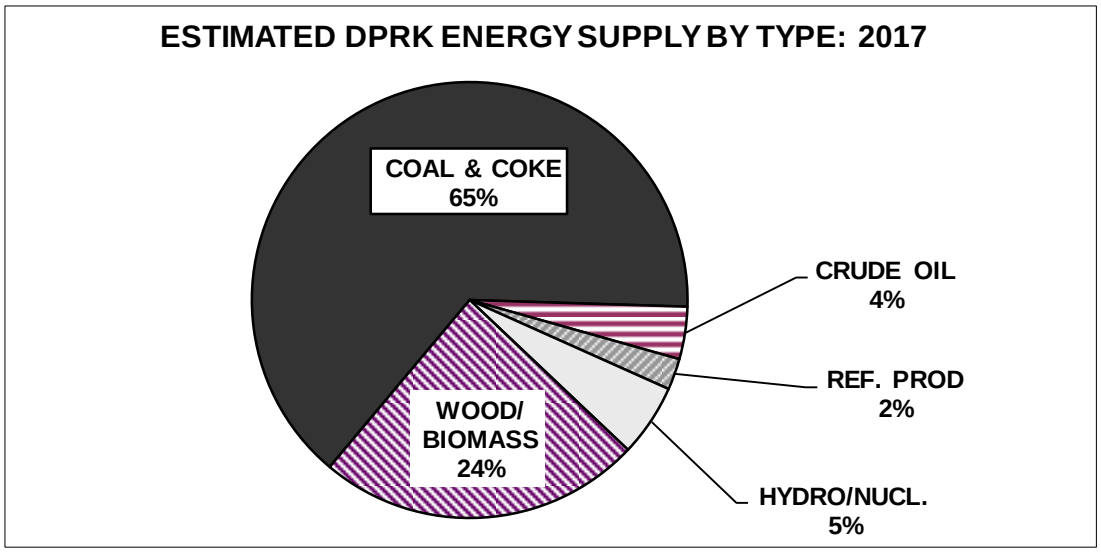
2020 UPDATE

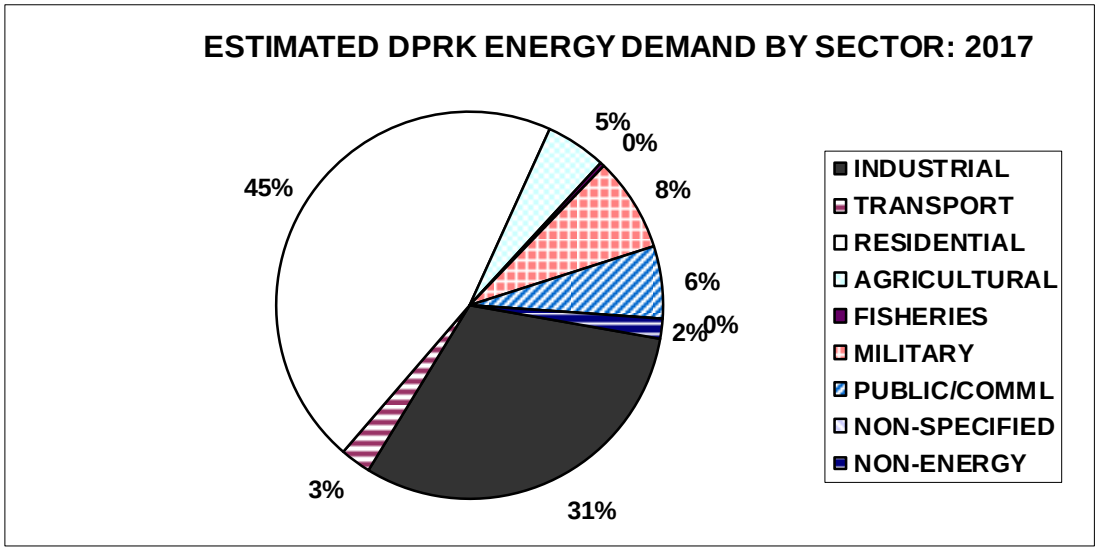
ESTIMATED SUMMARY ENERGY BALANCE FOR 2017

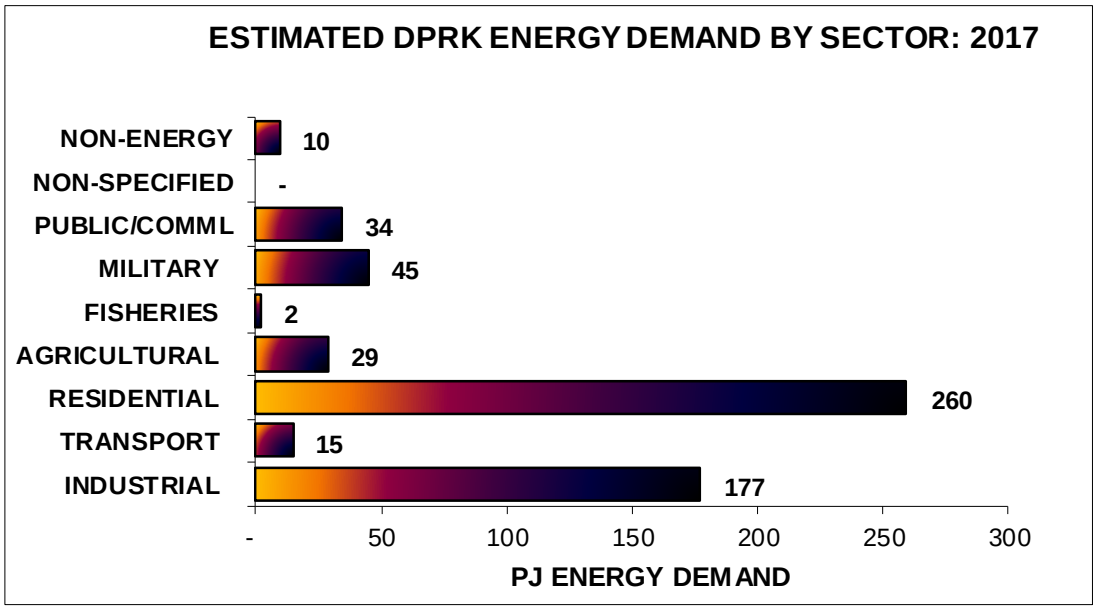
Prepared By David Von Hippel
Date Last Modified: 4/20/2020

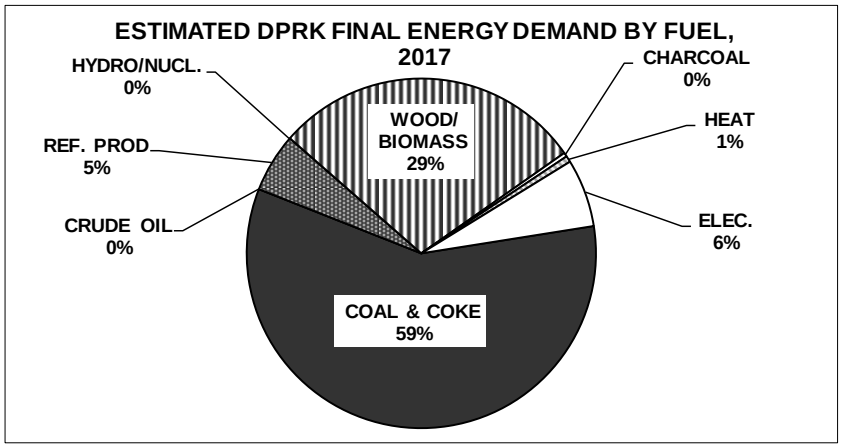
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	460	28	17	38	172	-	-	(1)	713
Domestic Production	567	0	-	38	169	-		-	774
Imports	29	27	17	-	4	-		0	77
Exports	137	-	0	-	1	-		1	139
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(126)	(28)	15	(38)	(7)	2	4	37	(142)
Electricity Generation	(90)	-	(11)	(38)	-	-	3	59	(77)
Petroleum Refining	-	(28)	28	-	-	-		(0)	(0)
Coal Prod./Prep.	(27)	-	-	-	-	-		(4)	(31)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(4)	(5)
Losses	(7)	-	-	-	-	-	(1)	(15)	(23)
FUELS FOR FINAL CONS.	334	-	31	-	165	2	4	36	571
ENERGY DEMAND	334	-	31	-	165	2	3	36	571
INDUSTRIAL	158	-	4	-	1	-	-	14	177
TRANSPORT	-	-	10	-	1	-	-	4	15
RESIDENTIAL	126	-	3	-	123	2	2	4	260
AGRICULTURAL	5	-	1	-	22	-	-	1	29
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	20	-	9	-	6	-	-	9	45
PUBLIC/COMML	23	-	1	-	5	-	1	4	34
NON-SPECIFIED			-						-
NON-ENERGY	2		1		6				10
Elect. Gen. (Gr. TWhe)	5.29	-	0.67	10.37	-	-		-	16.33

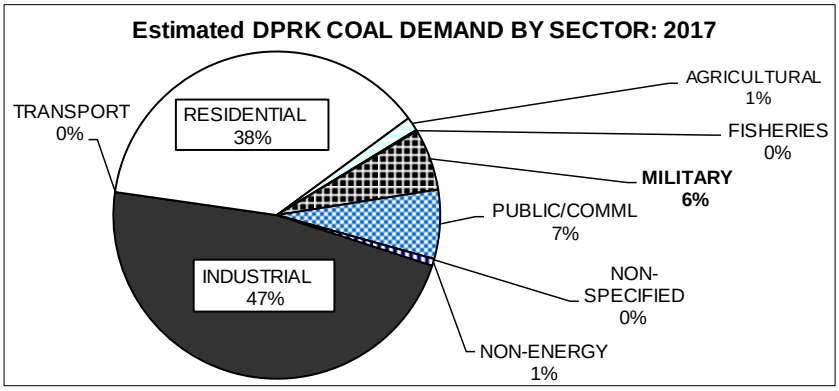
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

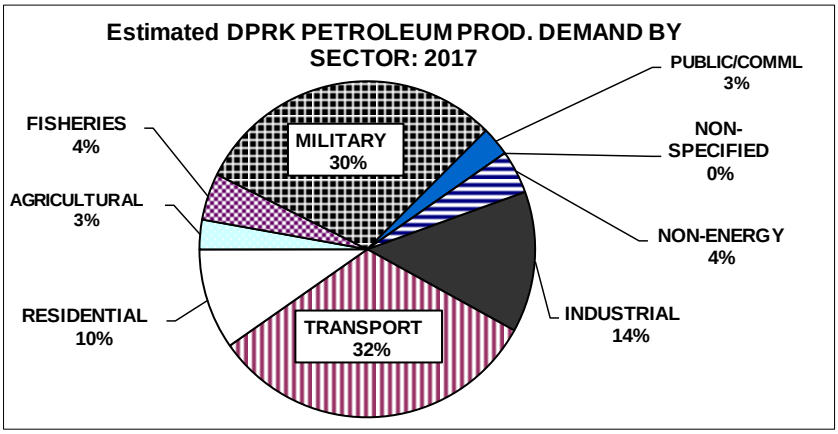

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2017
COAL & COKE 65%
CRUDE OIL 4%
REF. PROD 2%
WOOD/ BIOMASS 24%
HYDRO/NUCL. 5%

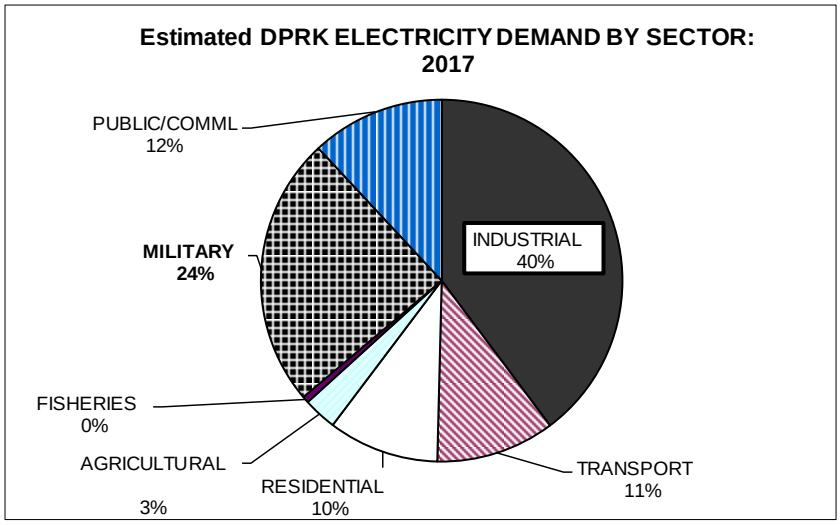

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2017
5%
0%
8%
6%
2%
0%
45%
3%
31%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2017
NON-ENERGY 10
NON-SPECIFIED -
PUBLIC/COMML 34
MILITARY 45
FISHERIES 2
AGRICULTURAL 29
RESIDENTIAL 260
TRANSPORT 15
INDUSTRIAL 177
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2017
HYDRO/NUCL. 0%
CHARCOAL 0%
WOOD/ BIOMASS 29%
HEAT 1%
REF. PROD 5%
ELEC. 6%
CRUDE OIL 0%
COAL & COKE 59%


Estimated DPRK COAL DEMAND BY SECTOR: 2017
AGRICULTURAL 1%
TRANSPORT 0%
RESIDENTIAL 38%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
INDUSTRIAL 47%
NON-SPECIFIED 0%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2017
PUBLIC/COMML 3%
FISHERIES 4%
MILITARY 30%
NON-SPECIFIED 0%
AGRICULTURAL 3%
NON-ENERGY 4%
RESIDENTIAL 10%
TRANSPORT 32%
INDUSTRIAL 14%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2017
PUBLIC/COMML 12%
MILITARY 24%
INDUSTRIAL 40%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 10%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

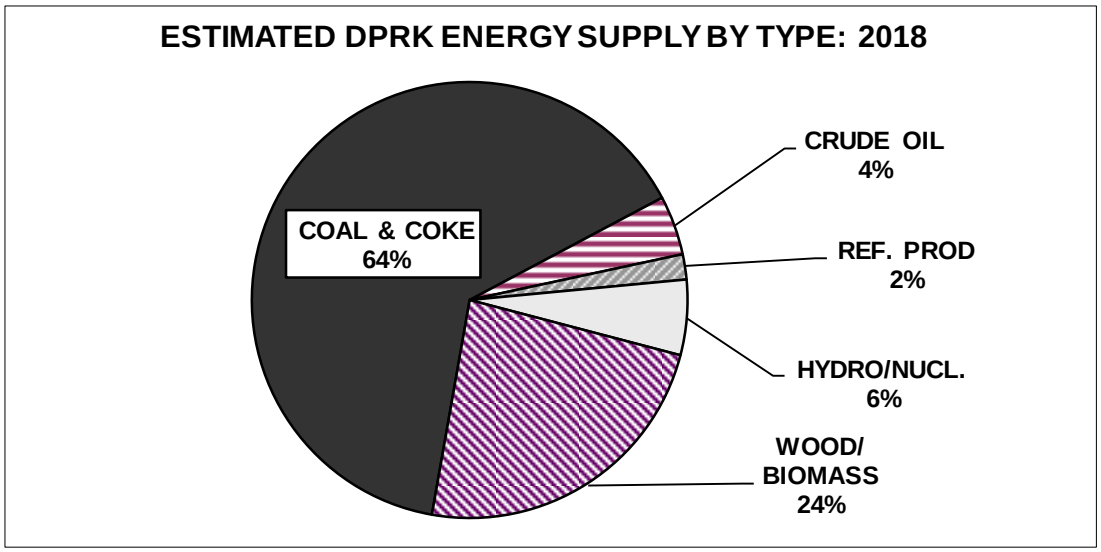
2020 UPDATE

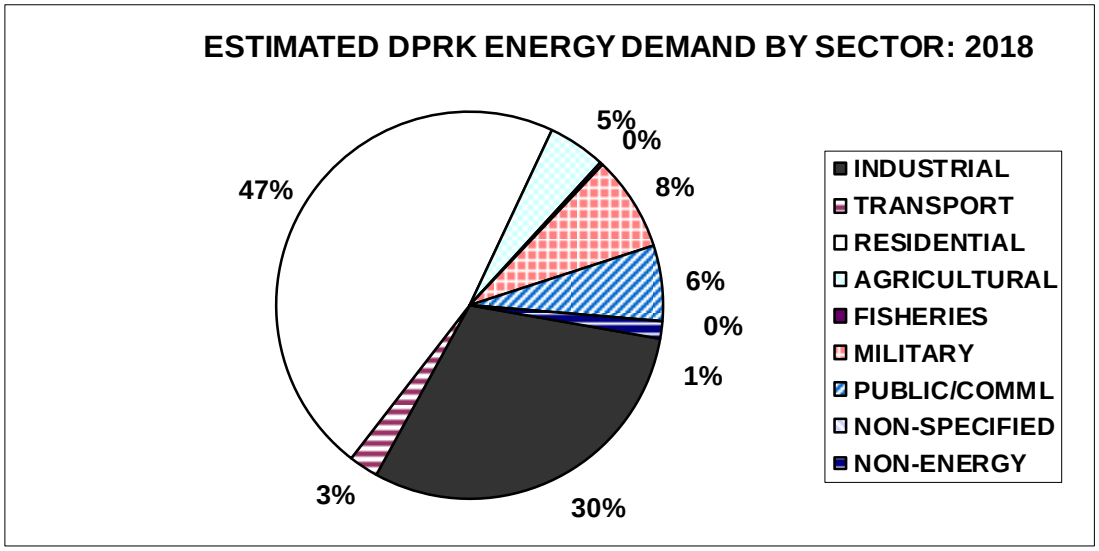
ESTIMATED SUMMARY ENERGY BALANCE FOR 2018

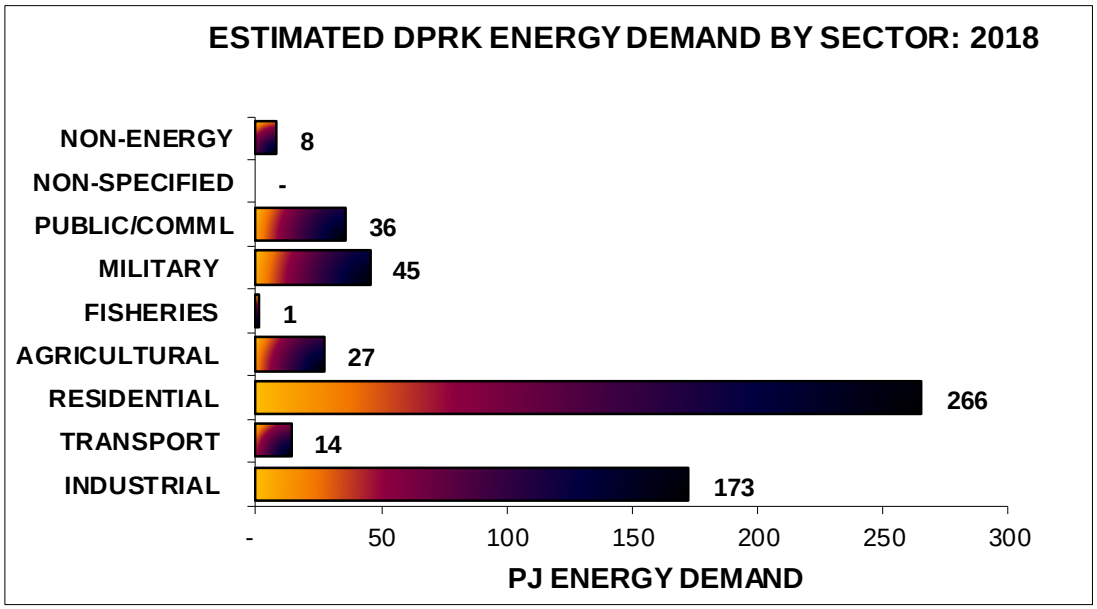
Prepared By David Von Hippel
Date Last Modified: 6/26/2020

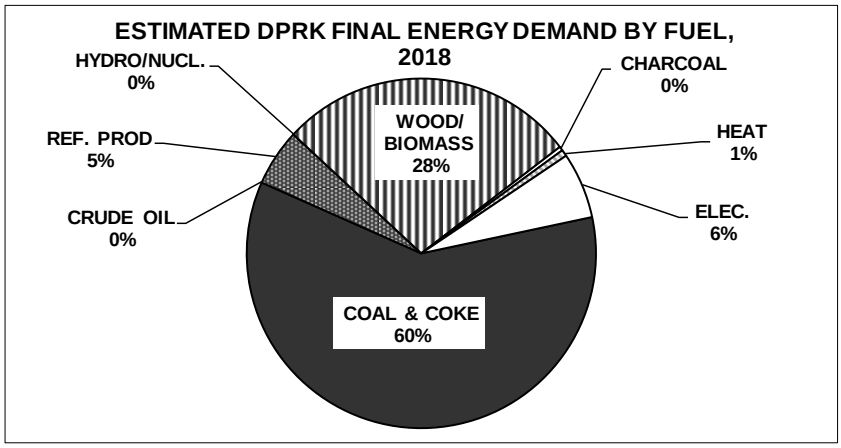
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	449	31	13	39	165	-	-	(1)	697
Domestic Production	531	0	-	39	161	-		-	732
Imports	0	30	13	-	4	-		0	48
Exports	82	-	0	-	0	-		1	83
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(107)	(31)	17	(39)	(7)	2	4	35	(125)
Electricity Generation	(73)	-	(12)	(39)	-	-	4	56	(64)
Petroleum Refining	-	(31)	31	-	-	-		(0)	(0)
Coal Prod./Prep.	(25)	-	-	-	-	-		(3)	(29)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(3)	(5)
Losses	(7)	-	-	-	-	-	(1)	(14)	(22)
FUELS FOR FINAL CONS.	343	-	30	-	158	2	4	35	571
ENERGY DEMAND	343	-	30	-	158	2	3	35	571
INDUSTRIAL	155	-	4	-	1	-	-	13	173
TRANSPORT	-	-	10	-	1	-	-	4	14
RESIDENTIAL	137	-	3	-	117	2	2	4	266
AGRICULTURAL	4	-	1	-	21	-	-	1	27
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	21	-	9	-	7	-	-	9	45
PUBLIC/COMML	24	-	1	-	5	-	1	4	36
NON-SPECIFIED			-						-
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	4.34	-	0.67	10.55	-	-		-	15.56

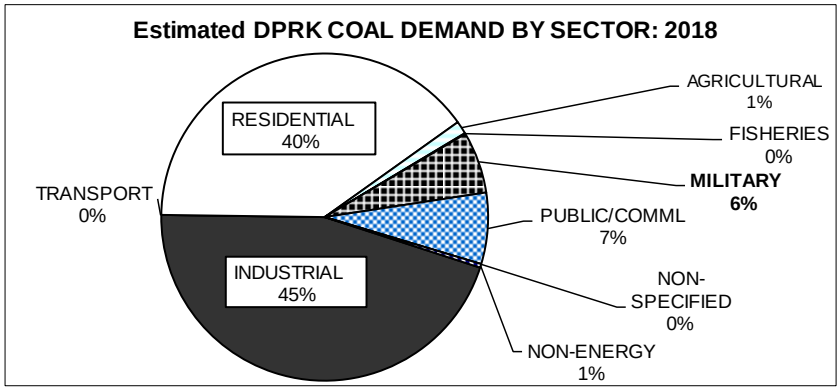
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

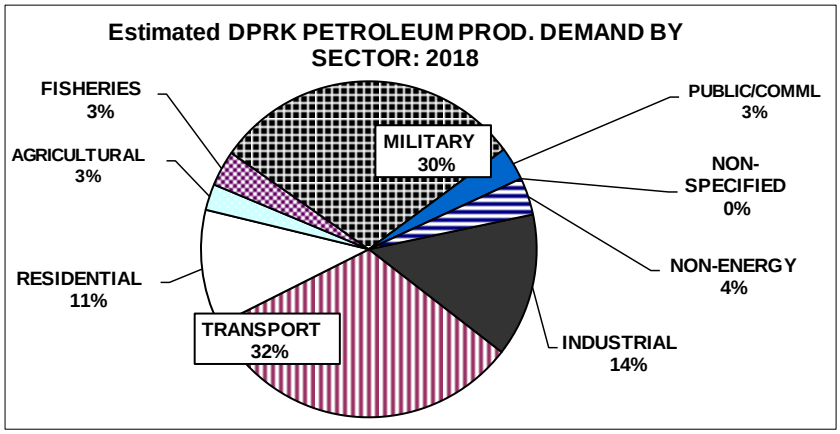

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2018
COAL & COKE 64%
CRUDE OIL 4%
REF. PROD 2%
HYDRO/NUCL. 6%
WOOD/ BIOMASS 24%

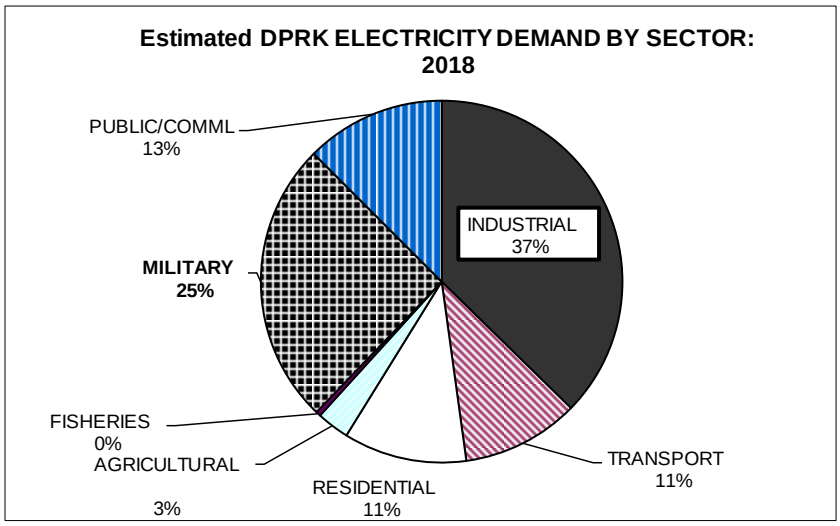

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2018
47%
5%
0%
8%
6%
0%
1%
3%
30%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2018
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 36
MILITARY 45
FISHERIES 1
AGRICULTURAL 27
RESIDENTIAL 266
TRANSPORT 14
INDUSTRIAL 173
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2018
HYDRO/NUCL. 0%
CHARCOAL 0%
WOOD/ BIOMASS 28%
HEAT 1%
REF. PROD 5%
ELEC. 6%
CRUDE OIL 0%
COAL & COKE 60%


Estimated DPRK COAL DEMAND BY SECTOR: 2018
AGRICULTURAL 1%
RESIDENTIAL 40%
FISHERIES 0%
MILITARY 6%
TRANSPORT 0%
PUBLIC/COMML 7%
INDUSTRIAL 45%
NON-SPECIFIED 0%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2018
FISHERIES 3%
PUBLIC/COMML 3%
MILITARY 30%
AGRICULTURAL 3%
NON-SPECIFIED 0%
NON-ENERGY 4%
RESIDENTIAL 11%
TRANSPORT 32%
INDUSTRIAL 14%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2018
PUBLIC/COMML 13%
INDUSTRIAL 37%
MILITARY 25%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 11%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

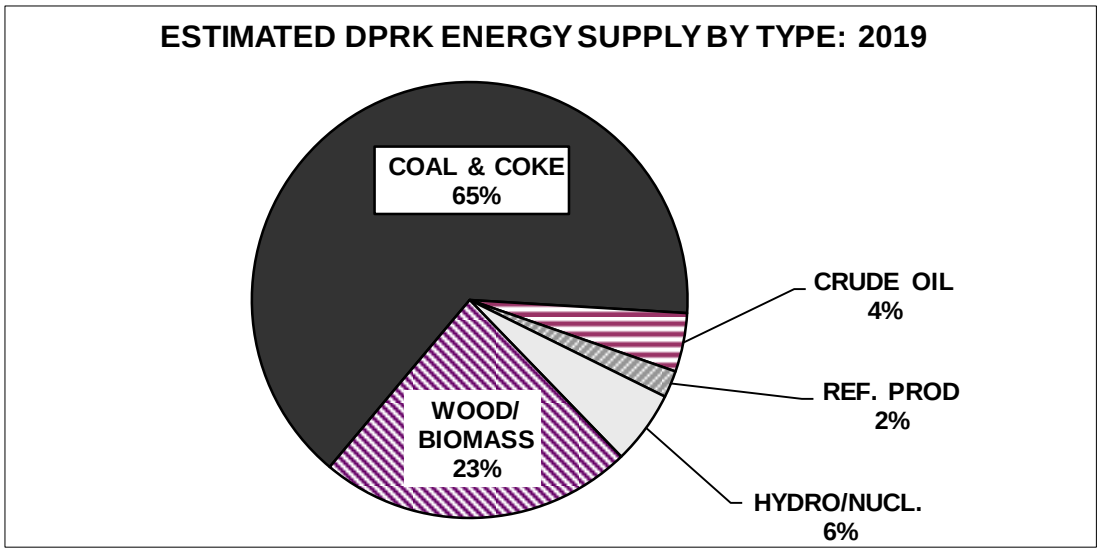
2020 UPDATE

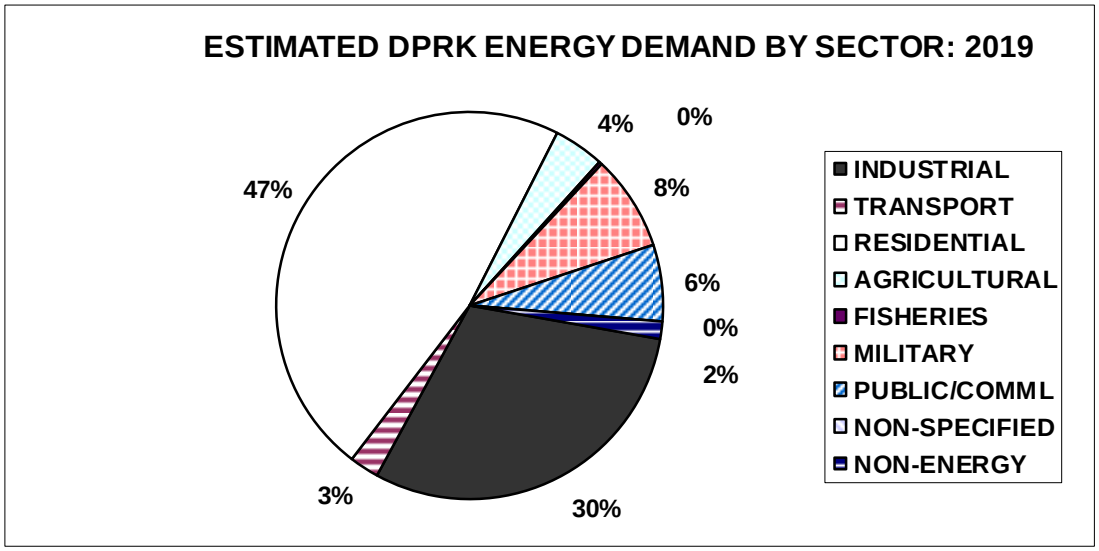
ESTIMATED SUMMARY ENERGY BALANCE FOR 2019

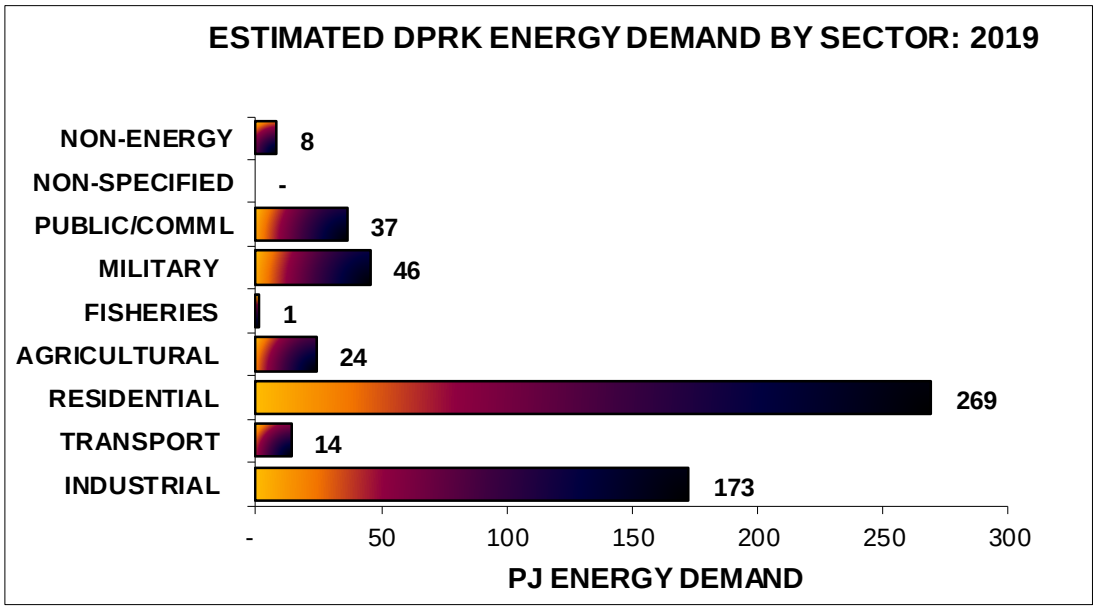
Prepared By David Von Hippel
Date Last Modified: 6/26/2020

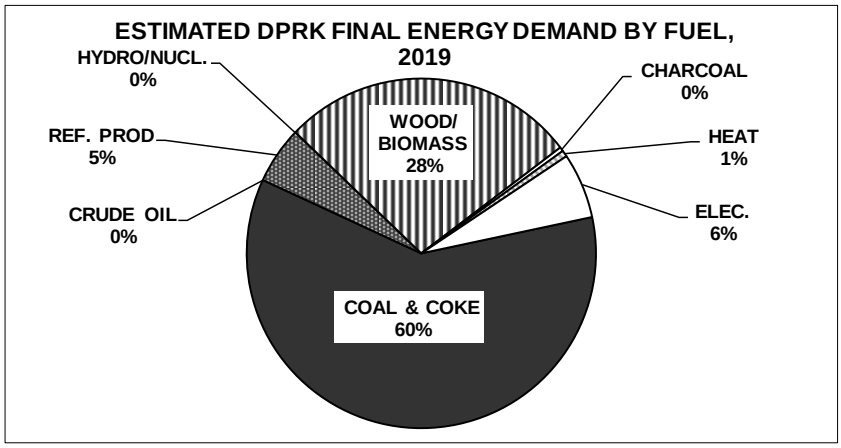
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	457	31	14	38	165	-	-	(1)	704
Domestic Production	619	0	-	38	161	-		-	819
Imports	0	30	14	-	4	-		0	49
Exports	163	-	0	-	-	-		1	164
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(112)	(31)	16	(38)	(7)	2	3	35	(131)
Electricity Generation	(73)	-	(13)	(38)	-	-	3	57	(64)
Petroleum Refining	-	(31)	31	-	-	-		(0)	(0)
Coal Prod./Prep.	(30)	-	-	-	-	-		(4)	(34)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(3)	(5)
Losses	(8)	-	-	-	-	-	(1)	(14)	(23)
FUELS FOR FINAL CONS.	345	-	30	-	157	2	3	35	572
ENERGY DEMAND	345	-	30	-	157	2	3	35	572
INDUSTRIAL	155	-	4	-	1	-	-	13	173
TRANSPORT	-	-	10	-	1	-	-	4	14
RESIDENTIAL	139	-	3	-	119	2	2	4	269
AGRICULTURAL	4	-	1	-	19	-	-	1	24
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	21	-	9	-	7	-	-	9	46
PUBLIC/COMML	25	-	1	-	5	-	1	4	37
NON-SPECIFIED			-						-
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	4.34	-	0.74	10.66	-	-		-	15.74

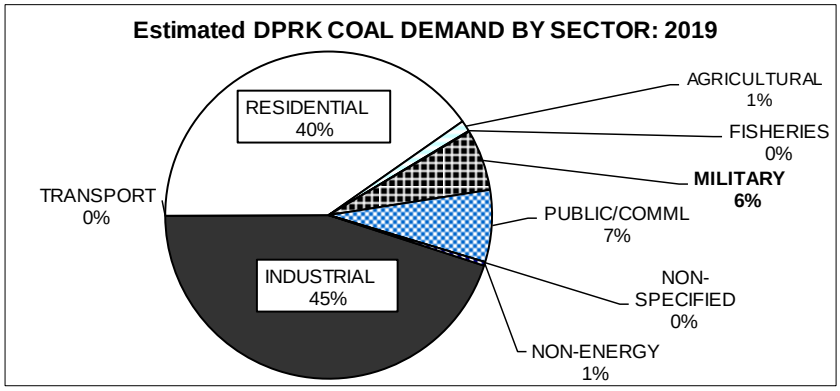
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

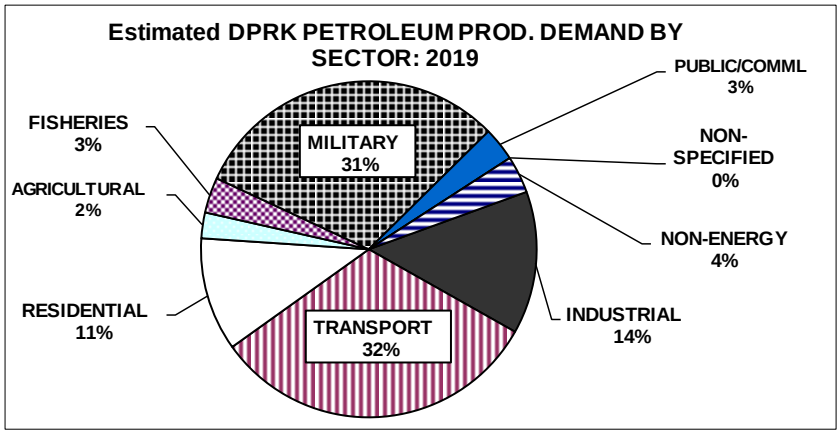

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2019
COAL & COKE
65%
CRUDE OIL
4%
REF. PROD
2%
WOOD/
BIOMASS
23%
HYDRO/NUCL.
6%

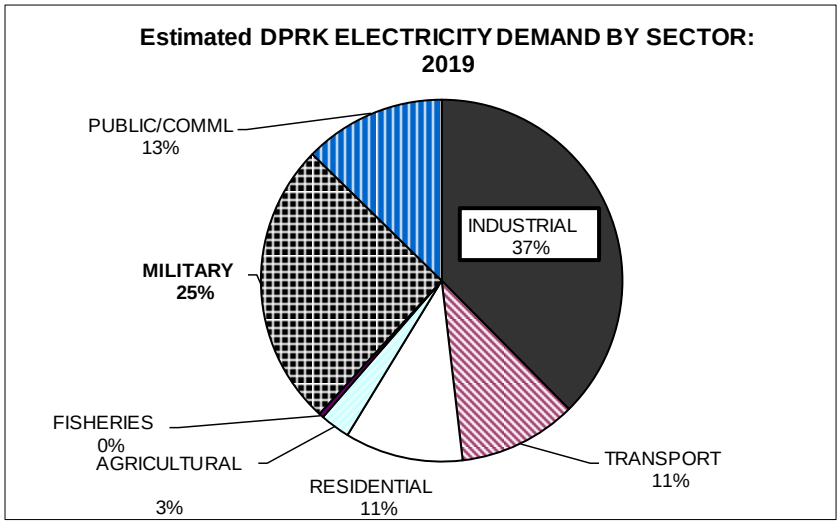

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2019
4%
0%
47%
8%
6%
0%
2%
3%
30%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2019
NON-ENERGY
8
NON-SPECIFIED
-
PUBLIC/COMML
37
MILITARY
46
FISHERIES
1
AGRICULTURAL
24
RESIDENTIAL
269
TRANSPORT
14
INDUSTRIAL
173
-
50
100
150
200
250
300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2019
HYDRO/NUCL. 0%
CHARCOAL 0%
WOOD/ BIOMASS 28%
REF. PROD 5%
HEAT 1%
CRUDE OIL 0%
ELEC. 6%
COAL & COKE 60%


Estimated DPRK COAL DEMAND BY SECTOR: 2019
AGRICULTURAL 1%
RESIDENTIAL 40%
FISHERIES 0%
MILITARY 6%
TRANSPORT 0%
PUBLIC/COMML 7%
INDUSTRIAL 45%
NON-SPECIFIED 0%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2019
PUBLIC/COMML 3%
FISHERIES 3%
MILITARY 31%
NON-SPECIFIED 0%
AGRICULTURAL 2%
NON-ENERGY 4%
RESIDENTIAL 11%
INDUSTRIAL 14%
TRANSPORT 32%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2019
PUBLIC/COMML 13%
INDUSTRIAL 37%
MILITARY 25%
FISHERIES 0%
AGRICULTURAL 3%
RESIDENTIAL 11%
TRANSPORT 11%

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

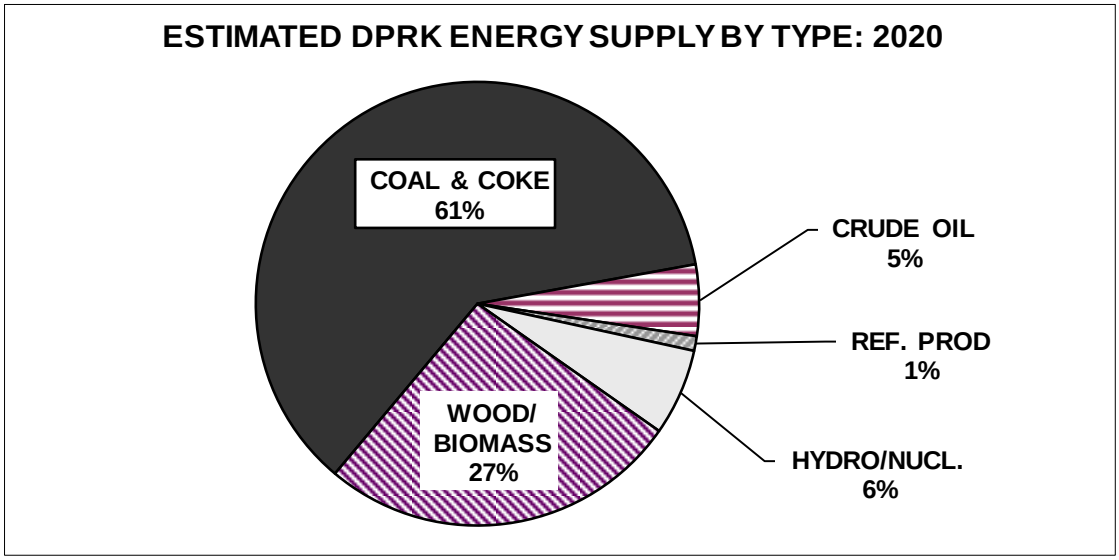
2020 UPDATE

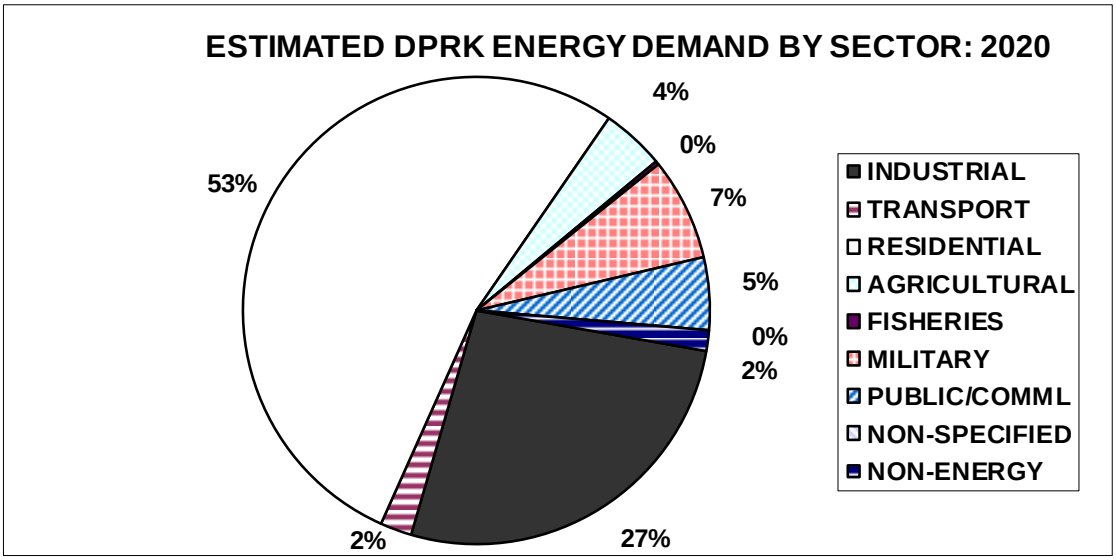
ESTIMATED SUMMARY ENERGY BALANCE FOR 2020

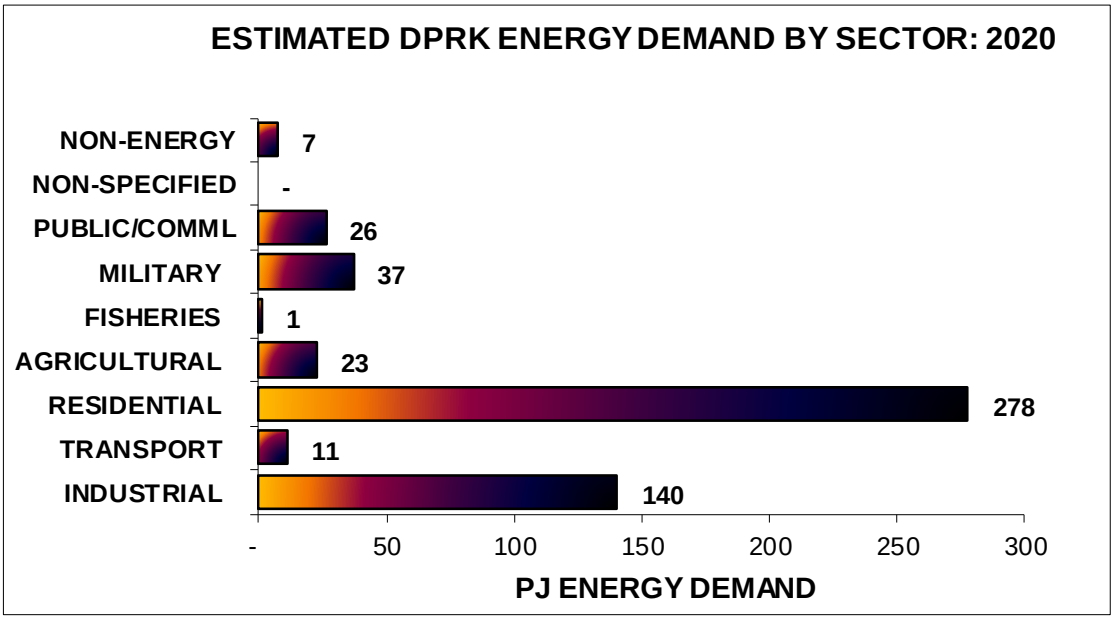
Prepared By David Von Hippel
Date Last Modified: 8/26/2020

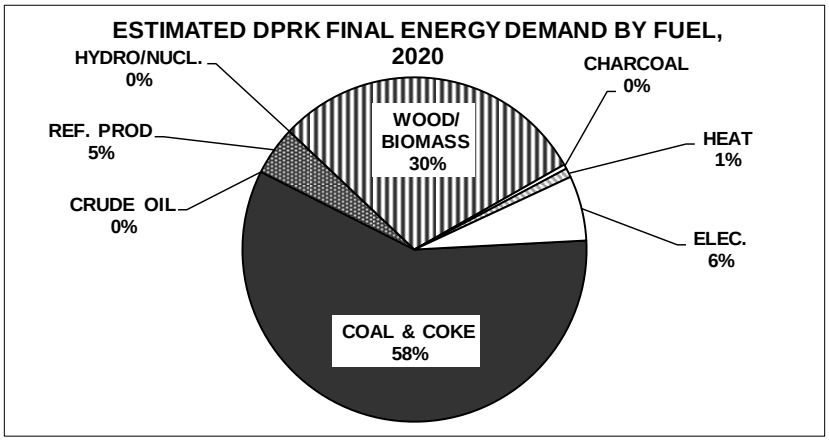
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	379	32	7	39	164	-	-	(1)	619
Domestic Production	461	0	-	39	162	-		-	662
Imports	0	32	7	-	2	-		0	41
Exports	82	-	-	-	-	-		1	83
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(73)	(32)	18	(39)	(7)	2	5	33	(94)
Electricity Generation	(43)	-	(13)	(39)	-	-	5	51	(40)
Petroleum Refining	-	(32)	32	-	-	-		(0)	(0)
Coal Prod./Prep.	(22)	-	-	-	-	-		(3)	(25)
Charcoal Production	-	-	-	-	(7)	2		-	(5)
District Heat Production	(2)		(0)				1		
Own Use	-	-	(2)	-	-	-		(2)	(4)
Losses	(6)	-	-	-	-	-	(1)	(13)	(20)
FUELS FOR FINAL CONS.	306	-	24	-	156	2	5	32	525
ENERGY DEMAND	306	-	24	-	156	2	4	32	525
INDUSTRIAL	125	-	4	-	1	-	-	10	140
TRANSPORT	-	-	7	-	1	-	-	4	11
RESIDENTIAL	141	-	3	-	121	2	4	6	278
AGRICULTURAL	4	-	1	-	18	-	-	1	23
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	17	-	6	-	7	-	-	8	37
PUBLIC/COMML	18	-	1	-	4	-	1	3	26
NON-SPECIFIED			-						-
NON-ENERGY	1		1		6				7
Elect. Gen. (Gr. TWhe)	2.58	-	0.72	10.74	-	-		-	14.04

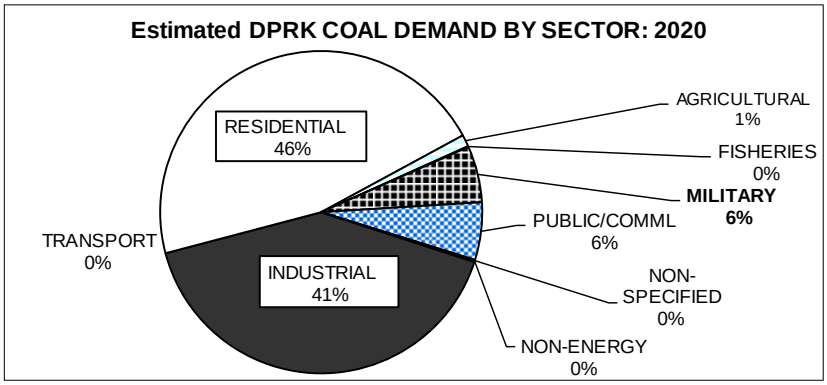
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

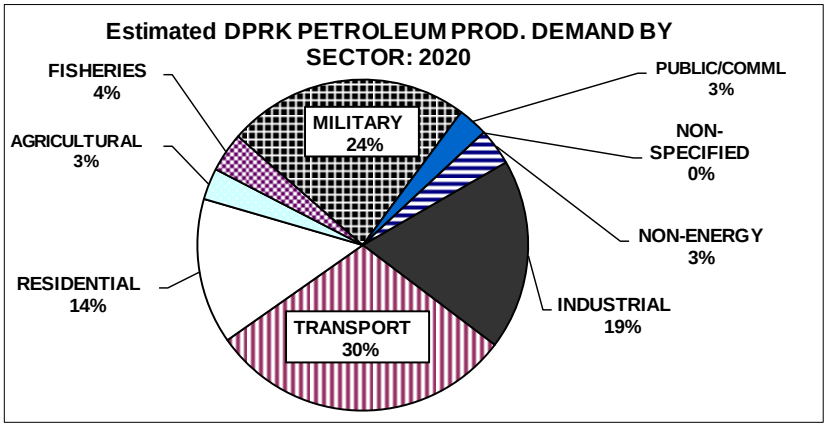

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2020
COAL & COKE 61%
CRUDE OIL 5%
REF. PROD 1%
HYDRO/NUCL. 6%
WOOD/ BIOMASS 27%

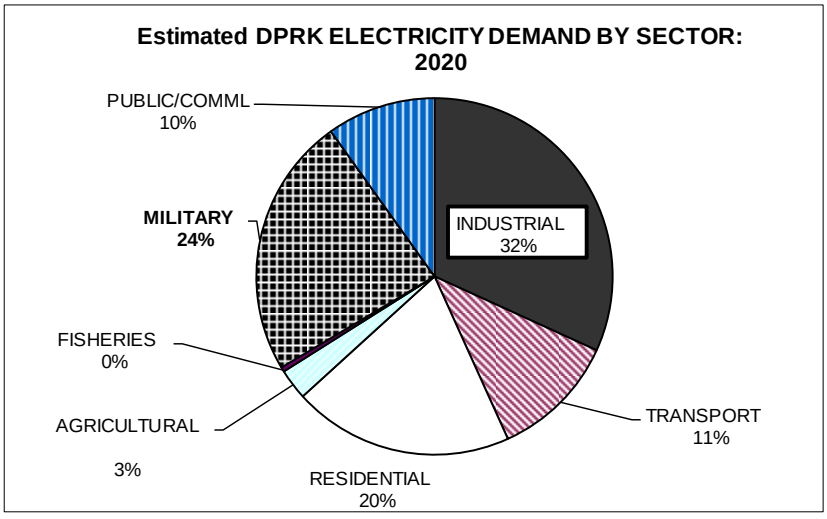

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2020
4%
0%
7%
5%
0%
2%
27%
2%
53%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2020
NON-ENERGY 7
NON-SPECIFIED -
PUBLIC/COMML 26
MILITARY 37
FISHERIES 1
AGRICULTURAL 23
RESIDENTIAL 278
TRANSPORT 11
INDUSTRIAL 140
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2020
HYDRO/NUCL. 0%
CHARCOAL 0%
WOOD/ BIOMASS 30%
REF. PROD 5%
HEAT 1%
CRUDE OIL 0%
ELEC. 6%
COAL & COKE 58%


Estimated DPRK COAL DEMAND BY SECTOR: 2020
RESIDENTIAL 46%
AGRICULTURAL 1%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
TRANSPORT 0%
INDUSTRIAL 41%
NON-SPECIFIED 0%
NON-ENERGY 0%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2020
FISHERIES 4%
PUBLIC/COMML 3%
MILITARY 24%
AGRICULTURAL 3%
NON-SPECIFIED 0%
NON-ENERGY 3%
RESIDENTIAL 14%
INDUSTRIAL 19%
TRANSPORT 30%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2020
PUBLIC/COMML 10%
MILITARY 24%
INDUSTRIAL 32%
FISHERIES 0%
TRANSPORT 11%
AGRICULTURAL 3%
RESIDENTIAL 20%

Electricity Balances and Electricity Demand Summary Tables/Figures

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2010

Prepared By David Von Hippel
Date Last Modified: 3/13/2020

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**
ENERGY SUPPLY							141	507	
Imports							292	1,053	
Exports							152	546	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,006	36,023	107,711
Electricity Generation, of which:							**15,706**	**56,540**	**107,711**
--Coal-fired							3,367	12,123	57,727
--Heavy Fuel Oil-fired							207	745	3,546
--Diesel-fueled							219	788	3,428
--Gasoline-fueled							4	16	135
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							1	2	10
--Hydroelectric Power							11,907	42,864	42,864
--Solar Power							0.5	1.8	2
--Wind Power							0.1	0.3	0
--Tidal Power							0.2	0.7	1
--Nuclear Power							-	-	-
Petroleum Refining		-					(41)	(149)	
Coal Production/Preparation							(885)	(3,188)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(665)	(2,395)	
Losses							(4,107)	(14,785)	
ELECTRICITY FOR FINAL CONSUMPTION							10,147	36,530	
ELECTRICITY DEMAND	4,955	1,449	2,469	152	129	993	10,147	36,530	
INDUSTRIAL SECTOR	2,562.7	1,449.4	211.2	-	-	-	4,223	15,204	
Iron and Steel	514.8	463.3	51.5				1,030	3,707	
Cement	689.0	-	36.3				725	2,611	
Fertilizers	213.2	191.9	21.3				426	1,535	
Other Chemicals	141.5	127.4	14.2				283	1,019	
Pulp and Paper	39.2	0.0	2.1				41	149	
Other Metals	146.3	548.5	36.6				731	2,633	
Other Minerals	56.4	-	3.0				59	214	
Textiles	116.0	0.0	6.1				122	439	
Building Materials	15.4	0.0	0.8				16	58	
Non-specified Industry	630.9	118.3	39.4				789	2,839	
TRANSPORT SECTOR	1,032.7	-	27.2	-	-	27.2	1,087	3,913	
Road	0.0						0	0	
Rail	1,032.7		27.2			27.2	1,087	3,913	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	93.5	-	534.6	27.9	4.8	408.4	1,069	3,849	
Urban	93.5		467.6	27.6	4.8	341.7	935	3,366	
Rural	-		67.0	0.3	-	66.7	134	483	
AGRICULTURAL SECTOR	324.9	-	7.0	-	-	4.7	337	1,211	
Field Operations	103.8		-			-	104	374	
Processing/Other	221.1		7.0			4.7	233	838	
FISHERIES SECTOR	48.4	-	1.5	-	-	1.0	51	183	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	48.4		1.5			1.0	51	183	
MILITARY SECTOR	644.6	-	1,066.7	-	-	427.4	2,139	7,699	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	4.8		0.3			0.9	6	21	
Buildings and Other	639.8		1,066.4			426.6	2,133	7,678	
PUBLIC/COMMERCIAL SECTORS	248.3		620.7	124.1	124.1	124.1	1,241	4,469	

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							140.7	12.1	
Imports							292.4	25.1	
Exports							151.7	13.0	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,006.4	860	2,573
Electricity Generation, of which:							**15,705.6**	**1,350.4**	**2,573**
--Coal-fired							3,367.4	289.5	1,379
--Heavy Fuel Oil-fired							206.9	17.8	85
--Diesel-fueled							219.0	18.8	82
--Gasoline-fueled							4.5	0.39	3
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.6	0.05	0
--Hydroelectric Power							11,906.5	1,023.8	1,024
--Solar Power							0.5	0.04	0.04
--Wind Power							0.1	0.01	0.01
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(41.4)	(4)	
Coal Production/Preparation							(885.5)	(76)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(665.4)	(57)	
Losses							(4,107.0)	(353)	
ELECTRICITY FOR FINAL CONSUMPTION							10,147.1	872.5	
ELECTRICITY DEMAND	4,955	1,449	2,469	152	129	993	10,147.1	872.5	
INDUSTRIAL SECTOR	2,562.7	1,449.4	211.2	-	-	-	4,223.3	363.1	
Iron and Steel	514.8	463.3	51.5				1,029.6	88.5	
Cement	689.0	-	36.3				725.2	62.4	
Fertilizers	213.2	191.9	21.3				426.5	36.7	
Other Chemicals	141.5	127.4	14.2				283.0	24.3	
Pulp and Paper	39.2	0.0	2.1				41.3	3.6	
Other Metals	146.3	548.5	36.6				731.3	62.9	
Other Minerals	56.4	-	3.0				59.4	5.1	
Textiles	116.0	0.0	6.1				122.1	10.5	
Building Materials	15.4	0.0	0.8				16.2	1.4	
Non-specified Industry	630.9	118.3	39.4				788.7	67.8	
TRANSPORT SECTOR	1,032.7	-	27.2	-	-	27.2	1,087.0	93.5	
Road							-	0.0	
Rail	1,032.7	-	27.2	-	-	27.2	1,087.0	93.5	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	93.5	-	534.6	27.9	4.8	408.4	1,069.2	91.9	
Urban	93.5		467.6	27.6	4.8	341.7	935.1	80.4	
Rural	-	-	67.0	0.3	-	66.7	134.0	11.5	
AGRICULTURAL SECTOR	325	-	7	-	-	5	336.5	28.9	
Field Operations	103.8		-			-	103.8	8.9	
Processing/Other	221.1		7.0			4.7	232.7	20.0	
FISHERIES SECTOR	48.4	-	1.5	-	-	1.0	51.0	4.4	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	48.4		1.5			1.0	51.0	4.4	
MILITARY SECTOR	645	-	1,067	-	-	427	2,138.7	183.9	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	4.8		0.3			0.9	6.0	0.5	
Buildings and Other	639.8		1,066.4			426.6	2,132.8	183.4	
								-	
PUBLIC/COMMERCIAL SECTORS	248.3		620.7	124.1	124.1	124.1	1,241.4	106.7	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2014

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**
ENERGY SUPPLY							174	628	
Imports							397	1,429	
Exports							222	801	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,202	36,726	150,645
Electricity Generation, of which:							**17,196**	**61,904**	**150,645**
--Coal-fired							5,854	21,073	100,347
--Heavy Fuel Oil-fired							230	829	3,949
--Diesel-fueled							505	1,820	7,279
--Gasoline-fueled							35	124	957
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							4	15	69
--Hydroelectric Power							10,556	38,002	38,002
--Solar Power							10.0	36.0	36
--Wind Power							1.4	5.2	5
--Tidal Power							0.2	0.7	1
--Nuclear Power							-	-	-
Petroleum Refining		-					(41)	(146)	
Coal Production/Preparation							(1,533)	(5,520)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(1,115)	(4,016)	
Losses							(4,305)	(15,496)	
ELECTRICITY FOR FINAL CONSUMPTION							10,376	37,354	
ELECTRICITY DEMAND	5,100	1,716	2,389	134	114	924	10,377	37,356	
INDUSTRIAL SECTOR	2,836.9	1,715.6	239.6	-	-	-	4,792	17,252	
Iron and Steel	491.1	441.9	49.1				982	3,536	
Cement	711.5	0.0	37.4				749	2,696	
Fertilizers	638.7	574.8	63.9				1,277	4,599	
Other Chemicals	111.2	100.1	11.1				222	801	
Pulp and Paper	27.1	-	1.4				28	103	
Other Metals	131.1	491.7	32.8				656	2,360	
Other Minerals	56.4	-	3.0				59	214	
Textiles	87.0	0.0	4.6				92	330	
Building Materials	12.1	0.0	0.6				13	46	
Non-specified Industry	570.8	107.0	35.7				714	2,569	
TRANSPORT SECTOR	909.2	-	23.9	-	-	23.9	957	3,445	
Road	1.1						1	4	
Rail	908.2		23.9			23.9	956	3,442	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	78.9	-	439.6	23.5	4.0	333.3	879	3,165	
Urban	78.9		394.3	23.2	4.0	288.2	789	2,839	
Rural	-		45.3	0.2	-	45.1	91	326	
AGRICULTURAL SECTOR	328.4	-	7.2	-	-	4.8	341	1,226	
Field Operations	99.0		-			-	99	357	
Processing/Other	229.4		7.2			4.8	241	869	
FISHERIES SECTOR	45.7	-	1.4	-	-	1.0	48	173	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	45.7		1.4			1.0	48	173	
MILITARY SECTOR	679.8	-	1,124.9	-	-	450.8	2,255	8,120	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.1		0.3			1.0	6	23	
Buildings and Other	674.7		1,124.6			449.8	2,249	8,097	
PUBLIC/COMMERCIAL SECTORS	220.8		552.0	110.4	110.4	110.4	1,104	3,975	

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							174.5	15.0	
Imports							396.9	34.1	
Exports							222.4	19.1	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,201.7	877	3,598
Electricity Generation, of which:							**17,195.7**	**1,478.6**	**3,598**
--Coal-fired							5,853.6	503.3	2,397
--Heavy Fuel Oil-fired							230.4	19.8	94
--Diesel-fueled							505.5	43.5	174
--Gasoline-fueled							34.6	2.97	23
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							4.0	0.35	2
--Hydroelectric Power							10,556.1	907.7	908
--Solar Power							10.0	0.86	0.86
--Wind Power							1.4	0.12	0.12
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(40.7)	(3)	
Coal Production/Preparation							(1,533.4)	(132)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(1,115.4)	(96)	
Losses							(4,304.5)	(370)	
ELECTRICITY FOR FINAL CONSUMPTION							10,376.2	892.2	
ELECTRICITY DEMAND	5,099	1,716	2,389	134	114	924	10,375.5	892.2	
INDUSTRIAL SECTOR	2,836.9	1,715.6	239.6	-	-	-	4,792.1	412.1	
Iron and Steel	491.1	441.9	49.1				982.1	84.4	
Cement	711.5	0.0	37.4				748.9	64.4	
Fertilizers	638.7	574.8	63.9				1,277.4	109.8	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	131.1	491.7	32.8				655.6	56.4	
Other Minerals	56.4	-	3.0				59.4	5.1	
Textiles	87.0	0.0	4.6				91.6	7.9	
Building Materials	12.1	0.0	0.6				12.7	1.1	
Non-specified Industry	570.8	107.0	35.7				713.5	61.4	
TRANSPORT SECTOR	908.2	-	23.9	-	-	23.9	956.0	82.3	
Road							-	0.1	
Rail	908.2	-	23.9	-	-	23.9	956.0	82.2	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	78.9	-	439.6	23.5	4.0	333.3	879.3	75.6	
Urban	78.9		394.3	23.2	4.0	288.2	788.6	67.8	
Rural	-	-	45.3	0.2	-	45.1	90.7	7.8	
AGRICULTURAL SECTOR	328	-	7	-	-	5	340.5	29.3	
Field Operations	99.0		-			-	99.0	8.5	
Processing/Other	229.4		7.2			4.8	241.5	20.8	
FISHERIES SECTOR	45.7	-	1.4	-	-	1.0	48.1	4.1	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	45.7		1.4			1.0	48.1	4.1	
MILITARY SECTOR	680	-	1,125	-	-	451	2,255.5	193.9	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.1		0.3			1.0	6.4	0.5	
Buildings and Other	674.7		1,124.6			449.8	2,249.1	193.4	
								-	
PUBLIC/COMMERCIAL SECTORS	220.8		552.0	110.4	110.4	110.4	1,104.1	94.9	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2015

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

	END USES									
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**	
ENERGY SUPPLY							365	1,314		
Imports							484	1,741		
Exports							119	427		
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,286	37,028	157,522	
Electricity Generation, of which:							**17,288**	**62,238**	**157,522**	
--Coal-fired							4,981	17,932	100,347	
--Heavy Fuel Oil-fired							219	790	3,762	
--Diesel-fueled							727	2,616	10,060	
--Gasoline-fueled							111	398	2,844	
--LPG-fueled							-	-	-	
--Natural Gas-fired							-	-	-	
--Other Fossil-fuel-fired							0	2	8	
--Hydroelectric Power							11,230	40,428	40,428	
--Solar Power							18.5	66.6	67	
--Wind Power							1.7	6.2	6	
--Tidal Power							0.2	0.7	1	
--Nuclear Power							-	-	-	
Petroleum Refining		-					(45)	(163)		
Coal Production/Preparation							(1,711)	(6,158)		
Charcoal Production										
Coke Production										
District Heat Production										
Other Transformation										
Own Use							(958)	(3,448)		
Losses							(4,289)	(15,441)		
ELECTRICITY FOR FINAL CONSUMPTION							10,651	38,342		
ELECTRICITY DEMAND	5,311	1,637	2,475	140	119	968	10,651	38,343		
INDUSTRIAL SECTOR	2,807.6	1,637.2	233.9	-	-	-	4,679	16,844		
Iron and Steel	434.3	390.9	43.4				869	3,127		
Cement	713.8	0.0	37.6				751	2,705		
Fertilizers	593.7	534.4	59.4				1,187	4,275		
Other Chemicals	111.2	100.1	11.1				222	801		
Pulp and Paper	27.1	-	1.4				28	103		
Other Metals	131.1	491.7	32.8				656	2,360		
Other Minerals	56.4	-	3.0				59	214		
Textiles	87.0	0.0	4.6				92	330		
Building Materials	12.1	0.0	0.6				13	46		
Non-specified Industry	640.9	120.2	40.1				801	2,884		
TRANSPORT SECTOR	1,109.2	-	29.1	-	-	29.1	1,167	4,203		
Road	1.8						2	6		
Rail	1,107.4		29.1			29.1	1,166	4,196		
Water							-	-		
Air							-	-		
Non-Specified							-	-		
RESIDENTIAL SECTOR	83.7	-	464.3	24.9	4.3	351.5	929	3,343		
Urban	83.7		418.3	24.6	4.3	305.7	837	3,012		
Rural	-		46.0	0.2	-	45.8	92	331		
AGRICULTURAL SECTOR	335.8	-	7.5	-	-	5.0	348	1,254		
Field Operations	99.1		-			-	99	357		
Processing/Other	236.6		7.5			5.0	249	897		
FISHERIES SECTOR	41.5	-	1.3	-	-	0.9	44	157		
Large Ships	-		-			-	-	-		
Collectives/Processing/Other	41.5		1.3			0.9	44	157		
MILITARY SECTOR	703.2	-	1,163.7	-	-	466.3	2,333	8,399		21.9%
Trucks and other Transport							-	-		
Armaments							-			
Air Force							-			
Naval Forces							-			
Military Manufacturing	5.2		0.3			1.0	6	23		
Buildings and Other	698.0		1,163.3			465.3	2,327	8,376		
PUBLIC/COMMERCIAL SECTORS	230.2		575.5	115.1	115.1	115.1	1,151	4,143		

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							364.9	31.4	
Imports							483.7	41.6	
Exports							118.7	10.2	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,285.6	884	3,762
Electricity Generation, of which:							**17,288.5**	**1,486.5**	**3,762**
--Coal-fired							4,981.1	428.3	2,397
--Heavy Fuel Oil-fired							219.4	18.9	90
--Diesel-fueled							726.6	62.5	240
--Gasoline-fueled							110.6	9.51	68
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.5	0.04	0
--Hydroelectric Power							11,229.9	965.6	966
--Solar Power							18.5	1.59	1.59
--Wind Power							1.7	0.15	0.15
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(45.3)	(4)	
Coal Production/Preparation							(1,710.6)	(147)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(957.8)	(82)	
Losses							(4,289.2)	(369)	
ELECTRICITY FOR FINAL CONSUMPTION							10,650.5	915.8	
ELECTRICITY DEMAND	5,309	1,637	2,475	140	119	968	10,649.1	915.8	
INDUSTRIAL SECTOR	2,807.6	1,637.2	233.9	-	-	-	4,678.8	402.3	
Iron and Steel	434.3	390.9	43.4				868.6	74.7	
Cement	713.8	0.0	37.6				751.4	64.6	
Fertilizers	593.7	534.4	59.4				1,187.5	102.1	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	131.1	491.7	32.8				655.6	56.4	
Other Minerals	56.4	-	3.0				59.4	5.1	
Textiles	87.0	0.0	4.6				91.6	7.9	
Building Materials	12.1	0.0	0.6				12.7	1.1	
Non-specified Industry	640.9	120.2	40.1				801.1	68.9	
TRANSPORT SECTOR	1,107.4	-	29.1	-	-	29.1	1,165.7	100.4	
Road							-	0.2	
Rail	1,107.4	-	29.1	-	-	29.1	1,165.7	100.2	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	83.7	-	464.3	24.9	4.3	351.5	928.6	79.8	
Urban	83.7		418.3	24.6	4.3	305.7	836.6	71.9	
Rural	-	-	46.0	0.2	-	45.8	92.0	7.9	
AGRICULTURAL SECTOR	336	-	7	-	-	5	348.2	29.9	
Field Operations	99.1		-			-	99.1	8.5	
Processing/Other	236.6		7.5			5.0	249.1	21.4	
FISHERIES SECTOR	41.5	-	1.3	-	-	0.9	43.7	3.8	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	41.5		1.3			0.9	43.7	3.8	
MILITARY SECTOR	703	-	1,164	-	-	466	2,333.2	200.6	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.2		0.3			1.0	6.5	0.6	
Buildings and Other	698.0		1,163.3			465.3	2,326.7	200.1	
								-	
PUBLIC/COMMERCIAL SECTORS	230.2		575.5	115.1	115.1	115.1	1,151.0	99.0	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2016

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

	END USES									
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**	
ENERGY SUPPLY							(82)	(295)		
Imports							85	307		
Exports							167	602		
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,811	38,921	152,401	
Electricity Generation, of which:							**18,150**	**65,340**	**152,401**	
--Coal-fired							5,331	19,192	91,391	
--Heavy Fuel Oil-fired							216	777	3,699	
--Diesel-fueled							992	3,570	13,221	
--Gasoline-fueled							111	400	2,667	
--LPG-fueled							-	-	-	
--Natural Gas-fired							-	-	-	
--Other Fossil-fuel-fired							2	6	27	
--Hydroelectric Power							11,466	41,279	41,279	
--Solar Power							30.0	108.0	108	
--Wind Power							2.1	7.7	8	
--Tidal Power							0.2	0.7	1	
--Nuclear Power							-	-	-	
Petroleum Refining		-					(47)	(170)		
Coal Production/Preparation							(1,836)	(6,610)		
Charcoal Production										
Coke Production										
District Heat Production										
Other Transformation										
Own Use							(1,022)	(3,679)		
Losses							(4,433)	(15,960)		
ELECTRICITY FOR FINAL CONSUMPTION							10,730	38,626		
ELECTRICITY DEMAND	5,222	1,692	2,545	146	124	1,002	10,730	38,627		
INDUSTRIAL SECTOR	2,654.4	1,692.4	228.8	-	-	-	4,576	16,472		
Iron and Steel	485.3	436.8	48.5				971	3,494		
Cement	739.5	-	38.9				778	2,802		
Fertilizers	673.1	605.8	67.3				1,346	4,846		
Other Chemicals	111.2	100.1	11.1				222	801		
Pulp and Paper	27.1	-	1.4				28	103		
Other Metals	129.9	487.3	32.5				650	2,339		
Other Minerals	55.9	-	2.9				59	212		
Textiles	87.0	0.0	4.6				92	330		
Building Materials	12.1	0.0	0.6				13	46		
Non-specified Industry	333.2	62.5	20.8				417	1,500		
TRANSPORT SECTOR	1,154.9	-	30.3	-	-	30.3	1,215	4,375		
Road	4.8						5	17		
Rail	1,150.1		30.3			30.3	1,211	4,358		
Water							-	-		
Air							-	-		
Non-Specified							-	-		
RESIDENTIAL SECTOR	88.1	-	487.2	26.2	4.5	368.4	974	3,508		
Urban	88.1		440.5	26.0	4.5	322.0	881	3,172		
Rural	-		46.7	0.2	-	46.4	93	336		
AGRICULTURAL SECTOR	312.0	-	6.7	-	-	4.5	323	1,163		
Field Operations	99.8		-			-	100	359		
Processing/Other	212.2		6.7			4.5	223	804		
FISHERIES SECTOR	52.6	-	1.7	-	-	1.1	55	199		
Large Ships	-		-			-	-	-		
Collectives/Processing/Other	52.6		1.7			1.1	55	199		
MILITARY SECTOR	720.7	-	1,192.7	-	-	478.0	2,391	8,609		22.3%
Trucks and other Transport							-	-		
Armaments							-			
Air Force							-			
Naval Forces							-			
Military Manufacturing	5.3		0.3			1.0	7	24		
Buildings and Other	715.5		1,192.4			477.0	2,385	8,585		
PUBLIC/COMMERCIAL SECTORS	238.9		597.2	119.4	119.4	119.4	1,194	4,300		

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							(81.9)	(7.0)	
Imports							85.3	7.3	
Exports							167.2	14.4	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,811.4	930	3,640
Electricity Generation, of which:							**18,149.9**	**1,560.6**	**3,640**
--Coal-fired							5,331.2	458.4	2,183
--Heavy Fuel Oil-fired							215.8	18.6	88
--Diesel-fueled							991.6	85.3	316
--Gasoline-fueled							111.1	9.56	64
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							1.6	0.13	1
--Hydroelectric Power							11,466.4	985.9	986
--Solar Power							30.0	2.58	2.58
--Wind Power							2.1	0.18	0.18
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(47.1)	(4)	
Coal Production/Preparation							(1,836.2)	(158)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(1,022.0)	(88)	
Losses							(4,433.2)	(381)	
ELECTRICITY FOR FINAL CONSUMPTION							10,729.5	922.6	
ELECTRICITY DEMAND	5,217	1,692	2,545	146	124	1,002	10,724.9	922.6	
INDUSTRIAL SECTOR	2,654.4	1,692.4	228.8	-	-	-	4,575.6	393.4	
Iron and Steel	485.3	436.8	48.5				970.7	83.5	
Cement	739.5	-	38.9				778.5	66.9	
Fertilizers	673.1	605.8	67.3				1,346.2	115.8	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	129.9	487.3	32.5				649.7	55.9	
Other Minerals	55.9	-	2.9				58.9	5.1	
Textiles	87.0	0.0	4.6				91.6	7.9	
Building Materials	12.1	0.0	0.6				12.7	1.1	
Non-specified Industry	333.2	62.5	20.8				416.5	35.8	
TRANSPORT SECTOR	1,150.1	-	30.3	-	-	30.3	1,210.6	104.5	
Road							-	0.4	
Rail	1,150.1	-	30.3	-	-	30.3	1,210.6	104.1	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	88.1	-	487.2	26.2	4.5	368.4	974.4	83.8	
Urban	88.1		440.5	26.0	4.5	322.0	881.0	75.8	
Rural	-	-	46.7	0.2	-	46.4	93.4	8.0	
AGRICULTURAL SECTOR	312	-	7	-	-	4	323.2	27.8	
Field Operations	99.8		-			-	99.8	8.6	
Processing/Other	212.2		6.7			4.5	223.4	19.2	
FISHERIES SECTOR	52.6	-	1.7	-	-	1.1	55.3	4.8	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	52.6		1.7			1.1	55.3	4.8	
MILITARY SECTOR	721	-	1,193	-	-	478	2,391.5	205.6	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.3		0.3			1.0	6.6	0.6	
Buildings and Other	715.5		1,192.4			477.0	2,384.8	205.1	
								-	
PUBLIC/COMMERCIAL SECTORS	238.9		597.2	119.4	119.4	119.4	1,194.4	102.7	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2017

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**
ENERGY SUPPLY							(249)	(898)	
Imports							20	72	
Exports							269	969	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,213	36,767	138,424
Electricity Generation, of which:							**16,330**	**58,789**	**138,424**
--Coal-fired							5,226	18,814	89,592
--Heavy Fuel Oil-fired							101	364	1,735
--Diesel-fueled							508	1,827	6,768
--Gasoline-fueled							124	447	2,982
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							1	3	14
--Hydroelectric Power							10,323	37,164	37,164
--Solar Power							44.3	159.3	159
--Wind Power							2.5	9.1	9
--Tidal Power							0.2	0.7	1
--Nuclear Power							-	-	-
Petroleum Refining		-					(45)	(162)	
Coal Production/Preparation							(1,021)	(3,675)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(986)	(3,551)	
Losses							(4,065)	(14,635)	
ELECTRICITY FOR FINAL CONSUMPTION							9,964	35,869	
ELECTRICITY DEMAND	4,736	1,431	2,523	145	123	1,005	9,964	35,870	
INDUSTRIAL SECTOR	2,333.7	1,430.9	198.1	-	-	-	3,963	14,266	
Iron and Steel	438.7	394.9	43.9				877	3,159	
Cement	721.7	0.0	38.0				760	2,735	
Fertilizers	460.8	414.8	46.1				922	3,318	
Other Chemicals	111.2	100.1	11.1				222	801	
Pulp and Paper	27.1	-	1.4				28	103	
Other Metals	123.6	463.4	30.9				618	2,224	
Other Minerals	50.8	-	2.7				53	192	
Textiles	79.7	0.0	4.2				84	302	
Building Materials	11.5	0.0	0.6				12	44	
Non-specified Industry	308.6	57.9	19.3				386	1,388	
TRANSPORT SECTOR	1,005.5	-	26.2	-	-	26.2	1,058	3,808	
Road	11.3						11	41	
Rail	994.2		26.2			26.2	1,047	3,767	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	89.2	-	493.5	26.5	4.5	373.2	987	3,553	
Urban	89.2		446.1	26.3	4.5	326.1	892	3,212	
Rural	-		47.4	0.2	-	47.1	95	341	
AGRICULTURAL SECTOR	287.8	-	6.1	-	-	4.1	298	1,073	
Field Operations	93.8		-			-	94	338	
Processing/Other	194.0		6.1			4.1	204	735	
FISHERIES SECTOR	55.3	-	1.7	-	-	1.2	58	210	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	55.3		1.7			1.2	58	210	
MILITARY SECTOR	726.6	-	1,202.4	-	-	481.8	2,411	8,679	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.3		0.3			1.0	7	24	
Buildings and Other	721.3		1,202.1			480.8	2,404	8,655	
PUBLIC/COMMERCIAL SECTORS	237.8		594.6	118.9	118.9	118.9	1,189	4,281	

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							(249.4)	(21.4)	
Imports							19.9	1.7	
Exports							269.3	23.2	
ENERGY TRANSFORMATION	-	-	-	-	-	-	10,213.1	878	3,306
Electricity Generation, of which:							**16,330.4**	**1,404.2**	**3,306**
--Coal-fired							5,226.2	449.4	2,140
--Heavy Fuel Oil-fired							101.2	8.7	41
--Diesel-fueled							507.6	43.6	162
--Gasoline-fueled							124.2	10.68	71
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.8	0.07	0
--Hydroelectric Power							10,323.4	887.6	888
--Solar Power							44.3	3.81	3.81
--Wind Power							2.5	0.22	0.22
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(44.9)	(4)	
Coal Production/Preparation							(1,020.7)	(88)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(986.5)	(85)	
Losses							(4,065.2)	(350)	
ELECTRICITY FOR FINAL CONSUMPTION							9,963.7	856.7	
ELECTRICITY DEMAND	4,725	1,431	2,523	145	123	1,005	9,952.5	856.7	
INDUSTRIAL SECTOR	2,333.7	1,430.9	198.1	-	-	-	3,962.8	340.7	
Iron and Steel	438.7	394.9	43.9				877.5	75.4	
Cement	721.7	0.0	38.0				759.7	65.3	
Fertilizers	460.8	414.8	46.1				921.7	79.3	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	123.6	463.4	30.9				617.8	53.1	
Other Minerals	50.8	-	2.7				53.5	4.6	
Textiles	79.7	0.0	4.2				83.9	7.2	
Building Materials	11.5	0.0	0.6				12.2	1.0	
Non-specified Industry	308.6	57.9	19.3				385.7	33.2	
TRANSPORT SECTOR	994.2	-	26.2	-	-	26.2	1,046.5	91.0	
Road							-	1.0	
Rail	994.2	-	26.2	-	-	26.2	1,046.5	90.0	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	89.2	-	493.5	26.5	4.5	373.2	987.0	84.9	
Urban	89.2		446.1	26.3	4.5	326.1	892.2	76.7	
Rural	-	-	47.4	0.2	-	47.1	94.7	8.1	
AGRICULTURAL SECTOR	288	-	6	-	-	4	298.0	25.6	
Field Operations	93.8		-			-	93.8	8.1	
Processing/Other	194.0		6.1			4.1	204.2	17.6	
FISHERIES SECTOR	55.3	-	1.7	-	-	1.2	58.3	5.0	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	55.3		1.7			1.2	58.3	5.0	
MILITARY SECTOR	727	-	1,202	-	-	482	2,410.8	207.3	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.3		0.3			1.0	6.6	0.6	
Buildings and Other	721.3		1,202.1			480.8	2,404.2	206.7	
								-	
PUBLIC/COMMERCIAL SECTORS	237.8		594.6	118.9	118.9	118.9	1,189.1	102.2	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2018

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

	END USES									
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**	
ENERGY SUPPLY							(168)	(605)		
Imports							111	401		
Exports							279	1,006		
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,841	35,428	122,775	
Electricity Generation, of which:							**15,556**	**56,003**	**122,775**	
--Coal-fired							4,259	15,332	73,012	
--Heavy Fuel Oil-fired							117	421	2,004	
--Diesel-fueled							505	1,820	6,740	
--Gasoline-fueled							127	456	3,041	
--LPG-fueled							-	-	-	
--Natural Gas-fired							-	-	-	
--Other Fossil-fuel-fired							0	1	6	
--Hydroelectric Power							10,485	37,746	37,746	
--Solar Power							59.7	214.9	215	
--Wind Power							2.9	10.5	11	
--Tidal Power							0.2	0.7	1	
--Nuclear Power							-	-	-	
Petroleum Refining		-					(50)	(179)		
Coal Production/Preparation							(956)	(3,443)		
Charcoal Production										
Coke Production										
District Heat Production										
Other Transformation										
Own Use							(816)	(2,936)		
Losses							(3,893)	(14,017)		
ELECTRICITY FOR FINAL CONSUMPTION							9,673	34,823		
ELECTRICITY DEMAND	4,535	1,247	2,572	174	131	1,012	9,673	34,822		
INDUSTRIAL SECTOR	2,182.4	1,246.7	180.5	-	-	-	3,610	12,995		
Iron and Steel	410.6	369.5	41.1				821	2,956		
Cement	673.4	0.0	35.4				709	2,552		
Fertilizers	257.9	232.1	25.8				516	1,857		
Other Chemicals	111.2	100.1	11.1				222	801		
Pulp and Paper	27.1	-	1.4				28	103		
Other Metals	123.6	463.4	30.9				618	2,224		
Other Minerals	50.8	-	2.7				53	192		
Textiles	79.7	0.0	4.2				84	302		
Building Materials	12.6	-	0.7				13	48		
Non-specified Industry	435.6	81.7	27.2				545	1,960		
TRANSPORT SECTOR	965.6	-	25.0	-	-	25.0	1,016	3,656		
Road	14.0						14	50		
Rail	951.6		25.0			25.0	1,002	3,606		
Water							-	-		
Air							-	-		
Non-Specified							-	-		
RESIDENTIAL SECTOR	96.7	-	532.9	53.5	10.5	372.2	1,066	3,837		
Urban	96.7		483.4	52.2	10.5	324.0	967	3,481		
Rural	-		49.4	1.3	-	48.1	99	356		
AGRICULTURAL SECTOR	271.9	-	5.9	-	-	3.9	282	1,014		
Field Operations	86.6		-			-	87	312		
Processing/Other	185.3		5.9			3.9	195	702		
FISHERIES SECTOR	38.7	-	1.2	-	-	0.8	41	147		
Large Ships	-		-			-	-	-		
Collectives/Processing/Other	38.7		1.2			0.8	41	147		
MILITARY SECTOR	738.2	-	1,221.8	-	-	489.6	2,450	8,819		25.3%
Trucks and other Transport							-	-		
Armaments							-			
Air Force							-			
Naval Forces							-			
Military Manufacturing	5.3		0.3			1.0	7	24		
Buildings and Other	732.9		1,221.5			488.6	2,443	8,795		
PUBLIC/COMMERCIAL SECTORS	242.0		604.9	121.0	121.0	121.0	1,210	4,355		

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							(168.0)	(14.4)	
Imports							111.3	9.6	
Exports							279.4	24.0	
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,841.1	846	2,932
Electricity Generation, of which:							**15,556.4**	**1,337.6**	**2,932**
--Coal-fired							4,259.0	366.2	1,744
--Heavy Fuel Oil-fired							116.9	10.1	48
--Diesel-fueled							505.5	43.5	161
--Gasoline-fueled							126.7	10.89	73
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.3	0.03	0
--Hydroelectric Power							10,485.1	901.6	902
--Solar Power							59.7	5.13	5.13
--Wind Power							2.9	0.25	0.25
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(49.8)	(4)	
Coal Production/Preparation							(956.4)	(82)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(815.6)	(70)	
Losses							(3,893.5)	(335)	
ELECTRICITY FOR FINAL CONSUMPTION							9,673.0	831.7	
ELECTRICITY DEMAND	4,522	1,247	2,572	174	131	1,012	9,658.9	831.7	
INDUSTRIAL SECTOR	2,182.4	1,246.7	180.5	-	-	-	3,609.6	310.4	
Iron and Steel	410.6	369.5	41.1				821.1	70.6	
Cement	673.4	0.0	35.4				708.8	60.9	
Fertilizers	257.9	232.1	25.8				515.8	44.4	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	123.6	463.4	30.9				617.8	53.1	
Other Minerals	50.8	-	2.7				53.5	4.6	
Textiles	79.7	0.0	4.2				83.9	7.2	
Building Materials	12.6	-	0.7				13.3	1.1	
Non-specified Industry	435.6	81.7	27.2				544.5	46.8	
TRANSPORT SECTOR	951.6	-	25.0	-	-	25.0	1,001.7	87.3	
Road							-	1.2	
Rail	951.6	-	25.0	-	-	25.0	1,001.7	86.1	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	96.7	-	532.9	53.5	10.5	372.2	1,065.7	91.6	
Urban	96.7		483.4	52.2	10.5	324.0	966.9	83.1	
Rural	-	-	49.4	1.3	-	48.1	98.8	8.5	
AGRICULTURAL SECTOR	272	-	6	-	-	4	281.6	24.2	
Field Operations	86.6		-			-	86.6	7.4	
Processing/Other	185.3		5.9			3.9	195.0	16.8	
FISHERIES SECTOR	38.7	-	1.2	-	-	0.8	40.8	3.5	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	38.7		1.2			0.8	40.8	3.5	
MILITARY SECTOR	738	-	1,222	-	-	490	2,449.6	210.6	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.3		0.3			1.0	6.6	0.6	
Buildings and Other	732.9		1,221.5			488.6	2,443.0	210.1	
								-	
PUBLIC/COMMERCIAL SECTORS	242.0		604.9	121.0	121.0	121.0	1,209.8	104.0	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2019

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**	
ENERGY SUPPLY							(232)	(834)		
Imports							48	172		
Exports							279	1,006		
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,841	35,428	124,123	
Electricity Generation, of which:							**15,743**	**56,674**	**124,123**	
--Coal-fired							4,260	15,336	73,027	
--Heavy Fuel Oil-fired							116	418	1,989	
--Diesel-fueled							576	2,074	7,681	
--Gasoline-fueled							126	454	3,029	
--LPG-fueled							-	-	-	
--Natural Gas-fired							-	-	-	
--Other Fossil-fuel-fired							0	1	6	
--Hydroelectric Power							10,586	38,109	38,109	
--Solar Power							75.1	270.2	270	
--Wind Power							3.3	11.9	12	
--Tidal Power							0.2	0.7	1	
--Nuclear Power							-	-	-	
Petroleum Refining		-					(50)	(179)		
Coal Production/Preparation							(1,115)	(4,014)		
Charcoal Production										
Coke Production										
District Heat Production										
Other Transformation										
Own Use							(816)	(2,937)		
Losses							(3,921)	(14,117)		
ELECTRICITY FOR FINAL CONSUMPTION							9,609	34,594		
ELECTRICITY DEMAND	4,511	1,247	2,551	173	132	996	9,609	34,593		
INDUSTRIAL SECTOR	2,182.4	1,246.7	180.5	-	-	-	3,610	12,995		
Iron and Steel	410.6	369.5	41.1				821	2,956		
Cement	673.4	0.0	35.4				709	2,552		
Fertilizers	257.9	232.1	25.8				516	1,857		
Other Chemicals	111.2	100.1	11.1				222	801		
Pulp and Paper	27.1	-	1.4				28	103		
Other Metals	123.6	463.4	30.9				618	2,224		
Other Minerals	50.8	-	2.7				53	192		
Textiles	79.7	0.0	4.2				84	302		
Building Materials	12.6	-	0.7				13	48		
Non-specified Industry	435.6	81.7	27.2				545	1,960		
TRANSPORT SECTOR	966.9	-	25.0	-	-	25.0	1,017	3,661		
Road	15.3						15	55		
Rail	951.6		25.0			25.0	1,002	3,606		
Water							-	-		
Air							-	-		
Non-Specified							-	-		
RESIDENTIAL SECTOR	91.9	-	508.1	50.9	10.0	355.4	1,016	3,659		
Urban	91.9		459.4	49.6	10.0	307.9	919	3,308		
Rural	-		48.7	1.3	-	47.4	97	351		
AGRICULTURAL SECTOR	248.9	-	5.1	-	-	3.4	257	927		
Field Operations	86.6		-			-	87	312		
Processing/Other	162.2		5.1			3.4	171	615		
FISHERIES SECTOR	38.7	-	1.2	-	-	0.8	41	147		
Large Ships	-		-			-	-	-		
Collectives/Processing/Other	38.7		1.2			0.8	41	147		
MILITARY SECTOR	738.2	-	1,221.8	-	-	489.6	2,450	8,819		25.5%
Trucks and other Transport							-	-		
Armaments							-			
Air Force							-			
Naval Forces							-			
Military Manufacturing	5.3		0.3			1.0	7	24		
Buildings and Other	732.9		1,221.5			488.6	2,443	8,795		
PUBLIC/COMMERCIAL SECTORS	243.7		609.3	121.9	121.9	121.9	1,219	4,387		

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							(231.7)	(19.9)	
Imports							47.7	4.1	
Exports							279.4	24.0	
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,841.0	846	2,965
Electricity Generation, of which:							**15,742.9**	**1,353.6**	**2,965**
--Coal-fired							4,259.9	366.3	1,744
--Heavy Fuel Oil-fired							116.0	10.0	48
--Diesel-fueled							576.0	49.5	183
--Gasoline-fueled							126.2	10.85	72
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.3	0.03	0
--Hydroelectric Power							10,585.8	910.2	910
--Solar Power							75.1	6.45	6.45
--Wind Power							3.3	0.29	0.29
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(49.8)	(4)	
Coal Production/Preparation							(1,114.9)	(96)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(815.9)	(70)	
Losses							(3,921.3)	(337)	
ELECTRICITY FOR FINAL CONSUMPTION							9,609.3	826.3	
ELECTRICITY DEMAND	4,495	1,247	2,551	173	132	996	9,594.0	826.2	
INDUSTRIAL SECTOR	2,182.4	1,246.7	180.5	-	-	-	3,609.6	310.4	
Iron and Steel	410.6	369.5	41.1				821.1	70.6	
Cement	673.4	0.0	35.4				708.8	60.9	
Fertilizers	257.9	232.1	25.8				515.8	44.4	
Other Chemicals	111.2	100.1	11.1				222.4	19.1	
Pulp and Paper	27.1	-	1.4				28.5	2.4	
Other Metals	123.6	463.4	30.9				617.8	53.1	
Other Minerals	50.8	-	2.7				53.5	4.6	
Textiles	79.7	0.0	4.2				83.9	7.2	
Building Materials	12.6	-	0.7				13.3	1.1	
Non-specified Industry	435.6	81.7	27.2				544.5	46.8	
TRANSPORT SECTOR	951.6	-	25.0	-	-	25.0	1,001.7	87.4	
Road							-	1.3	
Rail	951.6	-	25.0	-	-	25.0	1,001.7	86.1	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	91.9	-	508.1	50.9	10.0	355.4	1,016.3	87.4	
Urban	91.9		459.4	49.6	10.0	307.9	918.8	79.0	
Rural	-	-	48.7	1.3	-	47.4	97.5	8.4	
AGRICULTURAL SECTOR	249	-	5	-	-	3	257.4	22.1	
Field Operations	86.6		-			-	86.6	7.4	
Processing/Other	162.2		5.1			3.4	170.8	14.7	
FISHERIES SECTOR	38.7	-	1.2	-	-	0.8	40.8	3.5	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	38.7		1.2			0.8	40.8	3.5	
MILITARY SECTOR	738	-	1,222	-	-	490	2,449.6	210.6	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	5.3		0.3			1.0	6.6	0.6	
Buildings and Other	732.9		1,221.5			488.6	2,443.0	210.1	
								-	
PUBLIC/COMMERCIAL SECTORS	243.7		609.3	121.9	121.9	121.9	1,218.6	104.8	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED ELECTRICITY BALANCE FOR THE YEAR 2020

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (TJ)**	**GENERATION FUEL/ ENERGY INPUTS (TJ)**	
ENERGY SUPPLY							(232)	(834)		
Imports							48	172		
Exports							279	1,006		
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,124	32,846	94,384	
Electricity Generation, of which:							**14,045**	**50,560**	**94,384**	
--Coal-fired							2,505	9,018	42,949	
--Heavy Fuel Oil-fired							108	388	1,850	
--Diesel-fueled							525	1,891	7,002	
--Gasoline-fueled							163	585	3,900	
--LPG-fueled							-	-	-	
--Natural Gas-fired							-	-	-	
--Other Fossil-fuel-fired							0	1	6	
--Hydroelectric Power							10,657	38,366	38,366	
--Solar Power							82.7	297.9	298	
--Wind Power							3.5	12.5	13	
--Tidal Power							0.2	0.7	1	
--Nuclear Power							-	-	-	
Petroleum Refining		-					(52)	(188)		
Coal Production/Preparation							(829)	(2,985)		
Charcoal Production										
Coke Production										
District Heat Production										
Other Transformation										
Own Use							(499)	(1,796)		
Losses							(3,540)	(12,745)		
ELECTRICITY FOR FINAL CONSUMPTION							8,892	32,012		
ELECTRICITY DEMAND	3,963	936	2,552	177	105	1,160	8,893	32,013		
INDUSTRIAL SECTOR	1,750.9	935.6	141.4	-	-	-	2,828	10,180		
Iron and Steel	350.2	315.2	35.0				700	2,521		
Cement	534.1	0.0	28.1				562	2,024		
Fertilizers	128.9	116.1	12.9				258	928		
Other Chemicals	80.9	72.8	8.1				162	582		
Pulp and Paper	21.7	-	1.1				23	82		
Other Metals	93.3	349.9	23.3				467	1,679		
Other Minerals	39.5	0.0	2.1				42	150		
Textiles	58.0	0.0	3.1				61	220		
Building Materials	8.8	-	0.5				9	33		
Non-specified Industry	435.6	81.7	27.2				545	1,960		
TRANSPORT SECTOR	967.5	-	25.0	-	-	25.0	1,018	3,663		
Road	15.9						16	57		
Rail	951.6		25.0			25.0	1,002	3,606		
Water							-	-		
Air							-	-		
Non-Specified							-	-		
RESIDENTIAL SECTOR	161.0	-	889.7	89.2	17.5	622.1	1,779	6,406		
Urban	161.0		805.0	86.9	17.5	539.6	1,610	5,796		
Rural	-		84.8	2.2	-	82.5	170	610		
AGRICULTURAL SECTOR	240.5	-	4.9	-	-	3.2	249	895		
Field Operations	86.6		-			-	87	312		
Processing/Other	153.9		4.9			3.2	162	583		
FISHERIES SECTOR	34.9	-	1.1	-	-	0.7	37	132		
Large Ships	-		-			-	-	-		
Collectives/Processing/Other	34.9		1.1			0.7	37	132		
MILITARY SECTOR	632.9	-	1,050.7	-	-	420.7	2,104	7,575		23.7%
Trucks and other Transport							-	-		
Armaments							-			
Air Force							-			
Naval Forces							-			
Military Manufacturing	2.6		0.2			0.5	3	12		
Buildings and Other	630.3		1,050.5			420.2	2,101	7,564		
PUBLIC/COMMERCIAL SECTORS	175.6		439.0	87.8	87.8	87.8	878	3,161		

Following is same as above, but with energy in units of Thousand Tonnes of Oil Equivalent (kTOE)

Conversion, TJ per kTOE:	41.868

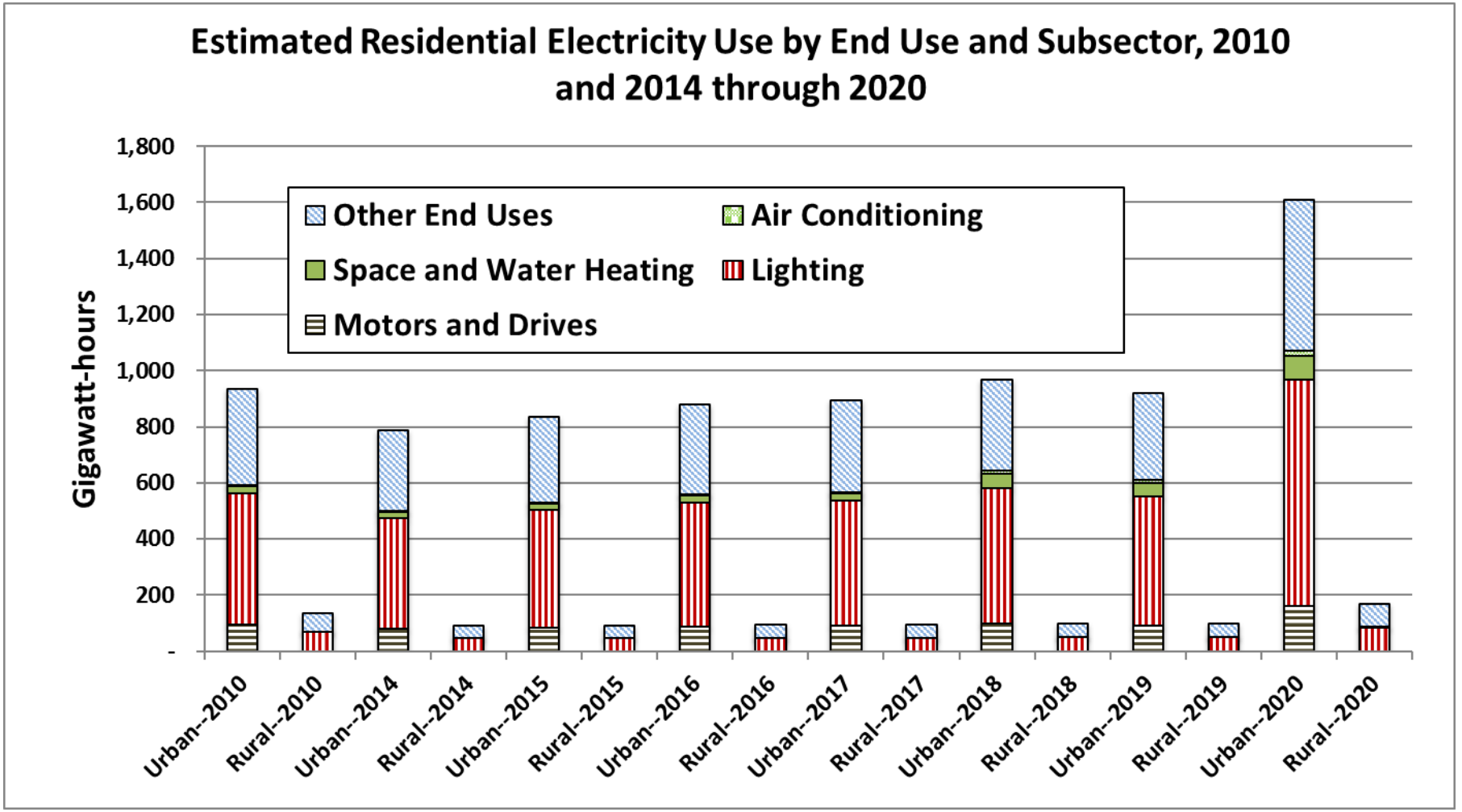
	END USES								
UNITS: GIGAWATT-HOURS (GWh) EXCEPT AS NOTED	**MOTORS AND DRIVES**	**PROCESS ELECTRICITY**	**LIGHTING**	**SPACE AND WATER HEATING**	**AIR CONDITIONING**	**OTHER END USES**	**TOTAL ELECTRICITY (GWh)**	**TOTAL ELECTRICITY (kTOE)**	**GENERATION FUEL/ ENERGY INPUTS (kTOE)**
ENERGY SUPPLY							(231.7)	(19.9)	
Imports							47.7	4.1	
Exports							279.4	24.0	
ENERGY TRANSFORMATION	-	-	-	-	-	-	9,124.0	785	2,254
Electricity Generation, of which:							**14,044.5**	**1,207.6**	**2,254**
--Coal-fired							2,505.0	215.4	1,026
--Heavy Fuel Oil-fired							107.9	9.3	44
--Diesel-fueled							525.2	45.2	167
--Gasoline-fueled							162.5	13.97	93
--LPG-fueled							-	-	-
--Natural Gas-fired							-	-	-
--Other Fossil-fuel-fired							0.3	0.03	0
--Hydroelectric Power							10,657.2	916.4	916
--Solar Power							82.7	7.11	7.11
--Wind Power							3.5	0.30	0.30
--Tidal Power							0.2	0.02	0.02
--Nuclear Power							-	-	-
Petroleum Refining		-					(52.2)	(4)	
Coal Production/Preparation							(829.3)	(71)	
Charcoal Production									
Coke Production									
District Heat Production									
Other Transformation									
Own Use							(498.8)	(43)	
Losses							(3,540.3)	(304)	
ELECTRICITY FOR FINAL CONSUMPTION							8,892.3	764.6	
ELECTRICITY DEMAND	3,947	936	2,552	177	105	1,160	8,876.7	764.6	
INDUSTRIAL SECTOR	1,750.9	935.6	141.4	-	-	-	2,827.8	243.1	
Iron and Steel	350.2	315.2	35.0				700.4	60.2	
Cement	534.1	0.0	28.1				562.2	48.3	
Fertilizers	128.9	116.1	12.9				257.9	22.2	
Other Chemicals	80.9	72.8	8.1				161.7	13.9	
Pulp and Paper	21.7	-	1.1				22.8	2.0	
Other Metals	93.3	349.9	23.3				466.5	40.1	
Other Minerals	39.5	0.0	2.1				41.6	3.6	
Textiles	58.0	0.0	3.1				61.0	5.2	
Building Materials	8.8	-	0.5				9.3	0.8	
Non-specified Industry	435.6	81.7	27.2				544.5	46.8	
TRANSPORT SECTOR	951.6	-	25.0	-	-	25.0	1,001.7	87.5	
Road							-	1.4	
Rail	951.6	-	25.0	-	-	25.0	1,001.7	86.1	
Water							-	-	
Air							-	-	
Non-Specified							-	-	
RESIDENTIAL SECTOR	161.0	-	889.7	89.2	17.5	622.1	1,779.5	153.0	
Urban	161.0		805.0	86.9	17.5	539.6	1,609.9	138.4	
Rural	-	-	84.8	2.2	-	82.5	169.5	14.6	
AGRICULTURAL SECTOR	240	-	5	-	-	3	248.6	21.4	
Field Operations	86.6		-			-	86.6	7.4	
Processing/Other	153.9		4.9			3.2	162.0	13.9	
FISHERIES SECTOR	34.9	-	1.1	-	-	0.7	36.7	3.2	
Large Ships	-		-			-	-	-	
Collectives/Processing/Other	34.9		1.1			0.7	36.7	3.2	
MILITARY SECTOR	633	-	1,051	-	-	421	2,104.3	180.9	
Trucks and other Transport							-	-	
Armaments							-		
Air Force							-		
Naval Forces							-		
Military Manufacturing	2.6		0.2			0.5	3.3	0.3	
Buildings and Other	630.3		1,050.5			420.2	2,101.0	180.7	
								-	
PUBLIC/COMMERCIAL SECTORS	175.6		439.0	87.8	87.8	87.8	878.1	75.5	

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ELECTRICITY END-USE SUMMARIES AND GRAPHICS

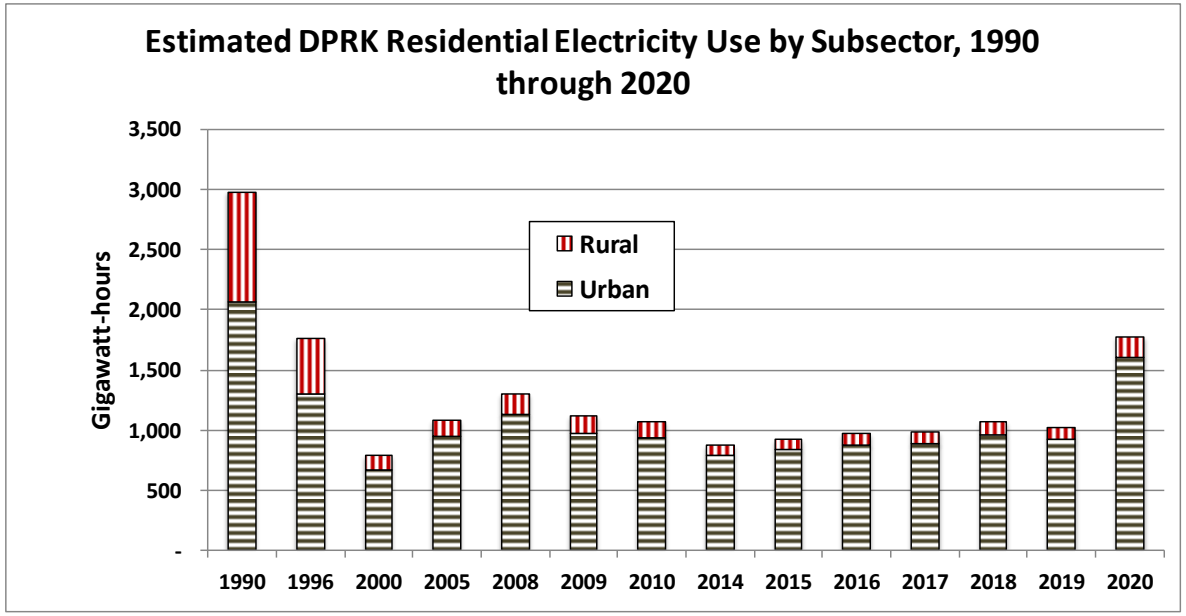
Estimated Residential Electricity Use (GWh)

	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
Urban--2010	93.51	467.55	27.55	4.76	341.73
Rural--2010	-	67.02	0.34	-	66.68
Urban--2014	78.86	394.30	23.23	4.02	288.19
Rural--2014	-	45.35	0.23	-	45.12
Urban--2015	83.66	418.30	24.65	4.26	305.73
Rural--2015	-	46.01	0.23	-	45.78
Urban--2016	88.10	440.52	25.96	4.49	321.97
Rural--2016	-	46.68	0.23	-	46.45
Urban--2017	89.22	446.11	26.29	4.55	326.06
Rural--2017	-	47.37	0.24	-	47.13
Urban--2018	96.69	483.43	52.20	10.50	324.05
Rural--2018	-	49.42	1.31	-	48.11
Urban--2019	91.88	459.40	49.60	9.98	307.94
Rural--2019	-	48.74	1.29	-	47.45
Urban--2020	160.99	804.97	86.91	17.48	539.58
Rural--2020	-	84.77	2.25	-	82.52


Estimated Residential Electricity Use by End Use and Subsector, 2010 and 2014 through 2020
Gigawatt-hours
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Other End Uses
Air Conditioning
Space and Water Heating
Lighting
Motors and Drives
Urban--2010
Rural--2010
Urban--2014
Rural--2014
Urban--2015
Rural--2015
Urban--2016
Rural--2016
Urban--2017
Rural--2017
Urban--2018
Rural--2018
Urban--2019
Rural--2019
Urban--2020
Rural--2020

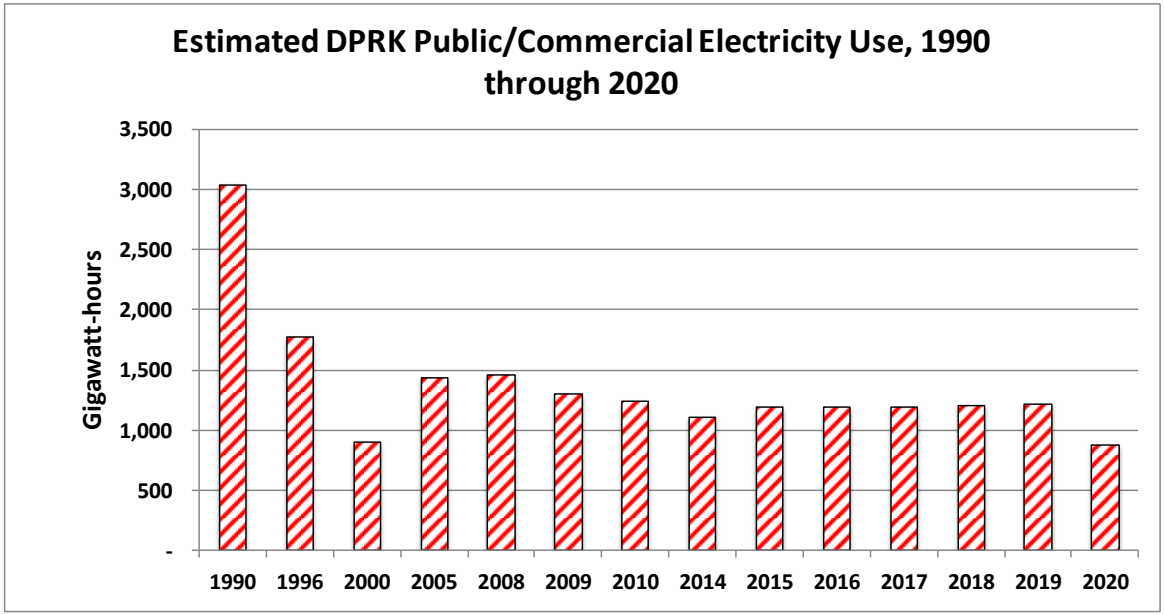
Estimated Residential Electricity Use (GWh)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Urban	2,061.21	1,301.43	672.53	945.15	1,124.95	978.91	935.11	788.61	836.60	881.03	892.22	966.86	918.79	1,609.9
Rural	916.09	464.97	120.84	135.69	173.70	143.99	134.04	90.69	92.01	93.36	94.75	98.84	97.48	169.54



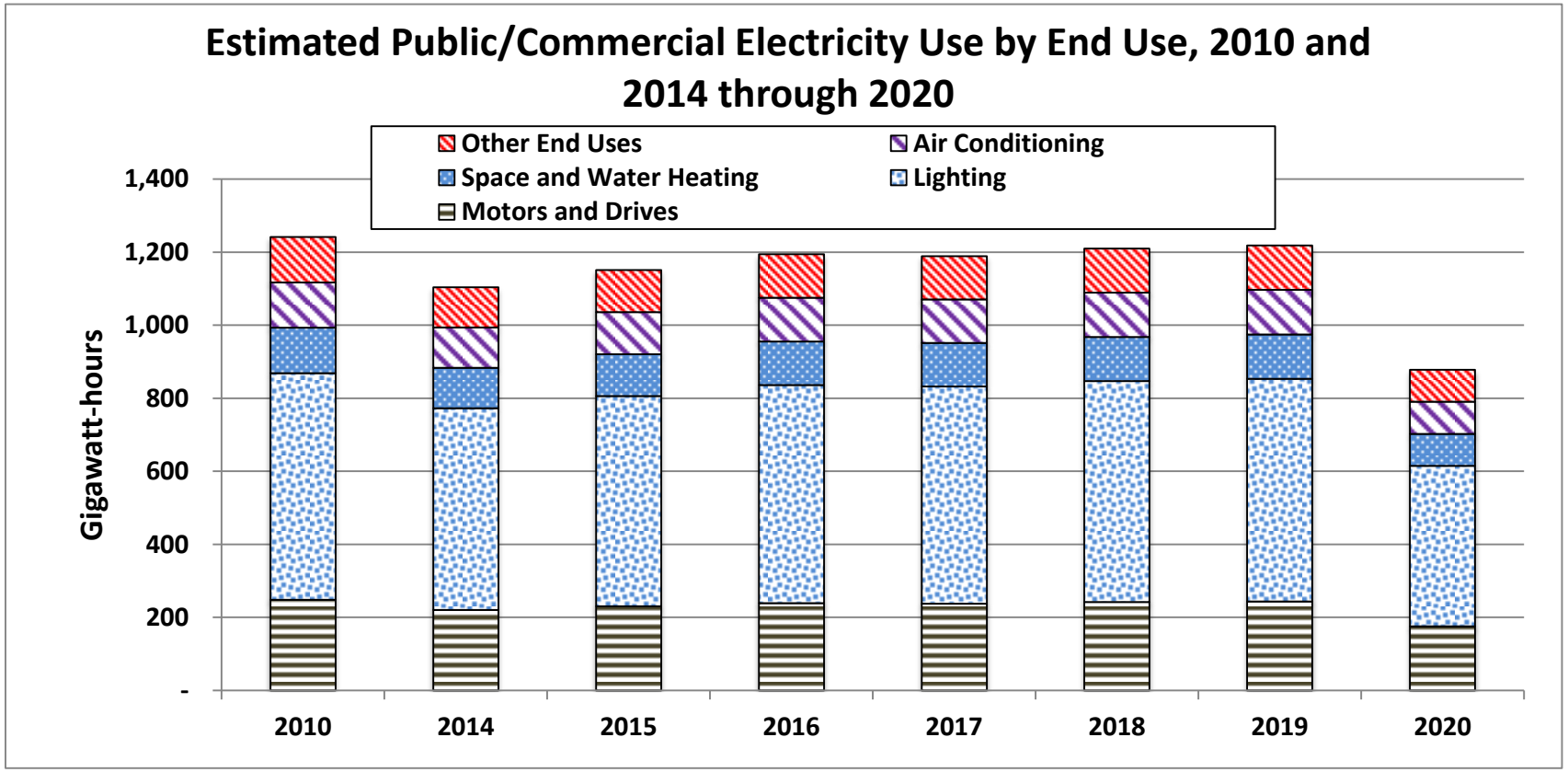
Estimated Public/Commercial Electricity Use (GWh)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Public/Commercial	3,036.8	1,774.1	905.1	1,430.4	1,454.1	1,306.9	1,241.4	1,104.1	1,189.1	1,189.1	1,189.1	1,209.8	1,218.6	878.1



Estimated Public/Commercial Electricity Use by End Use (GWh)

	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
2010	248.28	620.71	124.14	124.14	124.14
2014	220.81	552.03	110.41	110.41	110.41
2015	230.19	575.49	115.10	115.10	115.10
2016	238.88	597.19	119.44	119.44	119.44
2017	237.83	594.56	118.91	118.91	118.91
2018	241.97	604.91	120.98	120.98	120.98
2019	243.72	609.29	121.86	121.86	121.86
2020	175.61	439.03	87.81	87.81	87.81

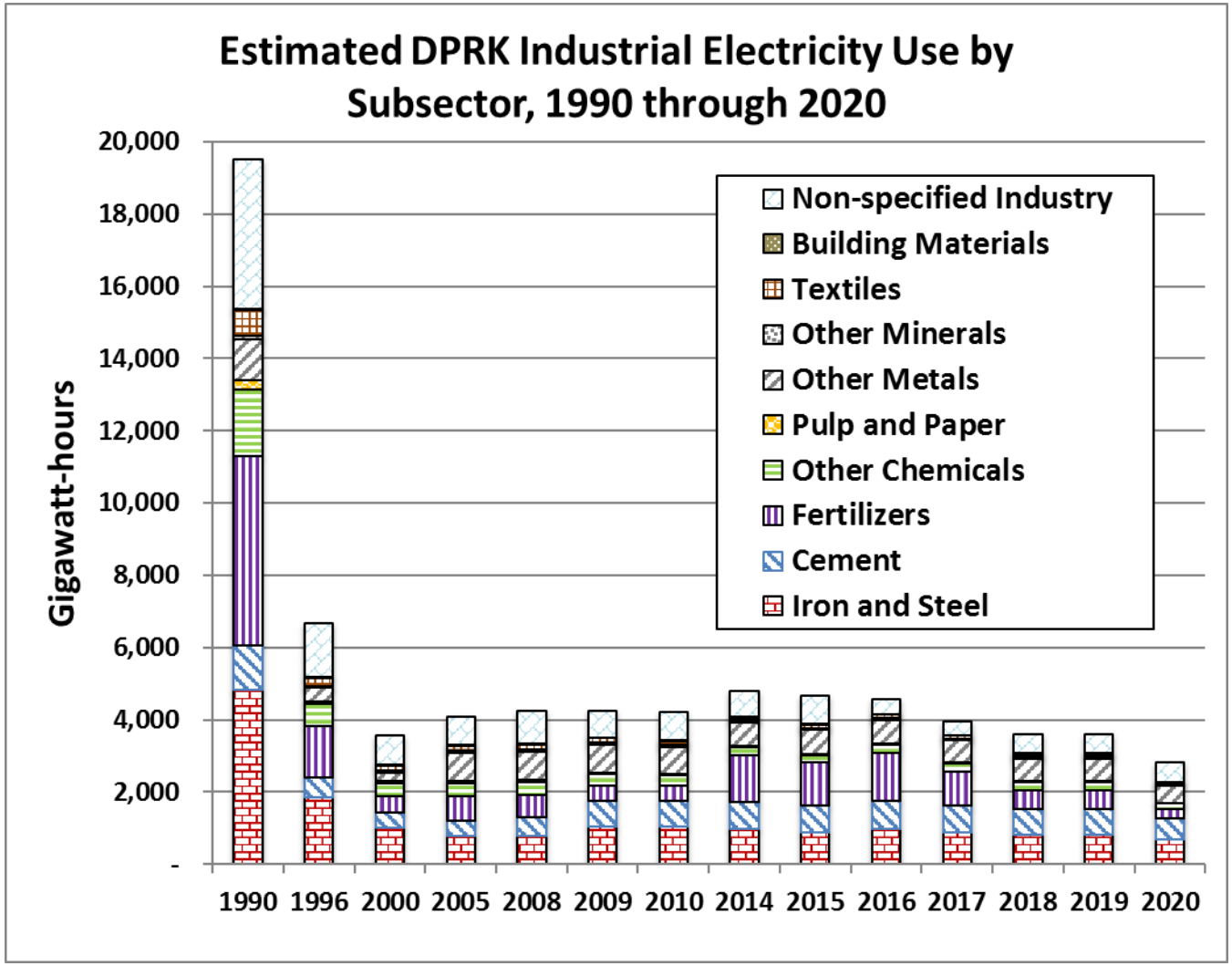


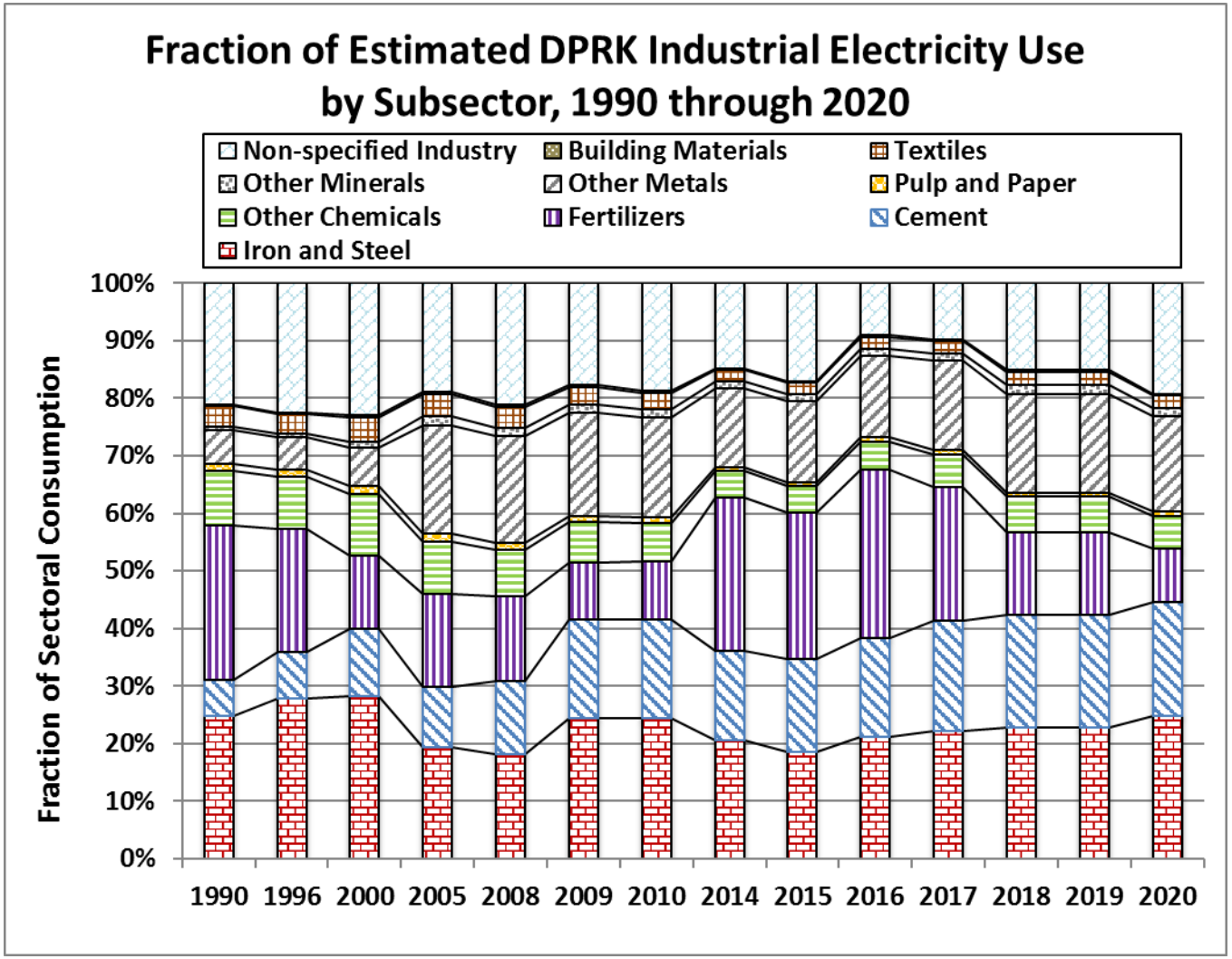
Estimated Imdustrial Electricity Use (GWh)

Subsector	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Iron and Steel	4,830.00	1,859.55	1,002.59	784.39	770.39	1,040.58	1,029.60	982.10	868.60	970.69	877.45	821.10	821.10	700.35
Cement	1,210.00	532.40	417.45	433.66	532.40	727.77	725.22	748.94	751.40	778.47	759.70	708.82	708.82	562.17
Fertilizers	5,247.47	1,424.87	452.59	658.24	628.19	416.08	426.50	1,277.41	1,187.49	1,346.22	921.69	515.79	515.79	257.90
Other Chemicals	1,837.84	606.49	381.49	371.54	343.68	303.24	283.03	222.38	222.38	222.38	222.38	222.38	222.38	161.73
Pulp and Paper	259.00	85.47	53.76	52.36	48.43	42.73	41.31	28.49	28.49	28.49	28.49	28.49	28.49	22.79
Other Metals	1,146.23	378.25	237.93	770.26	781.73	769.12	731.29	655.64	655.64	649.68	617.82	617.82	617.82	466.51
Other Minerals	110.00	36.30	37.95	61.60	62.92	60.50	59.40	59.40	59.40	58.85	53.46	53.46	53.46	41.58
Textiles	693.58	228.88	143.97	155.36	152.59	129.70	122.07	91.55	91.55	91.55	83.92	83.92	83.92	61.03
Building Materials	52.61	17.36	18.15	17.68	17.36	17.36	16.20	12.73	12.73	12.73	12.15	13.31	13.31	9.26
Non-specified Industry	4,125.00	1,497.38	817.35	772.29	895.43	748.89	788.66	713.50	801.08	416.54	385.69	544.50	544.50	544.50
TOTAL	19,512	6,667	3,563	4,077	4,233	4,256	4,223	4,792	4,679	4,576	3,963	3,610	3,610	2,828

Fraction of Total

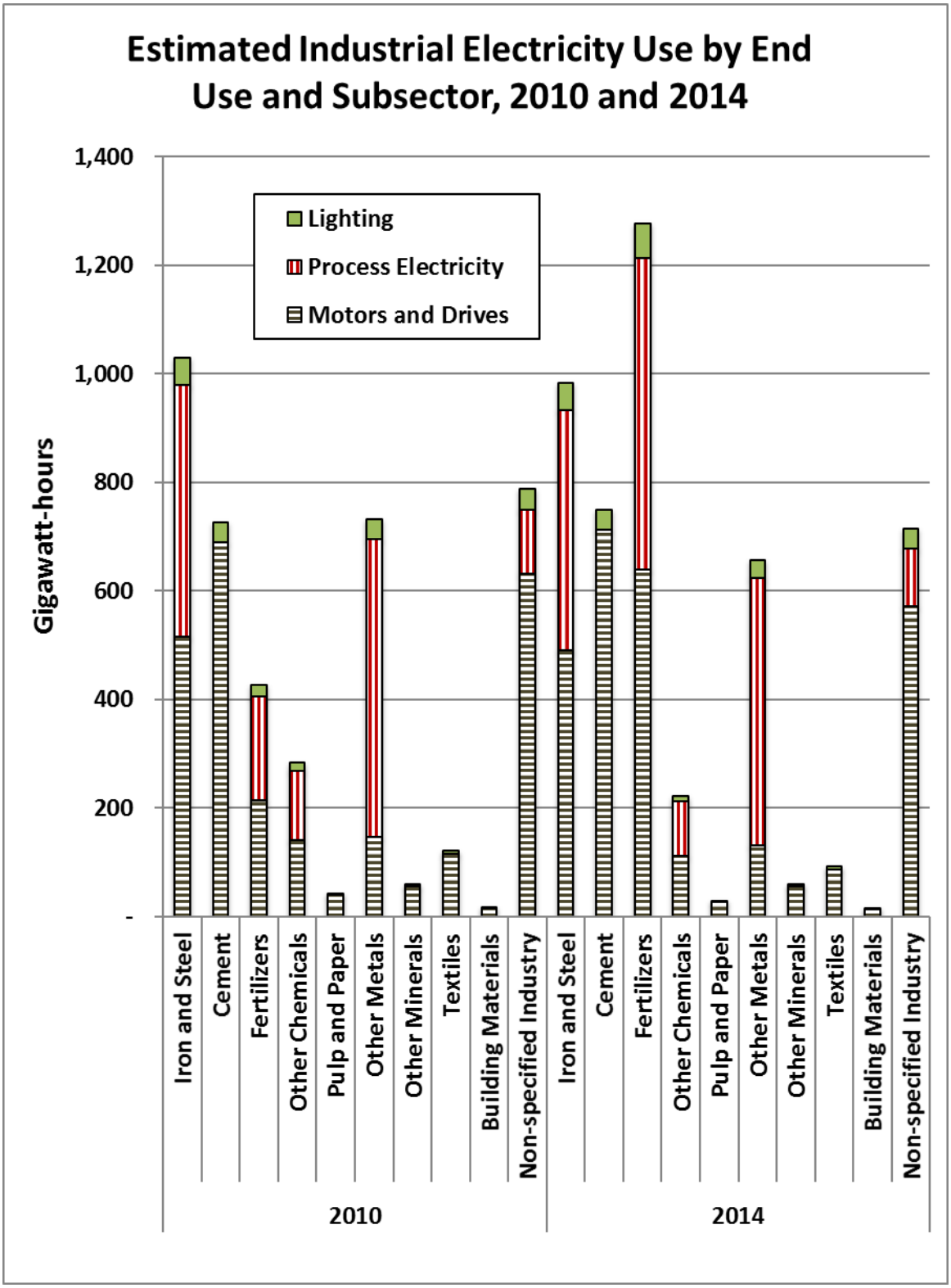
Subsector	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Iron and Steel	24.8%	27.9%	28.1%	19.2%	18.2%	24.4%	24.4%	20.5%	18.6%	21.2%	22.1%	22.7%	22.7%	24.8%
Cement	6.2%	8.0%	11.7%	10.6%	12.6%	17.1%	17.2%	15.6%	16.1%	17.0%	19.2%	19.6%	19.6%	19.9%
Fertilizers	26.9%	21.4%	12.7%	16.1%	14.8%	9.8%	10.1%	26.7%	25.4%	29.4%	23.3%	14.3%	14.3%	9.1%
Other Chemicals	9.4%	9.1%	10.7%	9.1%	8.1%	7.1%	6.7%	4.6%	4.8%	4.9%	5.6%	6.2%	6.2%	5.7%
Pulp and Paper	1.3%	1.3%	1.5%	1.3%	1.1%	1.0%	1.0%	0.6%	0.6%	0.6%	0.7%	0.8%	0.8%	0.8%
Other Metals	5.9%	5.7%	6.7%	18.9%	18.5%	18.1%	17.3%	13.7%	14.0%	14.2%	15.6%	17.1%	17.1%	16.5%
Other Minerals	0.6%	0.5%	1.1%	1.5%	1.5%	1.4%	1.4%	1.2%	1.3%	1.3%	1.3%	1.5%	1.5%	1.5%
Textiles	3.6%	3.4%	4.0%	3.8%	3.6%	3.0%	2.9%	1.9%	2.0%	2.0%	2.1%	2.3%	2.3%	2.2%
Building Materials	0.3%	0.3%	0.5%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.3%
Non-specified Industry	21.1%	22.5%	22.9%	18.9%	21.2%	17.6%	18.7%	14.9%	17.1%	9.1%	9.7%	15.1%	15.1%	19.3%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

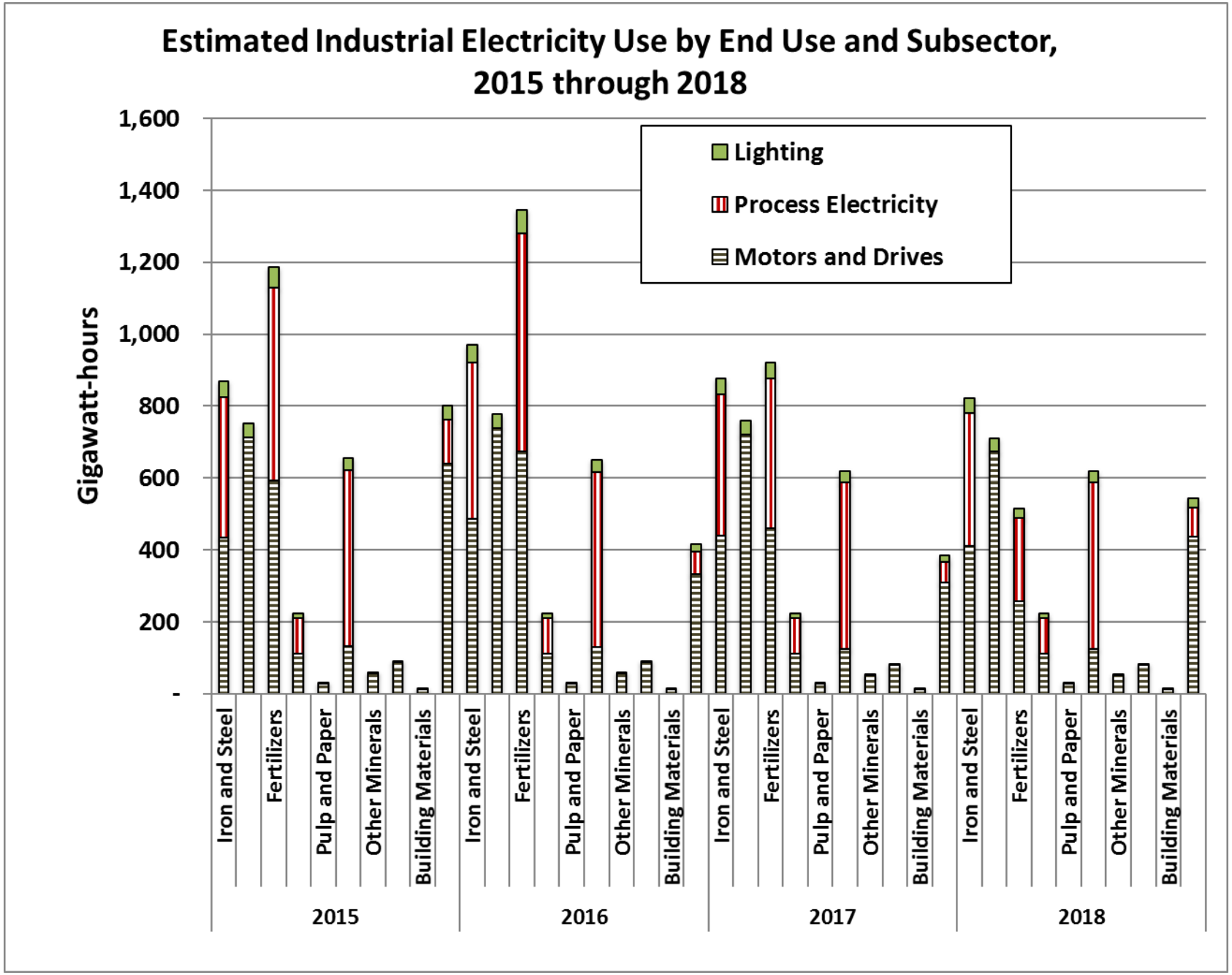

Estimated DPRK Industrial Electricity Use by Subsector, 1990 through 2020
Gigawatt-hours
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel

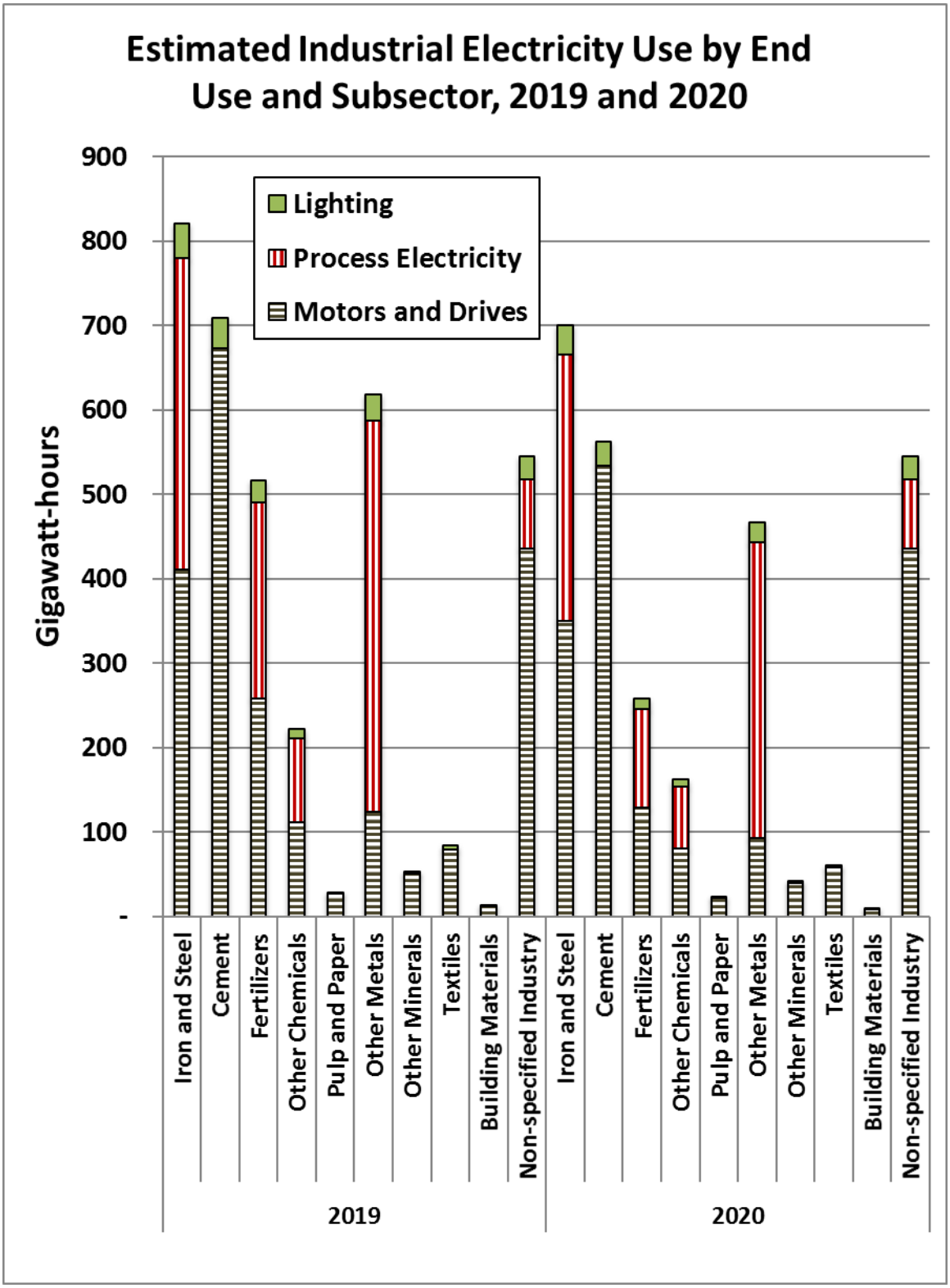

Fraction of Estimated DPRK Industrial Electricity Use by Subsector, 1990 through 2020
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Fraction of Sectoral Consumption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

Estimated Industrial Electricity Use by End Use (GWh)

Year	Subsector	Motors and Drives	Process Electricity	Lighting
2010	Iron and Steel	514.80	463.32	51.48
	Cement	688.96	-	36.26
	Fertilizers	213.25	191.92	21.32
	Other Chemicals	141.51	127.36	14.15
	Pulp and Paper	39.24	0.00	2.07
	Other Metals	146.26	548.47	36.56
	Other Minerals	56.43	-	2.97
	Textiles	115.97	0.00	6.10
	Building Materials	15.39	0.00	0.81
	Non-specified Industry	630.93	118.30	39.43
2014	Iron and Steel	491.05	441.95	49.11
	Cement	711.49	0.00	37.45
	Fertilizers	638.71	574.84	63.87
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	131.13	491.73	32.78
	Other Minerals	56.43	-	2.97
	Textiles	86.97	0.00	4.58
	Building Materials	12.09	0.00	0.64
	Non-specified Industry	570.80	107.03	35.68
2015	Iron and Steel	434.30	390.87	43.43
	Cement	713.83	0.00	37.57
	Fertilizers	593.75	534.37	59.37
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	131.13	491.73	32.78
	Other Minerals	56.43	-	2.97
	Textiles	86.97	0.00	4.58
	Building Materials	12.09	0.00	0.64
	Non-specified Industry	640.86	120.16	40.05
2016	Iron and Steel	485.34	436.81	48.53
	Cement	739.55	-	38.92
	Fertilizers	673.11	605.80	67.31
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	129.94	487.26	32.48
	Other Minerals	55.91	-	2.94
	Textiles	86.97	0.00	4.58
	Building Materials	12.09	0.00	0.64
	Non-specified Industry	333.23	62.48	20.83
2017	Iron and Steel	438.73	394.85	43.87
	Cement	721.72	0.00	37.99
	Fertilizers	460.85	414.76	46.08
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	123.56	463.36	30.89
	Other Minerals	50.79	-	2.67
	Textiles	79.73	0.00	4.20
	Building Materials	11.55	0.00	0.61
	Non-specified Industry	308.55	57.85	19.28
2018	Iron and Steel	410.55	369.50	41.06
	Cement	673.38	0.00	35.44
	Fertilizers	257.90	232.11	25.79
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	123.56	463.36	30.89
	Other Minerals	50.79	-	2.67
	Textiles	79.73	0.00	4.20
	Building Materials	12.64	-	0.67
	Non-specified Industry	435.60	81.68	27.23
2019	Iron and Steel	410.55	369.50	41.06
	Cement	673.38	0.00	35.44
	Fertilizers	257.90	232.11	25.79
	Other Chemicals	111.19	100.07	11.12
	Pulp and Paper	27.07	-	1.42
	Other Metals	123.56	463.36	30.89
	Other Minerals	50.79	-	2.67
	Textiles	79.73	0.00	4.20
	Building Materials	12.64	-	0.67
	Non-specified Industry	435.60	81.68	27.23
2020	Iron and Steel	350.18	315.16	35.02
	Cement	534.06	0.00	28.11
	Fertilizers	128.95	116.05	12.89
	Other Chemicals	80.87	72.78	8.09
	Pulp and Paper	21.65	-	1.14
	Other Metals	93.30	349.89	23.33
	Other Minerals	39.50	0.00	2.08
	Textiles	57.98	0.00	3.05
	Building Materials	8.80	-	0.46
	Non-specified Industry	435.60	81.68	27.23

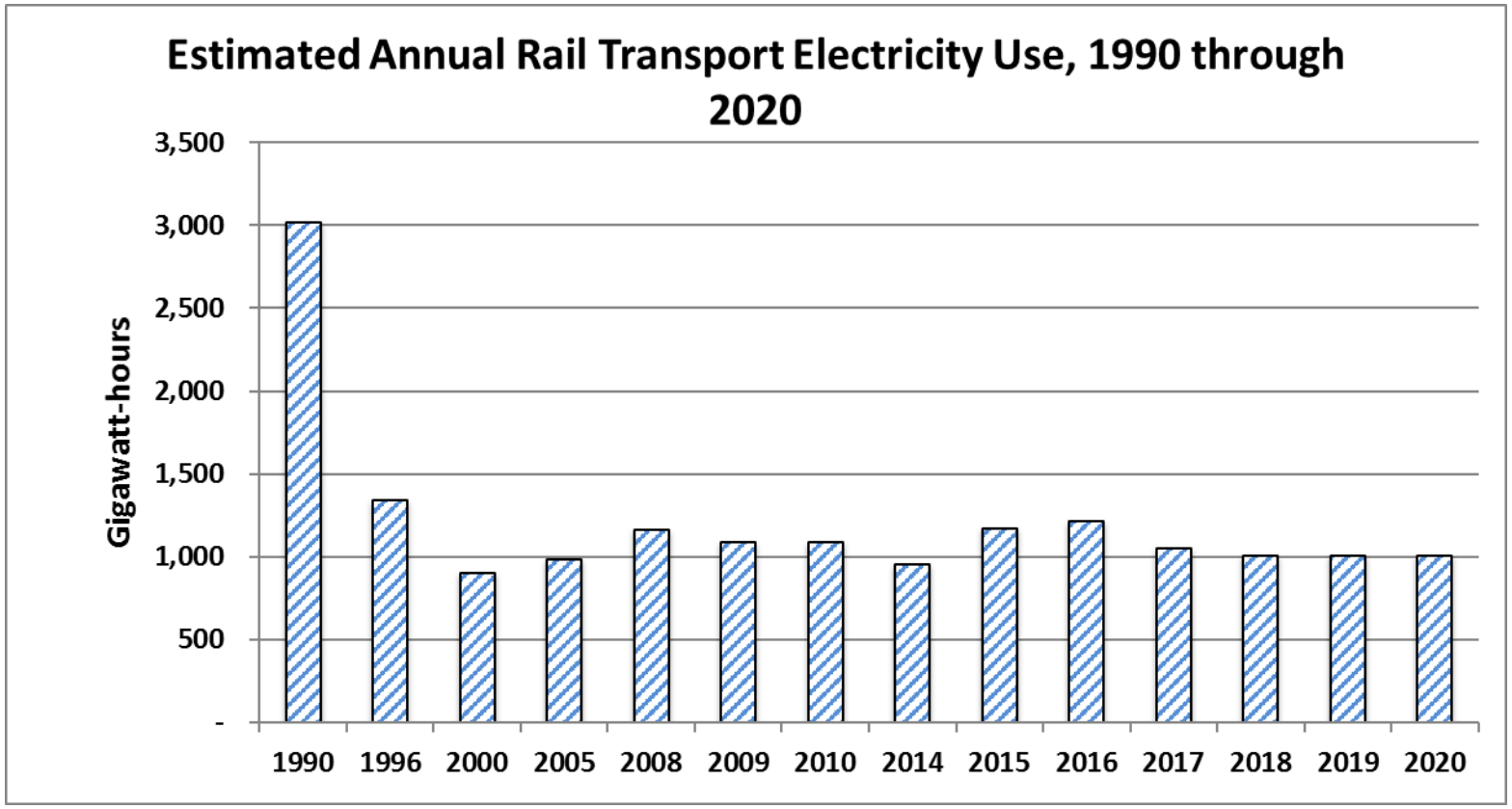

Estimated Industrial Electricity Use by End Use and Subsector, 2010 and 2014
Gigawatt-hours
1,400
1,200
1,000
800
600
400
200
-
Lighting
Process Electricity
Motors and Drives
Iron and Steel
Cement
Fertilizers
Other Chemicals
Pulp and Paper
Other Metals
Other Minerals
Textiles
Building Materials
Non-specified Industry
Iron and Steel
Cement
Fertilizers
Other Chemicals
Pulp and Paper
Other Metals
Other Minerals
Textiles
Building Materials
Non-specified Industry
2010
2014


Estimated Industrial Electricity Use by End Use and Subsector, 2015 through 2018
Gigawatt-hours
1,600
1,400
1,200
1,000
800
600
400
200
-
Lighting
Process Electricity
Motors and Drives
Iron and Steel
Fertilizers
Pulp and Paper
Other Minerals
Building Materials
2015
2016
2017
2018


Estimated Industrial Electricity Use by End Use and Subsector, 2019 and 2020
Gigawatt-hours
900
800
700
600
500
400
300
200
100
-
Lighting
Process Electricity
Motors and Drives
Iron and Steel
Cement
Fertilizers
Other Chemicals
Pulp and Paper
Other Metals
Other Minerals
Textiles
Building Materials
Non-specified Industry
Iron and Steel
Cement
Fertilizers
Other Chemicals
Pulp and Paper
Other Metals
Other Minerals
Textiles
Building Materials
Non-specified Industry
2019
2020

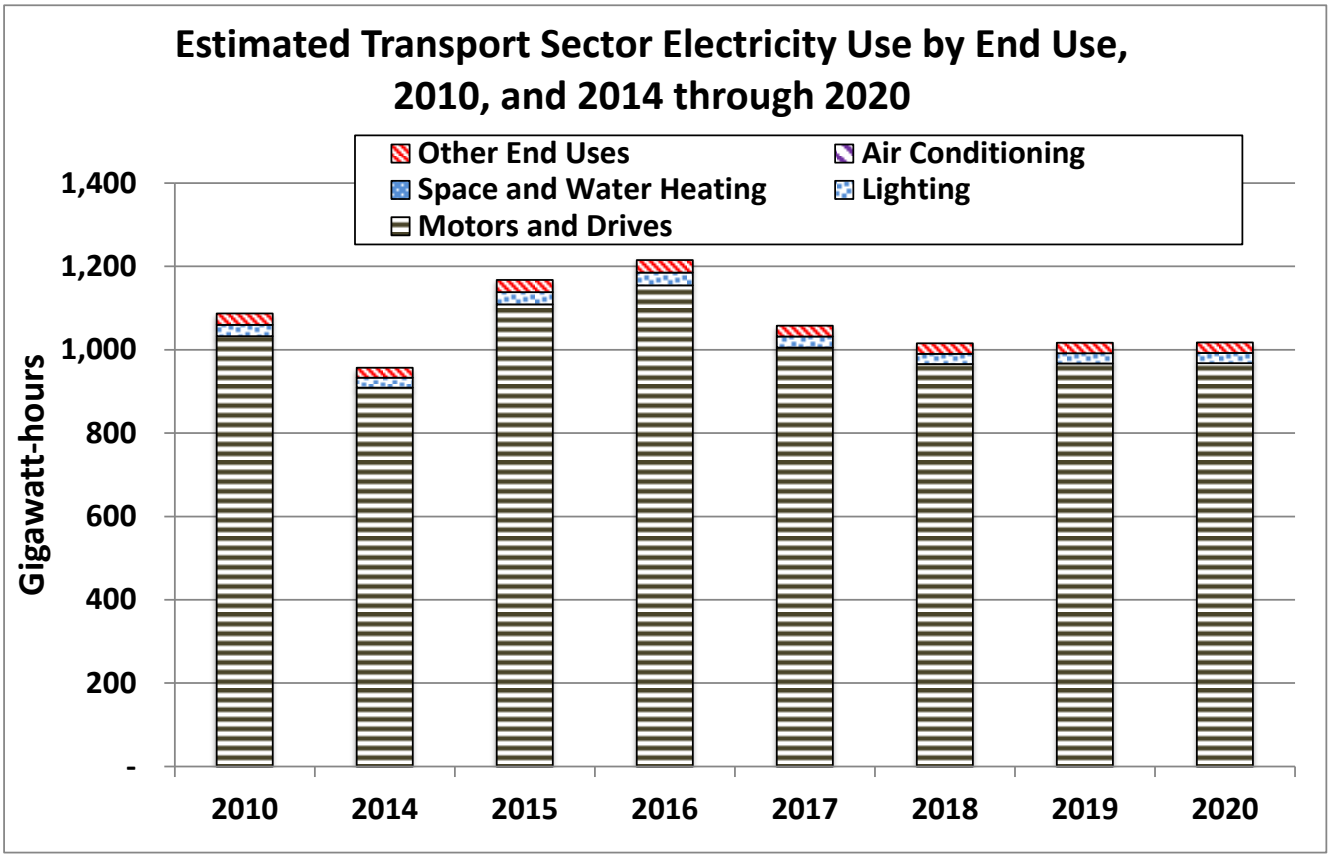
Estimated Transportation Electricity Use (GWh)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Transport--Rail	3,019.5	1,337.6	899.1	981.2	1,162.6	1,087.0	1,087.0	956.0	1,165.7	1,210.6	1,046.5	1,001.7	1,001.7	1,001.7



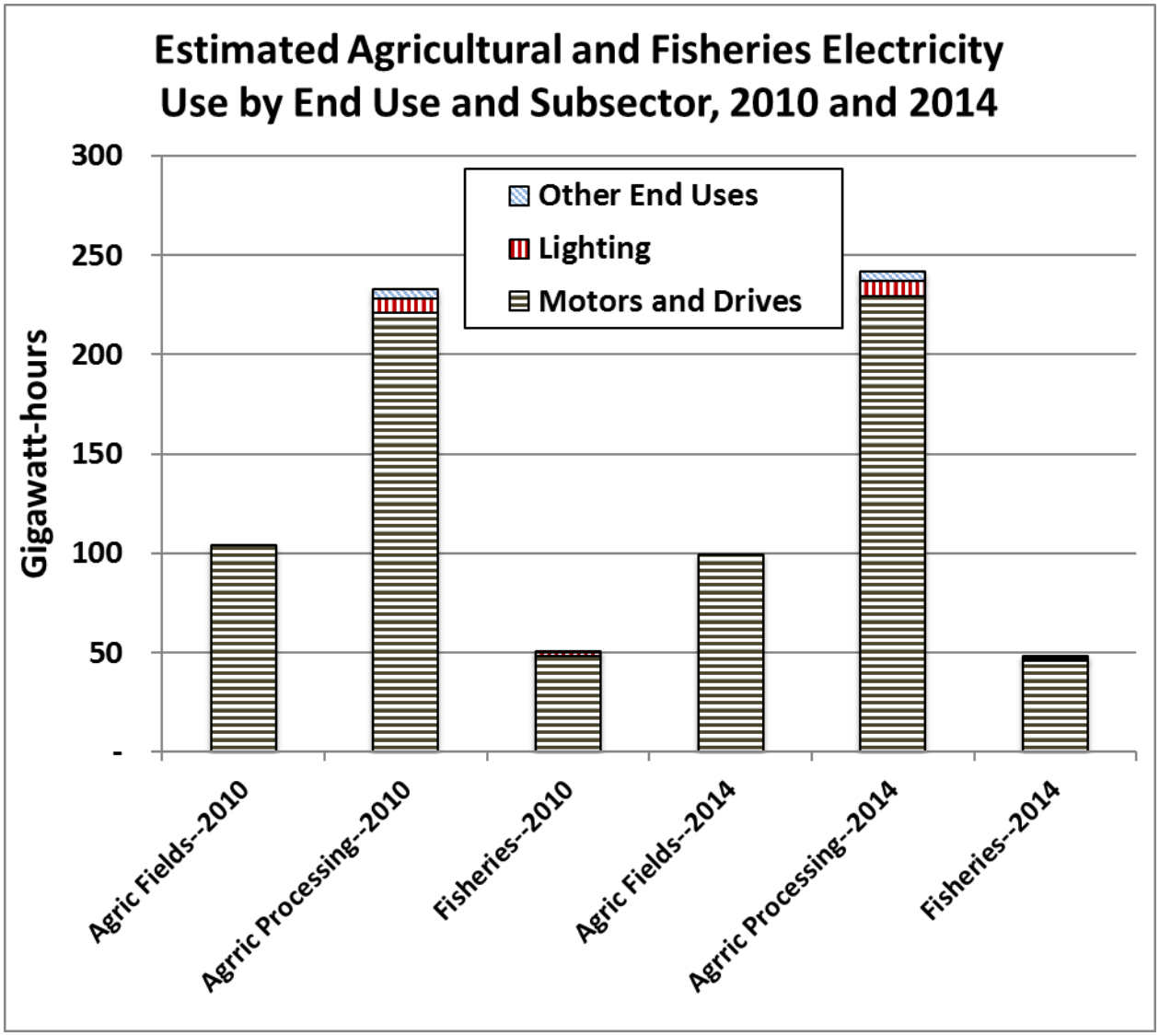
Estimated Transport Electricity Use by End Use (GWh)

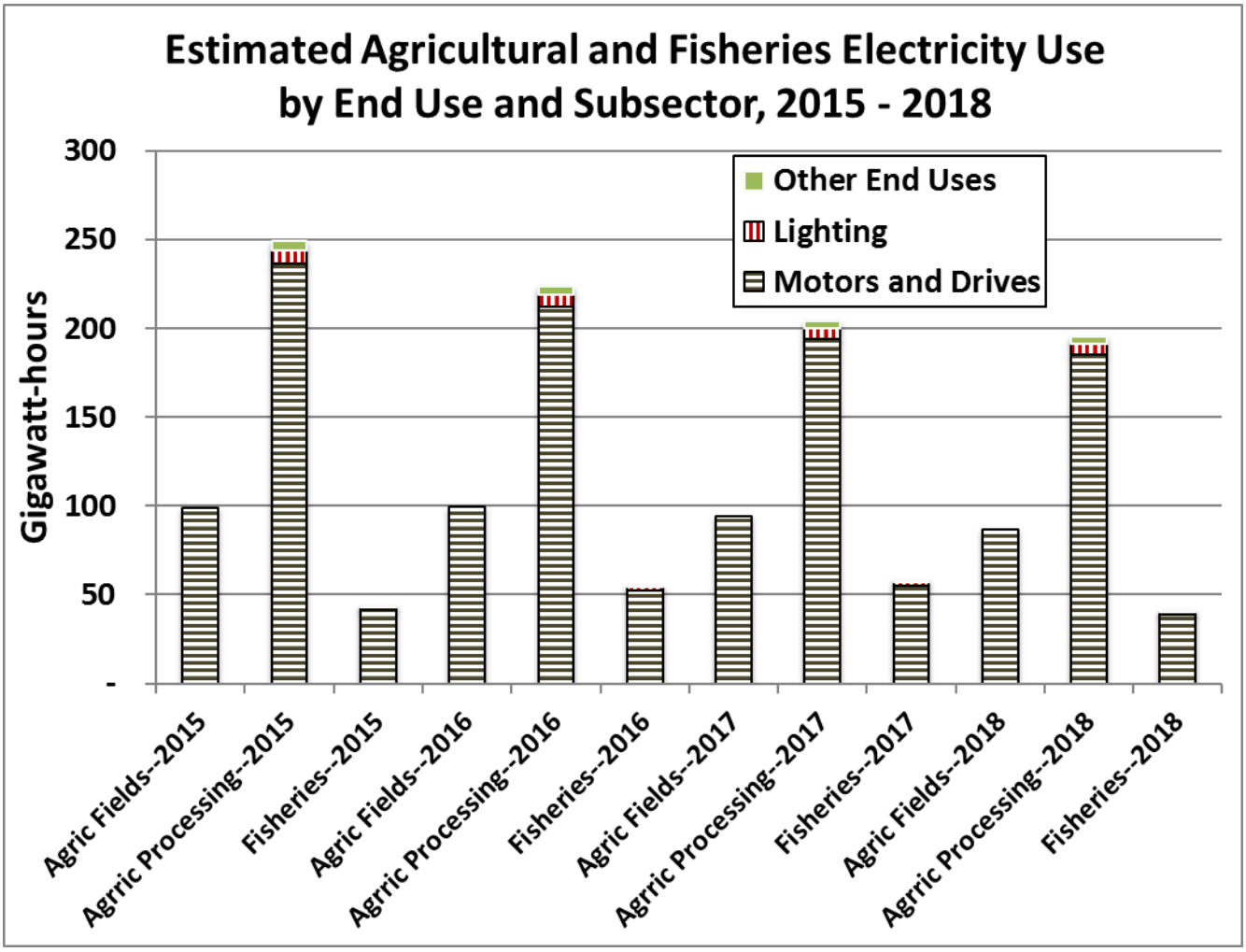
	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
2010	1,032.69	27.18	-	-	27.18
2014	909.23	23.90	-	-	23.90
2015	1,109.19	29.14	-	-	29.14
2016	1,154.86	30.27	-	-	30.27
2017	1,005.54	26.16	-	-	26.16
2018	965.60	25.04	-	-	25.04
2019	966.95	25.04	-	-	25.04
2020	967.51	25.04	-	-	25.04

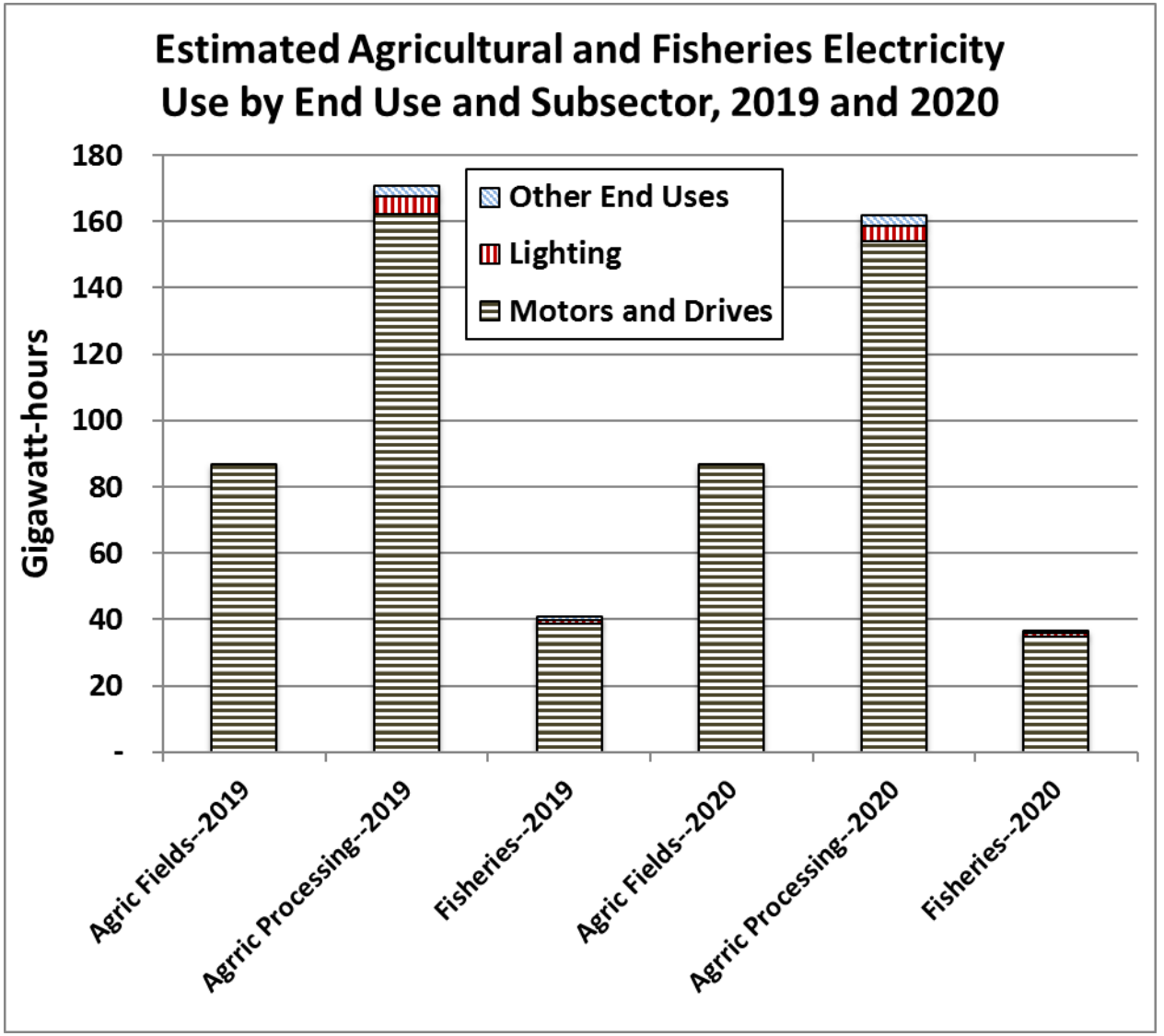


Estimated Agricultural and Fisheries Sector Electricity Use (GWh)

	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
Agric Fields--2010	103.80	-	-	-	-
Agrric Processing--2010	221.08	6.98	-	-	4.65
Fisheries--2010	48.42	1.53	-	-	1.02
Agric Fields--2014	99.04	-	-	-	-
Agrric Processing--2014	229.39	7.24	-	-	4.83
Fisheries--2014	45.65	1.44	-	-	0.96
Agric Fields--2015	99.14	-	-	-	-
Agrric Processing--2015	236.63	7.47	-	-	4.98
Fisheries--2015	41.50	1.31	-	-	0.87
Agric Fields--2016	99.82	-	-	-	-
Agrric Processing--2016	212.18	6.70	-	-	4.47
Fisheries--2016	52.57	1.66	-	-	1.11
Agric Fields--2017	93.82	-	-	-	-
Agrric Processing--2017	193.96	6.12	-	-	4.08
Fisheries--2017	55.34	1.75	-	-	1.17
Agric Fields--2018	86.62	-	-	-	-
Agrric Processing--2018	185.28	5.85	-	-	3.90
Fisheries--2018	38.74	1.22	-	-	0.82
Agric Fields--2019	86.62	-	-	-	-
Agrric Processing--2019	162.24	5.12	-	-	3.42
Fisheries--2019	38.74	1.22	-	-	0.82
Agric Fields--2020	86.62	-	-	-	-
Agrric Processing--2020	153.85	4.86	-	-	3.24
Fisheries--2020	34.86	1.10	-	-	0.73

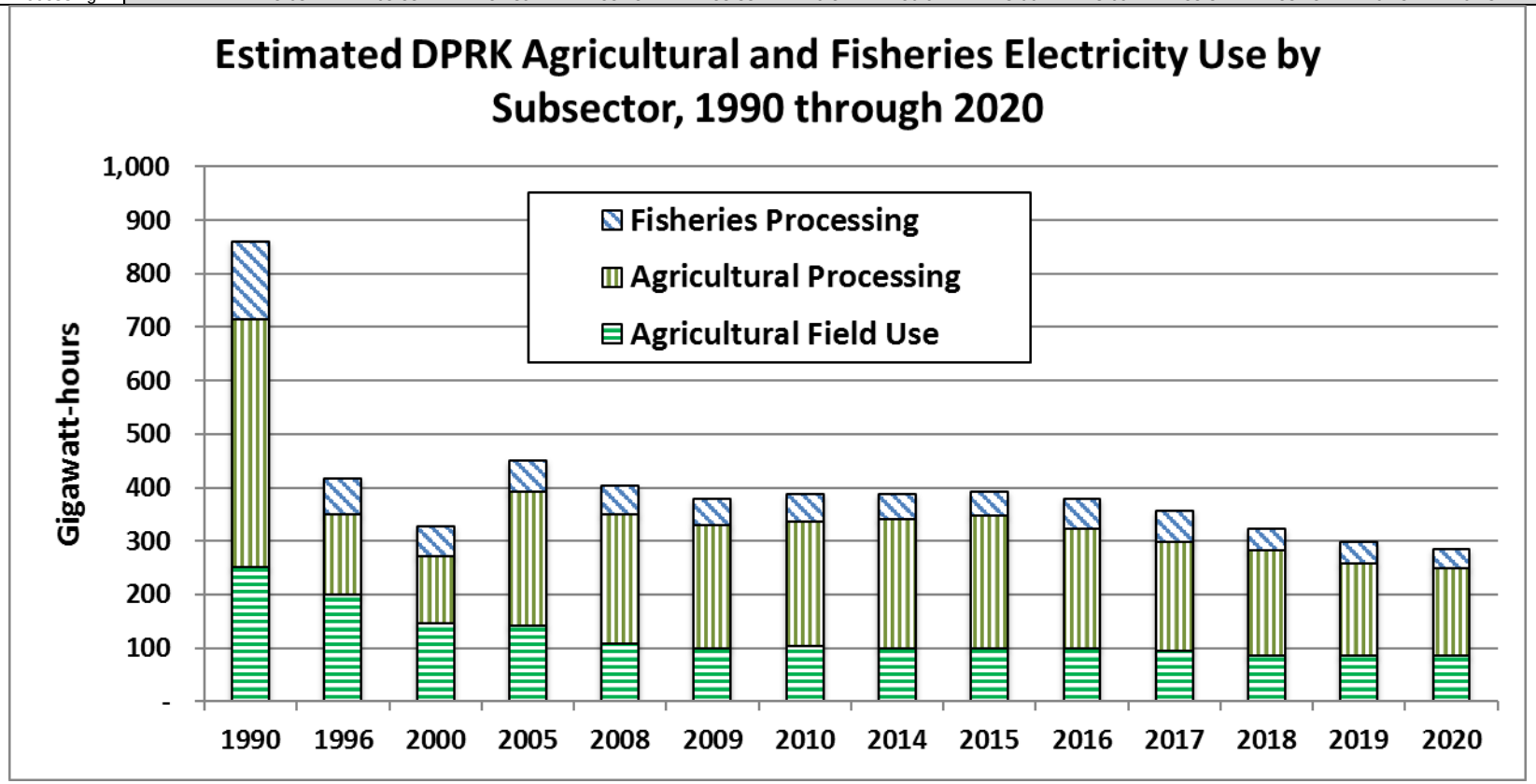

Estimated Agricultural and Fisheries Electricity Use by End Use and Subsector, 2010 and 2014
Gigawatt-hours
300
250
200
150
100
50
-
Other End Uses
Lighting
Motors and Drives
Agric Fields--2010
Agric Processing--2010
Fisheries--2010
Agric Fields--2014
Agrric Processing--2014
Fisheries--2014


Estimated Agricultural and Fisheries Electricity Use by End Use and Subsector, 2015 - 2018
Gigawatt-hours
300
250
200
150
100
50
-
Other End Uses
Lighting
Motors and Drives
Agric Fields--2015
Agrric Processing--2015
Fisheries--2015
Agric Fields--2016
Agrric Processing--2016
Fisheries--2016
Agric Fields--2017
Agrric Processing--2017
Fisheries--2017
Agric Fields--2018
Agrric Processing--2018
Fisheries--2018


Estimated Agricultural and Fisheries Electricity Use by End Use and Subsector, 2019 and 2020
Gigawatt-hours
180
160
140
120
100
80
60
40
20
-
Other End Uses
Lighting
Motors and Drives
Agric Fields--2019
Agric Processing--2019
Fisheries--2019
Agric Fields--2020
Agric Processing--2020
Fisheries--2020

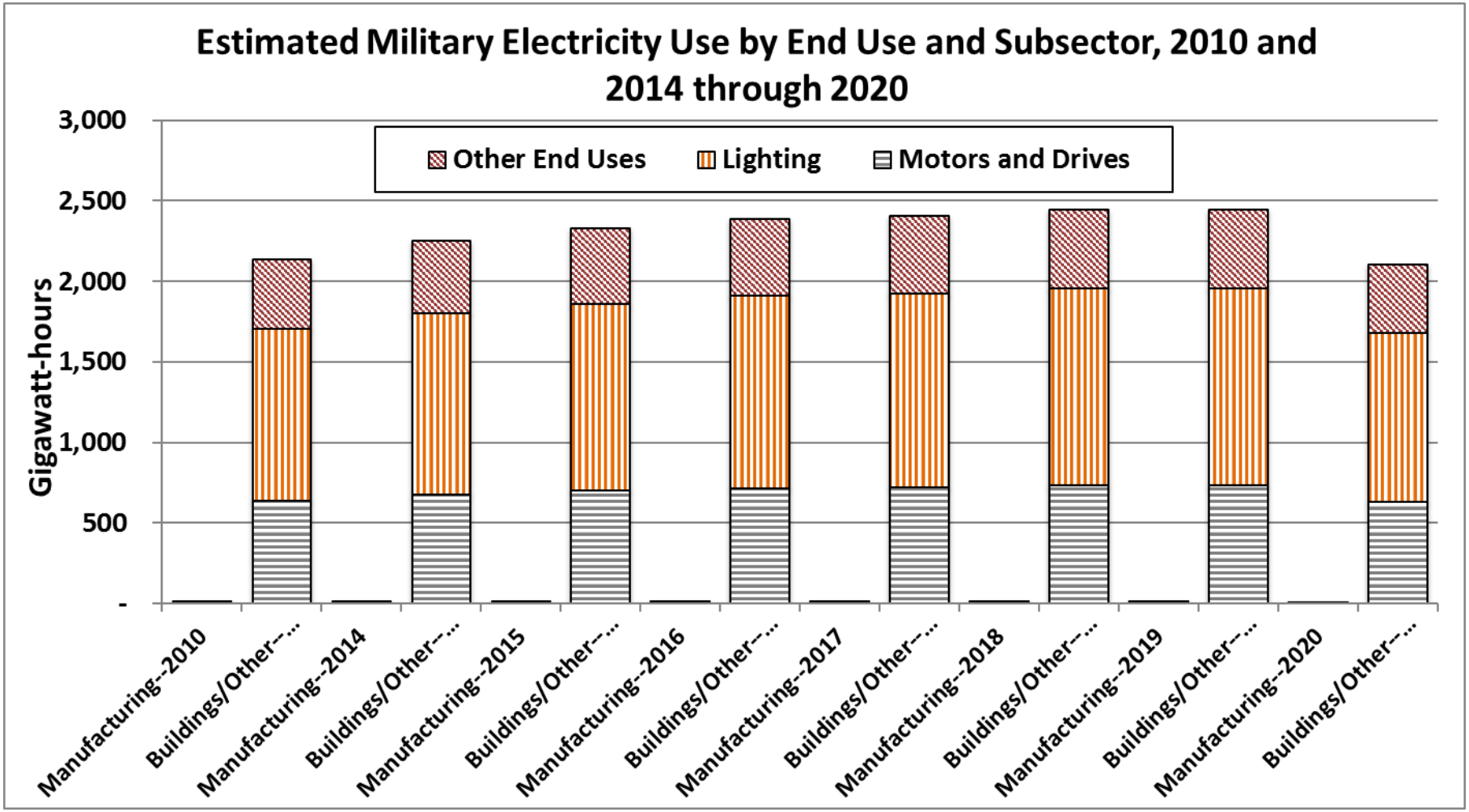
Estimated Agricultural and Fisheries Electricity Use (GWh)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Agricultural Field Use	252.00	199.27	146.23	141.14	108.81	99.66	103.80	99.04	99.14	99.82	93.82	86.62	86.62	86.62
Agricultural Processing	462.36	150.93	125.69	250.48	241.55	229.49	232.72	241.47	249.08	223.35	204.17	195.03	170.78	161.95
Fisheries Processing	145.63	65.53	54.39	58.25	53.88	49.51	50.97	48.06	43.69	55.34	58.25	40.78	40.78	36.70



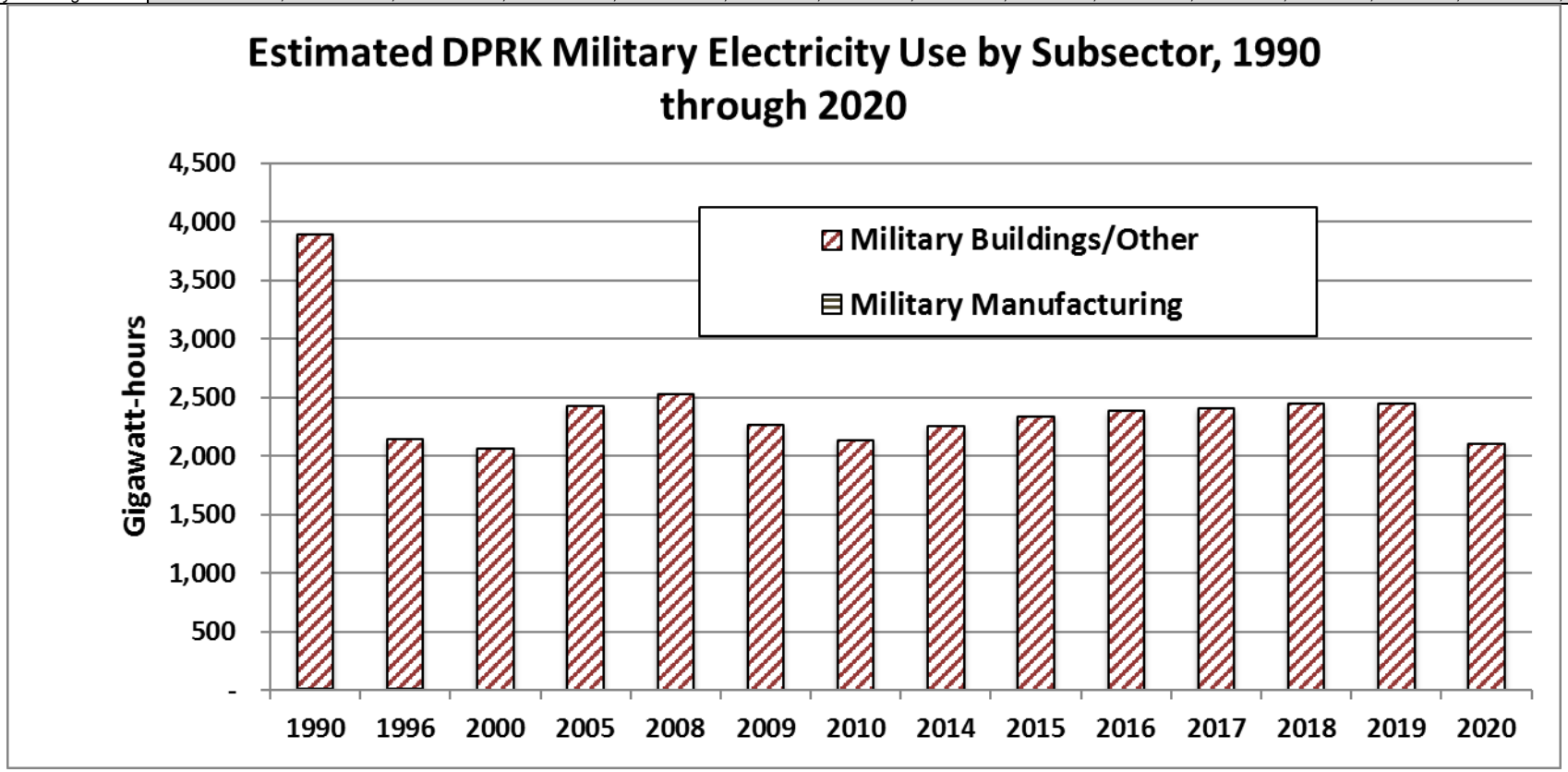
Estimated Military Electricity Use (GWh)

	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
Manufacturing--2010	4.77	0.30	-	-	0.89
Buildings/Other--2010	639.83	1,066.39	-	-	426.56
Manufacturing--2014	5.09	0.32	-	-	0.95
Buildings/Other--2014	674.73	1,124.56	-	-	449.82
Manufacturing--2015	5.19	0.32	-	-	0.97
Buildings/Other--2015	698.00	1,163.33	-	-	465.33
Manufacturing--2016	5.30	0.33	-	-	0.99
Buildings/Other--2016	715.45	1,192.42	-	-	476.97
Manufacturing--2017	5.30	0.33	-	-	0.99
Buildings/Other--2017	721.27	1,202.11	-	-	480.84
Manufacturing--2018	5.30	0.33	-	-	0.99
Buildings/Other--2018	732.90	1,221.50	-	-	488.60
Manufacturing--2019	5.30	0.33	-	-	0.99
Buildings/Other--2019	732.90	1,221.50	-	-	488.60
Manufacturing--2020	2.65	0.17	-	-	0.50
Buildings/Other--2020	630.29	1,050.49	-	-	420.20


Estimated Military Electricity Use by End Use and Subsector, 2010 and 2014 through 2020
Other End Uses
Lighting
Motors and Drives
Gigawatt-hours
3,000
2,500
2,000
1,500
1,000
500
-
Manufacturing--2010
Buildings/Other--...
Manufacturing--2014
Buildings/Other--...
Manufacturing--2015
Buildings/Other--...
Manufacturing--2016
Buildings/Other--...
Manufacturing--2017
Buildings/Other--...
Manufacturing--2018
Buildings/Other--...
Manufacturing--2019
Buildings/Other--...
Manufacturing--2020
Buildings/Other--...

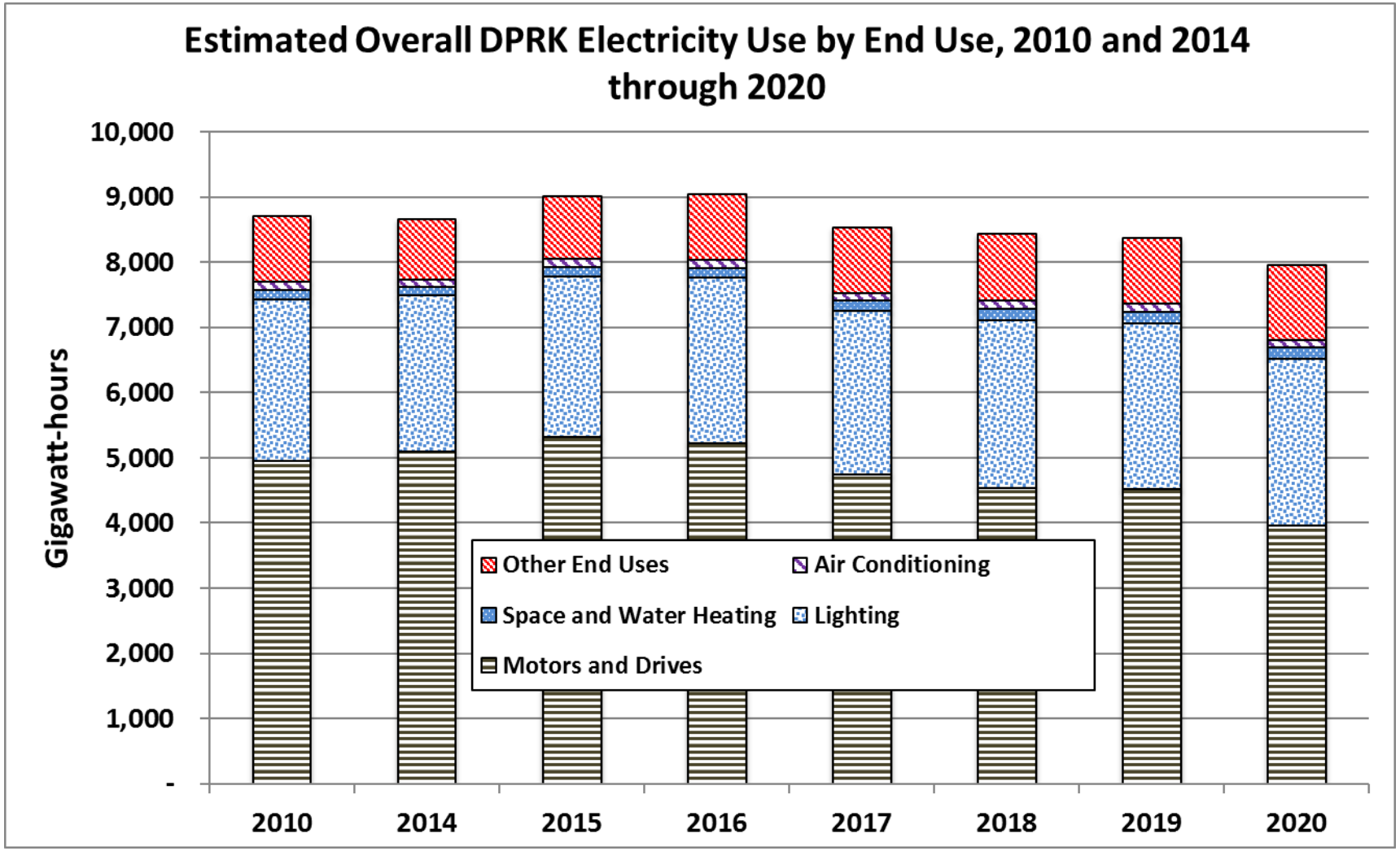
Estimated Military Electricity Use (GWh)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Military Manufacturing	13.25	9.27	5.96	5.96	5.96	5.96	5.96	6.36	6.49	6.62	6.62	6.62	6.62	3.31
Military Buildings/Other	3,877.8	2,132.8	2,055.2	2,423.6	2,520.6	2,255.7	2,132.8	2,249.1	2,326.7	2,384.8	2,404.2	2,443.0	2,443.0	2,101.0



Estimated Overall DPRK Electricity Use by End Use, 2010 and 2014 through 2020

Electricity Use (GWh)	Motors and Drives	Lighting	Space and Water Heating	Air Conditioning	Other End Uses
2010	4,955.13	2,468.82	152.03	128.91	992.85
2014	5,099.74	2,388.74	133.87	114.42	924.18
2015	5,311.13	2,475.31	139.98	119.36	967.91
2016	5,221.56	2,544.54	145.63	123.93	1,001.65
2017	4,735.99	2,522.66	145.44	123.46	1,005.35
2018	4,535.48	2,572.19	174.49	131.48	1,012.49
2019	4,510.74	2,551.13	172.75	131.84	996.11
2020	3,963.28	2,551.83	176.97	105.29	1,159.62
Fraction of Total by End Use					
2010	57.0%	28.4%	1.7%	1.5%	11.4%
2014	58.9%	27.6%	1.5%	1.3%	10.7%
2015	58.9%	27.5%	1.6%	1.3%	10.7%
2016	57.8%	28.2%	1.6%	1.4%	11.1%
2017	55.5%	29.6%	1.7%	1.4%	11.8%
2018	53.8%	30.5%	2.1%	1.6%	12.0%
2019	53.9%	30.5%	2.1%	1.6%	11.9%
2020	49.8%	32.1%	2.2%	1.3%	14.6%


Estimated Overall DPRK Electricity Use by End Use, 2010 and 2014 through 2020
Gigawatt-hours
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
2010
2014
2015
2016
2017
2018
2019
2020
Other End Uses
Air Conditioning
Space and Water Heating
Lighting
Motors and Drives

Workpapers—Energy Supply Sectors

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
COAL EXTRACTION AND PROCESSING, IMPORTS

Prepared By David Von Hippel
Date Last Modified: 6/24/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

						Source/Note:
Domestic Coal Production (official)						
Anthracite Coal	4.90E+07	te				*1, 21*
Brown Coal	2.10E+07	te				*1, 21*
Heat Content, Anthracite	6150	kcal/kg				*2*
Heat Content, Brown Coal	4250	kcal/kg				*2*
Weighted Ave Heat Content	5580	kcal/kg				
Official Ave. Heat Content	4500	kcal/kg				*10*
Conversion Factor	4.184	kJ/kcal				
Total Coal Production (official)	1317960000	GJ				
True-up factor to reduce coal supply to meet demand	98.7%					*Assumption*
Total Coal Production (revised)	1301287806	GJ				
Coal and Coke Imports						
Total Coal Imports	2.38E+06	te				*3*
Average Heat Content	26.2	GJ/te				*8*
Coal Imports	6.24E+07	GJ				
Coke Imports	2.09E+05	te				*3*
Average Heat Content	28.47	GJ/te				*4*
Coke Imports	5.95E+06	GJ, or	2.0308E+05	Tce		
Total Coal and Coke Imports	6.84E+07	GJ				
Coal Exports						
Total Coal Exports (Anthracite)	1,700,329	te	(to China and Japan)			*5, 16*
Heat Content, Anthracite	6200	kcal/kg				*8*
Conversion Factor	4.184	kJ/kcal				
Total Coal Exports (Anthracite)	4.41E+07	GJ				
Coal Use in Coal Mining						
Per-unit coal use in mining	39.1	kg/te				*7*
Weighted Ave Heat Content	5580	kcal/kg				
Conversion Factor	4.184	kJ/kcal				
Coal Use in Mining Industry	6.31E+07	GJ				
Coal Transport Losses						
Coal Loss Rate	1.0%	of mined				*Guess, see Note 24*
Mass of Coal Lost	6.91E+05	te				
Energy content of Coal Lost	1.61E+07	GJ				
Electricity Use in Coal Mining						
Electricity intensity of mining	34.34	kWh/te				*6*
Conversion Factor	0.0036	GJ/kWh				
Electricity Used in Coal Mining	8.54E+06	GJ, or	0.006901	GJ/GJ net coal output		

COAL SUPPLY ESTIMATE

Coal Imports to the DPRK (China)	1.75E+06	te	(In 1993)	*11*
Coke Imports from FSU	2.09E+05	te	(In 1990)	*3*
Coal Exports to China	1.55E+05	te	(In 1993)	*11*

	1996	2000	2005	2008	2009	2010	2014	
Coal Imports to the DPRK relative to 1993	18%	22%	77.1%	39.5%	13.5%	25.9%	16.3%	*17, 22, 23.25-27*
Coke (and Coal Tar and related products) Imports to the DPRK relative to 1990	52.7%	29%	17.8%	7.2%	6.2%	26.08%	5.58%	*17, 22, 23.25-27*
Total Estimated Coal+Coke Imports (GJ)	1.16E+07	1.20E+07	3.64E+07	1.86E+07	6.54E+06	1.34E+07	7.82E+06	*Calculated*
Coal and Coke Exp. from DPRK rel. to 1993 Exp. to China	301.74%	231.8%	1988.4%	1656%	2341%	3028%	10007%	*18, 19, 20, 27*
Total Estimated Coal Exports (GJ)	1.21E+07	9.31E+06	7.99E+07	6.66E+07	9.41E+07	1.22E+08	4.02E+08	*Calculated*
Domestic Coal Production relative to 1990	52.46%	25.83%	33.38%	32.80%	37.22%	37.79%	65.43%	*13*
Total Estimated Domestic Coal Production (GJ)	6.83E+08	3.36E+08	4.34E+08	4.27E+08	4.84E+08	4.92E+08	8.51E+08	*Calculated*
Estimated Coal Use in Coal Mining (GJ)	3.27E+07	1.61E+07	2.08E+07	2.04E+07	2.32E+07	2.35E+07	4.08E+07	*Calculated*
Estimated Coal Losses (GJ)	8.36E+06	4.12E+06	5.32E+06	5.23E+06	5.93E+06	6.02E+06	1.04E+07	*Calculated*
Estimated Electricity Use in Coal Mining (GJ)	4.43E+06	2.18E+06	2.82E+06	2.77E+06	3.14E+06	3.19E+06	5.52E+06	*Calculated*

	2015	2016	2017	2018	2019	2020		
Coal Imports to the DPRK relative to 1993	63.9%	89.7%	63%	0.0%	0.0%	0.0%		*17, 22, 23.25-27*
Coke (and Coal Tar and related products) Imports to the DPRK relative to 1990	5.2%	4.7%	9.0%	5.1%	5.1%	2.0%		*17, 22, 23.25-27, 33*
Total Estimated Coal+Coke Imports (GJ)	2.96E+07	4.14E+07	2.95E+07	3.01E+05	3.01E+05	1.20E+05		*Calculated*
Coal and Coke Exp. from DPRK rel. to 1993 Exp. to China	12851%	14537.4%	3403.6%	2040.9%	4045%	2041%		*18, 19, 20, 27, 29, 32*
Total Estimated Coal Exports (GJ)	5.16E+08	5.84E+08	1.37E+08	8.20E+07	1.63E+08	8.20E+07		*Calculated*
Domestic Coal Production relative to 1990	73.00%	78.36%	43.56%	40.81%	47.58%	35.39%		*13*
Total Estimated Domestic Coal Production (GJ)	9.50E+08	1.02E+09	5.67E+08	5.31E+08	6.19E+08	4.61E+08		*Calculated*
Estimated Coal Use in Coal Mining (GJ)	4.55E+07	4.88E+07	2.71E+07	2.54E+07	2.96E+07	2.20E+07		*Calculated*
Estimated Coal Losses (GJ)	1.16E+07	1.25E+07	6.94E+06	6.50E+06	7.58E+06	5.64E+06		*Calculated*
Estimated Electricity Use in Coal Mining (GJ)	6.16E+06	6.61E+06	3.67E+06	3.44E+06	4.01E+06	2.99E+06		*Calculated*

Data on Coal Imports from and Exports to Other Countries, 2000

Data on Coal Exports from China to the DPRK and Imports to China from the DPRK ***(Source 15)***

			Export			Import		
Mer. ID	Name	Unit	Amount		US $	Amount		US $
27011100	Blend coal	kg	1,024,000	$	40,960	8,142,700	$	90,332
27011100	anthracite coal	kg	1,024,000	$	40,960	8,142,700	$	90,332
27011210	agglomerating(cindery) coal	kg	100,489,900	$	3,616,390	-		-
27011290	other bituminous/soft coal	kg	17,406,100	$	519,652	-		-
27011900	other coal	kg	53,646,410	$	2,018,696	-		-
27040010	coking coal and semi-coking coal	kg	53,166,100	$	3,001,260	-		-
27060000	coke tar; oil tar from distilling minera	kg	154,500	$	37,600	-		-
			225,887,010					

Data on Coal Exports to Japan from the DPRK ***(Source 16)***

Mer. ID	Name		
27011100	anthracite coal	351,069	tonnes

Data on Coal Imports from Australia to the DPRK

Total estimated coal imports from Australia ***(see Notes 14, 23)*** 31,194 tonnes

Data on Coal Imports from and Exports to Other Countries, through 2018

Coal and coal products imports to the DPRK from China, as indicated in data collected as in ***Source 19***,

(China Customs Statistics, except for 1992 through 1994, and 2010-on, which are from UN Comtrade database) are as follows for selected years, and from other nations, from UN Comtrade statistics:

Units: metric tonnes

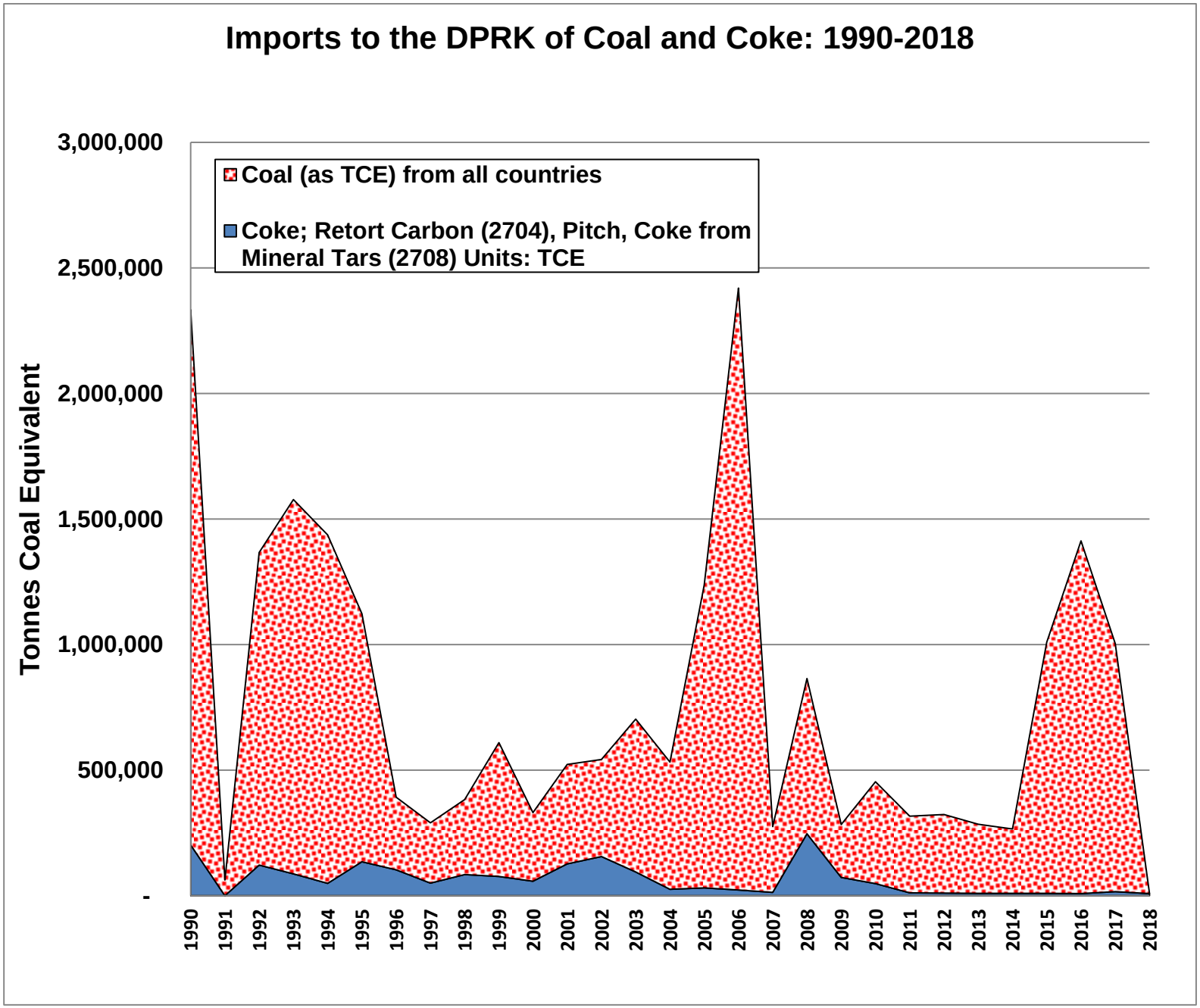
	IMPORTS FROM CHINA						
Year	Anthracite Coal	Bituminous Coal	Other Non-Agglomerated Coal and Briquettes	**Total Coals (HS 2701)**	Lignite, w hether or not agglomerated (excl. Jet) (HS 2702)	Coke; Retort Carbon (HS 2704)	Pitch, Coke from Mineral Tars (HS 2708)
1991							
1992				**1,369,165**		123,444	2,033
1993				**1,668,080**		83,335	2,671
1994				**1,552,365**		45,164	5,403
1995				**1,105,746**		96,222	23,873
1996				**323,772**	100	100,053	6,152
1997				268,440	0	48,875	2,877
1998				98,918	0	84,127	3,104
1999	2,700	429,574	2,488	434,762	55	72,971	5,635
2000	1,024	117,956	53,646	172,627		53,166	4,243
2001	200	267,697	151,954	419,851		125,497	4,306
2002	969	234,810	26,684	262,463		155,914	4,959
2003	4,867	367,315	32,969	405,152		87,141	6,179
2004	19,011	241,040	4,271	264,322		22,317	4,488
2005	4,858	142,419	195	147,471		25,878	5,721
2006	1,579	205,249	-	206,828		17,644	5,561
2007	-	227,250	-	227,250		7,534	6,186
2008	3,343	228,116	345	231,804		7,592	5,901
2009	5,674	84,234	483	90,390		3,948	7,635
2010	7,474	216,442	525	224,442	0	2,744	11,053
2011		204,214	525	204,214		3,290	8,759
2012		172,055		172,055		3,455	7,613
2013		129,041	8	129,049	29,879	2,886	7,386
2014		101,547	40	101,587	0	2,879	7,710
2015	3,057	72,617	45	75,718	0	2,493	7,391
2016	13,367	118,146	65	131,578	0	2,173	6,785
2017	7,910	47,440	96	55,446	0	2,313	12,367
2018						80	8,402
2019							
2020							

Except as shown, no 2018 inports of coal/coke into the DPRK appear in UN Comtrade data as of 3/3/2020.

	IMPORTS FROM CHINA AND OTHER NATIONS	IMPORTS FROM OTHER NATIONS					
Year	Coal Tars, Mineral Tars, Oils from Coal Tars (HS 2706, 2707, and 2709) (all from Comtrade)	Anthracite Coal (270111)	Bituminous Coal (270112)	Other Non-Agglomerated Coal (270119)	**Total Coals (HS 2701)**	Lignite, whether or not agglomerated (excl. Jet) (HS 2702)	Coke; Retort Carbon (HS 2704)
1991			70,100				
1992	208		23,432	10			
1993	3,441						
1994	233						
1995	18,961						
1996	302						
1997	36						
1998	36		147,596		234,340		
1999	272		161,737		161,737		
2000	309		82,095	20,000	102,095		2005
2001	607		23,059		23,059		
2002	484	11,274	169,432		180,706		
2003	3,955		275,975		275,975		
2004	161		301,160		301,160	1,110	
2005	927		1,200,888		1,200,888	1,263	
2006	29		2,473,908		2,473,908	1,142	
2007	157		65,669		65,669	0	
2008	240,338		192,388		192,388	0	
2009	63,227		145,349		145,349	0	
2010	35,749	9,861	219,241		229,101	74	
2011	131	6,884	65,239	65,236	137,359	20.45	
2012	8	38,972	139,366		178,338	0	
2013	233		178,676		178,676	0	
2014	18	8,840	155,523		164,363	20,045	
2015	36	0	1,002,831	10,350	1,013,181	30,115	
2016	27	0	1,320,852		1,320,852	118,600	
2017	2,343	0	662,275	0	662,275	387,464	
2018	1,133				-		22,000
2019					-		
2020					-		

David:
2008 through 2010 include relatively large reported trades from India in category 2707.

Except as shown Shaded above includes China Some years also include Imports in 2708 from other nations

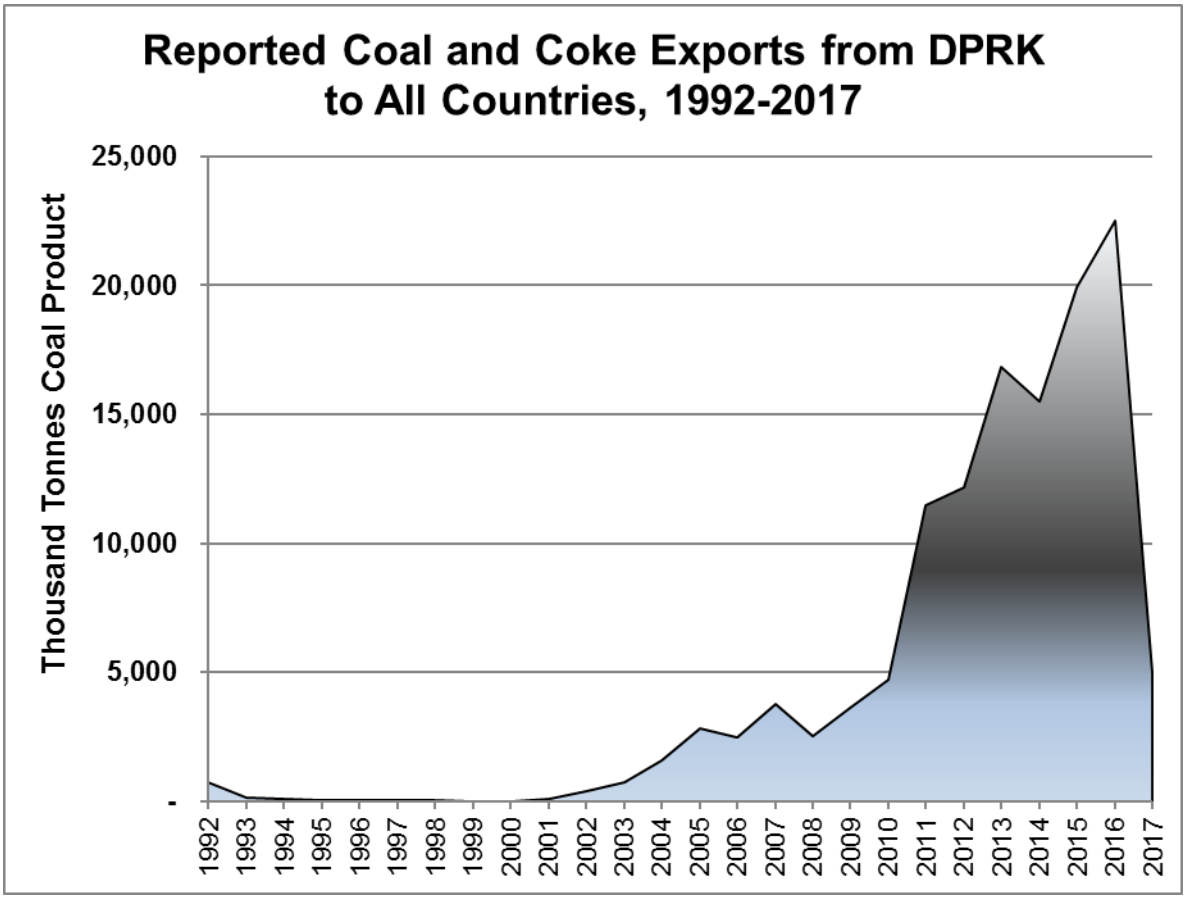

Imports to the DPRK of Coal and Coke: 1990-2018
Coal (as TCE) from all countries
Coke; Retort Carbon (2704), Pitch, Coke from Mineral Tars (2708) Units: TCE
Tonnes Coal Equivalent
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Coal and coal products exports from the DPRK to China, as indicated in data collected as in ***Source 19***,

(China Customs Statistics, except for 1992 through 1994 and for China and other countries 2010-2016, which are from UN Comtrade database) are as follows for selected years (tonnes):

	EXPORTS TO CHINA							
Year	Anthracite Coal (HS 270111)	Bituminous Coal (HS 270112)	Other Non-Agglomerated Coal	Briquettes, ovoids, and similar solid fuels manufactured from coal	**Total Coals (HS 2701)**	Lignite, whether or not agglomerated (excl. Jet) (HS 2702)	Coke and semi-coke, of coal, lignite, or peat (HS 2704)	Pitch, Coke from Mineral Tars (HS 2708)
1991								
1992					**711,150**			
1993					**154,926**			52
1994					**64,317**			184
1995					**28,836**			
1996					**33,777**			
1997					42,704			
1998					27,344			
1999					12,211			
2000					8,143			
2001					86,361			
2002					406,534			
2003					745,339			
2004					1,571,348			
2005					2,804,260	21		
2006	**2,484,991**		494		2,485,486	494		229
2007	**3,741,267**		2,177		3,743,444	2,177		
2008	**2,537,274**		2,322		2,539,596	2,322		
2009	**3,598,951**		3,083		3,602,034	3,083		
2010	**4,603,099**	1,898	6,346	36,117	4,647,459	5,644		
2011	11,169,098			122,490	11,301,133	**9,545**		
2012	11,862,908			67,654	11,932,960	**2,398**	0	
2013	16,531,693			54,617	16,616,188	**29,879**	0	
2014	15,459,494	-		37,528	15,502,032	**5,010**	0	
2015	19,578,090	82	312	51,752	19,630,236	**1,271**	3,398	
2016	22,388,634	1,901		55,779	22,446,314	**0.21**	0	
2017	4,899,906	-		12,223	4,912,129	**-**	0	12,367
2018					-			
2019					-			
2020					-			

	Exports to China and Other Nations	**EXPORTS TO OTHER NATIONS**				**Total Coal And Coke Exports from DPRK, All Nations**		Coal and Coke Exported (as thousand TCE, from DPRK to all countries)	Coal and Coke Exported (as TCE, from DPRK to all countries)
Year	Coal Tara, Mineral Tars, Oils from Coal Tars (HS 2706, 2707, 2709) (all from Comtrade)	Anthracite Coal (HS 270111)	Bituminous Coal (HS 270112)	Other Non-Agglomerated Coal, and Briquettes, ovoids, and similar solid fuels manufactured from coal	Lignite, whether or not agglomerated (excl. Jet) (HS 2702)				
1991							1990	1,505	1,505,389
1992	4					711.15	1991	441	441,177
1993						154.98	1992	954	954,276
1994	100					64.60	1993	545	545,224
1995	350					29.19	1994	420	419,944
1996	1,166					34.94	1995	383	382,828
1997	251					42.95	1996	414	413,985
1998	193					27.54	1997	390	389,620
1999	277					12.49	1998	334	333,738
2000	0					8.14	1999	234	233,782
2001	1					86.36	2000	318	318,029
2002						406.53	2001	441	440,581
2003	16					745.36	2002	674	673,775
2004	5					1,571.35	2003	957	957,443
2005	924					2,805.20	2004	1,618	1,617,797
2006	245					2,486.45	2005	2,728	2,728,013
2007	221					3,745.84	2006	2,298	2,298,287
2008	5					2,541.92	2007	3,314	3,314,263
2009		831				3,605.95	2008	2,272	2,272,477
2010	279	39,266	0	0	0	4,692.65	2009	3,212	3,211,709
2011	5,002	130,496		16,500		11,462.68	2010	4,155	4,154,643
2012	12,402	203,890		14,793		12,166.44	2011	10,148	10,148,498
2013	5,484	207,996			0	16,859.55	2012	10,772	10,771,580
2014	406	217	0	0	0	15,507.67	2013	14,927	14,926,626
2015	307	282,790	0	0	0	19,918.00	2014	13,730	13,729,735
2016	48	81,279	0	0	0	22,527.64	2015	17,631	17,631,425
2017	5,744	6,342	0	0	0	4,936.58	2016	19,945	19,944,882
2018						58.80	2017	4,360	4,359,661
2019							2018	-	-
2020								-	-
								-	-


Reported Coal and Coke Exports from DPRK to All Countries, 1992-2017
Thousand Tonnes Coal Product
25,000
20,000
15,000
10,000
5,000
-
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

Coal and coal products exports from the DPRK (country code 104 in Japan's trade statistics) to Japan as indicated in data collected as in ***Source 16***, (Japan Customs Statistics) are as follows for 1990 through 2011:

Mer. ID	Name
27011100	anthracite coal

Year	Tonnes	Average Cost, 1000 Yen/tonne	Value, 1000 Yen	
1988	497,794			1988 and 1989 values from UN Comtrade database
1989	501,597			
1990	528,329	6.73	3,558,217	
1991	498,307	6.40	3,187,789	
1992	366,700	5.88	2,156,175	
1993	459,585	4.82	2,216,519	
1994	409,931	4.15	1,702,676	
1995	403,566	3.89	1,570,310	
1996	428,772	4.89	2,094,622	
1997	397,370	5.48	2,177,716	
1998	349,611	5.49	1,918,955	
1999	251,844	4.23	1,065,360	
2000	351,069	3.61	1,266,121	
2001	411,178	4.06	1,668,661	
2002	354,491	4.15	1,470,955	
2003	333,545	3.75	1,250,831	
2004	255,945	4.47	1,144,447	
2005	277,017	6.95	1,924,606	
2006	110,418	8.42	929,947	
2007	-	-	-	No imports at all to Japan from DPRK listed for 2007
2008	-	-	-	No imports at all to Japan from DPRK listed for 2008
2009	-	-	-	No energy imports at all to Japan from DPRK listed for 2009
2010	-	-	-	No energy imports at all to Japan from DPRK listed for 2010
2011	-	-	-	No energy imports at all to Japan from DPRK listed for 2011
2012	-	-	-	No energy imports at all to Japan from DPRK listed for 2012
2013	-	-	-	No energy imports at all to Japan from DPRK listed for 2013
2014	-	-	-	No energy imports at all to Japan from DPRK listed for 2014
2015	-	-	-	No energy imports at all to Japan from DPRK listed for 2015
2016	-	-	-	No energy imports at all to Japan from DPRK listed for 2016
2017	-	-	-	No energy imports at all to Japan from DPRK listed for 2017
2018	-	-	-	No energy imports at all to Japan from DPRK listed for 2018
2019	-	-	-	No energy imports at all to Japan from DPRK listed for 2019
2020	-	-	-	Energy imports by Japan have yet been listed for 2020

Notes:

1 1989 value from document in authors' files [HT1]. Other estimates are as high as 87 total Mte, and as low as 43 (both for 1990), and more recent outside ROK estimates are even lower (For example, the ROK's MOCIE and the Korean National Statistical Office estimate 1990 output of 33.15 million tonnes, declining to 21 million tonnes in 1996. Based on other information we have received, and on our analysis of DPRK energy demand in 1990 and 1996, these estimates appear too low.

2 Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 14.

3 Imports to NK. Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 23. Based on various statistics, including UN (Note that UN Comtrade statistics for coke trades with the DPRK for 1990 include only 3500 tonnes imported from Japan, so the imports cited by Choi are likely to have been be "off-book", at least as far as the UN statistics are concerned.

4 J. Sinton, Editor, China Energy Databook, 1992 (Revised 1993). LBL. Page xii. Coal import figure assumes washed Chinese coal.

5 Exports to China. Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 25. Based on various statistics, including UN

6 Raw coal production electricity use, China, 1980, from "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL

7 Coal use in coal mining from [Chinese language spreadsheet dated 12-Feb-93 provided by J. Sinton],

8 Young Sik Jang, North Korean Energy Economics, Korea Development Institute, 1994 (p. 179). Value in this source for import coal to NK is within 1% of value for washed Chinese coal from reference 4.

10 Official 1989 value from document in authors' files [EE1].

11 J. Sinton, Editor, China Energy Databook (Revised 1996). Lawrence Berkeley National Laboratory (LBNL). Value is for the year 1993. Page VII-8.

12 All coke imports to the DPRK in 1996, 2005, 2008 through 2010, and 2014 through 2017 that were reported in customs statistics (Comtrade) came from China. Coke imports in these yeara are therefore assumed to be equal to imports from China as reflected in customs statistics, plus **10%** *to reflect additional "off-books" imports from China not reported in customs statistics, plus small-volume, non-reported imports from other countries, such as Russia.*

13 Set so as to balance demand+exports-imports. For 1996, value is consistent with the notes of some observers suggesting that coal output in that year was about half what it was in 1990, though estimates of of DPRK coal output over the years vary significantly. For 2005, the value shown is reasonably consistent with the "24.6 million tonnes of anthracite" figure provide in the State of the Environment DPR Korea 2003 report prepared with UNDP, and published by the United Nations Environment Programme, although the comparison depends on the conversion factor used. Of course, the value in the "SOE" report would have been a projection at the time that the report was written, but it is quite close to the value of 24 million tonnes cited by ROK sources (MOCIE, the National Statistical Service) for DPRK coal output in 2005. By comparison, the implied domestic coal output estimated here for 2000 is on the order of 25 to 35 percent lower than the 22.5 million tonnes that ROK sources (same as above) estimate for the DPRK. Values estimated above for 2008 and 2009 coal output are similarly somewhat lower than those estimated by ROK sources (25.06 and 25.50 million tonnes, respectively), though again the comparison depends on the coal heat content used by the ROK analysts, which is not immediately clear from our reading of the source material.

Notes:

1 1989 value from document in authors' files [HT1]. Other estimates are as high as 87 total Mte, and as low as 43 (both for 1990), and more recent outside ROK estimates are even lower (For example, the ROK's MOCIE and the Korean National Statistical Office estimate 1990 output of 33.15 million tonnes, declining to 21 million tonnes in 1996. Based on other information we have received, and on our analysis of DPRK energy demand in 1990 and 1996, these estimates appear too low.

2 Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 14.

3 Imports to NK. Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 23. Based on various statistics, including UN (Note that UN Comtrade statistics for coke trades with the DPRK for 1990 include only 3500 tonnes imported from Japan, so the imports cited by Choi are likely to have been be "off-book", at least as far as the UN statistics are concerned.

4 J. Sinton, Editor, China Energy Databook, 1992 (Revised 1993). LBL. Page xii. Coal import figure assumes washed Chinese coal.

5 Exports to China. Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 25. Based on various statistics, including UN

6 Raw coal production electricity use, China, 1980, from "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL

7 Coal use in coal mining from [Chinese language spreadsheet dated 12-Feb-93 provided by J. Sinton],

8 Young Sik Jang, North Korean Energy Economics, Korea Development Institute, 1994 (p. 179). Value in this source for import coal to NK is within 1% of value for washed Chinese coal from reference 4.

10 Official 1989 value from document in authors' files [EE1].

11 J. Sinton, Editor, China Energy Databook (Revised 1996). Lawrence Berkeley National Laboratory (LBNL). Value is for the year 1993. Page VII-8.

12 All coke imports to the DPRK in 1996, 2005, 2008 through 2010, and 2014 through 2017 that were reported in customs statistics (Comtrade) came from China. Coke imports in these yeara are therefore assumed to be equal to imports from China as reflected in customs statistics, plus **10%** *to reflect additional "off-books" imports from China not reported in customs statistics, plus small-volume, non-reported imports from other countries, such as Russia.*

13 Set so as to balance demand+exports-imports. For 1996, value is consistent with the notes of some observers suggesting that coal output in that year was about half what it was in 1990, though estimates of of DPRK coal output over the years vary significantly. For 2005, the value shown is reasonably consistent with the "24.6 million tonnes of anthracite" figure provide in the State of the Environment DPR Korea 2003 report prepared with UNDP, and published by the United Nations Environment Programme, although the comparison depends on the conversion factor used. Of course, the value in the "SOE" report would have been a projection at the time that the report was written, but it is quite close to the value of 24 million tonnes cited by ROK sources (MOCIE, the National Statistical Service) for DPRK coal output in 2005. By comparison, the implied domestic coal output estimated here for 2000 is on the order of 25 to 35 percent lower than the 22.5 million tonnes that ROK sources (same as above) estimate for the DPRK. Values estimated above for 2008 and 2009 coal output are similarly somewhat lower than those estimated by ROK sources (25.06 and 25.50 million tonnes, respectively), though again the comparison depends on the coal heat content used by the ROK analysts, which is not immediately clear from our reading of the source material.

Coal Imports to the DPRK from China *Units: Metric Tonnes*

Commodity Code	Product/Product Group
2701	SOLID FUELS FROM COAL
270111	ANTHRACIT COAL,N AG
270112	BITUMNOUS COAL,N AG
270119	OTHER COAL,NT AGGLM
270120	OTHER 2701
2702	LIGNITE,EXCLUDING JET

	Commodity Code					
Year	2701	270111	270112	270119	270120	2702
1992	1,369,165		1,369,165			
1993	1,668,080	6,593	1,593,195			
1994	1,552,365	37,871	1,505,994			
1995	1,105,746	17,434	1,030,173	58,140		
1996	323,672	3,412	311,235	9,025		100
1997	268,440	10,898	257,047	495		
1998	98,918	1,770	97,148			
1999	434,762	2,700	429,574	2,488		55
2000	172,627	1,024	117,956	53,646		
2001	419,851	200	267,697	151,954		
2002	262,523	969	234,810	26,684	60	
2003	405,152	4,867	367,315	32,969		
2004	264,357	19,011	241,040	4,271	35	
2005	147,471	4,858	142,419	195		
2006	206,828	1,579	205,249			
2007	227,250	0	227,250	*0*	0	
2008	231,804	3,343	228,116	345		
2009	90,390	5,674	84,234	*0*	483	
2010	224,442	7,474	216,442	-	525.3	0
2011	204,214	0	204,214	*0*	0	
2012	172,055	0	172,055	*0*	0	
2013	129,041	0	129,033	*0*	7.9	29,879
2014	101,587	0	101,547	40	0	0
2015	75,718	3,057	72,617	44.5	0	0
2016	131,578	13,367	118,146	0	65	0
2017	55,446	7910	47,440	0	*96.44*	0
2018*	-	0	-	0	*0*	0

* No trades with China in category 2701 or 2702 reported in Comtrade database as of 3/6/2020

Imports to the DPRK from China of Code 2704, "Coke and Semi-Coke....", 2708, "Pitch and Pitch coke from coal...", and "Asphalt or similar materials....".

Year	Code 2704	Code 2708	Code 6807
			Units: Metric Tonnes
1992	123,444	2,033	
1993	83,335	2,671	
1994	45,164	2,025	
1995	96,222	5,403	
1996	100,053	23,873	
1997	48,875	2,877	
1998	84,127	3,104	
1999	72,971	5,635	
2000	53,166	4,243	
2001	125,497	4,306	
2002	155,914	4,959	
2003	87,141	6,179	
2004	22,317	4,488	
2005	25,878	5,721	
2006	17,644	5,561	
2007	7,534	6,186	
2008	7,592	5,901	
2009	3,948	7,749	
2010	2,744	11,053	
2011	3,290	8,759	
2012	3,455	7,613	
2013	2,886	7,386	861
2014	2,879	7,710	692
2015	2,493	7,391	630
2016	2,173	6,785	837
2017	2,313	12,367	678
2018	80	8,402	-

Exports from the DPRK to China *Units: Metric Tonnes*

Commodity Code	Product/Product Group	2000	2001	2002	2003	2004	2005
2701	SOLID FUELS FROM COAL	8,143	86,361	406,534	745,339	1,571,348	2,804,260
2706	MINERAL TARS						920
2702	LIGNITE,EXCLUDING JET						21

Exports from the DPRK to China *Units: Metric Tonnes*

Commodity Code	Product/Product Group	2006	2007	2008	2009	2010	2011	2012
2701	SOLID FUELS FROM COAL	2,484,991	3,741,267	2,537,274	3,598,951	4,645,160	11,169,098	11,862,908
2706	MINERAL TARS	229	208	5				
2702	LIGNITE,EXCLUDING JET	494	2,177	2,322	3083	5,644	9,545	2,398
2701	SOLID FUELS FROM COAL--Value					$ 396,000,802	1,153,811,899	$ 1,215,197,712
	Implied average cost per tonne					$ 85.25	$ 103.30	$ 102.44

Commodity Code	Product/Product Group	2013	2014	2015	2016	2017	2018*
2701	SOLID FUELS FROM COAL	16,531,693	15,459,494	19,630,236	22,446,314	4,912,129	0
2706	MINERAL TARS					-	0
2702	LIGNITE,EXCLUDING JET	29,879	5,010		0.21	-	0
2701	SOLID FUELS FROM COAL--Value	$ 1,394,437,429	$1,143,172,194	$ 1,050,972,221	$ 1,182,762,524	$ 410,358,802	0
	Implied average cost per tonne	$ 84.35	$ 73.95	$ 53.54	$ 52.69	$ 83.54	0

* No trades with China in category 2701, 2701, or 2706 reported in Comtrade database as of 3/6/2020

21 *The report DPR KOREA : STATE OF THE ENVIRONMENT 2003, published by the United Nations Environment Programme, lists (tables 3.15 and 3.16) anthracite coal "primary consumption" of* 45,409 *thousand tonnes, "bitumimous coal" primary consumption of* 11,934 *thousand tonnes, and total coal consumption of* 60,000 *thousand tonnes. Given that the DPRK is said to have very limited reserves of bituminous coal, and lignite coal is not listed in the tables referenced, we consider 21 million tonnes of lignite to be more believable.*
A set of figures in the authors' files [NKES-01], dated 2001 and citing a DPRK source, lists 1991 output figures that are similar to the above--45.4 million tonnes anthracite, 14.3 million tonnes of lignite, and 365,000 tonnes of "raphaelite". This appears roughly consistent with an estimate of 70 million tonnes for 1990, given that production declined after 1990. The same source provided the following coal production estimates for other years.

Yearly coal production rates

Year	1991	1992	1993	1994	1995	1996	1997
Million* Tonnes	60	59	58	52.8	37.8	27.2	27
Year	1998	1999	2000				
Million* Tonnes	22	22.1	22.3				

** Stated by the source as "kilo-tonnes", which seems clearly to have been a units error.*

22 *The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 10/19/10, 8/23/12, and 5/30/2018) includes the following statistics on exports from Russia to the DPRK of coal products:*

	HS2701 = Coal			HS2702 = Lignite			HS2704 = Coke		
Period	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne
1998	$3,859,085	86,743,500	$ 44.49						
1999	$6,043,451	161,737,000	$ 37.37						
2000	$3,028,770	82,094,700	$ 36.89				$136,340	2,005,000	$ 68.00
2001	$898,866	23,059,100	$ 38.98						
2002	$3,947,190	158,158,020	$ 24.96						
2003	$5,041,736	214,629,750	$ 23.49						
2004	$11,634,797	301,159,810	$ 38.63	$20,863	1,110,000	$ 18.80			
2005	$53,522,090	1,170,252,170	$ 45.74	$28,039	1,263,000	$ 22.20			
2006	$101,085,805	2,277,528,770	$ 44.38	$24,331	1,142,300	$ 21.30			
2007	$3,274,753	65,668,900	$ 49.87						
2008	$15,198,654	192,388,250	$ 79.00						
2009	$4,937,349	37,719,950	$ 130.89						
2010	$10,982,385	87,457,440	$ 125.57	$2,005	37,000	$ 54.19			
2011	$828,838	6,886,950	$ 120.35	$1,499	20,450	$ 73.30			
2012	$19,292,577	178,338,100	$ 108.18						
2013	$19,921,297	178,675,600	$ 111.49						
2014	$12,858,033	164,363,050	$ 78.23	$1,233,323	20,044,600	$ 61.53			
2015	$44,676,477	992,480,730	$ 45.01	$1,134,883	30,114,500	$ 37.69			
2016	$51,096,897	1,231,677,750	$ 41.49	$3,465,720	118,599,950	$ 29.22			
2017	$39,596,356	662,275,100	$ 59.79	$14,040,594	387,463,750	$ 36.24			
2018	No trades in category 2701, 2702, or 2704 reported in Comtrade database as of 3/6/2020								

	HS270111 = Anthracite Coal			HS270112 = Bituminous Coal			HS6807 = "Articles of Asphalt or Similar Material (for example, petroleum bitumen or coal tar pitch)		
Period	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne
2008				$15,198,654	192,388,250	$ 79.00			
2009				$4,937,349	37,719,950	$ 130.89			
2010	$1,610,129	9,860,550	$ 163.29	$9,372,256	77,596,890	$ 120.78			
2011	$825,270	6,883,950	$ 119.88	$3,568	3,000	$ 1,189.33	$14,075	7,529	$ 1,869.44
2012									
2013									
2014	$585,986	8,840,000	$ 66.29	12,272,046	155,523,050	$ 78.91			
2015	0	0	N/A	$44,676,477	992,480,730	$ 45.01			
2016	$0	0	N/A	$ 51,096,897	1,231,677,750	$ 41.49			
2017	$0	0	N/A	$ 39,596,356	662,275,100	$ 59.79			
2018	No trades in category 2701, 2702, or 2704 reported in Comtrade database as of 3/6/2020								

23 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 3/11/11) includes the following statistics on exports from Australia to the DPRK of coal products:

	HS2701 = Coal			HS2702 = Lignite			HS2707 = Coal tar distillation products including oils		
Period	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne
1991	$1,488,759	35,000,000	$ 42.54						
1993							$160,309	2,000,000	$ 80.15
2000	$967,029	31,194,000	$ 31.00						

24 Though this is the roughest of estimates, it is of the same order of magnitude as the 0.5% implied for coal transport in the western US in Exporting Powder River Basin Coal: Risks and Costs, by the Western Organization of Resource Councils, dated January, 2011, available as http://www.worc.org/userfiles/file/Coal/Exporting_Powder_River_Basin_Coal_Risks_and_Cost.pdf. Of course, the transport distance for this US example, is much further than the average in the DPRK, but loading, unloading, and other coal transport infrastructure is likely better in the US. As another example, a 2006 calculation of fuel costs adjustments for electricity generation in the Indian state of Punjab used a coal loss factor of 0.8%, also in the same range as the assumed value (see http://pserc.nic.in/pages/7_2006.html). Yet another example from India is "Case Study Of The Damodar Valley Region", a chapter in an industrial ecology book, probably dated late 1990s, and available as http://www.roionline.org/books/Industrial%20ecology_chapter09_Damodar_Coal.pdf. This example suggests about 4 percent losses during transport, with an additional 6 percent losses during storage, though these estimates may also include pilferage.

25 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/27/2012 and 5/30/2018) includes the following statistics on exports from Indonesia to the DPRK of coal products:

	HS2701 = Coal			HS270112 = Bituminuous Coal			
Period	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	
2003	$1,525,650	61,345,000	$ 24.87	$1,525,650	61,345,000	$ 24.87	
2005	$965,034	30,636,000	$ 31.50	$965,034	30,636,000	$ 31.50	
2006	$6,199,674	196,379,000	$ 31.57	$6,199,674	196,379,000	$ 31.57	
2009	$4,907,379	107,628,922	$ 45.60	$4,907,379	107,628,922	$ 45.60	
2010	$8,578,390	141,643,841	$ 60.56	$8,578,390	141,643,841	$ 60.56	
2011	$4,239,690	65,236,000	$ 64.99	$4,239,690	65,236,000	$ 64.99	
2012							*No trades reported*
2013							*from 2011*
2014							*through 2014*
2015	*$277,380*	*10,350,000*	$ 26.80				
2016	$5,117,696	89,174,000	$ 57.39	$ 5,117,696	89,174,000	$ 57.39	
2017							*No trades reported in 2017*
2018							*No trades reported in 2018*

26 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/27/2012) includes the following statistics on exports from South Africa to the DPRK of coal products:

	HS2701 = Coal			HS270112 = Bituminuous Coal			HS2707 = Coal tar distillation products including			
Period	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	Trade Value	NetWeight (kg)	Implied Cost/tonne	Bituminous Cost/Ton for other NK imports
1992	$1,062,038	23,431,881	$ 45.32	$1,062,038	23,431,881	$ 45.32				*$ 45.32*
1998	$2,678,710	60,852,583	$ 44.02	$2,678,710	60,852,583	$ 44.02				*$ 44.02*
2001							$488,667	494,000	$ 989.20	
2002							$43,059	64,000	$ 672.80	
2008	$15,711,583	267,672,000	$ 58.70	$15,711,583	267,672,000	$ 58.70				

27 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/27/2012) includes the following statistics on trade in coal products with other nations not listed individually above (very small trades of less than 100 tons are mostly overlooked here):

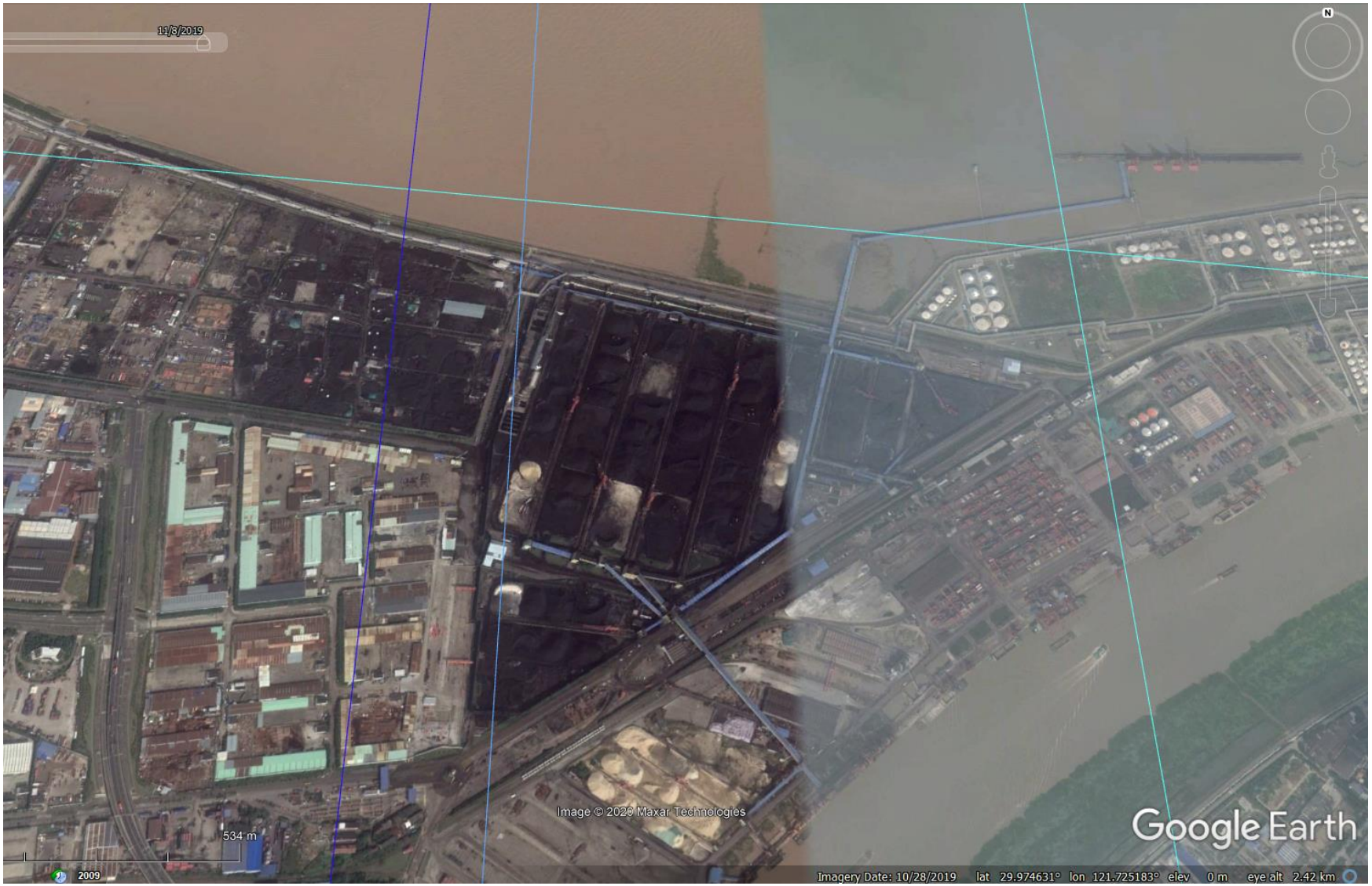
Period	Nation	Product (HS Code)	Import to the DPRK/ Export From the DPRK	Trade Value	NetWeight (kg)	Implied Cost/tonne	
1989	Malaysia	270112	Import	$309,954	8,000,000	$ 38.74	
1991	Canada	270112	Import	$1,319,479	27,500,000	$ 47.98	
1991	Malaysia	270112	Import	$112,531	7,600,000	$ 14.81	
1993	India	2708	Export	$348,724	1,200,000	$ 290.60	
1994	Singapore	270400	Export	$15,247	70,000	$ 217.81	
1996	Mauritius	270400	Export	$18,104	38,250	$ 473.31	
1996	South Africa	2708	Export	$931,029	4,558,000	$ 204.26	
2000	Vietnam	270119	Import	$380,000	20,000,000	$ 19.00	
2001	Bangladesh	270111	Export	$3,907	95,000	$ 41.13	
2002	Vietnam	270111	Import	$665,165	11,274,196	$ 59.00	
2003	Brazil	2708	Export	$551,446	2,317,000	$ 238.00	
2004	Brazil	2708	Import	$80,945	177,820	$ 455.21	
2005	Brazil	2708	Import	$58,249	128,060	$ 454.86	
2006	Brazil	2708	Import	$122,966	208,169	$ 590.70	
2007	Brazil	2708	Import	$167,043	237,096	$ 704.54	
2008	Brazil	2708	Import	$211,702	251,106	$ 843.08	
2008	Dominican Republic	270400	Export	$4,829,006	24,743,204	$ 195.16	
2009	Brazil	2708	Import	$158,700	175,110	$ 906.29	
2010	Brazil	2708	Import	$172,535	207,810	$ 830.25	
2011	Brazil	2708	Import	$109,072	93,950	$ 1,160.96	
2012	Other Asia NES	2701	Export	$32,501,092	218,683,000	$ 148.62	
2013	Other Asia NES	2701	Export	$29,399,416	207,996,000	$ 141.35	
2014	Other Asia NES	2701	Export	$29,712,093	216,881,000	$ 137.00	Quantity in Comtrade reported as 216,881 kg, which we assume is intended to be tonnes
2015	Other Asia NES	2701	Export	$24,317,157	282,790,000	$ 85.99	
2016	Other Asia NES	2701	Export	$4,221,057	81,279,000	$ 51.93	

28 *The following is an example of coal in storage at docks at Rason port, Google Earth image, 12/14/18*
Assumes pulverized coal bulk density of: 0.6 tonnes/cubic meter (see,
for example, https://www.binmaster.com/_resources/dyn/files/75343622z9caf67af/_fn/Bulk%20Density.pdf.

	Estimates (m) of					Approximate		
Number	Width	Length	Height	Implied Total Volume (cubic meters)	Implied Total mass (tonnes)	Latitude	Longitude	Notes
2	38	220	10	83,600	50,160	42.228	130.284	New-looking piers for storage; upper and lower piers look like they had coal piles located there recently..
Total of above				83,600	50,160			

29 *Although there are in fact no trades in the major coal categories involving the DPRK reported in Comtrade in 2018, at least as of 3/3/2020, a number of different authors suggest that off-books coal shipments from the DPRK to other nations, largely China and Russia, continue even in the presence of UNSC sanctions. See, for example, "A Snapshot of North Korea's Supply Chain Coal Activity",* ***38 North****, dated March 8, 2019, analysis by Peter Makowsky, Jenny Town and Samantha Pitz, a available as https://www.38north.org/2019/03/supplychaincoal030819/, and Ariel Cohen, "North Korea Illegally Trades Oil, Coal, With China's Help", Forbes, dated March 21, 2019, and available as https://www.forbes.com/sites/arielcohen/2019/03/21/north-korea-illegally-trades-oil-coal-with-chinas-help/#507e3b34301a. For 2018, our assumption is that the DPRK must have exported a significant amount of coal through off-books trades, probably mostly to China and Russia, to explain the continuing activity at mines described above, and to attempt to continue to generate foreign exchange revenue. We have not, to date, seen a full estimate of the annual volume of coal that might have been shipped in 2018 in evasion of sanctions, but the March 5, 2019* **Report of the Panel of Experts established pursuant to resolution 1874 (2009)***, includes anecdotal mention of potential ship-to-ship coal transfers allegedly used by the DPRK to circumvent UNSC sanctions restricting exports of coal. One anecdotal example (pages 23 and 24, plus annexes) of a vessel identified in the Panel of Experts report as being involved in ship-to-ship transfers of DPRK coal was carrying about 25,000 tonnes of coal worth about $3 million. It seems likely that other such shipments successfully reached their destinations during 2018. The Panel of Experts report suggests that the DPRK's largest coal freighters docked "monthly" at ports in the DPRK to load coal. A report from the Royal United Service Institute (RUSI),* ***The Phantom Fleet: North Korea's Smugglers in Chinese Waters****, by James Byrne, Joe Byrne, Gary Somerville and Hamish Macdonald, undated, but released in March, 2020, and available as https://rusi.org/sites/default/files/20200305_sandstone_phanton_fleet_final.pdf, tracks numerous DPRK vessels showing movements consistent with delivering coal to mostly Chinese ports via ship-to-ship transfers. An additional Panel of Experts report, number S/2019/691,* ***Report of the Panel of Experts established pursuant to resolution 1874 (2009)****, dated 30 August 2019, and available from https://undocs.org/S/2019/691, includes "According to a Member State, it is believed to have exported a total of 930,000 metric tons of coal through at least 127 deliveries during the first four months of 2019. In a reply to the Panel of Experts, a Chinese representative noted "the information provided by the Panel lacks timeliness and can not lead to on-site investigation. The information of relevant vessels is ambiguous and lacks accuracy, which does not constitute a full evidence chain or basis for further investigation." The DPRK ships tracked by the Panel of Experts appear to have deadweight capacities in the range from 1000 to 20,000 tonnes, as indicated by the Panel of Experts, and some of the vessels tracked by RUSI seem to be larger, some over 25,000 tonnes. The RUSI report documented "...around 175 separate trips to the [Zhoushan, on the coast south of Shanghai] area, often visiting the the same regions and anchorages next to major bulk-handling facilities where barges and other vessels designed to transfer cargo between vessels operate." Images of bulk storage/coal terminals in the Zhoushan area, from Google Earth Pro, are at right. Assuming that the number of deliveries noted by the Panel of Experts in early 2019 is both reasonably accurate and representative of the pattern of off-books deliveries during 2018, and lacking further details of this trade, we make the rough assumption that about 400 successful deliveries occurred in 2018, each transfering an average of 7,000 tonnes of coal. This would yield exports of* 2,800,000 *tonnes of coal, substantially less than reported exports in recent years, but still worth on the order of $300 million. Indications from these documents, plus the earlier Panel of Experts docuument S/2018/171,* ***Report of the Panel of Experts established pursuant to resolution 1874 (2009)****, dated 5 March 2018 and available as https://www.undocs.org/S/2018/171, are that off-books coal trades in violation of UNSC saNCTIONS probably started in 2017, when UNSC sanctions on DPRK coal exports came into force in . Annex 5-2 of that document includes reference to 23 transfers in 2017 after the in-force day of sanctions. Only some of these reports of transfers include eplicit references to volumes transferred, and those that do indicate a range of about 5000 to 20,000 tonnes per transfer. It seems likely that not all transfers in actually delivered in late 2017 appear on the Panel of Experts list. We therefore assume that about 50 off-books transfers at an average of about 7000 tonnes each occurred in 2017, for a total volume transferred of about* 350,000 tonnes.

Coal/bulk storage terminal on the coast near Ningbo, approximate coordinates 29.975, 121.725, image date November 2019.

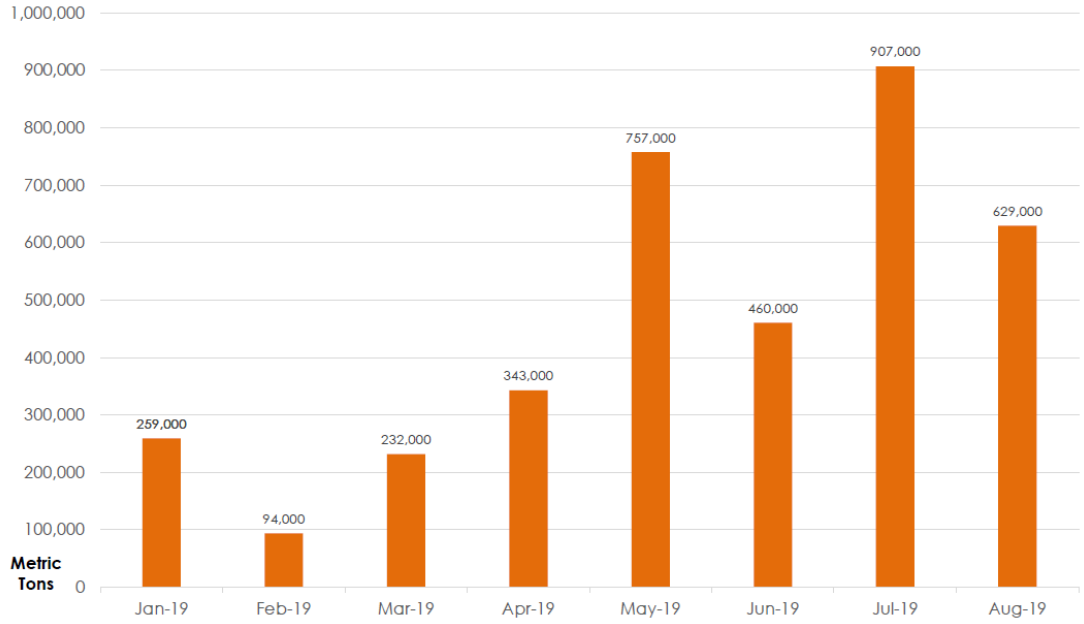


Coal/bulk storage terminal on the island of Zhoushan, approximate coordinates 30.056, 121.979, image date November 2019.

30 Following is a Google Earth Pro image of a coal port along the lower Taedong River in Nampo. Image taken November 2019, approximate coordinates 38.730, 125.415.

31 Following is a Google Maps image of a small coal port along the lower Yalu River in Sinuiju. Image probably taken in Spring of 2020,. approximate coordinates 40.093403, 124.370793. Coal trucks visible. Not clear if coal is being off-loaded from the ships for delivery by truck, or vice-versa, but we suspect that this particular image shows coal being collected for shipment via sea, either to elsewhere in the DPRK of to be exported. Note that this image also includes, at the bottom left, an image of a pile of sand. Sand exports in violation of UNSC sanctions have also taken place in recent years (see reference in note 32, page 39 and 40), although we do not know if exports from this particular port are involved in these sand export operations.

32 *The UNSC "Panel of Experts" in UNSC (2020),* ***Note by the President of the Security Council****, number S/2020/151, dated 2 March 2020, and including "Annex: Letter dated 26 February 2020 from the Panel of Experts established pursuant to resolution 1874 (2009) addressed to the President of the Security Council", available as https://undocs.org/S/2020/151, includes information on estimated exports to China from the DPRK of coal by ship. Based on US estimates, the report places the quantity of coal exported in violation of sanctions at* 3.7 million tonnes *over the period from January through August, 2019 (see figure below, from paragraph 55, page 25 and 26 of source document. Most of this export quantity was estimated to be "conducted via ship-to-ship transfers from [DPRK]-flagged vessels to Chinese local barges, but other methods of transfers, including the use of self-propelled Chinese barges over 100 m in length undertaking ocean journeys, the use of larger foreign-flagged vessels to carry DPRK coal, and the use of a bulk carrier from China that was supposed to have been broken up for scrap as a carrier by the DPRK for coal exports, were also reported. Assuming the estimate of January to August exports above and in the figure below to be approximately accurate, an extrapolated value for the entire year of 2019 would be* 5.55 million tonnes. Given that detected *(suspected) off-books coal shipments increased in May through August, relative to the early part of 2019, this estimate may in fact be low.*



33 *No UN Comtrade data on DPRK coke and related products imports in 2019 or 2020 are available as of late April 2019. We assume that 2019 imports were* 100% *of 2018 imports, and that 2020 imports will be lower, about* 40% *of 2018 levels, due to reduced trade due to Covid-19-related border restrictions in the DPRK.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
OIL IMPORTS, EXPORTS, AND REFINING

Prepared By David Von Hippel
Date Last Modified: 6/19/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

						Source/Note:
Domestic Crude Oil Production			0	te		
Crude Oil Imports, Total			2.60E+06	te		1
Conversion Factor			4.26E+01	GJ/te		
Crude Oil Imports, Total			1.11E+08	GJ		
Refined Products Imports						
	FUEL	te	toe/te	Toe		
	Gasoline	1.20E+05	1.05E+00	1.26E+05		3
	Kerosene	5.00E+04	1.03E+00	5.16E+04		3
	Diesel	3.00E+05	1.03E+00	3.10E+05		3
	Heavy Oil	1.50E+05	9.91E-01	1.49E+05		3
	TOTAL			6.36E+05	toe	
Conversion Factor			4.1868E+01	GJ/toe		
Total Refined Products Imports				2.66E+07	GJ	
Total Oil Imports				1.37E+08	GJ	
Energy Use in Refining--West Coast Refinery			0.0578	toe/te of input		2
Energy Use in Refining-East Coast Refinery			0.0523	toe/te of input		17
Conversion Factor			4.1868E+01	GJ/toe		
Total Refining Losses			6.29E+06	GJ		
Production of Refined Products, Total			1.04E+08	GJ		

LPG Consumption	2.55E+03	te		4
Conversion Factor	4.24E+01	GJ/te		
LPG Consumption, Total	1.08E+05	GJ		

ESTIMATE OF CURRENT AND FUTURE CRUDE OIL AND OIL PRODUCTS SUPPLY						
Input Data for the Year 1996						
Crude Oil Imports from China, 1st through 3rd Quarters, 1996			7.48E+05	tonnes		5
Recorded Crude Oil Imports from China, all of 1996			936,170	tonnes		30
Estimate of other crude oil imports, 1996			0.00E+00	tonnes		13
Conversion Factor			4.26E+01	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 1996			3.99E+07	GJ		
Official Refined Prod. Imports from China, 1st - 3rd Q., 1996			42,744	tonnes		5,6
Recorded Refined Products Imports from China, all of 1996			68,378	tonnes		30
Conversion Factor		1.050	toe/te			
HFO Supplied by KEDO, 1996 (11/1/95 to 10/31/96)			**500,000**	tonnes		7
Est. Conversion Factor, KEDO Oil		1.00	toe/te			
Other Imports of Refined Products, 1996	tonnes		toe/te	GJ		
Gasoline	1.26E+05		1.050	5.54E+06		14
Kerosene	1.20E+04		1.032	5.18E+05		14
Diesel	1.20E+05		1.032	5.18E+06		14
HFO	9.40E+04		0.991	3.90E+06		14
LPG/Refinery Gas/Non-Energy	3.70E+03		1.012	1.57E+05		
Total Estimated Refined Product Imports to DPRK, 1996			3.92E+07	GJ		
Estimated Refined Product Exports from DPRK, 2000 (all countries)			tonnes	GJ		
HFO			-	0.00E+00		
LPG/Refinery Gas/Non-Energy			12,300.08	5.21E+05		
Total of above			12,300	5.21E+05		
Estimated HFO placed in storage, 1996			154,538	tonnes		8
			6.41E+06	GJ		8

Input Data for the Year 2000					
DPRK Crude Oil Production		7,000	tonnes		*27*
Reported Crude Oil Imports from China, 2000		3.89E+05	tonnes		*18*
Other Imports of Crude Oil from China not Reported to Customs		0.00E+00	tonnes		
Total Estimated Crude Oil Imports from China, 2000		3.89E+05	tonnes		
Estimate of other crude oil imports, 2000 (unknown source)		0.00E+00	tonnes		*See below*
Conversion Factor		4.26E+01	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2000		1.66E+07	GJ		
Official Refined Prod. Imports from China, 2000		1.17E+05	tonnes		*18*
Extrapolated Official Refined Prod. Imports from China, 2000		1.17E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by KEDO, 2000 (1/1/2000 to 12/31/2000)		**394,722**	tonnes		*19*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2000	tonnes	toe/te	GJ		
Gasoline	1.09E+05	1.050	4.79E+06	*Sum of*	
Kerosene	2.20E+04	1.032	9.51E+05	*Imports from*	
Diesel	1.90E+05	1.032	8.22E+06	*all nations*	
HFO	5.40E+05	0.991	2.24E+07	*(see below,*	
LPG/Refinery Gas/Non-Energy	6.43E+04	1.012	2.72E+06	*and note 15)*	
Total Estimated Refined Product Imports to DPRK, 2000		3.91E+07	GJ		
Estimated Refined Product Exports from DPRK, 2000 (to China)		tonnes	GJ		
HFO		68,135	2.83E+06	*See below*	
LPG/Refinery Gas/Non-Energy		4,381	1.86E+05	*and 32,50*	
Total of above		72,516	3.01E+06		
Estimated Net HFO placed in storage, 2000		(30,000)	tonnes		*26*
		-1.245E+06	GJ		*26*

Input Data for the Year 2005					
DPRK Crude Oil Production		7,000	tonnes		*27*
Reported Crude Oil Imports from China, 2005		522,844	tonnes		*30*
Other Imports of Crude Oil from China not Reported to Customs		-	tonnes		
Total Estimated Crude Oil Imports from China, 2005		522,844	tonnes		
Estimate of other crude oil imports, 2005 (unknown source)		-	tonnes		*See below*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2005		2.23E+07	GJ		
Official Refined Prod. Imports from China, 2005		148,963	tonnes		*31*
Extrapolated Official Refined Prod. Imports from China, 2005		1.49E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by KEDO, 2005		**0**	tonnes		*31*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2005	tonnes	toe/te	GJ		
Gasoline	41,846	1.050	1.84E+06	*Sum of*	
Kerosene	46,994	1.032	2.03E+06	*Imports from*	
Diesel	2.95E+05	1.032	1.27E+07	*all nations*	
HFO	1.318E+05	0.991	5.47E+06	*(see below,*	
LPG/Refinery Gas/Non-Energy	9.67E+03	1.012	4.10E+05	*notes 36, 50)*	
Total Estimated Refined Product Imports to DPRK, 2005		2.25E+07	GJ		
Estimated Refined Product Exports from DPRK, 2005 (to China)		tonnes	GJ		
HFO		-	0.00E+00		
LPG/Refinery Gas/Non-Energy		4,424	1.88E+05	*Notes 32, 50*	
Total of above		4,424	1.88E+05		
Estimated Net HFO placed in storage, 2005		(5,000)	tonnes		*26*
		-2.07E+05	GJ		*26*

Implied total 2005 crude oil, oil products into the DPRK: 4.48E+07 GJ/yr, which implies annual use of (at a conversion rate of 7.33 bbl oil equivalent per tonne oil equivalent) 7.84E+06 bbl/yr or an average of 21,470 bbl per day, which is somewhat higher than totals estimated by source in *Note 37*.

Input Data for the Year 2008					
DPRK Crude Oil Production		7,000	tonnes		*27*
Reported Crude Oil Imports from China, 2008		528,577	tonnes		*30*
Other Imports of Crude Oil from China not Reported to Customs		-	tonnes		
Total Estimated Crude Oil Imports from China, 2008		528,577	tonnes		
Estimate of other crude oil imports, 2008 (unknown source)		-	tonnes		*See below*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2008		2.25E+07	GJ		
Official Refined Prod. Imports from China, 2008		117,743	tonnes		*31*
Extrapolated Official Refined Prod. Imports from China, 2008		1.18E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties, 2008		**304,000**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2008	tonnes	toe/te	GJ		
Gasoline	1.16E+05	1.050	5.09E+06		*Sum of*
Kerosene	50,542	1.032	2.18E+06		*Imports from*
Diesel	2.02E+05	1.032	8.75E+06		*all nations*
HFO	3.19E+05	0.991	1.33E+07		*(see below,*
LPG/Refinery Gas/Non-Energy	9.15E+03	1.012	3.88E+05		*notes 36, 50)*
Total Estimated Refined Product Imports to DPRK, 2008		2.97E+07	GJ		
Estimated Refined Product Exports from DPRK, 2008 (to all nations)		tonnes	GJ		
HFO		92,830.92	3.85E+06		*(See notes 30,*
LPG/Refinery Gas/Non-Energy		3,198.82	1.36E+05		*32, 44, 50)*
Total of above		96,030	3.99E+06		
Estimated Net HFO placed in storage, 2008		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2008 crude oil, oil products into the DPRK:	5.22E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	9.13E+06	bbl/yr or
an average of	25,025	bbl per day.		

Input Data for the Year 2009					
DPRK Crude Oil Production		5,900	tonnes		*27*
Reported Crude Oil Imports from China, 2009		519,814	tonnes		*30*
Other Imports of Crude Oil from China not Reported to Customs		-	tonnes		
Total Estimated Crude Oil Imports from China, 2009		519,814	tonnes		
Estimate of other crude oil imports, 2009 (unknown source)		-	tonnes		*See below*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2009		2.21E+07	GJ		
Official Refined Prod. Imports from China, 2009		126,741	tonnes		*31*
Official Refined Prod. Imports from China, 2009		1.27E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties, 2009		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2009	tonnes	toe/te	GJ		
Gasoline	79,130	1.050	3.48E+06		*Sum of*
Kerosene	35,230	1.032	1.52E+06		*Imports from*
Diesel	1.80E+05	1.032	7.79E+06		*all nations*
HFO	9.53E+03	0.991	3.95E+05		*(see below,*
LPG/Refinery Gas/Non-Energy	7.54E+03	1.012	3.19E+05		*notes 36, 50)*
Total Estimated Refined Product Imports to DPRK, 2009		1.35E+07	GJ		
Estimated Refined Product Exports from DPRK, 2009 (to all countries)		tonnes	GJ		
HFO		1,015.64	4.21E+04		
LPG/Refinery Gas/Non-Energy		3,059.07	1.30E+05		*30, 50*
Total of above		4,075	1.72E+05		
Estimated Net HFO placed in storage, 2009		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2009 crude oil, oil products into the DPRK:	3.56E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	6.24E+06	bbl/yr or
an average of	17,098	bbl per day.		

Input Data for the Year 2010					
DPRK Crude Oil Production		5,900	tonnes		*27*
Reported Crude Oil Imports from China, 2010		528,315	tonnes		*30*
Other Imports of Crude Oil from China not Reported to Customs			tonnes		
Total Estimated Crude Oil Imports from China, 2010		528,315	tonnes		
Estimate of other crude oil imports, 2010 (Russia, unofficial, estimated)		60,000	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2010		2.51E+07	GJ		
Official Refined Prod. Imports from China, 2010		145,015	tonnes		*31*
Official Refined Prod. Imports from China, 2010		1.45E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties, 2010		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2010	tonnes	toe/te	GJ		
Gasoline	83,011	1.050	3.65E+06		*Sum of*
Kerosene	40,295	1.032	1.74E+06		*Imports from*
Diesel	230,392	1.032	9.95E+06		*all nations*
HFO	16,483	0.991	6.84E+05		*(see below,*
LPG/Refinery Gas/Non-Energy	9,917	1.012	4.20E+05		*notes 36, 50)*
Total Estimated Refined Product Imports to DPRK, 2010		1.64E+07	GJ		
Estimated Refined Product Exports from DPRK, 2010 (all countries)		tonnes	GJ		
HFO		26,746.20	1.11E+06		*32, 46, 47, 51*
Diesel		10,000	4.32E+05		*51*
LPG/Refinery Gas/Non-Energy		3,016.60	1.28E+05		*30, 50*
Total of above		39,763	1.67E+06		
Estimated Net HFO placed in storage, 2010		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2010 crude oil, oil products into the DPRK:	4.15E+07	GJ/yr, which implies annual imports of			
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	7.27E+06	bbl/yr or	
an average of	19,909	bbl per day.			

Input Data for the Year 2014					
DPRK Crude Oil Production		5,900	tonnes		*27*
Reported Crude Oil Imports from China, 2014		-	tonnes		*30; none reported*
Other Imports of Crude Oil from China not Reported to Customs		578,002	tonnes		*Assumed similar to reported 2013*
Total Estimated Crude Oil Imports from China, 2014		578,002	tonnes		
Estimate of other crude oil imports, 2014 (Russia, unofficial, estimated)		-	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2014		2.46E+07	GJ		
Official Refined Prod. Imports from China, 2014		166,128	tonnes		*31*
Official Refined Prod. Imports from China, 2014		1.66E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2014		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2014	tonnes	toe/te	GJ		
Gasoline	111,827	1.050	4.92E+06		*Sum of*
Kerosene	36,869	1.032	1.59E+06		*Imports from*
Diesel	316,961	1.032	1.37E+07		*all nations*
HFO	8,415	0.991	3.49E+05		*(see below, notes 36 through 50, 52*
LPG/Refinery Gas/Non-Energy	25,619	1.012	1.09E+06		*through 57)*
Total Estimated Refined Product Imports to DPRK, 2014		2.16E+07	GJ		
Estimated Refined Product Exports from DPRK, 2014 (all countries)		tonnes	GJ		
HFO		-	0.00E+00		*32, 46, 47, 51*
Diesel		19,704	8.51E+05		*51*
LPG/Refinery Gas/Non-Energy		6,480	2.75E+05		*30, 50*
Total of above		26,184	1.13E+06		
Estimated Net HFO placed in storage, 2014		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2014 crude oil, oil products into the DPRK:	4.63E+07	GJ/yr, which implies annual imports of			
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	8,098,610	bbl/yr or	
an average of	22,188	bbl per day.			

Input Data for the Year 2015					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2015		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		645,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2015		645,000	tonnes		
Estimate of other crude oil imports, 2015 (Russia, unofficial, estimated)		230	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2015		2.75E+07	GJ		
Official Refined Prod. Imports from China, 2015		218,087	tonnes		*31*
Official Refined Prod. Imports from China, 2015		2.18E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2015		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2015	tonnes	toe/te	GJ		
Gasoline	151,734.77	1.050	6.67E+06		*Sum of*
Kerosene	49,014	1.032	2.12E+06		*Imports from*
Diesel	345,832.11	1.032	1.49E+07		*all nations*
HFO	11,188	0.991	4.64E+05		*(see below,*
					notes 36
					through 50, 52
LPG/Refinery Gas/Non-Energy	30,179	1.012	1.28E+06		*through 57)*
Total Estimated Refined Product Imports to DPRK, 2015		2.55E+07	GJ		
Estimated Refined Product Exports from DPRK, 2015 (all countries)		tonnes	GJ		
HFO		-	0.00E+00		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		4,476	1.90E+05		*30, 50*
Total of above		4,476	1.90E+05		
Estimated Net HFO placed in storage, 2015		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2014 crude oil, oil products into the DPRK:		5.30E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		9,271,315	bbl/yr or
an average of	25,401	bbl per day.			

Input Data for the Year 2016					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2016		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		645,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2016		645,000	tonnes		
Estimate of other crude oil imports, 2016 (Russia, unofficial, estimated, and Qatar from customs statistics)		13,107	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2016		2.80E+07	GJ		
Official Refined Prod. Imports from China, 2016		274,067	tonnes		*31*
Official Refined Prod. Imports from China, 2016		2.74E+05	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2016		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2016	tonnes	toe/te	GJ		
Gasoline	146,354	1.050	6.43E+06		*Sum of*
Kerosene	56,751	1.032	2.45E+06		*Imports from*
Diesel	439,817	1.032	1.90E+07		*all nations*
HFO	12,953	0.991	5.37E+05		*(see below,*
					notes 36
					through 50, 52
LPG/Refinery Gas/Non-Energy	27,849	1.012	1.18E+06		*through 57)*
Total Estimated Refined Product Imports to DPRK, 2016		2.96E+07	GJ		
Estimated Refined Product Exports from DPRK, 2016 (all countries)		tonnes	GJ		
HFO		247.22	1.03E+04		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		224	9.50E+03		*30, 50*
Total of above		471	1.98E+04		
Estimated Net HFO placed in storage, 2016		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2016 crude oil, oil products into the DPRK:		5.76E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		10,090,940	bbl/yr or
an average of	27,646	bbl per day.			

Input Data for the Year 2017					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2017		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		645,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2017		645,000	tonnes		
Estimate of other crude oil imports, 2017 (Russia, unofficial, estimated)		164.97	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2017		2.75E+07	GJ		
Official Refined Prod. Imports from China, 2017		90,866	tonnes		*31*
Official Refined Prod. Imports from China, 2017		9.09E+04	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2017		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2017	tonnes	toe/te	GJ		
Gasoline	92,751	1.050	4.08E+06		*Sum of*
Kerosene	31,537	1.032	1.36E+06		*Imports from*
Diesel	226,299	1.032	9.78E+06		*all nations*
HFO	3,774	0.991	1.57E+05		*(see below,*
					notes 36
					through 50, 52
LPG/Refinery Gas/Non-Energy	27,245	1.012	1.15E+06		*through 57)*
Total Estimated Refined Product Imports to DPRK, 2017		1.65E+07	GJ		
Estimated Refined Product Exports from DPRK, 2017 (all countries)		tonnes	GJ		
HFO		-	0.00E+00		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		0.25	1.06E+01		*30, 50*
Total of above		0	1.06E+01		
Estimated Net HFO placed in storage, 2017		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2017 crude oil, oil products into the DPRK:		4.40E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		7,704,814	bbl/yr or
an average of	21,109	bbl per day.			

Input Data for the Year 2018					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2018		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		715,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2018		715,000	tonnes		
Estimate of other crude oil imports, 2018 (Russia, unofficial, estimated)		-	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2018		3.05E+07	GJ		
Official Refined Prod. Imports from China, 2018		6,913	tonnes		*31*
Official Refined Prod. Imports from China, 2018		6.91E+03	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2018		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2018	tonnes	toe/te	GJ		
Gasoline	65,478	1.050	2.88E+06		*Sum of*
Kerosene	18,157	1.032	7.85E+05		*Imports from*
Diesel	191,244	1.032	8.26E+06		*all nations*
HFO	721	0.991	2.99E+04		*(see below,*
					notes 36
					through 50, 52
					through 57, 61,
LPG/Refinery Gas/Non-Energy	25,121	1.012	1.06E+06		*62)*
Total Estimated Refined Product Imports to DPRK, 2018		1.30E+07	GJ		
Estimated Refined Product Exports from DPRK, 2018 (all countries)		tonnes	GJ		
HFO		-	0.00E+00		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		159.52	6.76E+03		*30, 50*
Total of above		160	6.76E+03		
Estimated Net HFO placed in storage, 2018		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2018 crude oil, oil products into the DPRK:		4.35E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		7,611,337	bbl/yr or
an average of	20,853	bbl per day.			

Input Data for the Year 2019					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2019		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		715,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2019		715,000	tonnes		
Estimate of other crude oil imports, 2019 (Russia, unofficial, estimated)		-	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2019		3.05E+07	GJ		
Official (Comtrade Reported) Refined Prod. Imports from China, 2019		-	tonnes		*31*
Official (Comtrade Reported) Refined Prod. Imports from China, 2019		0.00E+00	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2019		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2019	tonnes	toe/te	GJ		
Gasoline	60,947	1.050	2.68E+06		*Sum of*
Kerosene	20,000	1.032	8.64E+05		*Imports from*
Diesel	218,293	1.032	9.43E+06		*all nations*
HFO	1,940	0.991	8.05E+04		*(see below,*
					notes 36
					through 50, 52
					through 57, 61
LPG/Refinery Gas/Non-Energy	25,121	1.012	1.06E+06		*through 64)*
Total Estimated Refined Product Imports to DPRK, 2019		1.41E+07	GJ		
Estimated Refined Product Exports from DPRK, 2019 (all countries)		tonnes	GJ		
HFO		1,893	7.85E+04		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		0.29	1.22E+01		*30, 48, 50*
Total of above		1,893	7.86E+04		
Estimated Net HFO placed in storage, 2019		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2019 crude oil, oil products into the DPRK:		4.46E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		7,803,876	bbl/yr or
an average of	21,380	bbl per day.			

Input Data for the Year 2020					
DPRK Crude Oil Production		5,900	tonnes		*27*
					30; none
Reported Crude Oil Imports from China, 2020		-	tonnes		*reported*
Other Imports of Crude Oil from China not Reported to Customs		750,000	tonnes		*See Note 56*
Total Estimated Crude Oil Imports from China, 2020		750,000	tonnes		
Estimate of other crude oil imports, 2020 (Russia, unofficial, estimated)		-	tonnes		*51*
Conversion Factor		42.59	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2020		3.19E+07	GJ		
Official (Comtrade Reported) Refined Prod. Imports from China, 2020		-	tonnes		*31*
Official (Comtrade Reported) Refined Prod. Imports from China, 2020		0.00E+00	tonnes		
Conversion Factor	1.050	toe/te			
HFO Supplied by Six-Party Talks Parties or Equivalent, 2020		**0**	tonnes		*41, 42*
Est. Conversion Factor, KEDO Oil	1.00	toe/te			
Total Imports of Refined Products, 2020	tonnes	toe/te	GJ		
Gasoline	8,665	1.050	3.81E+05		*Sum of*
Kerosene	1,000	1.032	4.32E+04		*Imports from*
Diesel	134,157	1.032	5.80E+06		*all nations*
HFO	721	0.991	2.99E+04		*(see below,*
					notes 36
					through 50, 52
					through 57, 61
LPG/Refinery Gas/Non-Energy	8,792	1.012	3.73E+05		*through 64)*
Total Estimated Refined Product Imports to DPRK, 2020		6.62E+06	GJ		
Estimated Refined Product Exports from DPRK, 2020 (all countries)		tonnes	GJ		
HFO		-	0.00E+00		*32, 46, 47, 51*
Diesel		-	0.00E+00		*51*
LPG/Refinery Gas/Non-Energy		-	0.00E+00		*30, 48, 50*
Total of above		-	0.00E+00		
Estimated Net HFO placed in storage, 2020		-	tonnes		*26*
		0.00E+00	GJ		*26*

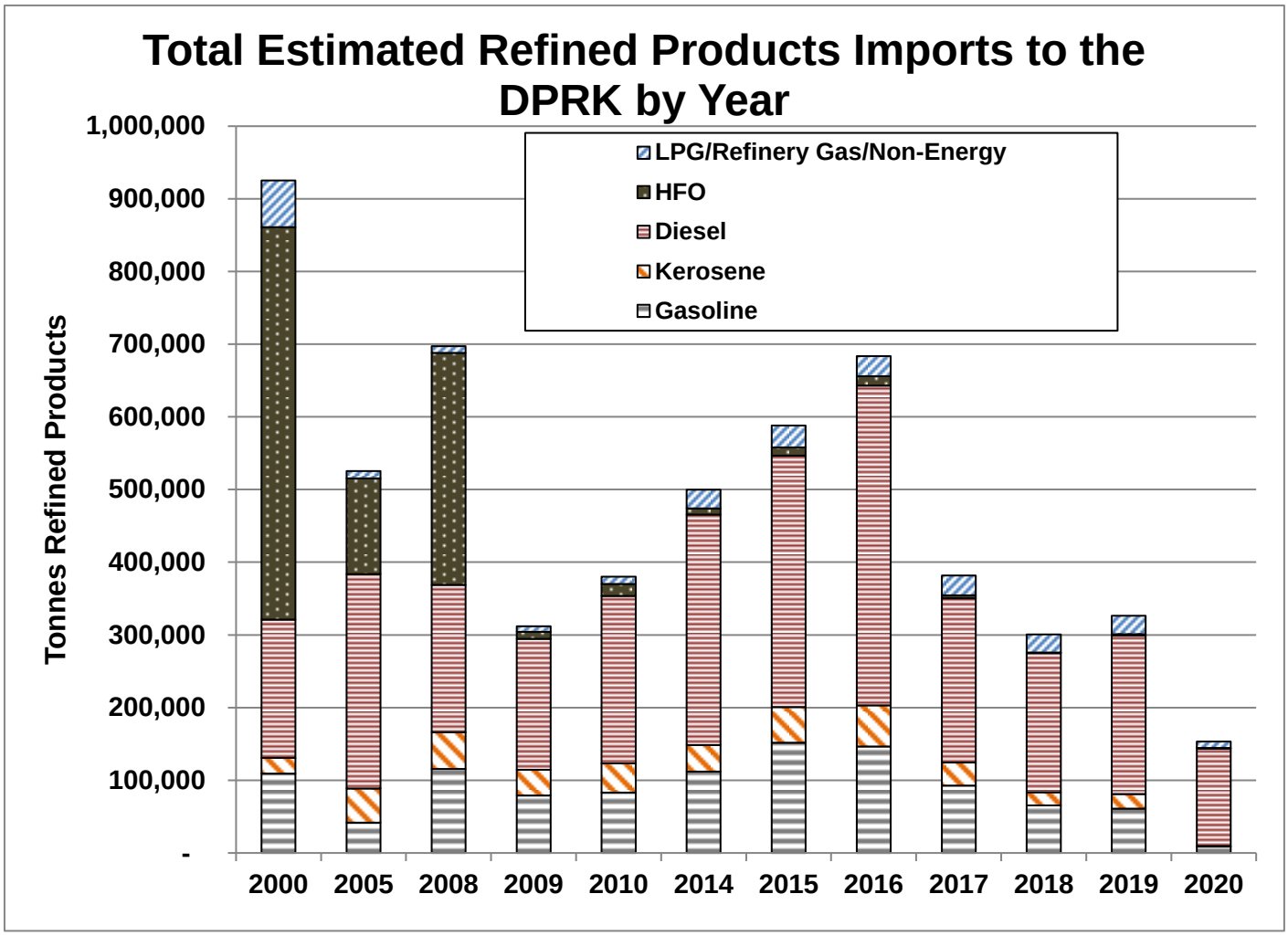
Implied total 2020 crude oil, oil products into the DPRK:		3.86E+07	GJ/yr, which implies annual imports of		
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)		6,752,281	bbl/yr or
an average of	18,499	bbl per day.			

Summaries of Annual Estimates Above for Entry into Energy Balances

		2000	2005	2008	2009	2010	
Crude Oil Imports from China relative to 1996 (rel to 2000 for 2005-on)		42%	134%	136%	134%	136%	
Other Crude Oil Imports (tonnes)		0.00E+00	-	-	-	60,000	
Domestic DPRK Crude Oil Production (tonnes)		7,000	7,000	7,000	5,900	5,900	
Official Refined Products Imports from China relative to 1996 (rel to 2000 for 2005 through 2010)		172%	127%	100%	108%	123%	
HFO Supplied by KEDO or through 6-Party Talks (tonnes)		394,722	-	304,000	-	-	
Total Imports of Refined Products (tonnes)	Gasoline	108,991	41,846	115,755	79,130	83,011	*15, 36*
	Kerosene	22,000	46,994	50,542	35,230	40,295	*15, 36*
	Diesel	190,258	294,885	202,405	180,292	230,392	*15, 36*
	HFO	539,652	131,847	319,409	9,527	16,483	*15, 36*
	LPG/Refinery Gas/Non-Energy	64,282	9,671	9,145	7,538	9,917	

		2014	2015	2016	2017	2018
Crude Oil Imports from China relative to 1996 (rel to 2000 for 2005-on)		148%	166%	166%	166%	184%
Other Crude Oil Imports (tonnes)		-	230	13,107	165	-
Domestic DPRK Crude Oil Production (tonnes)		5,900	5,900	5,900	5,900	5,900
Official Refined Products Imports from China relative to 1996 (rel to 2000 for 2005 through 2017)		141%	186%	233%	77%	6%
HFO Supplied by KEDO or through 6-Party Talks (tonnes)		-	-	-	-	-
Total Imports of Refined Products (tonnes)	Gasoline	111,827	151,735	146,354	92,751	65,478
(Includes "off-books" trades, both documented and	Kerosene	36,869	49,014	56,751	31,537	18,157
assumed)	Diesel	316,961	345,832	439,817	226,299	191,244
	HFO	8,415	11,188	12,953	3,774	721
	LPG/Refinery Gas/Non-Energy	25,619	30,179	27,849	27,245	25,121

		2019	2020
Crude Oil Imports from China relative to 1996 (rel to 2000 for 2005-on)		184%	193%
Other Crude Oil Imports (tonnes)		-	-
Domestic DPRK Crude Oil Production (tonnes)		5,900	5,900
Official Refined Products Imports from China relative to 1996 (rel to 2000 for 2005 through 2017), as reported in Comtrade		-	-
HFO Supplied by KEDO or through 6-Party Talks (tonnes)		-	-
Total Imports of Refined Products (tonnes)	Gasoline	60,947	8,665
(Includes "off-books" trades, both documented and	Kerosene	20,000	1,000
assumed)	Diesel	218,293	134,157
	HFO	1,940	721
	LPG/Refinery Gas/Non-Energy	25,121	8,792


Total Estimated Refined Products Imports to the DPRK by Year
Tonnes Refined Products
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
LPG/Refinery Gas/Non-Energy
HFO
Diesel
Kerosene
Gasoline
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

Estimated Refinery Statistics--1990					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.446E+06	2.095E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 1990 (tonnes)	1.16E+06	1.44E+06			
Estimated Refinery Output, 1990 (tonnes)			Toe/Te		
Heavy Fuel Oil	440,800	489,600	0.991		
Gasoline	255,200	345,600	1.050		
Diesel Oil	232,000	216,000	1.032		
Kerosene	46,400	158,400	1.032		
LPG/Refinery Gas/Non-energy (gross)	139,200	158,400	1.012		
Estimated Refinery Fuel Use (toe)	67,048	75,312			
Estimated Net Refinery Output, 1990 (GJ)			% of Net		
Heavy Fuel Oil	1.83E+07	2.03E+07	36.84%		
Gasoline	1.12E+07	1.52E+07	25.21%		
Diesel Oil	1.00E+07	9.33E+06	18.47%		
Kerosene	2.00E+06	6.84E+06	8.45%		
LPG/Refinery Gas/Non-Energy	5.06E+06	6.50E+06	11.03%		*10*
TOTAL	4.66E+07	5.82E+07	100.00%		
Estimated Net Refinery Output, 1990 (tonnes)	1,093,869	1,362,884	2,456,753		
Estimated Net Refinery Output, 1990 (TOE)	1,113,042	1,389,628	2,502,670		
Refinery use of electricity, kWh/tonne output	67.04				*28*
Estimated 1990 Refinery use of electricity	165	GWh or	5.93E+05	GJ	
Estimated Net Output of East Coast Refinery based roughly on scaling the figure above using non-Chinese oil import estimates from Reference *3*.					
Estimated Net Refinery Output, 1991 (TOE)		773,103			
Estimated Net Refinery Output, 1992 (TOE)		411,017			

Estimated Refinery Statistics--1996					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.446E+06	2.095E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 1996 (tonnes)	9.36E+05	0			
Estimated Refinery Output, 1996 (tonnes)			Toe/Te		
Heavy Fuel Oil	355,745	-	0.991		
Gasoline	205,957	-	1.050		
Diesel Oil	187,234	-	1.032		
Kerosene	37,447	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	112,340	-	1.012		
Estimated Refinery Fuel Use (toe)	54,111	-			
Estimated Net Refinery Output, 1996 (GJ)			% of Net		
Heavy Fuel Oil	1.48E+07	0.00E+00	39.25%		
Gasoline	9.05E+06	0.00E+00	24.07%		
Diesel Oil	8.09E+06	0.00E+00	21.51%		
Kerosene	1.62E+06	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	4.09E+06	0.00E+00	10.87%		*10*
TOTAL	3.76E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 1996 (tonnes)	882,799		882,799		
Estimated Net Refinery Output, 1996 (TOE)	898,273	-	898,273		
Refinery use of electricity, kWh/tonne output	67.04				*28*
Estimated 1996 Refinery use of electricity	59	GWh or	2.13E+05	GJ	

Estimated Refinery Statistics--2000				
(See below for smaller W. Coast Refinery)	West Coast	East Coast		
Capacity, barrels of crude/day	2.90E+04	4.20E+04		*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06		
Output (Weight fraction of input)				
Heavy Fuel Oil	38%	34%		*11, 17*
Gasoline	22%	24%		*11, 17*
Diesel Oil	20%	15%		*11, 17*
Kerosene	4%	11%		*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%		*11, 17*
TOTAL	96%	95%		
Estimated Refinery Input, 2000 (tonnes)	3.72E+05	0.00E+00		
Estimated Refinery Output, 2000 (tonnes)			Toe/Te	
Heavy Fuel Oil	141,445	-	0.991	
Gasoline	81,889	-	1.050	
Diesel Oil	74,445	-	1.032	
Kerosene	14,889	-	1.032	
LPG/Refinery Gas/Non-energy (gross)	44,667	-	1.012	
Estimated Refinery Fuel Use (toe)	21,515	-		
Estimated Net Refinery Output, 2000 (GJ)			% of Net	
Heavy Fuel Oil	5.87E+06	0.00E+00	39.25%	
Gasoline	3.60E+06	0.00E+00	24.07%	
Diesel Oil	3.22E+06	0.00E+00	21.51%	
Kerosene	6.43E+05	0.00E+00	4.30%	
LPG/Refinery Gas/Non-Energy	1.62E+06	0.00E+00	10.87%	*10*
TOTAL	1.50E+07	0.00E+00	100.00%	
Estimated Net Refinery Output, 2000 (tonnes)	351,004		351,004	
Estimated Net Refinery Output, 2000 (TOE)	357,157	-	357,157	
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996		*28*
Estimated 2000 Refinery use of electricity	27.61	GWh or	9.94E+04 GJ	
(Includes small West Coast refinery)				

Estimated Refinery Statistics--2005				
(See below for smaller W. Coast Refinery)	West Coast	East Coast		
Capacity, barrels of crude/day	2.90E+04	4.20E+04		*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06		
Output (Weight fraction of input)				
Heavy Fuel Oil	38%	34%		*11, 17*
Gasoline	22%	24%		*11, 17*
Diesel Oil	20%	15%		*11, 17*
Kerosene	4%	11%		*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%		*11, 17*
TOTAL	96%	95%		
Estimated Refinery Input, 2005 (tonnes)	5.06E+05	0.00E+00		
Estimated Refinery Output, 2005 (tonnes)			Toe/Te	
Heavy Fuel Oil	192,217	-	0.991	
Gasoline	111,283	-	1.050	
Diesel Oil	101,167	-	1.032	
Kerosene	20,233	-	1.032	
LPG/Refinery Gas/Non-energy (gross)	60,700	-	1.012	
Estimated Refinery Fuel Use (toe)	29,237	-		
Estimated Net Refinery Output, 2005 (GJ)			% of Net	
Heavy Fuel Oil	7.98E+06	0.00E+00	39.25%	
Gasoline	4.89E+06	0.00E+00	24.07%	
Diesel Oil	4.37E+06	0.00E+00	21.51%	
Kerosene	8.74E+05	0.00E+00	4.30%	
LPG/Refinery Gas/Non-Energy	2.21E+06	0.00E+00	10.87%	*10*
TOTAL	2.03E+07	0.00E+00	100.0%	
Estimated Net Refinery Output, 2005 (tonnes)	476,996		476,996	
Estimated Net Refinery Output, 2005 (TOE)	485,356	0	485,356	
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%	*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996		*28*
Estimated 2000 Refinery use of electricity	36.90	GWh or	1.33E+05 GJ	
(Includes small West Coast refinery)				

Estimated Refinery Statistics--2008					
(See below for smaller W. Coast Refinery)	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2008 (tonnes)	5.12E+05	0.00E+00			
Estimated Refinery Output, 2008 (tonnes)			Toe/Te		
Heavy Fuel Oil	194,395	-	0.991		
Gasoline	112,544	-	1.050		
Diesel Oil	102,313	-	1.032		
Kerosene	20,463	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	61,388	-	1.012		
Estimated Refinery Fuel Use (toe)	29,569	-			
Estimated Net Refinery Output, 2008 (GJ)			% of Net		
Heavy Fuel Oil	8.07E+06	0.00E+00	39.25%		
Gasoline	4.95E+06	0.00E+00	24.07%		
Diesel Oil	4.42E+06	0.00E+00	21.51%		
Kerosene	8.84E+05	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	2.23E+06	0.00E+00	10.87%		*10*
TOTAL	2.06E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2008 (tonnes)	482,401		482,401		
Estimated Net Refinery Output, 2008 (TOE)	490,857	0	490,857		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2000 Refinery use of electricity	37.30	GWh or	1.34E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2009					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	1.05E+05			*12, 16*
Capacity, tonnes of crude per year	1.45E+06	5.24E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2009 (tonnes)	5.02E+05	0.00E+00			
Estimated Refinery Output, 2009 (tonnes)			Toe/Te		
Heavy Fuel Oil	190,647	-	0.991		
Gasoline	110,375	-	1.050		
Diesel Oil	100,340	-	1.032		
Kerosene	20,068	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	60,204	-	1.012		
Estimated Refinery Fuel Use (toe)	28,998	-			
Estimated Net Refinery Output, 2009 (GJ)			% of Net		
Heavy Fuel Oil	7.91E+06	0.00E+00	39.25%		
Gasoline	4.85E+06	0.00E+00	24.07%		
Diesel Oil	4.34E+06	0.00E+00	21.51%		
Kerosene	8.67E+05	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	2.19E+06	0.00E+00	10.87%		*10*
TOTAL	2.02E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2009 (tonnes)	473,100		473,100		
Estimated Net Refinery Output, 2009 (TOE)	481,393	0	481,393		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2009 Refinery use of electricity	36.62	GWh or	1.32E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2010					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene/Jet Fuel	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2010 (tonnes)	5.10E+05	60,000			*51*
Estimated Refinery Output, 2010 (tonnes)			Toe/Te		
Heavy Fuel Oil	193,877	20,400	0.991		
Gasoline	112,245	14,400	1.050		
Diesel Oil	102,041	9,000	1.032		
Kerosene	20,408	6,600	1.032		
LPG/Refinery Gas/Non-energy (gross)	61,224	6,600	1.012		
Estimated Refinery Fuel Use (toe)	29,490	3,468			
Estimated Net Refinery Output, 2010 (GJ)			% of Net		
Heavy Fuel Oil	8.04E+06	8.46E+05	38.81%		
Gasoline	4.93E+06	6.33E+05	24.30%		
Diesel Oil	4.41E+06	3.89E+05	20.94%		
Kerosene	8.82E+05	2.85E+05	5.09%		
LPG/Refinery Gas/Non-Energy	2.23E+06	2.57E+05	10.84%		*10*
TOTAL	2.05E+07	2.41E+06	100.00%		
Estimated Net Refinery Output, 2010 (tonnes)	481,117	56,461	537,578		
Estimated Net Refinery Output, 2010 (TOE)	489,550	57,571	547,122		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2010 Refinery use of electricity	41.37	GWh or	1.49E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2014					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene/Jet Fuel	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2014 (tonnes)	5.60E+05	-			*51*
Estimated Refinery Output, 2014 (tonnes)			Toe/Te		
Heavy Fuel Oil	212,758	-	0.991		
Gasoline	123,176	-	1.050		
Diesel Oil	111,978	-	1.032		
Kerosene	22,396	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	67,187	-	1.012		
Estimated Refinery Fuel Use (toe)	32,362	-			
Estimated Net Refinery Output, 2014 (GJ)			% of Net		
Heavy Fuel Oil	8.83E+06	0.00E+00	39.25%		
Gasoline	5.41E+06	0.00E+00	24.07%		
Diesel Oil	4.84E+06	0.00E+00	21.51%		
Kerosene	9.68E+05	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	2.44E+06	0.00E+00	10.87%		*10*
TOTAL	2.25E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2014 (tonnes)	527,971	-	527,971		
Estimated Net Refinery Output, 2014 (TOE)	537,226	-	537,226		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2014 Refinery use of electricity	40.66	GWh or	1.46E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2015					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene/Jet Fuel	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2015 (tonnes)	627,120	-			*51*
Estimated Refinery Output, 2015 (tonnes)			Toe/Te		
Heavy Fuel Oil	238,305	-	0.991		
Gasoline	137,966	-	1.050		
Diesel Oil	125,424	-	1.032		
Kerosene	25,085	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	75,254	-	1.012		
Estimated Refinery Fuel Use (toe)	36,248	-			
Estimated Net Refinery Output, 2015 (GJ)			% of Net		
Heavy Fuel Oil	9.89E+06	0.00E+00	39.25%		
Gasoline	6.07E+06	0.00E+00	24.07%		
Diesel Oil	5.42E+06	0.00E+00	21.51%		
Kerosene	1.08E+06	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	2.74E+06	0.00E+00	10.87%		*10*
TOTAL	2.52E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2015 (tonnes)	591,368	-	591,368		
Estimated Net Refinery Output, 2015 (TOE)	601,733	-	601,733		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2015 Refinery use of electricity	45.34	GWh or	1.63E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2016					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	38%	34%			*11, 17*
Gasoline	22%	24%			*11, 17*
Diesel Oil	20%	15%			*11, 17*
Kerosene/Jet Fuel	4%	11%			*11, 17*
LPG/Refinery Gas/Non-Energy	12%	11%			*11, 17*
TOTAL	96%	95%			
Estimated Refinery Input, 2016 (tonnes)	653,102	-			*51*
Estimated Refinery Output, 2016 (tonnes)			Toe/Te		
Heavy Fuel Oil	248,179	-	0.991		
Gasoline	143,682	-	1.050		
Diesel Oil	130,620	-	1.032		
Kerosene	26,124	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	78,372	-	1.012		
Estimated Refinery Fuel Use (toe)	37,749	-			
Estimated Net Refinery Output, 2016 (GJ)			% of Net		
Heavy Fuel Oil	1.03E+07	0.00E+00	3.92E-01		
Gasoline	6.32E+06	0.00E+00	2.41E-01		
Diesel Oil	5.64E+06	0.00E+00	2.15E-01		
Kerosene	1.13E+06	0.00E+00	4.30E-02		
LPG/Refinery Gas/Non-Energy	2.85E+06	0.00E+00	1.09E-01		*10*
TOTAL	2.62E+07	0.00E+00	1.00E+00		
Estimated Net Refinery Output, 2016 (tonnes)	615,868	-	615,868		
Estimated Net Refinery Output, 2016 (TOE)	626,664	-	626,664		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2016 Refinery use of electricity	47.14	GWh or	1.70E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2017					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	19.0%	34%			*11, 17, 58*
Gasoline	32.1%	24%			*11, 17, 58*
Diesel Oil	23.1%	15%			*11, 17, 58*
Kerosene/Jet Fuel	4.6%	11%			*11, 17, 58*
LPG/Refinery Gas/Non-Energy	16.6%	11%			*11, 17, 58*
TOTAL	95.4%	95%			
Estimated Refinery Input, 2017 (tonnes)	627,219	-			*51*
Estimated Refinery Output, 2017 (tonnes)			Toe/Te		
Heavy Fuel Oil	119,172	-	0.991		
Gasoline	201,629	-	1.050		
Diesel Oil	144,729	-	1.032		
Kerosene	28,946	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	104,194	-	1.012		
Estimated Refinery Fuel Use (toe)	36,253	-			
Estimated Net Refinery Output, 2017 (GJ)			% of Net		
Heavy Fuel Oil	4.94E+06	0.00E+00	19.62%		
Gasoline	8.86E+06	0.00E+00	35.18%		
Diesel Oil	6.25E+06	0.00E+00	24.82%		
Kerosene	1.25E+06	0.00E+00	4.96%		
LPG/Refinery Gas/Non-Energy	3.88E+06	0.00E+00	15.42%		*10*
TOTAL	2.52E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2017 (tonnes)	586,132	-	586,132		
Estimated Net Refinery Output, 2017 (TOE)	601,828	-	601,828		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2017 Refinery use of electricity	44.95	GWh or	1.62E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2018					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	19.0%	34%			*11, 17, 58*
Gasoline	32.1%	24%			*11, 17, 58*
Diesel Oil	23.1%	15%			*11, 17, 58*
Kerosene/Jet Fuel	4.6%	11%			*11, 17, 58*
LPG/Refinery Gas/Non-Energy	16.6%	11%			*11, 17, 58*
TOTAL	95.4%	95%			
Estimated Refinery Input, 2018 (tonnes)	696,889	-			*51, 56*
Estimated Refinery Output, 2018 (tonnes)			Toe/Te		
Heavy Fuel Oil	132,409	-	0.991		
Gasoline	224,025	-	1.050		
Diesel Oil	160,805	-	1.032		
Kerosene	32,161	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	115,767	-	1.012		
Estimated Refinery Fuel Use (toe)	40,280	-			
Estimated Net Refinery Output, 2018 (GJ)			% of Net		
Heavy Fuel Oil	5.49E+06	0.00E+00	19.62%		
Gasoline	9.85E+06	0.00E+00	35.18%		
Diesel Oil	6.95E+06	0.00E+00	24.82%		
Kerosene	1.39E+06	0.00E+00	4.96%		
LPG/Refinery Gas/Non-Energy	4.32E+06	0.00E+00	15.42%		*10*
TOTAL	2.80E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2018 (tonnes)	651,239	-	651,239		
Estimated Net Refinery Output, 2018 (TOE)	668,678	-	668,678		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2018 Refinery use of electricity	49.75	GWh or	1.79E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2019					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	19.0%	34%			*11, 17, 58*
Gasoline	32.1%	24%			*11, 17, 58*
Diesel Oil	23.1%	15%			*11, 17, 58*
Kerosene/Jet Fuel	4.6%	11%			*11, 17, 58*
LPG/Refinery Gas/Non-Energy	16.6%	11%			*11, 17, 58*
TOTAL	95.4%	95%			
Estimated Refinery Input, 2019 (tonnes)	696,889	-			*51, 56*
Estimated Refinery Output, 2019 (tonnes)			Toe/Te		
Heavy Fuel Oil	132,409	-	0.991		
Gasoline	224,025	-	1.050		
Diesel Oil	160,805	-	1.032		
Kerosene	32,161	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	115,767	-	1.012		
Estimated Refinery Fuel Use (toe)	40,280	-			
Estimated Net Refinery Output, 2019 (GJ)			% of Net		
Heavy Fuel Oil	5.49E+06	0.00E+00	19.62%		
Gasoline	9.85E+06	0.00E+00	35.18%		
Diesel Oil	6.95E+06	0.00E+00	24.82%		
Kerosene	1.39E+06	0.00E+00	4.96%		
LPG/Refinery Gas/Non-Energy	4.32E+06	0.00E+00	15.42%		*10*
TOTAL	2.80E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2019 (tonnes)	651,239	-	651,239		
Estimated Net Refinery Output, 2019 (TOE)	668,678	-	668,678		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2019 Refinery use of electricity	49.75	GWh or	1.79E+05	GJ	
(Includes small West Coast refinery)					

Estimated Refinery Statistics--2020					
	West Coast	East Coast			
Capacity, barrels of crude/day	2.90E+04	4.20E+04			*12*
Capacity, tonnes of crude per year	1.45E+06	2.09E+06			
Output (Weight fraction of input)					
Heavy Fuel Oil	19.0%	34%			*11, 17, 58*
Gasoline	32.1%	24%			*11, 17, 58*
Diesel Oil	23.1%	15%			*11, 17, 58*
Kerosene/Jet Fuel	4.6%	11%			*11, 17, 58*
LPG/Refinery Gas/Non-Energy	16.6%	11%			*11, 17, 58*
TOTAL	95.4%	95%			
Estimated Refinery Input, 2020 (tonnes)	731,889	-			*51, 56*
Estimated Refinery Output, 2020 (tonnes)			Toe/Te		
Heavy Fuel Oil	139,059	-	0.991		
Gasoline	235,276	-	1.050		
Diesel Oil	168,881	-	1.032		
Kerosene	33,776	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	121,582	-	1.012		
Estimated Refinery Fuel Use (toe)	42,303	-			
Estimated Net Refinery Output, 2020 (GJ)			% of Net		
Heavy Fuel Oil	5.77E+06	0.00E+00	20.61%		
Gasoline	1.03E+07	0.00E+00	36.94%		
Diesel Oil	7.30E+06	0.00E+00	26.06%		
Kerosene	1.46E+06	0.00E+00	5.21%		
LPG/Refinery Gas/Non-Energy	4.53E+06	0.00E+00	16.19%		*10*
TOTAL	2.94E+07	0.00E+00	105.02%		
Estimated Net Refinery Output, 2020 (tonnes)	683,946	-	683,946		
Estimated Net Refinery Output, 2020 (TOE)	702,261	-	702,261		
Input to/Output of Smaller Western Refinery relative to 2000 Estimate:			100%		*Assumption*
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2020 Refinery use of electricity	52.16	GWh or	1.88E+05	GJ	
(Includes small West Coast refinery)					

Crude Oil and Refined Products Imports from and Exports to China, 2000 ***(kilograms: See Note 18)***

Commodity	Imports	Exports
asphalt	4,203,170	
asphalt coke	40,000	
crude petroleum and crude oil from asphalt	389,236,142	
vehicle use gasoline and aviation gasoline	22,091,731	
rubber solvent oil, oil paint solvent	87,621	
Jet fuel	46,853,114	
light diesel oil	29,108,167	
other diesel oil and fuel oil	3,589,984	
lubricant grease	168,652	
lubricant oil	7,781,450	14,016
lubricant oil basic oil	1,789,195	
other heavy oil		19,920,914
liquefied butane for lighter, volume > 300 cuom	16,000	
other liquefied butane	30,400	
other unlisted liquefied petroleum gas and other aromatic gas		4,314,996
vaseline	75,735	
paraffin wax, content less than 0.75% in terms of weight	10,000	
microcystal wax	2,200	
unburnt petroleum coke	843,000	
petroleum asphalt	211,289	
other petroleum or residuals from asphalt smelting	563,217	
emulsified asphalt	10,450	
Total refined products (above less crude oil)	117,475,375	24,249,926

Summary of Above in Refined Products Balance Reporting Categories (tonnes)

Commodity	Imports	Exports
Heavy Fuel Oil	-	19,921
Gasoline/Aviation Gasoline	22,092	
Diesel Oil	32,698	
Kerosene/Jet Fuel	46,853	
LPG/Refinery Gas/Non-Energy	15,832	4,329
Total of Above	117,475	24,250

Refined Products Imports from and Exports to China, 2005 ***(tonnes: See Note 30)***

Commodity	Imports	Exports
Light diesel oil	46,668	
Aviation kerosene	46,994	
Basic oils for lubricating oils	3,629	
Lubricating oils	2,320	
Fuel oils No. 5 ~ No. 7	3,573	
Other diesel oils and other fuel oils	1,187	
Lubricating grease	168	
Liquid paraffin and heavy liquid paraffin	0	
Other lubricating oils, greases and other heavy oil	4	
Motor gasoline, aviation gasoline	40,893	
Rubber solvent, paint solvent, extractive solvent	3.3	
Other light oils and preparations	51	
PETROLEUM,OTHER GASES	497	4,393
PETROLEUM JELLY;WAXES	109	
PETROLEUM COKE,RESIDUES	2,865	
BITMN,ASPHLT;TAR SAND	-	
BITUMEN,TAR RELATED	1.5	
Total refined products (above less crude oil)	148,963	4,393

Summary of Above in Refined Products Balance Reporting Categories (tonnes)

Commodity	Imports	Exports
Heavy Fuel Oil	3,573	-
Gasoline/Aviation Gasoline	40,893	
Diesel Oil	47,855	
Kerosene/Jet Fuel	46,994	
LPG/Refinery Gas/Non-Energy	9,646	4,393
Total of Above	148,963	4,393

Summary of Refined Products Imports from and Exports to China, 2008 through 2010 ***(tonnes: See Note 30)***

	2008		2009		2010	
Commodity	Imports	Exports	Imports	Exports	Imports	Exports
Light diesel oil	14,047		10,460		37,378	
Aviation kerosene	50,542		35,230		40,295	
Basic oils for lubricating oils	1,681		1,686		1,630	
Lubricating oils	3,370		1,290		1,872	
Fuel oils No. 5 ~ No. 7	3,982		2,576		8,131	
Other diesel oils and other fuel oils	0	1.805	0	-	4	2
Lubricating grease	939		142		189	
Liquid paraffin and heavy liquid paraffin	0		0		0	
Other lubricating oils, greases and other heavy oil	8		306		4	
Motor gasoline, aviation gasoline	43,166		38,738		55,413	
Rubber solvent, paint solvent, extractive solvent	8		20		88	
Other light oils and preparations	0.00		0.00		0.00	
PETROLEUM,OTHER GASES	480	3,148	543	2,908	-	2,940
PETROLEUM JELLY;WAXES	252		117		113	
PETROLEUM COKE,RESIDUES	2,330		3,284		5,745	
BITMN,ASPHLT;TAR SAND	43		34		-	
BITUMEN,TAR RELATED	18		111		215	
Total refined products (above less crude oil)	120,865	3,150	94,536	2,908	151,077	2,943

Summary of Above in Refined Products Balance Reporting Categories (tonnes)

	2008		2009		2010	
Commodity	Imports	Exports	Imports	Exports	Imports	Exports
Heavy Fuel Oil	3,982	-	2,576	-	8,131	-
Gasoline/Aviation Gasoline	43,166		38,738		55,413	
Diesel Oil	14,047		10,460		37,382	
Kerosene/Jet Fuel	50,542		35,230		40,295	
LPG/Refinery Gas/Non-Energy	9,129	3,148	7,533	2,908	9,857	2,940
Total of Above	120,865	3,148	94,536	2,908	151,077	2,940

Estimates of HFO Stock Build-up and Draw-down Related to HFO Imports from KEDO and 6-PT Agreements

	Additions to/depletions from stocks		Implied HFO in Storage (year end)		*See Note 26*
Year	GJ	Tonnes	GJ	Tonnes	
1996	6.412E+06	154,538	6.41E+06	1.55E+05	
1997	-1.245E+06	(30,000)	5.17E+06	1.25E+05	
1998	-1.245E+06	(30,000)	3.92E+06	9.45E+04	
1999	-1.245E+06	(30,000)	2.68E+06	6.45E+04	
2000	-1.245E+06	(30,000)	1.43E+06	3.45E+04	
2001	-2.075E+05	(5,000)	1.23E+06	2.95E+04	
2002	-2.075E+05	(5,000)	1.02E+06	2.45E+04	
2003	-2.075E+05	(5,000)	8.11E+05	1.95E+04	
2004	-2.075E+05	(5,000)	6.03E+05	1.45E+04	
2005	-2.075E+05	(5,000)	3.96E+05	9.54E+03	
2006	-2.075E+05	(5,000)	1.88E+05	4.54E+03	
2007	0.000E+00		1.88E+05	4.54E+03	
2008	0.000E+00		1.88E+05	4.54E+03	
2009	0.000E+00		1.88E+05	4.54E+03	
2010	0.000E+00		1.88E+05	4.54E+03	
2011	0.000E+00		1.88E+05	4.54E+03	
2012	0.000E+00		1.88E+05	4.54E+03	
2013	0.000E+00		1.88E+05	4.54E+03	
2014	0.000E+00		1.88E+05	4.54E+03	
2015	0.000E+00		1.88E+05	4.54E+03	
2016	0.000E+00		1.88E+05	4.54E+03	
2017	0.000E+00		1.88E+05	4.54E+03	
2018	0.000E+00		1.88E+05	4.54E+03	
2019	0.000E+00		1.88E+05	4.54E+03	
2020	0.000E+00		1.88E+05	4.54E+03	

Estimate of 2000, 2005, and 2008 - 2010 Imports of Petroleum Products from Russia

Total Imports in 2000 were estimated at:	1.5	kbbl/day		*Source 20*
at an estimated	7.24	bbl/tonne	(assumes average product density of .87 kg/l)	
implies an annual level of imports of		7.56E+04	tonnes	
The UN Comtrade statistics database for that year lists total export from the RF to the DPRK (*see Note 41*) of		6.86E+03	tonnes, quite a bit lower than the estimate.	
Assume that	60%	of these imports were diesel/gas oil, and		
	35%	were gasoline		
	5%	were heavy oil or the equivalent, then total		
imports from Russia (tonnes) were		4.12E+03	of diesel,	
		2.40E+03	gasoline, and	
		3.43E+02	heavy oil.	
Imports in 2005 are estimated at	7	kbbl/day on average. This is a rough estimate, pending		
receipt of better data, but yields an approximate value for oil exports from Russia to the DPRK, if one				
assumes an average price of	$70	per bbl, of	$ 178.85	million, which is about
the level of 2005 oil products trade suggested by Petrov (*see Note 41*).				
Implied annual level of imports,		3.53E+05	tonnes	
The UN Comtrade statistics database for that year lists total export from the RF to the DPRK (*see Note 41*) of		338,919	tonnes oil products.	
Assume that	65%	of these imports are diesel/gas oil, and		
	0%	are gasoline (based on trade statistics), and		
	35%	are heavy oil or the equivalent, then total		
import from Russia were		2.29E+05	of diesel and	
		4.63E-01	of gasoline	
		1.24E+05	of heavy oil.	
Imports in 2008 are estimated at	1	kbbl/day on average. This is a rough estimate, pending		
receipt of better data, but yields an approximate value for oil exports from Russia to the DPRK, if one				
assumes an average price of	$90	per bbl, of	$ 27.45	million, which is about
the level of 2008 petroleum products trade suggested by combining data on "mineral products" trade in *Note 40*				
with petroleum products trade from data from *Note 41*. This implies			5.04E+04	tonnes total imports.
The UN Comtrade statistics database for that year lists total export from the RF to the DPRK (*see Note 41*) of		42,126	tonnes oil products.	
Assume that	80%	of these imports are diesel/gas oil, and		
	0%	are gasoline, and		
	20%	are heavy oil or the equivalent, then total		
imports from Russia were		3.37E+04	of diesel and	
		1.40E+00	of gasoline	
		8.42E+03	of heavy oil.	
The UN Comtrade statistics database for 2009 lists total export from the RF to the DPRK (*see Note 41*) of		4,318	tonnes oil products.	
Assume that	40%	of these imports are diesel/gas oil, and		
	0%	are gasoline (based on trade statistics), and		
	60%	are heavy oil or the equivalent, then total		
		1.73E+03	of diesel and	
		5.68E-01	of gasoline	
		2.59E+03	of heavy oil.	
The UN Comtrade statistics database for 2010 lists total export from the RF to the DPRK (*see Note 41*) of		28,333	tonnes oil products.	
Assume that	95%	of these imports are diesel/gas oil, and		
	0.004%	are gasoline (based on trade statistics), and		
	5%	are heavy oil or the equivalent, then total		
		2.69E+04	of diesel and	
		1.06E+00	of gasoline	
		1.42E+03	of heavy oil.	

Year 2000 Oil products imports from other countries

Oil products imports from Japan: 4.43E+04 tonnes — *See Note 21*

Fraction as heavy fuel oil: 99.51%

Fraction as non-energy (solvents and lubricants): 0.49%

Total imports of heavy fuel oil from Japan: 4.41E+04 *tonnes*

Total imports of non-energy petrol. products from Japan: 2.15E+02 *tonnes*

Oil products from Singapore: Value: $9,986,108 — *See Note 22*

Volume: 56,649.85 tonnes

Implying an average price of $ 176.28 per tonne

Year 2000 average price per gallon: $ 0.78 gasoline — *See Note 23*

$ 0.77 gasoil

at an average density of 0.74 kg/liter for gasoline and

and 0.87 kg/liter for diesel and

at 3.78 liters per gallon

implies year 2000 average prices per tonne: $ 277.45 for gasoline

235.99 for diesel

Since the average price paid in 2000 by the DPRK was lower than the diesel (gasoil) price calculated above, we assume that imports are 15% gasoline and

85% diesel, and thus total

implied oil imports are 8.50E+03 tonnes of gasoline and

4.82E+04 tonnes of diesel.

Oil Products from the ROK:

Rough estimate of maximum rate of imports from ROK: 10,000 Bbl/day for — *See Note 24*

10% of the year, or an average of 1000 Bbl/day.

Assume that these oil products are (or can be used as) 70% diesel

and 30% heavy fuel oil at an assumed density of 0.95 kg/liter.

This implies imports from the ROK of 16,515 tonnes of heavy fuel oil and

35,290 of diesel.

Imports and Exports Associated with Asphalt Use for Road ***(see worksheet "Oil_Asphalt")***

Middle of estimated asphalt requirements for Nampo-Pyongyang Road built in 2000

48,214 tonnes

Assumed mass of heavy oil traded (probably to China) per tonne asphalt received:

1.00, which implies heavy fuel oil exports of: 48,214 tonnes

Estimate of Output of Smaller West Coast Refinery *(see Note 25)*

We know little about the small refinery on the West Coast of the DPRK, except that it is thought to be dedicated all or in part to the military, and is a relatively crude fractionation or "topper"-type refinery. It is not know where the oil for this refinery comes from--it could be some of the Russian oil described above, or could be oil supplied in barter from China (and thus not part of trade statistics), or could be purchased on the spot market. It operates in a batch mode, and reportedly had an capacity factor of about 20% in 2000. We do not know the capacity of this refinery, but estimate it below based on what is known about the capacity of the oil-fired power plant that is near the refinery site, and on the following rough estimates of refinery outputs and related assumptions.

Fraction of heavy fuel oil produced by the refinery used in the nearby power plant: 95% *Assumption*

Gross efficiency of power plant (assumes relatively poor condition and operation in a cogeneration mode to provide steam for the refinery). 19%

Implied heavy oil input to power plant: 1,991,747 GJ, or 47,572 toe when the powerplant and refinery operate at **full capacity**. Assuming that the refinery and power plant operate at the capacity level indicated above, the output of the refinery is roughly:

		Implied Output	
Output (Energy fraction of input)	Assumptions	toe	GJ
Heavy Fuel Oil	41%	10,015	4.19E+05
Gasoline	24%	5,863	2.45E+05
Diesel Oil	21%	5,130	2.15E+05
Kerosene/Jet Fuel	5%	1,221	5.11E+04
LPG/Refinery Gas/Non-Energy	5%	1,221	5.11E+04
TOTAL	96%	23,450	9.82E+05

Implied required crude oil input to refinery 24,427 toe or 1.02E+06 GJ

The refinery would produce 1.17E+05 toe operating at full capacity, with crude oil input of 1.22E+05 toe.

Consider 0% of these inputs to be crude oil imports not accounted for elsewhere. For 2000 and 2005 it is assumed that the DPRK has produced roughly 30,000 tonnes per year of crude oil from domestic sources (see Note 27). The reported site of the oil production is close enough to the reported site of the small West Coast refinery, and the estimated volume is on the same order of magnitude as the assumed output of DPRK crude oil, that we assume that either the domestic production goes to the small West Coast refinery, or, if there is in fact no significant domestic crude oil production in the DPRK, the crude oil used as feedstock from that refinery is imported from elsewhere (that is, is not captured in China Customs Statistics, or may come from Russia by truck or coastal tanker, or directly or indirectly from one of the countries that report oil exports to the DPRK, but in quantities that seem unreasonably high; see *Note 49*).

Input of refinery fuel to refinery (own use) at 0.0578 toe/te of input at above, for a total of 1,412 toe or 5.91E+04 GJ

plus the "shrinkage" indicated above at 977 toe or 4.09E+04 GJ

For a total of 2,389 toe or 1.00E+05 GJ

Refinery Net Output (for LEAP) is 22,038 toe

Year 2005 Oil products imports from other countries

Oil products imports from Japan: 99.46 tonnes *See Note 34*

Fraction as heavy fuel oil: 75.01%

Fraction as non-energy (solvents and lubricants): 24.99%

Total imports of heavy fuel oil from Japan: 74.61 *tonnes*

Total imports of non-energy petrol. products from Japan: 24.86 *tonnes*

Oil products from Singapore: *See Note 35*

Reported value: $904,790

Reported quantity: 952.04 tonnes

Implied average price: $ 950.37 per tonne

Assume that imports are 100% gasoline and 0% diesel, and thus having

an average density of 0.74 kg/liter for gasoline and

and 0.87 kg/liter for diesel and

implied oil imports are 9.52E+02 tonnes of gasoline and 0.00E+00 tonnes of diesel.

Oil products from India:

No oil products were reported exported by India to the DPRK in India's reporting year 2005-2006, so we assume that 0 tonnes of oil products were received in the DPRK by India in that year.

Oil Products from the ROK:

Rough estimate of rate of imports from ROK: 10,000 Bbl/day for *See Note 24*

5% of the year, or an average of 500 Bbl/day.

Assume that these oil products are (or can be used as) 70% diesel

and 30% heavy fuel oil at an assumed density of 0.95 kg/liter.

then at 3.78 liters per gallon,

This implies imports from the ROK of 8,258 tonnes of heavy fuel oil and 17,645 of diesel.

Year 2008 through 2010 Oil products imports from other countries

Oil products imports from Japan, 2008: 53.89 tonnes — *See Note 38*

Fraction as heavy fuel oil:	90.42%	
Fraction as non-energy (solvents and lubricants):	9.58%	
Total imports of heavy fuel oil from Japan	48.73	*tonnes*
Total imports of non-energy petrol. products from Japan	5.16	tonnes

Oil products imports from Japan, 2009

Imports from Japan in 2009 (and 2010/2011) relative to 2008	0%	*from UN Comtrade Statistics*
Total imports of heavy fuel oil from Japan	-	*tonnes*
Total imports of non-energy petrol. products from Japan	-	tonnes

Oil products from Singapore (2008 - 2010):

	2008	2009	2010	
Reported value:	$42,004,340	$ 100,937	$ 43,875	*See Note 35*
Reported quantity:	112,733.46	43.12	21.81	tonnes
Implied average price:	$ 372.60	$ 2,340.84	$ 2,011.69	per tonne

Assume that imports were

2008	2009	2010	
0%	100%	100%	gasoline and
100%	0%	0%	diesel, thus annual estimated imports were:
2008	2009	2010	
0.00E+00	0.00E+00	2.18E+01	tonnes of gasoline and
1.13E+05	4.31E+01	0.00E+00	tonnes of diesel.

Oil products from Malaysia (2009):

	2009	
Reported value:	$ 1,427,390	*See Note 45*
Reported quantity:	3,718.48	tonnes
Implied average price:	$ 383.86	per tonne

Assume that imports were

2009	
0%	gasoline and
100%	diesel, thus annual estimated imports were:
2009	
0.00E+00	tonnes of gasoline and
3.72E+03	tonnes of diesel.

No imports to the DPRK from Malaysia were recorded in UN Comtrade in 2010 (or 2011).

Oil products from India:

Indian customs statistics (see *Note 43*) include huge, and in all likelihood impossibly huge, exports of oil products from India to the DPRK in 2008 and 2009. The categories of these recorded exports (largely napthas and other products that may be inputs for the chemical industry), their volumes, and the volumes (typically of the same order of magnitude or larger for the same products) of products that India reports were exported from India to the ROK, suggest that the large volumes exported to the DPRK probably mostly, if not totally, represent mis-reporting by India, as has been suggested by other analysts. Moreover, the value of HS 27 (fuel products) trade reported by the ROK as coming from India (the vast bulk of which is in petroleum products), several billion dollars worth per year in recent years, is significantly greater in both of these years than the volume of exports to the ROK reported by India. We are inclined, pending further research into this issue, to conclude that the export of of petroleum products from India to the DPRK in 2008 and 2009 was probably non-zero, but small. As placeholder assumptions, we assume that the following volumes of fuel were exported to the DPRK from India:

2008	2009	2010	
2.00E+04	4.00E+04	0.00E+00	tonnes of gasoline and
0.00E+00	6.44E+04	39,920	tonnes of diesel.

Values above for gasoline are guesses. Significant exports to DPRK from India are reported in a category that would include gasoline (possibly "off-spec"?) and other light oil products, but the volumes reported, as noted above, are sufficiently high as to be not credible. 2009 diesel imports are are reported in the Indian statistics, and 2010 non-light oil products are listed in UN Comtrade statistics. These may well be over-estimates, given that the ROK also imported large quantities of diesel (or rather, non-specified diesel-like fuels) in the same years, but it would seem consistent with the much lower volumes of diesel imported from Singapore in 2009 relative to 2008--that is, maybe the DPRK got their supplies from India instead. An interesting, but hardly definitive, additional note about reported Indian petroleum products exports to the DPRK is that significant quantities of HS 27101190, of which at least one transformer oil is an example, were recorded. Perhaps the DPRK imported transformer oil in an attempt to improve the performance of their electrical tranformers? This is probably not likely, but intriguing.

Oil Products from the ROK (2008/2009/2010):

Rough estimate of rate of imports from ROK: 12,000 Bbl/day for *See Note 24*
7% of the year, or an average of 840 Bbl/day.
Assume that these oil products are (or can be used as) 85% diesel
at 0.87 kg/liter for diesel and
and 15.0% heavy fuel oil at an assumed density of 0.95 kg/liter.
Conversion: 3.78 liters per gallon,
This implies imports from the ROK of 6,936 tonnes of heavy fuel oil and
35,996 of diesel.

Oil Products from Other Countries (2008 - 2010; see ***Note 47***):

UN Comtrade data lists oil exports from a number of other countries, besides the ones identified individually above, for 2008 and 2009. These are mostly quite small quantities.
Most of the quantity under HS 271019 imported in 2008 seems to come from the Netherlands (see *Note 46*). The totals for
HS 271019 (assumed to be diesel or similar) and HS 271011 (assumed to be gasoline or similar) are provided below. It is possible that some of these could be specialty oils or lubricants.

	2008			2009		
	Value	Quantity (te)	Implied price ($/te)	Value	Quantity (te)	Implied price ($/te)
HS 271019	$ 3,237,684	5,927.89	$ 546.18	$ 1,638,241	3,947.21	$ 415.04
HS 271011	$ 49,673,911	52,588.23	$ 944.58	$ 16,574,700	28,669.55	$ 578.13

	2010		
	Value	Quantity (te)	Implied price ($/te)
HS 271019	$ 44,630,588	40,177.54	$ 1,110.83
HS 271011	$ 19,464,875	27,574.31	$ 705.91

Even including all recorded (and in the case of ROK, guessed at) oil products imports, 2009 and 2010 were unusually low years for supplies of diesel fuel. We assume that an additional 60,000 tonnes of diesel fuel was available for use in the DPRK in 2009, though the source could have been unrecorded (smuggled) imports,
For 2010, we assume that an additional 50,000 tonnes of diesel fuel were somehow imported.
In 2009, these imports could be thouse reported in Comtrade statistics as being from India but that we have provisionally suggested were probably imports into the ROK instead (this would be about equal to the amount of heavier oil products recorded as shipped from India to the DPRK in 2009; see ***note 47***), withdrawls from stocks, or possibly refinery output from crude oil imports (see, for example, ***Note 51***) that were not recorded otherwise. These amounts of oil are equivalent to one or two cargo deliveries by a small to medium-sized tanker ship.

Estimates of HFO and "Other Petroleum" (mostly Non-Energy) Imports in Other Years (for LEAP database), tonnes

In Non-KEDO column, 1990, 1996, 2000, 2005 values from above, others are interpolated.

	Heavy Fuel Oil				
Year	Non-KEDO	KEDO/6-Party Talks	Total	Other Petrol.	
1990	150,000	0	150,000	16,068	
1991	141,423	0	141,423	16,068	
1992	132,847	0	132,847	16,068	
1993	124,270	0	124,270	16,068	
1994	115,694	0	115,694	16,068	
1995	107,117	150,000	257,117	16,068	
1996	98,541	500,000	598,541	16,068	
1997	110,138	500,000	610,138	16,068	
1998	121,735	500,000	621,735	16,068	
1999	133,333	500,000	633,333	16,068	
2000	144,930	394,722	539,652	64,282	
2001	142,313	559,613	701,926	14,789	
2002	139,696	456,893	596,589	13,509	
2003	137,080	0	137,080	12,230	
2004	134,463	0	134,463	10,951	
2005	131,847	0	131,847	9,671	
2006	85,151	0	85,151	9,496	
2007	46,787	146,000	192,787	9,321	*See Notes 41 and 42 for 6-PT totals*
2008	15,409	304,000	319,409	9,145	*See Notes 41 and 42 for 6-PT totals*
2009	9,527	0	9,527	7,538	*See Notes 41 and 42 for 6-PT totals*
2010	16,483	0	16,483	9,917	*See Notes 41 and 42 for 6-PT totals*
2011		0			
2012		0			
2013		0			
2014		0			
2015		0			
2016		0			
2017		0			
2018		0			

Calculation of Net Refining Output Shares by Year, for LEAP Input, based on Balance figures and data above

Fuel Category	1990	1996	2000	2005	2008	2009	2010
Gasoline	24.2%	21.8%	20.1%	22.0%	22.0%	22.0%	22.4%
Aviation Gas	1.03%	2.32%	4.12%	2.14%	2.23%	2.23%	2.01%
Kero/Jet	8.45%	4.30%	4.37%	4.36%	4.36%	4.36%	5.11%
Diesel	18.5%	21.5%	21.6%	21.6%	21.6%	21.6%	21.0%
Residual Oil	36.8%	39.2%	39.6%	39.52%	39.5%	39.5%	39.1%
LPG	2.0%	4.7%	4.1%	7.13%	7.13%	6.80%	6.81%
Other	9.0%	6.1%	6.1%	3.22%	3.2%	3.6%	3.6%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Refined product balances in this workbook do not separately estimate LPG and "other" oil products. At present, we assume the following fractions by year of the aggregate category "LPG/Refinery Gas/Non-Energy" is composed of LPG.

1990	1996	2000	2005	2008	2009	2010
12%	28%	25%	43%	43%	41%	41%

These fractions will vary by year and be different for different refineries.

Sources/Notes:

1 Reference 3 reports 2.8 Mte. Note that the Korea Foreign Trade Association, in "Major Economic Indicators for North Korea", 1993. P. 33, lists a total of 2.43 million te oil, which includes imports from the former USSR, China, and Iran, but apparently does not include oil purchased On the spot market. 1990 figures. Other sources suggest that 2.8 Mte in 1990 is an over-estimate, thus we have assumed crude oil imports of 2.6 Mte in 1990.

2 Based on figures in: "Progress of Energy Saving in China's Petrochemical Industry", W.B. Shen, in Energy Markets and the Future of Energy Demand, LBL, 1988, p. 24-2.

3 Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 40

4 Young Sik Jang, North Korean Energy Economics, Korea Development Institute, 1994 (p. 62)

5 Exports to the DPRK from China. Source: China Customs Statistics.

6 Probably mostly gasoline (David Fridley, Lawrence Berkeley National Laboratory, Personal Communication).

7 Korean Peninsula Energy Development Organization (KEDO, 1996), Korean Peninsula Energy Development Organization, Annual Report, 1995. KEDO, Washington, D.C., July 31, 1996

8 Calculated estimate based on difference between estimated demand and estimated supply for heavy oil in 1996.

9 Note that 110% of estimated 1996 imports approximates the level of refined products imported from China (at least officially) as of 1993 (Sinton, J. (1996), China Energy Databook).

10 Net of refinery gas used in-plant, and calculated as LPG/Refinery gas-(input-other products output-refining loss)

11 Data for Western refinery estimates based on similar Chinese plants from David Fridley, Lawrence Berkeley National Laboratory (personal communication, 12/96). Data for Eastern (Russian-built) refinery from Source 17. Estimate from Fridley was modified by reducing heavy oil total by 7% to account for probable production of heavy non-energy products (bitumens/asphalts, petroleum coke, wax, lubricants), based very roughly on Chinese petroleum output statistics for 1990 (from Sinton, J. (China Energy Databook), p. II-55).

12 From International Petroleum Encyclopedia, 1996. Confirmed by other sources. East coast refinery has 7,300 barrels per day fluid cracking capacity.

13 Several sources have suggested that little, if any, crude oil beyond that imported from China has come into the DPRK in the two years prior to 1997--possibly one cargo at most (which would have been refined at Sonbong) --and almost certainly not in 1996.

14 Includes petroleum product imports reported to be "one-half of the output" of a 750,000 te (output) Chinese refinery located north of the Tumen River. This refinery is assumed to operate at a maximum of 80 percent of capacity (David Fridley, personal communication), yielding total output of 600,000 tonnes. Output shares of that refinery are assumed to be the same as in the West Coast DPRK refinery, but it is assumed that the products exported to the DPRK are weighted slightly toward diesel and gasoline and away from HFO, based on the higher need for motor fuels in the DPRK and the need for HFO to fuel power plants in adjacent areas of China. Our assumption is that 10,000 tonnes more of gasoline and of diesel are exported to the DPRK, and 20,000 tonnes less of HFO, relative to simply splitting the product slate of the refinery evenly between the two countries. For 1996, product imports also include 50,000 te each of gasoline and diesel reported to be provided by ship and rail from Russia. [Industry source--should be confirmed independently]

15 For 2000, includes quantities reported separately from the ROK, Russia, Singapore, and Japan, plus amounts of products similar to those received in 1996 from the Chinese refinery near the border (note 14).

16 [Not used]

17 Personal communication [QR 9/97].

18 Exports to the DPRK from China from China Customs Report 2000, pp. 1483-1495 (in Chinese).

19 From "Appendix 1: HFO Deliveries" of Korean Peninsula Energy Development Organization (KEDO) Annual Report 2001, obtained from www.kedo.org, 5/31/2002. Note that this figure is for oil actually delivered during the calendar year 2000, as two of the shipments of the "HFO Year 2000" occurred in 2001. Other annual reports from the same website (as of 2/2008) yield the following data for other years

Year	tonnes HFO delivered by calendar year	
1995	150,000	estimate based on stated plans
1996	500,000	estimate based on stated plans
1997	500,000	estimate based on stated plans
1998	500,000	estimate based on stated plans
1999	500,000	estimate based on stated plans
2000	394,722	
2001	559,613	
2002	456,893	
2003-on	none	
Sum of above	3,561,228	

Sum of all deliveries as reported in 2002 KEDO Annual Report 3,520,000

Since these two figures are very close, we use the unadjusted estimates for 1995 through 1999 as estimates of KEDO HFO deliveries in those years.

20 Industry source reports probable barter imports of oil products ("gas oil and light crude") from Russia at "less than 1.5 kbbl/day". We have assumed an average of 1500 bbl/day.

21 From Japan customs statistics, http://www.customs.go.jp/toukei/info/index_e.htm. Composed of a combination of products, but 99 percent by mass are in the class designated "HS# 271000400". The designation of this code appears to be Heavy Fuel Oil of some kind, which is consistent with its specific gravity of near one.

22 Based on text in "Singapore" section of "Current Status and Features of North Korean Foreign Trade of the First Half of 2001", from www.kotra.or.kr/main/common_bbs which suggests that the maximum value of oil exports to the DPRK in the first half of 2000 would have been about $8.5 million (but could have been considerably less). The actual data on sales of oil products from Singapore to the DPRK in 2000 are as follows (from UN Comtrade statistics) for HS 271000 (oil products):

Trade value:	$9,986,108	volume (kg)	56,649,852	implied cost:	$ 176.28	$/tonne

23 Data from the US DOE Energy Information Administration (table http://www.eia.doe.gov/pub/oil_gas/petroleum (downloaded from http://www.eia.doe.gov/emeu/international/prices.html#Motor) suggests that spot prices for diesel fuel and gasoline in Singapore averaged $ 0.7761 *and* $ 0.7735 *per gallon, respectively, in 2000.*

These figures are used to roughly calculate oil product quantities purchased from Singapore.

24 An industry source suggests that the ROK sent to the DPRK in 2000 a maximum of "8 - 10 kbbl/day of off-spec HSFO for brief periods". "Off-spec" fuels do not meet ROK specifications for quality. We assume a rate of shipment of about 10 kbbl/day for about 10 percent of 2000. Lacking additional information, we assume a lower rate of exports from the ROK to the DPRK in 2005, 2008. and 2009.

25 Information on this refinery from industry sources. Fuel output shares of refinery are very rough Nautilus estimates.

26 Assumes, based on industry sources, that relatively little KEDO HFO remained in storage at the end of 2000.
We assume that stocks accrued in 1996 were drawn down at 30,000 *tonnes per year through 2002,*
when KEDO deliveries ceased, then were drawn down more slowly, at 5000 *tonnes per year, through 2006.*

27 There have been reports that the DPRK "began to produce crude oil in a sea well off Sukchon County, South Pyongan Province" in 1998 (Lee Kyo Kwan, writing on www.chosun.com, "North Korea Exports Petroleum", probably sometime in 2001). This article suggests, without citing any figures that DPRK production was significant enough to allow the reduction of petroleum imports. Though our conversations with some experts in the industry have suggested that any production from DPRK wells was minimal, other sources in the literature suggest that DPRK oil production has indeed been enough to supply a significant fraction of DPRK needs. For example, Selig Harrison writes in Toward Oil and Gas Cooperation in Northeast Asia: New Opportunities for Reducing Dependence on the Middle East (published as Woodrow Wilson Center for International Scholars Asia Program Special Report No. 106, dated December 2002, and available as http://www.wilsoncenter.org/topics/pubs/asiarpt_106.pdf), that "an oil well [in Sukchon] began producing 2.2 million barrels annually in 1999". This is similar to a figure of 300,000 *tonnes crude oil per year quoted in several publications by Keun-Wook Paik, including Pipeline Gas Introduction to the Korean Peninsula, published by Chatham House, January 2005, and available as http://www.chathamhouse.org.uk/pdf/research/sdp/KPJan05.pdf.*
In the Chatham House report, Paik writes (p. 37) "Even though the scale of annual crude oil production from the Sook-Cheong County's Anju Basin is very small (0.3 mt/y), to the North Korean authorities it is a significant volume."
In personal correspondence with Dr. Paik, he indicates that the information for this estimate came from an article in the ROK press in approximately 2001, and that while he has not seen the quantity of oil production confirmed, he he believes that some oil production is ongoing. Dr. Harrison indicates that his figure for DPRK oil production was likely taken from the work of Dr. Paik, or from the same original source. Other experts in the field consulted on this question have expressed skepticism that DPRK domestic oil production to date, if any, has been even close to as significant as the quantity reported.
Accordingly, it is possible that a more reasonable figure for ongoing DPRK domestic oil production is 10% *of this reported value (which might also have been misreported due to an error in reporting units, as happens occasionally in the DPRK and elsewhere).*
Oil from this production could go to the small western refinery, apparently located nearby.

Another reference to the chronology of oil exploration in the DPRK includes the statement "The DPRK obtained 450 barrels of petroleum in the offshore areas of Nampo" ("Interview with DPRK's Oil Project Planner" [Mr. Choi Dong Ryong], The People's Korea, 1998, available as http://www1.korea-np.co.jp/pk/073rd_issue/98120902.htm). Given that Nampo is well south of Sukchon county.it seems unlikely, though not impossible, that this production and the 1998 production described above are from the same offshore oilfield.
An alternative estimate of DPRK oil production, from index mundi (http://www.indexmundi.com/g/g.aspx?c=kn&v=88), based on data from the CIA World Factbook, which suggests that DPRK oil production in 2004 to 2007 was about 140 bbl per day, declining to 118 bbl per day in 2009 (and 2010, according to the CIA World Factbook). See that graph below. At 140 *bbly/day, oil production would have been about* 51,100 *bbl/yr, which, at* 7.3 *bbl/tonne, would be* 7,000 *tonnes/yr. This is lower than the rough estimate above, though approximately on the same order of magnitude.*
Both estimates are likely to be quite speculative, but we use the CIA estimate for this analysis because it seems consistent with qualitative reports to date. For 2009 and 2010, we therefore use 118 *bbly/day of oil production, or* 5,900 *tonnes/yr, pending receipt of more specific information.*

28 Calculated based on 1990 data for China from J.E. Sinton, ed (1992). China Energy Databook. Lawrence Berkeley National Laboratory, Berkeley, CA, USA. (Revised 1996).

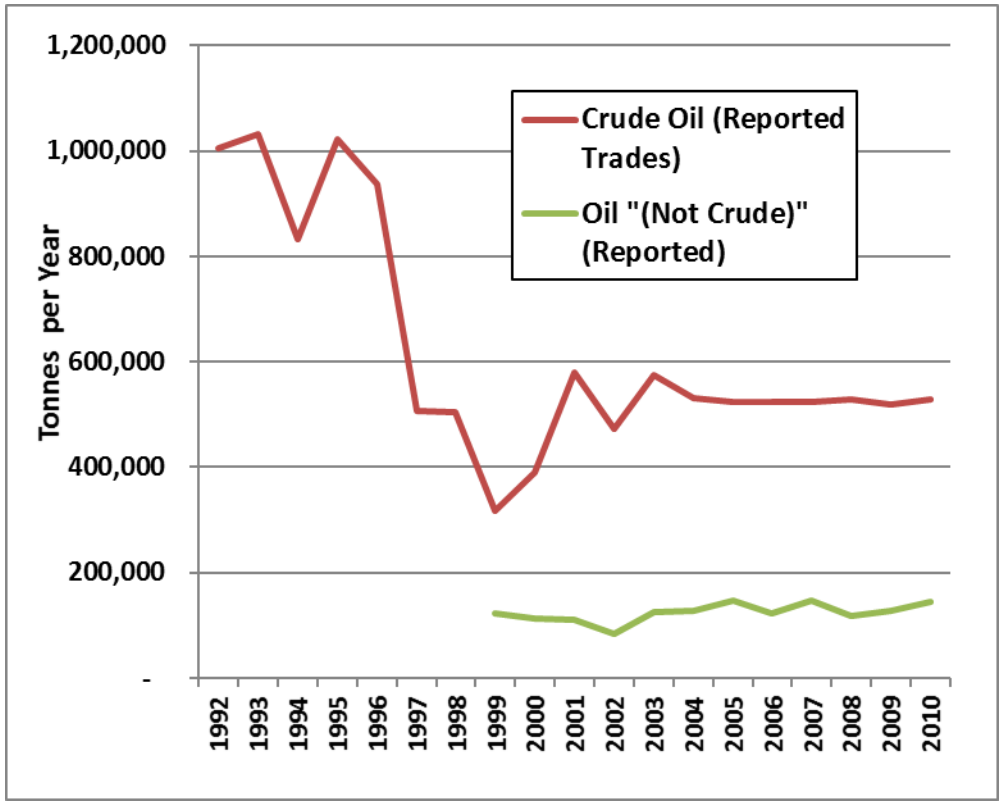
29 The website http://www.answers.com/topic/north-korea, visited 1/15/07, listed oil pipelines in the DPRK of total length 154 km as of 2004.

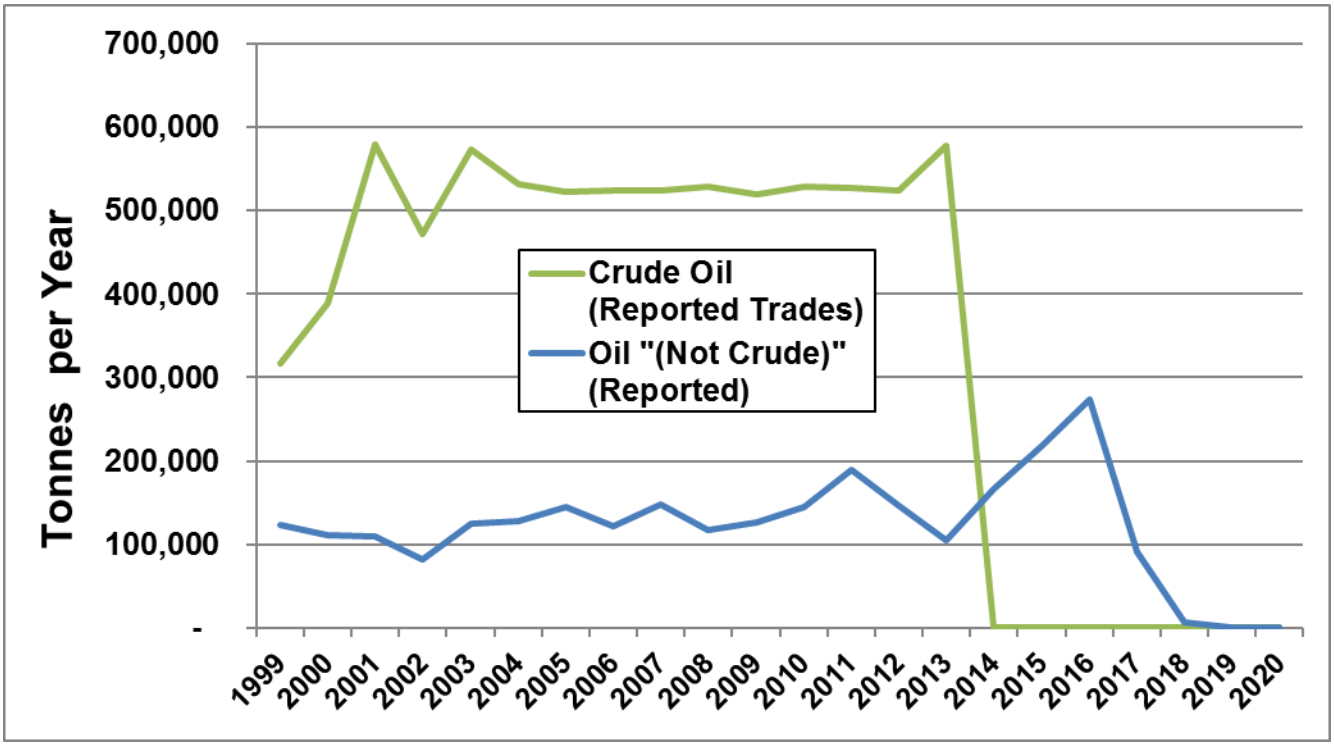
30 China Customs Statistics reported crude oil exports from China to the DPRK of 522,844.40 tonnes *in 2005. As compiled by Nathanial Aden, 2006, 2008, and 2010. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's 2006 paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf. Crude oil and oil products imports to DPRK from China, as indicated by the same source, are as follows for other years: (Values for 1992-95, 1997, 1998, 2010 and 2011 and on are from UN Comtrade database.)*

Year	Crude Oil (Reported Trades)	Oil "(Not Crude)" (Reported)	"PETROLEUM COKE,RESIDU"	"PETROLEUM OTHER GASES"
1992	1,005,642			
1993	1,032,954			
1994	832,786			
1995	1,021,520			
1996	936,170	66,533	1,845	-
1997	506,147			
1998	503,931			
1999	317,241	122,966.47	1,791.57	11.13
2000	389,236	111,501.04	1,617.51	46.40
2001	579,278	109,311.22	2,065.68	149.80
2002	472,167	82,471.55	6,547.86	215.85
2003	573,558	124,726.96	4,369.66	232.34
2004	531,785	127,968.58	5,283.75	354.37
2005	522,844	145,506.35	2,864.52	496.80
2006	524,040	122,303.02	1,532.99	755.77
2007	523,160	147,678.87	3,083.45	770.05
2008	528,577	117,742.86	2,330.22	479.73
2009	519,814	126,741.40	3,283.52	543.00
2010	528,315	145,015.29	5,638.29	663.70
2011	526,176	188,700.24	7,063.80	4,311.46
2012	523,041	146,794.55	3,128.02	2,164.11
2013	578,002	105,037.32	4,174.47	2,577.17
2014	-	166,128.30	11,057.33	3,157.95
2015	-	218,087.25	11,540.78	3,031.28
2016	-	274,066.75	4,780.05	1,074.68
2017	-	90,865.51	6,590.60	1,765.31
2018	-	6,912.69	12,244.49	1,715.55
2019	-	-	-	-
2020	-	-	-	-

Units: metric tonnes

All crude oil shipped to the DPRK from China was recorded as coming from the Dalian district from 1999-2005.
No official reports of exports of refined products were available in the UN Comtrade statistics for 2019 and 2020 as of 5/1/2020.
No crude trades reported by from 2014-2020, but trade us assumed to have continued. See Note 56.


1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Tonnes per Year
Crude Oil (Reported Trades)
Oil "(Not Crude)" (Reported)
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
Tonnes per Year
Crude Oil (Reported Trades)
Oil "(Not Crude)" (Reported)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Units: Kilograms

Commodity Code	Product/Product Group	2002	2003	2004	2005	2006
2710	OIL (NOT CRUDE)	82,471,546	124,726,964	127,968,583	145,506,346	122,303,020
271019	OIL (NOT CRUDE) FROM PETROL	63,900,162	78,280,544	89,821,556	104,543,577	91,422,768
27101921	Light diesel oil	3,647,230	20,871,299	34,458,192	46,668,386	
27101911	Aviation kerosene	46,649,237	46,307,578	46,572,203	46,994,450	
27101993	Basic oils for lubricating oils	2,722,165	3,435,866	2,524,002	3,628,783	
27101991	Lubricating oils	6,366,340	4,170,232	2,705,837	2,320,426	
27101922	Fuel oils No. 5 ~ No. 7	-	2,569,560	2,600,000	3,573,156	
27101929	Other diesel oils and other fuel oils	4,268,282	490,000	-	1,186,911	
27101992	Lubricating grease	246,908	254,890	183,135	167,665	
27101994	Liquid paraffin and heavy liquid paraffin	-	990	-	170	
27101999	Other lubricating oils, greases and other heavy oil	-	180,129	778,187	3,630	

Commodity Code	Product/Product Group	2007	2008	2009	2010*	2011*
2710	OIL (NOT CRUDE)	147,678,866	117,742,858	90,447,291	145,015,288	192,387,198
271019	OIL (NOT CRUDE) FROM PETROL	122,963,762	74,568,855	51,689,392	89,502,995	130,414,603
27101921	Light diesel oil	12,496,241	14,046,689	10,460,146	37,377,619	77,062,665
27101911	Aviation kerosene	51,205,986	50,542,083	35,229,535	40,294,669	40,611,621
27101993	Basic oils for lubricating oils	1,958,658	1,680,951	1,686,362	1,630,412	1,830,858
27101991	Lubricating oils	1,942,129	3,370,020	1,289,901	1,872,114	1,175,256
27101922	Fuel oils No. 5 ~ No. 7	9,422,740	3,981,836	2,575,871	8,131,040	9,269,624
27101929	Other diesel oils and other fuel oils	45,789,974	-	-	3,960	-
27101992	Lubricating grease	139,217	938,921	141,577	189,221	184,374
27101994	Liquid paraffin and heavy liquid paraffin	-	-	-	-	1,980
27101999	Other lubricating oils, greases and other heavy oil	8,817	8,355	306,000	3,960	278,225

Commodity Code	Product/Product Group	2012 and 2013 include trades with Hong Kong SAR 2012	2013	2014	2015	2016	2017	2018	2019	2020
2710	OIL (NOT CRUDE)	146,794,545	105,037,323	166,128,300	218,087,246	274,066,748	90,865,506	6,912,693	-	-
271019	OIL (NOT CRUDE) FROM PETROL	95,095,269	51,028,254	87,396,626	123,078,114	177,899,648	44,523,546	6,873,273	-	-
27101921	Light diesel oil									
27101911	Aviation kerosene									
27101993	Basic oils for lubricating oils									
27101991	Lubricating oils									
27101922	Fuel oils No. 5 ~ No. 7									
27101929	Other diesel oils and other fuel oils									
27101992	Lubricating grease									
27101994	Liquid paraffin and heavy liquid paraffin									
27101999	Other lubricating oils, greases and other heavy oil									

**2010 and 2011 values by product (above, for category 27109, and below for 27011 in 2011) are based on values from China Customs database as compiled by Nate Aden, 10-3-2012. Most other values from UN Comtrade statistics.*

Units: Kilograms

Commodity Code	Product/Product Group	2002	2003	2004	2005	2006	2007	2008
2710	OIL (NOT CRUDE)	82,471,546	124,726,964	127,968,583	145,506,346	122,303,020	147,678,866	117,742,858
271011	LIGHT OILS & PREP (NOT CRUDE)	18,571,384	46,446,418	38,147,027	40,947,469	30,880,249	24,715,104	43,174,003
271012								
271019		63,900,162	78,280,544	89,821,556	104,543,577	91,422,768	122,963,762	
27101110	Motor gasoline, aviation gasoline	18,328,384	46,199,539	38,144,787	40,893,374		24,574,734	43,165,743
27101130	Rubber solvent, paint solvent, extractive solvent	143,000	188,179	2,240	3,300		140,370	8,260
27101190	Other light oils and preparations	100,000	-	-	-		-	-
27101199	Other light oils and preparations	-	58,700	-	50,795		-	-
Differences from totals for 2710		-	2	-	15,300			-

Commodity Code	Product/Product Group	2009	2010*	2011*	2012	2013	2014	2015
2710	OIL (NOT CRUDE)	90,447,291	145,015,288	192,387,198	146,794,545	105,037,323	166,128,300	218,087,246
271011	LIGHT OILS & PREP (NOT CRUDE)	38,757,899	55,501,253	58,285,641				
271012					56,330,475	54,158,294	78,731,274	95,009,132
271019					95,095,269	51,028,254	87,396,626	123,078,114
27101110	Motor gasoline, aviation gasoline	38,737,609	55,413,344	58,182,039				
27101130	Rubber solvent, paint solvent, extractive solvent	20,290	87,909	103,602				
27101190	Other light oils and preparations	-	-					
27101199	Other light oils and preparations	-	-					
Differences from totals for 2710		-	11,040	3,686,954	(4,631,199)	(149,225)	400	-

Commodity Code	Product/Product Group	2016	2017*	2018	2019	2020
2710	OIL (NOT CRUDE)	274,066,748	90,865,506	6,912,693	0	0
271011	LIGHT OILS & PREP (NOT CRUDE)			0		
271012		96,167,100	46,341,960	30,020	0	0
271019		177,899,648	44,523,546	6,873,273	0	0
27101110	Motor gasoline, aviation gasoline					
27101130	Rubber solvent, paint solvent, extractive solvent					
27101190	Other light oils and preparations					
27101199	Other light oils and preparations					
Differences from totals for 2710		-	-			

Units: Metric Tonnes

Commodity Code	Product/Product Group	1992	1993	1994	1995	1996	1997	1998	1999
2712	PETROLEUM JELLY;WAXES	93.2	-	-	-	3.2	113.1	13.1	95.5
2713	PETROLEUM COKE,RESIDUES	486.9	8,518.0	6,591.7	17,908.6	1,844.7	781.8	1,227.4	1,791.6
2714	BITMN,ASPHLT;TAR SAND	-	-	-	-	-	5.0	-	-
2715	BITUMEN,TAR RELATED	-	-	-	-	-	57.5	-	-

Above data (1992-2001) from UN Comtraded Database

Units: Metric Tonnes

Commodity Code	Product/Product Group	2000	2001	2002	2003	2004	2005
2708	PITCH,COKE FM MN TARS	4,243.2	4,306.3	4,959.2	6,179.5	4,488.2	5,720.6
2711	PETROLEUM,OTHER GASES	46.4	149.8	215.9	232.3	354.4	496.8
2712	PETROLEUM JELLY;WAXES	87.9	59.0	187.0	157.8	149.0	108.9
2713	PETROLEUM COKE,RESIDUES	1,617.5	2,065.7	6,547.9	4,369.7	5,283.8	2,864.5
2714	BITMN,ASPHLT;TAR SAND	10.5	2.0	-	26.1	0.5	-
2715	BITUMEN,TAR RELATED	-	8.0	-	29.0	1.6	1.5

Commodity Code	Product/Product Group	2006	2007	2008	2009	2010	2011
2708	PITCH,COKE FM MN TARS	5,560.9	6,186.5	5,901.5	7,635.3	11,053	8,759.3
2711	PETROLEUM,OTHER GASES	755.8	770.1	479.7	543.0	663.7	1,292.2
2712	PETROLEUM JELLY;WAXES	133.2	111.2	251.8	117.1	113.05	126.9
2713	PETROLEUM COKE,RESIDUES	1,533.0	3,083.5	2,330.2	3,283.5	5,745.3	7,063.8
2714	BITMN,ASPHLT;TAR SAND	0.5	9.8	42.8	34.0	-	-
2715	BITUMEN,TAR RELATED	-	-	17.6	111.2	214.6	102.0

Commodity Code	Product/Product Group	2012	2013	2014	2015	2016	2017	2018	2019	2020
2708	PITCH,COKE FM MN TARS	7,612.7	7,386.0	5,010.0	7,391.1	6,784.7	12,366.8	8,401.8	-	-
2711	PETROLEUM,OTHER GASES	2,164.1	2,577.17	3,158.0	3,031.3	1,074.7	1,765.3	1,715.6	-	-
2712	PETROLEUM JELLY;WAXES	103.9	80.4	52.2	50.4	55.8	77.3	43.2	-	-
2713	PETROLEUM COKE,RESIDUES	3,128.0	4,174.5	11,057.3	11,540.8	4,780.1	6,590.6	12,244.5	-	-
2714	BITMN,ASPHLT;TAR SAND	1.7		0.4	-	-	2.1	0.7	-	-
2715	BITUMEN,TAR RELATED	127.3	101.04	50.4	2,347.6	123.6	2.0	4.7	-	-

Note that the highlighted values for "oil, not crude" in the first table in this note does not match the value for the same quantity in the second and third tables. The reason for this is that in its 2009 customs statistics, China placed four months (August-November 2009) of its exports to the DPRK under the category "Asia, NES".
The total in the first table above includes exports from China to "NES", while the totals in the second and third tables do not. As a consequence, we have attempted to categorize the individual fuels in the additional "Asia NES"-designated imports (about 37,000 tonnes total) by fuel type in the calculations in the "Refined Products Imports from and Exports to China, 2008 and 2009" table above. Relevant data from the UN Comtrade database for 2009 through 2011 (exports to the DPRK from China) are as follows:

		2009		2010		2011	
Commodity Code	Product/Product Group	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)
2710	OIL (NOT CRUDE)	$ 69,252,199	126,741,402	$ 104,886,571	145,015,288	$ 192,387,198	188,700,244
271011	LIGHT OILS & PREP (NOT CRUDE)	$26,288,119	50,621,296	$40,629,283	55,501,253	$ 58,445,319	58,285,641
271019	OIL (NOT CRUDE) FROM PETROL	$42,964,080	76,120,106	$64,257,288	89,514,035	$ 133,941,879	130,414,603

Export to China from the DPRK as recorded (by China) in the UN COMTRADE database are as follows:

		2009		2010		2011		2012		2013	
Commodity Code	Product/Product Group	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)
2710	OIL (NOT CRUDE)			$ 3,942	2,340	$ 20,496	12,560				

		2013		2014		2015		2016		2017	
Commodity Code	Product/Product Group	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)
2710	OIL (NOT CRUDE)			$ 717	31	$ 20,496	12,560				
271019	OIL (NOT CRUDE) FROM PETROL							$302,959	247,216		

		2018		2019		2020	
Commodity Code	Product/Product Group	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)
2710	OIL (NOT CRUDE)						
271019	OIL (NOT CRUDE) FROM PETROL						

No trades reported in Comtrade as of 2/26/20 for 2018 through 2020

Imports to DPRK from China from UN Comtrade Database

	Commodity Code 381121: Additives for lubricating oils containing petroleum oils/oils obtained from bituminous materials		
	Volume (te)	Value	$/Tonne
1996	19.80	$31,679	$ 1,600
2000	19.89	$38,189	$ 1,920
2001	32.06	$59,099	$ 1,843
2002	37.67	$59,600	$ 1,582
2003	92.01	$113,917	$ 1,238
2004	139.39	$205,723	$ 1,476
2005	190.60	$334,970	$ 1,757
2006	101.99	$170,731	$ 1,674
2007	90.08	$234,588	$ 2,604
2008	338.24	$1,053,679	$ 3,115
2009	210.01	$593,900	$ 2,828
2010	170.53	$555,181	$ 3,256
2011	284.98	$1,033,059	$ 3,625
2012	391.46	$1,394,578	$ 3,563
2013	485.53	$1,833,941	$ 3,777
2014	402.74	$1,454,147	$ 3,611
2015	217.93	$890,418	$ 4,086
2016	163.14	$619,424	$ 3,797
2017	245.68	$601,659	$ 2,449
2018	182.50	$412,325	$ 2,259
2019	-	$0	
2020	-	$0	

No trades reported in Comtrade as of 2/26/20 for 2019 through 2020

31 Assumes no KEDO oil remained in storage as of end-2005. KEDO suspended shipments of heavy oil to the DPRK as of December, 2002 (see, for example, http://www.kedo.org/).

32 Source cited in note 30 lists no imports of oil products from the DPRK into China in the categories below for the years 1995 to 2005 with the exception of 2002, as shown.

27101919	Other kerosene distillages	1,098	tonnes
27101999	Other lubricating oils, greases and other heavy oil	8,593	tonnes

and for the following years in a more aggregate categories "OIL (NOT CRUDE)" and "OIL (NOT CRUDE) FROM PETROL & BITUM MINERAL ETC" (used in 2002), as shown. (Category 271019 in 2007-2009; values for 2010-2017 from UN Comtrade database)

1997	**1998**	**1999**	**2000**	**2002**	**2003**	**2004**	**2005**	
236,478	7,175	19,180	19,935	11,704				tonnes

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	
	0	1.805	-	2.34	12.56	0	-	tonnes

2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
-	0	247.216	-	-	-	-	tonnes

Exports to China from the DPRK of gaseous petroleum products were recorded as:

Units: tonnes

Commodity Code	Product/Product Group	1995	1996	1997	1998	1999	2000	2001	2002	2003
271119	OTHER,LIQUEFIED	11,703	10,450	5,874	4,100	4,534	4,315	8,747	8,558	4,679
2711	PETROLEUM,OTHER GASES	11,703	10,490	5,874	4,100	4,534	4,315	8,747	8,558	4,679

Commodity Code	Product/Product Group	2004	2005	2006	2007	2008	2009	2010	2011
271119	OTHER,LIQUEFIED	6,598	3,844						
271112	PROPANE, LIQUEFIED								
271113	BUTANES, LIQUEFIED								
271114	Ethylene, propylene, butylene, butadiene, liquefied	0	549	4,118	5,230	3,148	2,908	2,940	4,311
2711	PETROLEUM,OTHER GASES	6,598	4,393	4,118	5,230	3,148	2,908	2,940	4,311

Commodity Code	Product/Product Group	2012	2013	2014	2015	2016	2017	2018	2019	2020
2711	PETROLEUM,OTHER GASES	3,089	2,963	3,405	4,352	224	-	-	-	-

33 Source cited in note 30 lists the following detail on imports of gaseous oil products into the DPRK from China in the categories below (2010, 2011, and some data by gas from UN Comtrade statistics).

Units: Kilograms

Commodity Code	Product/Product Group	1999	2000	2001	2002	2003	2004	2005
2711	PETROLEUM,OTHER GASES	11,130	46,400	149,800	215,850	232,335	354,365	497,397
271119	OTHER,LIQUEFIED**	-	-	17,400	13,850	21,550	55,707	125,894
271113	BUTANES, LIQUEFIED	11,130	46,400	132,400	202,000	210,755	298,658	361,826
271111	NATURAL,LIQUEFIED	-	-	-	-	-	-	9,677
271112	PROPANE, LIQUEFIED	-	-	-	-	-	-	-
271129	OTHER GASES,GASEOUS*	-	-	-	-	30	-	-

Units: Kilograms

Commodity Code	Product/Product Group	2006	2007	2008	2009	2010	2011
2711	PETROLEUM,OTHER	756,070	770,052	479,727	543,001	663,704	1,292,235
271119	OTHER,LIQUEFIED**	327,030	418,950	346,426	461,022	510,685	1,008,644
271113	BUTANES, LIQUEFIED	423,940	351,102	133,301	81,979	147,019	283,591
271111	NATURAL,LIQUEFIED						
271112	PROPANE, LIQUEFIED	100				6,000	
271114	Ethylene, propylene, butylene, butadiene, liquefied						
271129	OTHER GASES,GASEOUS*	5,000					

* Petroleum gases and gaseous hydrocarbons nes, as gas

**Petroleum gases & gaseous hydrocarbons nes, liquefied

Commodity Code	Product/Product Group	2012	2013	2014	2015	2016	2017	2018	2019	2020
2711	PETROLEUM,OTHER	2,164,108	2,577,169	3,157,951	3,031,277	1,074,682	1,765,312	1,715,552		
271119	OTHER,LIQUEFIED**	1,334,415	1,381,990	1,706,780	1,697,510	484,610	741,550	524,920		
271113	BUTANES, LIQUEFIED	829,693	1,195,179	1,451,171	1,333,767	588,597	1,023,762	1,190,632		
271111	NATURAL,LIQUEFIED						0	0		
271112	PROPANE, LIQUEFIED					1,475	0	0		
	Ethylene, propylene, butylene, butadiene,									
271114	liquefied						0	0		
271129	OTHER GASES,GASEOUS*						0	0		

**Petroleum gases & gaseous hydrocarbons nes, liquefied; No trades reported for 2019 in Comtrade as of 5/5/2020

34 Data from files downloaded from http://www.customs.go.jp/toukei/download/index_d012_e.htm yields the following summary of oil products exports from Japan to the DPRK in 2005:

Commodity Code	Product/Product Group (Probable)	Quantity, kl	Quantity, kg	Value-Year (1000 Yen)	Implied value, 1000 yen/unit
'271019520'	"SOLID OR SEMI-SOLID LUBRICANT PREPN"	16	14397	4484	0.311
'271019590'	"Other Heavy Oils and Preparations"	78	74605	19174	0.257
'271019600'		0	1328	839	0.632
'271019900'	OTHER LUBRICATING OILS, OTH. HEAVY OILS	9	9131	1951	0.214
Sum of Petroleum Products Above			99,461		

Total petroleum products exports from Japan to the DPRK in 2005 were a tiny fraction of those in 2000.

35 *Singapore oil trade statistics for 2005, 2008, and 2009 are as provided below (from United Nations "Comtrade" database, as downloaded and provided by Jennifer Lee of the Peterson Institute for International Economics, 10/2010). In 2005, an industry source suggested that there may have been approximately 25,000 tonnes of petroleum products shipped periodically, perhaps every six weeks or so, from Singapore to the DPRK. The product shipped was reported to be likely "gas oil" for use in power generation, industry, and marine diesel engines. We assume that the imports from Singapore listed below are diesel oil or similar fuels. 2010 data taken directly from UN Comtrade database, 8/28/12.*

Commodity Code 271019 "Petroleum oils & oils obt. from bituminous mins. (excl. crude) & preps. oth …"

Year	Value ($ thousand)	Quantity (tonnes)	Implied price ($/ton)
2005	905	952.04	$ 950.37
2008	42,004	112,733.46	$ 372.60
2009	101	43.12	$ 2,340.84
2010	44	21.81	$ 2,011.69

Most additional trades from Singapore (from 2011-on) are cataloged below (note 47), but one trade in 2017, listed at 60 *kg, but listing a value of* $103,195 *is not included below, as the cost per kg seems extreme, probably indicating a reporting error.*

36 *For 2005 and on, includes quantities reported/estimated separately from China, the ROK, Russia, and Japan, but without those estimated to have been received in 1996 from the Chinese refinery near the border (note 14), as those exports, if they continue today, are thought to now be reflected in official Chinese customs statistics (Nate Aden, personal communication).*

37 *A source familiar with the oil industry estimates that the DPRK in 2005 used "no more than 18 - 19 thousand barrels [of crude oil and oil products] per day" on average. Given the considerable uncertainties in some of the reported oil products imports to the DPRK (and a small portion of the DPRK's crude oil inputs), we have taken the middle of this range as a target total for the overall oil supply to the DPRK.*

38. Data from files downloaded from http://www.customs.go.jp/toukei/download/index_d012_e.htm
yields the following summary of oil products exports from Japan to the DPRK in 2009, 2008, and 2007:
No exports from Japan to the DPRK in oil products categories are listed in statistics for 2010 or 2011.

Commodity Code	Product/Product Group (Probable)	Quantity, kl	Quantity, kg	Value-Year (1000 Yen)	Implied value, 1000 yen/unit	Year
'271019520'	"SOLID OR SEMI-SOLID LUBRICANT PREPN"	0	0	0		2009
'271019590'	"Other Heavy Oils and Preparations"	12	12600	5250	0.417	2009
'271019600'		0	320	446	1.394	2009
'271019900'	OTHER LUBRICATING	0	0	0		2009
Sum of Petroleum Products Above			12,920			2009
'271019520'	"SOLID OR SEMI-SOLID LUBRICANT PREPN"	5	5000	1734	0.347	2008
'271019590'	"Other Heavy Oils and Preparations"	47	48727	17322	0.355	2008
'271019600'		0	160	216	1.350	2008
'271019900'	OTHER LUBRICATING	0	0	0		2008
Sum of Petroleum Products Above			53,887			2008
'271019520'	"SOLID OR SEMI-SOLID	1	1000	600	0.600	2007
'271019590'	"Other Heavy Oils and Preparations"	712	23145	7064	0.305	2007
'271019600'		0	0	0		2007
'271019900'	OTHER LUBRICATING	0	480	213	0.444	2007
Sum of Petroleum Products Above			24,625			2007

39. Based on data from GlobalSecurity.org, "Weapons of Mass Destruction (WMD), Six-Party Talks" (http://www.globalsecurity.org/wmd/world/dprk/6-party.htm)
The DPRK received 150,000 *tonnes of heavy fuel oil under the 6-Party Talks agreement in 2007.*

40 Dick K. Nanto and Emma Chanlett-Avery, "North Korea: Economic Leverage and Policy Analysis" , US Congressional Research Service, dated January 22, 2010, and available as http://www.fas.org/sgp/crs/row/RL32493.pdf, includes the following passage regarding Russian fuels trade with the DPRK:

> Major Russian exports to the DPRK include mineral fuels, wood pulp, machinery, non-rail vehicles, iron and steel, and wood. Russian exports of mineral fuels have been declining from a peak of $224.4 million in 2005 to $73.5 million in 2007 and $41.6 million in 2008.

41 *In "Russian 'Power Politics', North Korea and the Future of Northeast Asia" (In The Asia-Pacific Journal: Japan Focus), Leonid Petrov dated on July 29, 2008, and available as http://www.japanfocus.org/-Leonid-Petrov/2835, includes the following passages:*

> "…During 2004–2005, petroleum [products] trade between Russia and North Korea grew from $105 million to $172.3 million."
> and
> "The Maritime Province (Primorsky Krai) itself exports to North Korea more than $4 million worth of refined oil per year. There are no oil fields in the Russian Maritime Province and oil has to be obtained through a chain of federal bureaucratic structures from the oil-rich areas of Eastern Siberia. Instead of money, the local governments agree to receive the labour of North Korean workers."
> and
> "This year, Russia has already delivered 100,000 tons of fuel oil to the DPRK in two batches and, according to Russian Deputy Foreign Minister Alexei Borodavkin, a top Russian envoy to the Six-Party Talks, will deliver another 100,000 tons by October 2008."
> and
> "Recently, for the first time in the post-Soviet era, North Korea saw a major Russian investment. In the city of Pyeongseong the Russian auto plant KamAZ opened its first assembly line, specialising in the production of medium-size trucks named "Taebaeksan-96". Although less than 50 trucks were assembled in 2007 this cooperation became an important milestone in the development of bilateral relations. While the project doesn't violate United Nations sanctions on North Korea, it shows Moscow's drive to expand its influence in the country. Ironically, the more trucks assembled the heavier North Korea's dependence on imported fuel, engine oils and other petrochemical products. "

The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 10/19/10, 8/23/12, and 6/8/18, and 2/27/20) includes the exports from Russia to the DPRK of oil products.

	HS271011: Light oils and preparations (2710112 after 2011)			HS271019: 'Petroleum oils & oils obtained from bituminous minerals (other than crude) & preparations not elsewhere specified…" probably diesel and heavy oils			HS2710: 'Petroleum oils and oils obtained from bituminous minerals, other than crude; preparations not elsewhere specified or included....", aggregate category for petroleum products		
Period	Trade Value	NetWeight (kg)	Cost per Tonne	Trade Value	NetWeight (kg)	Cost per Tonne	Trade Value	NetWeight (kg)	Cost per Tonne
2000							$1,621,861	6,862,811	$ 236.33
2005	$3,867,434	8,704,467	$ 444.30	$140,877,871	330,214,190	$ 426.63	$144,745,305	338,918,657	$ 427.08
2006	$1,779,745	2,879,099	$ 618.16	$67,031,085	116,715,130	$ 574.31	$68,810,830	119,594,229	$ 575.37
2007	$837,987	1,101,248	$ 760.94	$69,340,553	133,045,608	$ 521.18	$70,178,540	134,146,856	$ 523.15
2008	$644,830	460,593	$ 1,400.00	$25,770,853	41,665,420	$ 618.52	$26,415,683	42,126,013	$ 627.06
2009	$1,373,927	2,419,666	$ 567.82	$1,513,772	1,898,396	$ 797.40	$2,887,699	4,318,062	$ 668.75
2010	$326	307	$ 1,061.89	$16,454,259	28,332,755	$ 580.75	$16,454,585	28,333,062	$ 580.76
2011	$10,587	8,764	$ 1,208.01	$37,373,167	41,015,117	$ 911.20	$37,383,754	41,023,881	$ 911.27
2012	$49,028	35,511	$ 1,380.64	$3,955,876	2,372,221	$ 1,667.58	$4,004,903	2,407,732	$ 1,663.35
2013	$3,501,125	3,992,726	$ 876.88	$20,158,818	25,027,164	$ 805.48	$23,659,942	29,019,890	$ 815.30
2014			#DIV/0!	$19,857,418	26,045,014	$ 762.43	$19,857,418	26,045,014	$ 762.43
2015	$5,403,501	10,255,658	$ 526.88	$13,122,328	26,082,223	$ 503.11	$18,525,829	36,337,881	$ 509.82
2016			#DIV/0!	$1,747,276	3,212,469	$ 543.90	$1,747,276	3,212,469	$ 543.90
2017	$321,813	410,020	$ 784.87	$5,279,897	8,548,930	$ 617.61	$5,601,710	8,958,950	$ 625.26
2018	$18,282,618	22,092,724	$ 827.54	$2,077,077	2,827,687	$ 734.55	$20,359,695	24,920,411	$ 816.99
2019									
2020									
Sum/Average, 2005 -2018	$36,072,921	52,360,783	$ 688.93	$ 424,560,250	787,002,324	$ 539.47	$ 460,633,169	839,363,107	$ 548.79

	HS381121: Additives for lubricating oils containing petroleum oils/oils obtained from bituminous materials			HS 340319: Lubricating preparations containing petroleum oils/oils obtained from bituminous minerals (not for textile/fur treatment)			HS 3354: "Petroleum Bitumin, Petroleum Coke, and Bituminous Mixtures"		
Period	Trade Value	NetWeight (kg)	Trade Quantity	Trade Value	NetWeight (kg)	Cost per Tonne	Trade Value	NetWeight (kg)	Trade Quantity
2008				$21,174	579	$ 36,569.95			
2009				$4,504	411	$ 10,958.64			
2010				$62,587	51,605	$ 1,212.81			
2011	$8,000	238	238	$25,519	207	$ 123,280.19	$7,471	1,952	1,952
2012	No trades reported in UN Comtrade			$42,240	22,000	$ 1,920.00	This category is no longer available in		
2013	through 2018			$143,244	65,795	$ 2,177.13	UN Comtrade as of 10/2018. Presumably		
2014				$14,950	489	$ 30,572.60	it is now included in other categories, such		
2015				0	-	#DIV/0!	as 2713, 2714…		
2016				$15,771	972	$ 16,225.31			
2017				$ 395	84	$ 4,702.38			
2018				$ 13,804	204	$ 67,666.67			
2019									
2020									

No trades reported in Comtrade for 2019 ast of 5/5/2020

	HS2711: Petroleum Gases and Other Gaseous Hydrocarbons					
Period	Trade Value	NetWeight (kg)	Cost per Tonne			
2008	No significant imports to the DPRK from Russia recorded until 2014					
2009						
2010						
2011						
2012						
2013						
2014	$24,703	35,290	$ 700.00	ll "other" (271119)		
2015	$722,542	1,470,454	$ 491.37	Mostly "271114", no LPG		
2016	$1,191,951	2,962,664	$ 402.32	Mostly "other", not LPG (about	2.4%	propane).
2017	$2,329,145	5,021,839	$ 463.80	Mostly "other" and "271114", not LPG (about	14.4%	propane).
2018	$1,202,636	2,249,621	$ 534.59	Mostly "other" and "271114", not LPG (about	18.5%	propane).
2019				No trades reported in Comtrade as of 5/5/2020		
2020						

42 In CRS Report to Congress, U.S. Assistance to North Korea, by Mark E. Manyin and Mary Beth Nikitin, available as http://www.fas.org/sgp/crs/row/RS21834.pdf, and dated July 31, 2008, included the statement:

> "North Korea has received a total of 330,000 tons of heavy fuel oil and 60,000 tons of fuel equivalent (i.e., steel products to renovate aging power plants)."

Ambassador Chris Hill's testimony on July 31, 2008 described delivery of a total of 420,000 *tonnes of heavy fuel oil, out of a total promised volume of 950,000 tonnes, as of that date (see http://www.ncnk.org/resources/publications/Amb_Hill_Testimony_SASC_July_08.pdf) A further delivery of* 50,000 *tonnes was shipped from the US in late 2008 (see http://www.nautilus.org/mailing-lists/napsnet/dr/2008/20081113.html).*

Following from http://www.icks.org/publication/pdf/2009-SPRING-SUMMER/5.pdf, "U.S. Assistance to North Korea", by Mark E. Manyin and Mary Beth Nikitin, of the US Congressional Research Service, International Journal of Korean Studies · Vol. XIII, No. 1, pp. 85-105.

Table 2. Delivery of Heavy Fuel Oil to the DPRK, July 2007 – December 2008

Shipment Date	Donor Country	Amount HFO Delivered (MT)
Jul-07	ROK	50,000
Sep-07	China	50,000
Nov-07	USA	46,000
Jan-08	Russia	50,000
Mar-08	USA	54,000
May-08	Russia	50,000
Jul-08	USA	34,000
Aug-08	USA	16,000
Nov-08	USA	50,000
Dec-08	Russia	50,000
TOTAL		450,000
Source: Compiled by the Congressional Research Service		

43 Indian trade statistics record substantial flows of oil products to the DPRK in recent years. In some cases, these flows appear to be hundreds of thousands of tonnes per year, with values in the hundreds of millions, and in one year on the order of a billion, dollars. Given that some of these volumes are A) sufficiently large as to be on the same order as all known (or strongly suspected) oil and oil products imports from elsewhere, and B) placed overwhelmingly in product categories such as naptha (mostly used as an input to chemicals manufacture) and other (unspecified) light oil products, that it, categories that do not necessarily correspond with major DPRK oil requirements, it is clear that the data cannot be accepted on face value. Some analysts (Jennifer Lee, Petersen Institute, personal communications, 10/2010) suggest that it is possible that Indian statistics have inadvertently mis-categorized oil products exported to the ROK as oil products exported to the DPRK. A summary of statistics related to oil exports from India to the DPRK and ROK follows.

Reported Oil Exports to DPRK from India, Quantity in Tonnes

	Year									
HS Code	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010	HS Code	Products Included in Code
27074000	4.3					240,000.00	63,000.00		27074000	NAPTHALENE
27082000		60							27082000	PITCH COKE
27101119									27101119	OTHER MOTOR SPIRIT
27101190					752340	633130	371500		27101190	OTHER LIGHT OILS AND PREPARATIONS
27100094	22500	35060		55000	268450				27100094	P.O.L. PRODUCTS
27101920	10	40000			20	20			27101920	AUIATION TURBINE FUEL (ATF)
27101930					22500				27101930	HIGH SPEED DIESEL (HSD)
27101950									27101950	FUEL OIL
27101960									27101960	BASE OIL
27101990				30000			64400		27101990	OTHER PETROLEUM OILS AND OILS OBTAINE FROMBITUMINOUS MINERALS NES
27122090	12								27122090	OTHER PARAFFIN WAS CNTNG BY WT
27109900				29700					27109900	OTHER WASTE OIL
27129090					10	1.67	5		27129090	OTHER PARAFFIN WAXES OBTAINED BY SYNTHESIS/OTHER PROCESS W/N COLOURED NES
271011	*From UN Comtrade Database*							246,800		
271019	*From UN Comtrade Database*							39,920		

Reported Oil Exports to ROK from India, Quantity in Tonnes

	Year								
HS Code	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	HS Code	Products Included in Code
27074000					38,750.00	108,000.00	29,700.00	27074000	NAPTHALENE
27079900			0.42	14	14			27079900	OTHR OIL & OIL PROCUCTS OF DISTILLATION OFHIGH TEMP COAL TAR ETC
27090000				29700				27090000	PETROLEUM OILS & OILS OBTAINED FROM BITUMINOUS MINERALS CRUDE
27101119			85000	564840	259200	970680	618990	27101119	OTHER MOTOR SPIRIT
27101190			15750	88540	170630	657470	1,377,060	27101190	OTHER LIGHT OILS AND PREPARATIONS
27082000								27082000	PITCH COKE
27100094		194820	219430	54000	110000			27100094	P.O.L. PRODUCTS
27101111				174040				27101111	SPECIAL BOILING POINT MOTOR SPIRITS (OTHERTHAN BENZENE TOLUOL) WITH NOMIAL BOILING POINT RANGE 55-1150C
27101920		30	50	50	30	312740	990	27101920	AUIATION TURBINE FUEL (ATF)
27101930					5500	1,345,710	15000	27101930	HIGH SPEED DIESEL (HSD)
27101950			17500		10		96280	27101950	FUEL OIL
27101980			10	200		80000	50	27101980	LUBRICATING OIL
27101990		80000	632760	553100	131620	526960	182990	27101990	OTHER PETROLEUM OILS AND OILS OBTAINE FROMBITUMINOUS MINERALS NES
27109900			38000		202960		15000	27109900	OTHER WASTE OIL
27111400				12,253.00				27111400	LQFD ETHYLNE PROPYLENE BUTYLENE & BUTADENE
27111900							13,280.00	27111900	OTHR LQFD PETRLM GASES & GASEOUS HYDRCRBN
27121010			15	14				27121010	CRUDE PETROLEUM JELLY
27121090			8	89.66	14	129.3	76.55	27121090	OTHER PETROLEUM JELLY
27122010			16		59	19.6	80.2	27122010	CHLORONATED PARAFFIN WAX
27122090					2.7			27122090	OTHER PARAFFIN WAS CNTNG BY WT
27129010						0.29		27129010	MICRO-CRYSTALLINE PETROLEUM WAS
27129090			10	7.07	73	103.38	83.86	27129090	OTHER PARAFFIN WAXES OBTAINED BY SYNTHESIS/OTHER PROCESS W/N COLOURED NES
27131100			0.08					27131100	PETROLEUM COKE NOT CALCINED
27131200			0.04					27131200	PETROLEUM COKE CALCINED
27149090			12		0.3			27149090	OTHER ASPHALTITES & ASPHALTIC ROCKS

Data above (and first two rows of table below) from http://commerce.nic.in/eidb/ecntcomq.asp

Total value of HS 27 Imports to ROK or DPRK from India, $$ thousand

	Year							
Reported by	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	
India to DPRK	$ 5,610	$ 30,800	$ -	$ 65,400	$ 777,850	$ 844,930	$ 330,120	
India to ROK	$ 41,050	$ 103,610	$ 496,190	$ 869,070	$ 733,430	$ 2,170,610	$ 1,526,960	
	2003	2004	2005	2006	2007	2008	2009	2010
ROK from India (UN)	$281,159	$434,860	$835,148	$1,754,345	$2,592,060	$3,944,862	$2,289,798	
ROK from India (KITA)	$ 281,159	$ 434,860	$ 835,148	$ 1,754,345	$ 2,592,060	$ 3,944,862	$ 2,289,798	$ 2,115,057

"UN" data from United Nations Comtrade System for Exports from India to the ROK, as reported by the ROK.
"KITA" data from Korea International Trade Association, http://global.kita.net/.
Note that in each year, the value of HS 27 products reported exported by India to both Koreas combined is much less than the value of HS 27 products reported imported from India by the ROK alone.

44 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 10/19/10, 8/23/12, and 8/2018) includes the following statistics on exports from the DPRK to Russia of oil products (none reported in 2011):

Period	Code	Trade Value	NetWeight (kg)	Trade Quantity
2006	271019	$7,646	10,645	10,645
2008	271019	$9,433	3,697	3,697
2010	271019	$10,977	5,940	5,940
2011	271019	$0	0	-
2012	271019	$1	1	1
2013	271019	$3,624	947	947
2014	271019	$0	0	-
2015	271019	$0	0	-
2016	271019	$0	0	-
2017	271019	$532	117	117
2018	No exports reported for 2018 in Comtrade as of 3/2/2020			

45 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 2/10/11 and 8/28/12) includes the following statistics on exports to the DPRK from Malaysia of oil products in 2008 through 2011 (none reported in 2010 or 2011):

Period	Code	Trade Value	NetWeight (kg)	Implied cost per ton
2008	271011	78	200	$ 390.00
2009	271019	$1,427,390	3,718,477	$ 383.86
2009	271011	$424,445	1,082,255	$ 392.19

46 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 2/10/11 and 28/28/2012) includes the following statistics on exports to the DPRK from the Netherlands (and some imports to the Netherlands from the DPRK, as marked) of oil products in recent years:

Period	Code	Trade Value	NetWeight (kg)	Trade Quantity	Code Definition	
2005	271019	$9,949	394	394	petroleum oils except light oil/waste oils	
2007	271019	$46,676	11,350	11,350	petroleum oils except light oil/waste oils	
2008	271019	$2,478,562	5,245,516	5,245,516	petroleum oils except light oil/waste oils	
2007	340319	$5,491	2	2	Lubricating oil etc containing <70% petroleum oil nes	
2009	271019	$670,934	458,692	458,692	petroleum oils except light oil/waste oils	Exports to Netherlands
2010	271019	$73,129,414	115,934,196	115,934,196	petroleum oils except light oil/waste oils	Exports to Netherlands*

** This reported trade is sufficiently large that we assume that it is mis-reported, perhaps confused with a trade with the ROK, which reported exports of over a billion dollars worth of fuel in this category to the Netherlands in 2010.*

47 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/28/2012 and 6/6/2018) includes the following statistics on trade flows of oil products between the DPRK and a number of countries not included in the notes above.
We omit trade flows of less than 1 ton of product (or the equivalent in value) from this summary. Note that some of the quantities shown are sufficiently high as to be not credible as actual transactions. We believe that those listings are probably recording errors, not actual transactions involving the DPRK, and they are marked with yellow highlights..

Period	Country	Import to the DPRK/ Export From the DPRK	Code	Trade Value	NetWeight (kg)	Implied cost/te	Notes
2008	Côte d'Ivoire	Import	271019	$ 15,651	17,083	$ 916.17	
2008	Germany	Import	271019	$ 29,000	10,600	$ 2,735.85	
2008	Greece	Import	271019	$ 173,412	149,800	$ 1,157.62	
2008	India	Import	271011	$ 753,555,357	799,726,016	$ 942.27	
2008	India	Import	271019	$ 18,370,926	22,525,000	$ 815.58	
2008	Italy	Import	271011	$ 26,444,721	25,114,640	$ 1,052.96	
2008	Romania	Import	271019	$ 108,400	107,590	$ 1,007.53	
2008	Spain	Import	271011	$ 23,229,112	27,473,393	$ 845.51	
2008	Tunisia	Import	271019	$ 62,205	43,922	$ 1,416.26	
2008	Turkey	Import	271019	$ 176,797	299,396	$ 590.51	
2008	Australia	Export	271019	$ 29,267	28,825	$ 1,015.33	
2008	Australia	Export	271091	$ 119,074	N/A	#VALUE!	271091 - "Waste oils containing PCBs, PCTs, PBBs…"
2008	Bulgaria	Export	271019	$ 47,635	9,657	$ 4,932.69	
2008	Pakistan	Export	271019	$ 58,522	84,000	$ 696.69	
2008	Peru	Export	271019	$ 18,268,432	36,525,068	$ 500.16	
2008	Tunisia	Export	271019	$ 5,611,559	4,979,340	$ 1,126.97	
2008	Turkey	Export	271019	$ 48,572,265	51,186,085	$ 948.93	
2008	Yemen	Export	271019	$ 13,651	12,440	$ 1,097.35	
2009	Bulgaria	Import	271019	$ 1,988	2,694	$ 737.94	
2009	Côte d'Ivoire	Import	271019	$ 5,639	1,850	$ 3,048.11	
2009	Germany	Import	271019	$ 19,000	5,200	$ 3,653.85	
2009	Greece	Import	271019	$ 114,498	186,151	$ 615.08	
2009	India	Import	271011	$ 174,656,196	301,400,000	$ 579.48	
2009	India	Import	271019	$ 41,933,181	64,400,000	$ 651.14	
2009	Italy	Import	271011	$ 16,150,255	27,587,298	$ 585.42	
2009	Turkey	Import	271019	$ 33,127	26,080	$ 1,270.21	
2009	Bulgaria	Export	271019	$ 34,086	18,531	$ 1,839.40	
2009	Mozambique	Export	271019	$ 51,970	35,530	$ 1,462.71	
2009	Nepal	Export	271019	$ 597,702	408,626	$ 1,462.71	
2009	Thailand	Export	271019	$ 93,656	64,029	$ 1,462.71	
2009	Uganda	Export	271019	$ 10,099	30,228	$ 334.09	
2010	Canada	Import	271019	$ 12,759	11,446	$ 1,114.71	
2010	Côte d'Ivoire	Import	271019	$ 21,703	14,920	$ 1,454.62	
2010	Egypt	Import	271019	$ 205,384,031	315,000,000	$ 652.01	
2010	India	Import	271011	$ 163,152,578	246,800,432	$ 661.07	
2010	India	Import	271019	$ 44,501,319	39,920,472	$ 1,114.75	
2010	Italy	Import	271011	$ 19,464,875	27,574,309	$ 705.91	
2010	Turkey	Import	271019	$ 94,807	230,700	$ 410.95	
2010	Benin	Export	271019	$ 22,697	940,982	$ 24.12	
2010	Brazil	Export	271019	$ 29,023,298	47,292,757	$ 613.69	
2010	Chile	Export	271099	$ 642	6,640	$ 96.69	271099 = Waste oils other than those containing polychlorinated biphenyls (PCBs)/polychlorinated terphenyls (PCTs)/polybrominated biphenyls (PBBs)
2010	Mexico	Export	271019	$ 9,942	8,253	$ 1,204.65	
2010	Niger	Export	271019	$ 376,515	446,291	$ 843.65	
2010	Sri Lanka	Export	271019	$ 4,623,240	4,210,544	$ 1,098.01	
2010	Uganda	Export	271019	$ 7,432	29,585	$ 251.21	
2010	United Rep. of Tanzania	Export	271019	$ 830,261	1,108,208	$ 749.19	
2011	Greece	Import	271019	$ 54,653	24,384	$ 2,241.35	
2011	India	Import	271011	$ 39,919	10,000	$ 3,991.90	
2011	India	Import	271019	$ 1,217	1,426	$ 853.44	
2011	South Africa	Import	271011	$ 29,652	15,000	$ 1,976.80	
2011	Turkey	Import	271019	$ 32,850	15,262	$ 2,152.40	
2011	Guyana	Export	271019	$ 22,135	3,884	$ 5,699.02	
2011	India	Export	271019	$ 3,476,764	2,620,000	$ 1,327.01	
2011	Indonesia	Export	271011	$ 2,572,466	2,001,984	$ 1,284.96	
2011	Mexico	Export	271019	$ 10,862	7,957	$ 1,365.09	
2011	Niger	Export	271019	$ 31,308	6,709	$ 4,666.57	
2011	Pakistan	Export	271019	$ 189,313	245,000	$ 772.71	
2011	Rwanda	Export	271019	$ 10,712	25,900	$ 413.59	
2012	Ecuador	Import	271019	$386,094	141,850	$ 2,721.85	
2012	Guyana	Import	271019	$52,480	10,670	$ 4,918.46	
2012	Mozambique	Import	271019	$44,580	23,380	$ 1,906.76	

Period	Country	Import from the DPRK/ Export to the DPRK	Code	Trade Value	NetWeight (kg)	Implied cost/te	Notes
2012	Rwanda	Import	271019	$4,527	3,980	$ 1,137.44	
2012	India	Export	271019	$30,622,183	36,697,000	$ 834.46	
2012	Colombia	Import	271019	$51,528	15,498	$ 3,324.82	
2012	Germany	Export	271019	$68,119	10,861	$ 6,271.89	
2012	Italy	Export	271019	$46,276	2,820	$ 16,409.93	
2012	Pakistan	Import	271019	$201,873	255,000	$ 791.66	
2012	Papua New Guinea	Import	271019	$86,474	45,351	$ 1,906.76	Weight not provided by Comtrade, estimated roughly based on guess of cost of ~$1900/te
2012	Singapore	Export	271019	$36,893	16,620	$ 2,219.80	
2012	Turkey	Export	271019	$33,421	32,068	$ 1,042.19	
2013	Benin	Import	271019	$882,477	1,500,000	$ 588.32	
2013	Guyana	Import	271019	$57,188	13,084	$ 4,370.83	
2013	Kenya	Import	271019	$8,144	*6,440*	$ 1,264.60	
2013	Kyrgyzstan	Import	271019	$28,754	18,700	$ 1,537.65	
2013	Mauritania	Import	271019	$52,429	61,800	$ 848.37	
2013	Niger	Import	271019	$83,720	73,115	$ 1,145.05	
2013	Niger	Export	271019	$44,783	39,676	$ 1,128.72	
2013	Suriname	Import	271019	$36,287	12,501	$ 2,902.73	
2013	Burkina Faso	Import	271019	$7,088,487	6,134,187	$ 1,155.57	
2013	Germany	Export	271019	$152,321	16,650	$ 9,148.41	
2013	Guinea	Import	271019	$5,172,529	6,061,914	$ 853.28	
2013	Netherlands	Import	271019	$123,779,987	128,074,331	$ 966.47	
2013	Pakistan	Import	271019	$134,539	180,000	$ 747.44	
2013	Rwanda	Import	271019	$11,170	10,920	$ 1,022.89	
2013	India	Export	271019	$68,243,094	68,139,000	$ 1,001.53	
2013	Singapore	Export	271019	$451,543	170,490	$ 2,648.50	
2013	Thailand	Import	271019	$2,588	*1,615*	$ 1,602.48	
2013	Turkey	Export	271019	$4,706,381	4,550,230	$ 1,034.32	
2014	Benin	Import	271019	$4,989,453	7,500,000	$ 665.26	
2014	Guyana	Import	271019	$27,197	5,252	$ 5,178.41	
2014	Niger	Import	271019	$38,528	34,040	$ 1,131.84	
2014	Nigeria	Import	271019	$38,996	*21,929*	$ 1,778.28	
2014	Suriname	Import	271019	$20,208	6,285	$ 3,215.27	
2014	Brazil	Import	271019	$104,411	75,342	$ 1,385.83	
2014	Germany	Export	271019	$251,093	30,247	$ 8,301.42	
2014	Guinea	Import	271019	$14,300	18,182	$ 786.49	
2014	Pakistan	Import	271019	$393,485	373,000	$ 1,054.92	
2014	India	Import	271019	$132,102	84,000	$ 1,572.64	
2014	India	Export	271019	$145	1,000	$ 145.00	
2014	Singapore	Export	271019	$251,432	100,980	$ 2,489.92	
2014	Thailand	Import	271019	$7,709	*4,335*	$ 1,778.32	
2014	United Arab Emirates	Export	271019	$38,465	69,980	$ 549.66	
2014	United Arab Emirates	Re-Export	271019	$38,465	69,980	$ 549.66	
2014	Turkey	Export	271019	$4,760,967	4,753,271	$ 1,001.62	
2014	Uganda	Import	271019	$7,329,875	7,381,975	$ 992.94	
2014	United Rep. of Tanzania	Import	271019	$3,900,827	4,200,000	$ 928.77	
2015	Brazil	Import	271019	$39,600	37,540	$ 1,054.87	
2015	Benin	Import	271019	$9,272,598	15,335,880	$ 604.63	
2015	Honduras	Import	271019	$32,069	1,424	$ 22,520.37	
2015	Malaysia	Export	271019	$53,110	17,964	$ 2,956.47	
2015	Pakistan	Import	271019	$145,863	132,000	$ 1,105.02	
2015	India	Import	271019	$864,167	1,288,000	$ 670.94	
2015	Singapore	Export	271019	$491,422	127,070	$ 3,867.33	
2015	Turkey	Import	271019	$13,054,833	26,903,555	$ 485.25	
2015	Turkey	Export	271019	$4,632,530	8,092,310	$ 572.46	
2015	Uganda	Import	271019	$618,469	924,364	$ 669.08	
2015	Burkina Faso	Import	271019	$33,395,798	47,041,362	$ 709.92	
2015	Philippines	Import	271019	$1,924,222	6,071,305	$ 316.94	

2016	Philippines	Import	271019	$11,965,872	40,815,208	$ 293.17	
2016	Fiji	Import	271019	$41,621	*28,849*	$ 1,442.72	
2016	Other Asia, nes	Export	271019	$67,141	31,000	$ 2,165.84	
2016	Nepal	Import	271019	$44,230	23,948	$ 1,846.92	
2016	Niger	Export	271019	$2,107	2,523	$ 835.12	
2016	Pakistan	Import	271019	$321,330	434,000	$ 740.39	
2016	India	Import	271019	$24,993	13,000	$ 1,922.54	
2016	India	Export	271019	$6,331	8,000	$ 791.38	
2016	Singapore	Export	271019	$146,644	78,900	$ 1,858.61	
2016	Turkey	Import	271019	$1,397,450	3,000,000	$ 465.82	
2016	Turkey	Export	271019	$430,086	1,010,199	$ 425.74	
2016	Burkina Faso	Import	271019	$7,573,630	11,732,475	$ 645.53	
2017	Import	Solomon Isds	271019	$5,682	*289,818*	$ 19.61	
2017	Import	Ecuador	271019	$64,131	82,098	$ 781.15	
2017	Import	Pakistan	271019	$736,674	1,242,000	$ 593.14	
2017	Import	India	271019	$418,806	689,000	$ 607.85	
2017	Export	Turkey	271019	$18,239	30,962	$ 589.08	
2012	Import	Bangladesh	271012	$50,533,746	130,986,938	$ 385.79	
2012	Import	Indonesia	271012	$7,573,361	6,551,038	$ 1,156.06	271012 = "Petroleum Spirit for Motor Vehicles-- LEGACY NON-WCO CODE"
2012	Import	Papua New Guinea	271012	$326,430	289,170	$ 1,128.85	Quantity is a rough estimate based on cost
2012	Import	Turkey	271012	$1,123,900	995,615	$ 1,128.85	
2013	Import	Bangladesh	271012	$3,153,389	8,289,925	$ 380.39	
2013	Import	Indonesia	271012	$3,302,030	2,817,464	$ 1,171.99	
2013	Import	Pakistan	271012	$78,296	99,000	$ 790.87	
2013	Export	South Africa	271012	$16,464	74,986	$ 219.56	
2014	Import	Sri Lanka	271012	$23,215	18,220	$ 1,274.15	
2014	Export	South Africa	271012	$104,448	*95,578*	$ 1,092.80	
2015	Import	Fiji	271012	$8,736,477	*8,233,236*	$ 1,061.12	
2015	Export	Mexico	271012	$45,328,837	*45,712,940*	$ 991.60	
2015	Export	South Africa	271012	$750,683	*757,044*	$ 991.60	
2016	Import	Fiji	271012	$3,856,201	4,772,526	$ 808.00	Quantity is a rough estimate based on cost
2016	Import	Pakistan	271012	$45,248	56,000	$ 808.00	
2016	Export	India	271012	$238	*526*	$ 452.47	
2016	Export	South Africa	271012	$323,306	*504,879*	$ 640.36	
2017	Export	India	271012	$16,493,194	34,947,000	$ 471.95	
2017	Export	South Africa	271012	$613,957	2,727,188	$ 225.12	
2018	Import	Pakistan	271012	$48,068	89,000	$ 540.09	
2018	Export	South Africa	271012	$491,565	2,171,864	$ 226.33	
2018	Import	Guyana	271019	$67,240	30,303	$ 2,218.92	
2018	Import	Suriname	271019	$26,693	14,094	$ 1,893.93	
2018	Import	Solomon Isds	271019	$10,491	12,000	$ 874.25	
2018	Import	Benin	271019	$2,548,551	4,002,340	$ 636.77	
2018	Export	Benin	271019	$238,478	430,527	$ 553.92	
2018	Re-Export	Benin	271019	$238,478	430,527	$ 553.92	
2018	Import	Saudi Arabia	271019	$3,600	266	$ 13,533.83	
2018	Import	Burkina Faso	271019	$77,635	109,641	$ 708.08	
2018	Import	Brunei Darussalam	271019	$7,932	528	$ 15,022.73	
2018	Import	Fiji	271019	$67,354	31,408	$ 2,144.49	
2018	Import	Ghana	271019	$10,979	16,180	$ 678.55	
2018	Export	Greece	271019	$4,493	5,466	$ 821.99	
2018	Import	Nicaragua	271019	$1,501	262	$ 5,729.01	
2018	Import	Pakistan	271019	$377,136	221,000	$ 1,706.50	
2018	Import	South Africa	271019	$81,462	15,300	$ 5,324.31	
2018	Import	Zambia	271019	$41,229	39,620	$ 1,040.61	
2019	Import	Armenia	271019	$2,232	720	$ 3,100.00	
2019	Import	Pakistan	271019	$1,301,620	1,694,000	$ 768.37	
2019	Import	Zambia	271019	$186,910	198,430	$ 941.94	

Summary of above, by product, import/export, and year, excluding waste oil shipments and highlighted trades that (highlighted in yellow) that are likely included in Comtrade statistics as a result of erroneous reporting.

Period	Import to the DPRK/ Export From the DPRK	Code	Trade Value	NetWeight (kg)	NetWeight (te)	Implied cost/te
2008	Import	271011	$ 49,673,833	52,588,033	52,588	$ 944.58
2008	Import	271019	$ 565,465	628,391	628	$ 899.86
2008	Export	271019	$ 72,601,331	92,825,415	92,825	$ 782.13
2009	Import	271011	$ 16,150,255	27,587,298	27,587	$ 585.42
2009	Import	271019	$ 174,252	221,975	222	$ 785.01
2009	Export	271019	$ 787,513	556,944	557	$ 1,413.99
2010	Import	271011	$ 19,464,875	27,574,309	27,574	$ 705.91
2010	Import	271019	$ 44,630,588	40,177,538	40,178	$ 1,110.83
2010	Export	271019	$ 5,870,087	6,743,863	6,744	$ 870.43
2011	Import	271011	$ 69,571	25,000	25	$ 2,782.84
2011	Import	271019	$ 88,720	41,072	41	$ 2,160.11
2011	Export	271011	$ 2,572,466	2,001,984	2,002	$ 1,284.96
2011	Export	271019	$ 3,741,094	2,909,450	2,909	$ 1,285.84
2012	Import	271012	$ -		-	#DIV/0!
2012	Import	271019	$ 30,806,892	36,759,369	36,759	$ 838.07
2012	Export	271012	$ 9,023,691	7,835,823	7,836	$ 1,151.59
2012	Export	271019	$ 827,556	495,729	496	$ 1,669.37
2013	Import	271012	$ 16,464	74,986	75	$ 219.56
2013	Import	271019	$ 73,598,122	72,916,046	72,916	$ 1,009.35
2013	Export	271012	$ 6,533,715	11,206,389	11,206	$ 583.03
2013	Export	271019	$ 13,555,724	14,072,661	14,073	$ 963.27
2014	Import	271012	$ 104,448	95,578	96	$ 1,092.80
2014	Import	271019	$ 5,302,102	4,955,478	4,955	$ 1,069.95
2014	Export	271012	$ 23,215	18,220	18	$ 1,274.15
2014	Export	271019	$ 16,997,091	19,704,340	19,704	$ 862.61
2015	Import	271012	$ 46,079,520	46,469,984	46,470	$ 991.60
2015	Import	271019	$ 5,177,062	8,237,344	8,237	$ 628.49
2015	Export	271012	$ 8,736,477	8,233,236	8,233	$ 1,061.12
2015	Export	271019	$ 59,347,619	97,735,430	97,735	$ 607.23
2016	Import	271012	$ 323,544	505,405	505	$ 640.17
2016	Import	271019	$ 652,309	1,130,622	1,131	$ 576.95
2016	Export	271012	$ 3,901,449	4,828,526	4,829	$ 808.00
2016	Export	271019	$ 21,369,126	56,047,480	56,047	$ 381.27
2017	Import	271012	$ 17,107,151	37,674,188	37,674	$ 454.08
2017	Import	271019	$ 18,239	30,962	31	$ 589.08
2017	Export	271012			-	#DIV/0!
2017	Export	271019	$ 1,225,293	2,302,916	2,303	$ 532.06
2018	Import	271012	$ 491,565	2,171,864	2,172	$ 226.33
2018	Import	271019	$ 242,971	435,993	436	$ 557.28
2018	Export	271012	$ 48,068	89,000	89	$ 540.09
2018	Export	271019	$ 3,316,702	4,492,414	4,492	$ 738.29
2019	Import	271012			-	
2019	Import	271019			-	
2019	Export	271012			-	
2019	Export	271019	$ 1,490,762	1,893,150	1,893	$ 787.45
2020	Import	271012				
2020	Import	271019				
2020	Export	271012				
2020	Export	271019				

48 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/28/2012, 6/8/18, and 2/27/20) includes the following statistics on trade flows of gaseous oil products (HS 2711 and related) between the DPRK and a number of countries not included in the notes above. The following summarizes significant trades (>1000 te) since 1988 (>1 te from 2008 on). Note that it seems likely that the most of the reports of trades in HS 271111, which is Liquefied Natural Gas, have been reported in error, as the DPRK has not traditionally had infrastructure to use gas. The trades highlighted in yellow below are assumed to have been reported in error (for example, should have been indicated as trades to the ROK).

Period	Country	Import to the DPRK/ Export From the DPRK	Code	Trade Value	NetWeight (kg)	Implied cost/te	
1990	Thailand	Import	271111	$ 8,059,222	33,528,035	$ 240.37	
1991	Thailand	Import	271111	$ 16,545,202	84,684,250	$ 195.38	
1992	Thailand	Import	271111	$ 5,673,827	35,652,074	$ 159.14	
1994	Brazil	Export	271112	$ 3,002,745	19,904,776	$ 150.86	
1996	Thailand	Import	271111	$ 5,971,960	29,767,371	$ 200.62	
2000	Qatar	Import	271111	$ 32,939,788	131,346,312	$ 250.79	
2002	Thailand	Import	271112	$ 2,145,546	11,459,236	$ 187.23	
2003	Thailand	Import	271112	$ 4,572,091	12,315,050	$ 371.26	
2006	Algeria	Import	271111	$ 22,575,964	3,066,263	$ 7,362.70	
2009	Trinidad and Tobago	Import	271111	$ 18,165,475	58,625,000	$ 309.86	
2010	Egypt	Import	271111	$ 59,974,580	317,610,000	$ 188.83	
2011	Trinidad and Tobago	Import	271111	$14,536,477	17,948,980	$ 809.88	
2012	Trinidad and Tobago	Import	271111	$52,953,923	308,639,340	$ 171.57	
2015	Qatar	Import	271111	$4,264,561	10,529,792	$ 405.00	
2008	France	Export	2711	$10,314	2,700	$ 3,820.00	
2010	Spain	Export	2711	$17,044	6,381	$ 2,671.05	
2012	Brazil	Export	2711	$126,033	40,408	$ 3,119.01	
2012	Uganda	Export	2711	$18,400	6,105	$ 3,013.92	
2013	Bahamas	Export	2711	$281,126	145,742	$ 1,928.93	
2013	Brazil	Export	2711	$190,968	61,514	$ 3,104.46	
2013	Brunei Darussalam	Export	2711	$31,906	9,600	$ 3,323.54	
2013	India	Export	2711	$12,843	3,800	$ 3,379.74	
2013	Thailand	Import	2711	$2,147,379	2,074,762	$ 1,035.00	
2014	Bahamas	Export	2711	$52,841	27,397	$ 1,928.71	
2014	Brazil	Export	2711	$236,392	74,882	$ 3,156.86	
2014	France	Export	2711	$37,412	13,769	$ 2,717.12	
2015	Bahamas	Export	2711	$87,576	49,488	$ 1,769.64	
2015	Brazil	Export	2711	$202,706	70,949	$ 2,857.07	
2015	Brunei Darussalam	Export	2711	$17,904	9,088	$ 1,970.07	
2015	France	Export	2711	$31,585	13,388	$ 2,359.20	
2015	Qatar	Import	2711	$4,264,561	10,529,792	$ 405.00	
2016	Brazil	Export	2711	$45,892	15,084	$ 3,042.43	
2017	Honduras	Export	2713	$5,949	1,303	$ 4,565.62	
2018	Brunei Darussalam	Export	271113	$16,635	9,800	$ 1,697.45	
2018	United Kingdom	Export	271113	$30,652	20,544	$ 1,492.02	
2018	Estonia	Export	271129	$5,551	1,505	$ 3,688.37	
2019	Bosnia Herzegovina	Export	2711	913	253	$ 3,608.70	
2019	Estonia	Export	2711	125	35	$ 3,571.43	
2019	Bosnia Herzegovina	Export	271113	913	253	$ 3,608.70	Butanes
2019	Estonia	Export	271129	125	35	$ 3,571.43	Gases other than natural gas

49 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 8/28/2012 and on several later dates) includes the following statistics on trade flows of crude oil (HS 2709) between the DPRK and a number of countries not included in the notes above. The following summarizes significant trades (>1000 te) since 1988. Note that many of these trades, particularly reported oil exports to the DPRK from Middle Eastern or African countries since the mid-1990s, seem either sufficiently high or otherwise suspect as to be not credible, in our view. That is, they probably represent reporting errors, possibly oil imported by the ROK that was mis-cataloged as going to the DPRK. The trades that we consider unlikely to have actually occurred, and have thus discounted for the purposes of this analysis, are highlighted in yellow below.

Period	Country	Import to the DPRK/ Export From the DPRK	Code	Trade Value	NetWeight (kg)	Implied cost/te	Notes
1992	Algeria	Import	2709	$ 12,210,181	70,198,872	$ 173.94	
1993	Gabon	Import	2709	$ 16,182,800	132,226	$ 122,387.43	Mismatch between value and volume
1998	Gabon	Import	2709	$ 14,432,382	110,301,187	$ 130.85	
1999	Nigeria	Import	2709	$ 25,093,372	266,299,008	$ 94.23	Probably actually to ROK
2000	Gabon	Import	2709	$ 36,890,878	269,103,625	$ 137.09	Probably actually to ROK
2000	Nigeria	Import	2709	$ 31,640,873	129,960	$ 243,466.24	Mismatch between value and volume
2001	Nigeria	Import	2709	$ 25,758,277	143,273	$ 179,784.59	Mismatch between value and volume
2002	Algeria	Import	2709	$ 9,315,889	63,244,973	$ 147.30	
2002	Qatar	Import	2709	$ 5,992,096	33,584,000	$ 178.42	Probably actually to ROK
2002	Russian Federation	Import	2709	$ 19,460,090	124,959,000	$ 155.73	
2002	Thailand	Import	2709	$ 6,860,529	39,615,848	$ 173.18	
2004	Brazil	Import	2709	$ 30,868,612	141,078,726	$ 218.80	Probably actually to ROK
2004	Ecuador	Import	2709	$ 21,512,613	109,186,687	$ 197.03	Probably actually to ROK
2004	Qatar	Import	2709	$ 34,411,572	140,089,000	$ 245.64	Probably actually to ROK
2004	Russian Federation	Import	2709	$ 15,400	56,000	$ 275.00	
2004	Thailand	Import	2709	$ 20,587,059	96,553,280	$ 213.22	
2005	Gabon	Import	2709	$ 61,537,849	257,261,594	$ 239.20	Nearly identical trade reported by/to ROK
2005	Qatar	Import	2709	$ 171,197,260	848,771,741	$ 201.70	Probably actually to ROK
2006	Qatar	Import	2709	$ 132,437,967	304,913,000	$ 434.35	Probably actually to ROK
2006	Yemen	Import	2709	$ 215,922,394	450,048,804	$ 479.78	Probably actually to ROK
2007	Congo	Import	2709	$ 214,163,318	508,365,254	$ 421.28	Quantity not credible
2008	Brazil	Import	2709	$ 40	80	$ 500.00	
2008	Qatar	Import	2709	$ 27,050,318	76,602,135	$ 353.13	Probably actually to ROK
2009	Qatar	Import	2709	$ 118,445,515	234,133,811	$ 505.89	Probably actually to ROK
2015	Poland	Import	2709	$21,500	230	$ 93,478.26	Cost per tonne doesn't make sense, so assumed to be 230 tonnes, not kg (but a small trade anyway)
2016	Qatar	Import	2709	$3,357,875	13,106,550	$ 256.20	
2017	Russian Federation	Import	2709	$76,272	164,965	$ 462.35	

No 2018 trades in this category reported in Comtrade statistics as of 3/2/2020

50 The following summarizes UN Comtrade statistics for imports into and exports from the DPRK from and to countries other than China (for China, see Note 30, above) of non-energy petroleum-based commodities in HS codes 2712 through 2715. These imports and exports are largely modest in scale.

Units: kg	Imports into the DPRK				Exports from the DPRK				
Commodity Code	*2712*	*2713*	*2714*	*2715*	*2712*	*2713*	*2714*	*2715*	
Product/ Product Group	PETROLEUM JELLY; WAXES	PETROLEUM COKE, RESIDUES	BITMN,ASPHLT;TAR SAND	BITUMEN,TAR RELATED	PETROLEUM JELLY; WAXES	PETROLEUM COKE, RESIDUES	BITMN,ASPHLT;TAR SAND	BITUMEN,TAR RELATED	
1988	27,000							61,699	
1989	75,375		6,999,898						
1990	44,000	3,000,000			102,000		15,000		
1991	149,000	3,548,000							
1992	39,531	5,075,949	1,999,875		26				
1993	65,937	1,003,000							
1994	8,375	4,409,000		16,000	497,324	11,742,000			
1995	3,937				268,624	108,000		660,000	
1996		1,849,937			2,060,000				
1997					176,601		5,500		
1998	89,000				34,937	58,269			
1999	18,000	17,500		531		24,005,000		300,000	
2000	16,010			5,000	52,000				
2001	16,186	18,000	5,000		151,359				
2002	82,250				357,282				
2003	21,427	28,331,620			173,750				
2004		21,500			37,079				
2005				0	31,000			0	
2006					547,150				
2007		11,000	80,398		185,875				
2008	11,670				50,920	69		46	
2009	5,000			145	151,440				
2010	60,272	-		0	76,304			0	
2011	5,000	-		1,952	78,742	0	2,000	28,000	
2012	29,206	-	0	316	38,224	5,451,511	902,143	42	
2013	47,700	-	0	1,437	230,020	0	0	0	
2014	1,660	27,387	0	400	201,320	0	0	2,873,005	
2015	6,600	39,400	0	0	112,150	0	0	62	
2016	31,920	7,184,528	0	0	21	0	0	0	
2017	5,703	-	2,100	0	250	0	0	0	
2018	0	63,140	0	0	127,674	429,091	0	0	0= None reported as of 2/26/20
2019	0	0	0	0	0	0	0	0	0= None reported as of 5/1/20
2020	0	0	0	0	0	0	0	0	

51 We have received a report that in recent years the refinery at Sonbong on the DPRK East Coast has been operating occasionally, converting crude oil imported from Russia into refined products, and exporting some refined products, primarily to China and Russia. We consider this report plausible, as it would help to provide a rationale for the continued operation, albeit at low capacity factors, of the oil-fired power plant at Sonbong (see Note 15 on the "ELECTRICITY GENERATION AND FUEL REQUIREMENTS IN 1996 THROUGH 2010" page), but since, as yet, we have no quantitative information regarding how much the plant might be running, we are obliged to speculate. As neither exports of crude oil from Russia nor imports of refined products, in siginficant quantity, to Russia or China appear in the official trade statistics, we assume that these trades are unofficial, and relatively small. We therefore assume that, for 2010, the Sonbong refinery (the Sungri Chemical Factory) operated sufficiently to process 60,000 *tonnes of Russian crude oil, which is consistent with a capacity factor of about 3%, somewhat less than we are assuming the Sonbong oil-fired electricity plant operates. We are currently seeking more information, but for now the above assumptions should be considered highly speculative. In addition, we assume that* 10,000 *tonnes of diesel and* 20,000 *tonnes of heavy fuel oil produced by the plant were exported, unofficially from this plant to China and/or Russia, though this is also a highly speculative assumption. For 2014 through 2020, we assume that the Sonbong plant did not run at all.*

52 As detailed imports statistics from China for 2012 on are not yet available to us, estimates for the individual products diesel, heavy fuel oil, kerosene, and others (but not gasoline) for 2014 through 2017 were developed by assuming that the fractions of indivdiual products within the overall 271019 category were similar to those reported by China for 2011.

53 A Reuters article in 2017 ("Russia says its oil supplies to North Korea are negligible", by Denis Pinchuk, dated September 5, 2017, and available as https://www.reuters.com/article/us-russia-northkorea/russia-says-its-oil-supplies-to-north-korea-are-negligible-idUSKCN1BG13N, quotes Russian President Vladimir Putin as saying "We have supplies of 40,000 tonnes of oil and oil products to North Korea a quarter", which would imply about 160,000 *tonnes per year. This is close to the lower end of the range of oil exports from Russia to the DPRK, as estimated by other analysts.*

54 In the report "The Rise of Phantom Traders: Russian Oil Exports to North Korea", dated July 2018, The Asan Institute for Policy Studies estimates, based on tracking customs transactions between the Russian firm Independent Petroleum Company (IPC) and three North Korean business entities resulted in refined oil product sales to the DPRK in the years 2015 through 2017 as follows (document available as http://en.asaninst.org/wp-content/themes/twentythirteen/action/dl.php?id=45032):

"Table [from page 27 of Asan Institute Report]: IPC oil export to North Korea"

Tons of Oil	2015	2016	2017	Total	**Revenue (USD)**	2015	2016	2017	Total
Land	42,026	88,066	18,610	148,702	Land	$ 19,583,733	$ 31,742,448	$ 8,176,724	$ 59,502,905
Sea	150,800	258,743	64,634	474,177	Sea	$ 65,791,118	$ 82,061,148	$ 30,740,194	$ 178,592,460
Total	192,825	346,810	83,244	622,878	Total	$ 85,374,851	$ 113,803,596	$ 38,916,918	$ 238,095,365

Implied Cost per Tonne

	2015	2016	2017	Average 2015-2017
Land	$ 465.99	$ 360.44	$ 439.37	$ 400.15
Sea	$ 436.28	$ 317.15	$ 475.60	$ 376.64
Total	$ 442.76	$ 328.14	$ 467.50	$ 382.25

These figures are reasonably consistent with the estimates offered in both the references cited above (53) and below (55). We therefore assume that the Asan Institute estimates apply as the total amount of oil exported "off books" from Russia to the DPRK in 2015 through 2017, and further estimate that 90% *of the oil products in these shipments were diesel fuel, with the other* 10% *being gasoline, based roughly on the pattern of on-books trades in the two products from 2005 through 2017 (see note 41, above). We further assume that this pattern of trade was established prior to 2014, but that in 2014 imports from Russia by this mode were a bit lower, at* 180,000 *total tonnes, with diesel and gasoline (or similar products) sold in approximately the same proportions as assumed for 2015 through 2018. We assume that deliveries of oil to the DPRK via this route in 2018 were* 100% *of those reported in 2017, and that similarly, deliveries in 2019 were* 100% *of reported 2017 deliveries. For 2020, as a result of oil trading ships being idled by COVID-19 movement restrictions for at least a large part of the year, we assume that imports via this route will be about* 30% *of 2017 levels.*

55 *A North Korean émigré has been quoted in various publications as estimating that Russia exported 200,000 to 300,000 tonnes of oil products annually in recent years to the DPRK via dealers based in Singapore (",,,Ri Jong Ho, a former official in North Korea's Office 39, supplied in a recent interview with Kyodo News.." See, for example, Benjamin Katzeff Silberstein (2017), "North Korea's ICBM-test, Byungjin and the economic logic", dated, July 4th, 2017, and available as http://www.nkeconwatch.com/category/energy/oil/.*

56 *A 2018 article in NK Economy Watch, "Chinese oil exports to N Korea increased after KJU's third visit to China", dated July 19th, 2018, by Benjamin Katzeff Silberstein includes the following passage: "China also dramatically increased oil shipments to the North. A source in Beijing said it nearly doubled crude oil supplies to the North through pipelines from Dandong since Kim's recent visits. 'Some 30,000 to 40,000 tons of oil is enough in the summer to maintain the lowest possible flow of oil in the pipelines to ensure that they don't clog, and about 80,000 tons in winter," the source added. "Though it's summer now China has recently increased flow to the winter level." Original source, "China Doubles Oil Shipments to N.Korea After Kim's Visit", Original Source, Lee Kil-seong and Kim Myong-song, Chosun Ilbo, 2018-07-19.*

Assuming that this physical reason for China to maintain minimum flows through the pipeline is correct (and we have heard this explanation elsewhere), One can estimate a minimum flow through the pipeline in a "normal" year by assuming 35,000 *tonnes per month over a* 7 *-month (April-October) "summer" season of warmer months, with a corresponding average of* 80,000 *tonnes per month over the remainder of the year, which would yield an average of* 645,000 *tonnes of crude oil annually. We assume crude imports via pipeline at this rate from 2015 through 2017, with 2018 imports likely, based on the above, to be at least somewhat higher, assuming two months of higher flows in the summer as reported above, for a total of* 715,000 *tonnes of crude oil annually in 2018.*

We assume that inputs of crude oil by pipeline from China were the same in 2019 as assumed for 2018. For 2020 we assume that in China's desire to help the DPRK manage the coronavirus pandemic (see, for example, BBC News (2020), "Coronavirus: China offers to help North Korea fight pandemic", dated 9 May 2020, and available as https://www.bbc.com/news/world-asia-52597749), it provides more oil by pipeline to the DPRK. We thus assume that the flow through the pipeline in 2020 will be 750,000 *tonnes of crude oil, about 5 percent higher than in 2018.*

A 2013 article "China's Aid to North Korea— Centered on the China-North Korea Oil Pipeline", by Yukihiro Hotta, dated November, 2013, and available as http://www2.jiia.or.jp/en/pdf/digital_library/korean_peninsula/160331_Yukihiro_Hotta_.pdf, including an excellent description of the infrastructure that supports the China-DPRK pipeline that supplies oil to the Ponghwa Chemical Factory outside Sinuiju in the DPRK. The oil for this short (30 km) pipeline is moved by train from the Daqing oilfields, likely in heated tank cars, to a terminal in the village of Xing Guang Cun outside Dandong. This implies a rail journey of well over 700 kilometers. From Dandong, crude oil is unloaded into the pipeline, and travels through the pipeline via a "Yalu River Oil Transportation Station" and "the valve room in Tajido on the North Korean side". Due to the paraffin content of the Daqing oil, the crude oil must be heated to a minimum of 28 C, and the oil solidifies at 24 C. The author also notes "However, the heat of the pipeline is easily lost because on the North Korean side which accounts for two-thirds of its length, it is buried to a very shallow depth or passes beneath rice fields". As a conseqence there are maximum periods during which flow can be stopped, and minimum monthly flows, both varying by month as shown in the tables below from the article (page 11).

China-North Korea Oil Pipeline Maximum Permitted Oil Transport Suspension Time

(Hours)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Time	4	2	2	4	6	8	12	12	12	6	4	4

(Pipeline Branch of PetroChina Company Limited 2001; 1)

China-North Korea Oil Pipeline Minimum Oil Transport Quantities

(10,000 tons)

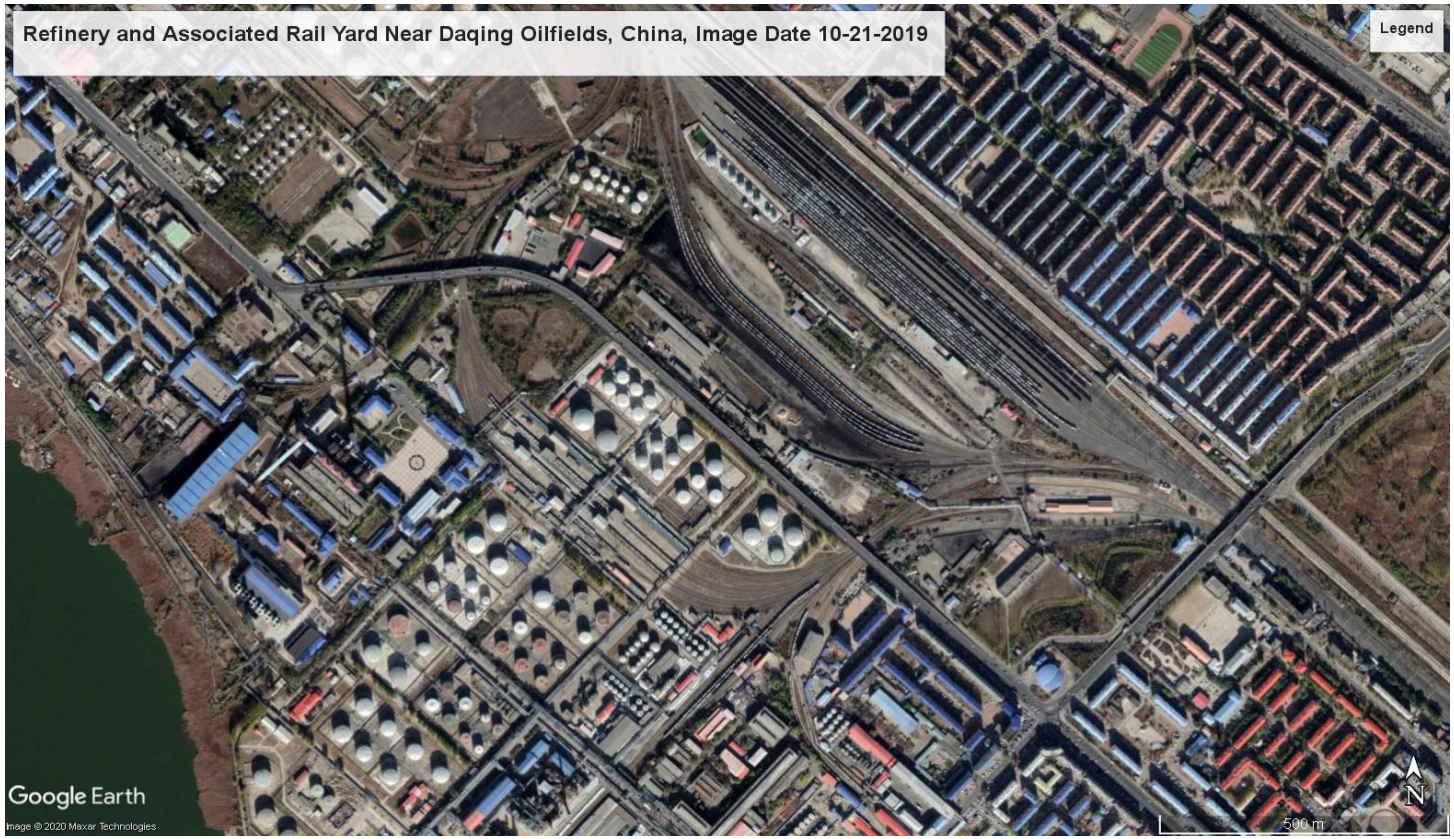
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	5	5	5.5	4.5	4	3	2.5	2.5	2.5	3.5	5	5

(Pipeline Branch of PetroChina Company Limited 2001; 2)

The minimum yearly safe transport through the pipeline is listed as 525,000 tonnes, which is just slightly more than the total of the sum of the monthly figures in the table above, and is consistent with the volume that is exempted from UNSC sanctions each year at China's request.

The article was originally published as This article was originally published as 堀田幸裕「中国の対北朝鮮援助」("Chuugoku no Tai Kita Chousen Enjo") 『現代韓国朝鮮研究』第13号、2013年11月、14-26頁 ("Gendai Kankoku Chousen Kenkyu" [The Journal of Contemporary Korean Studies] vol.13, 14-25, November 2013).

The image below, from Google Earth Pro, shows a rail terminal for oil transfers near the Daqing oilfields, adjacent to a large refinery. We do not know if this is the terminal from which trains bearing crude oil destined for the DPRK are dispatched, but its size and location are consistent with such shipments. The location of this oil terminal is approximately 46.54, 125.098.



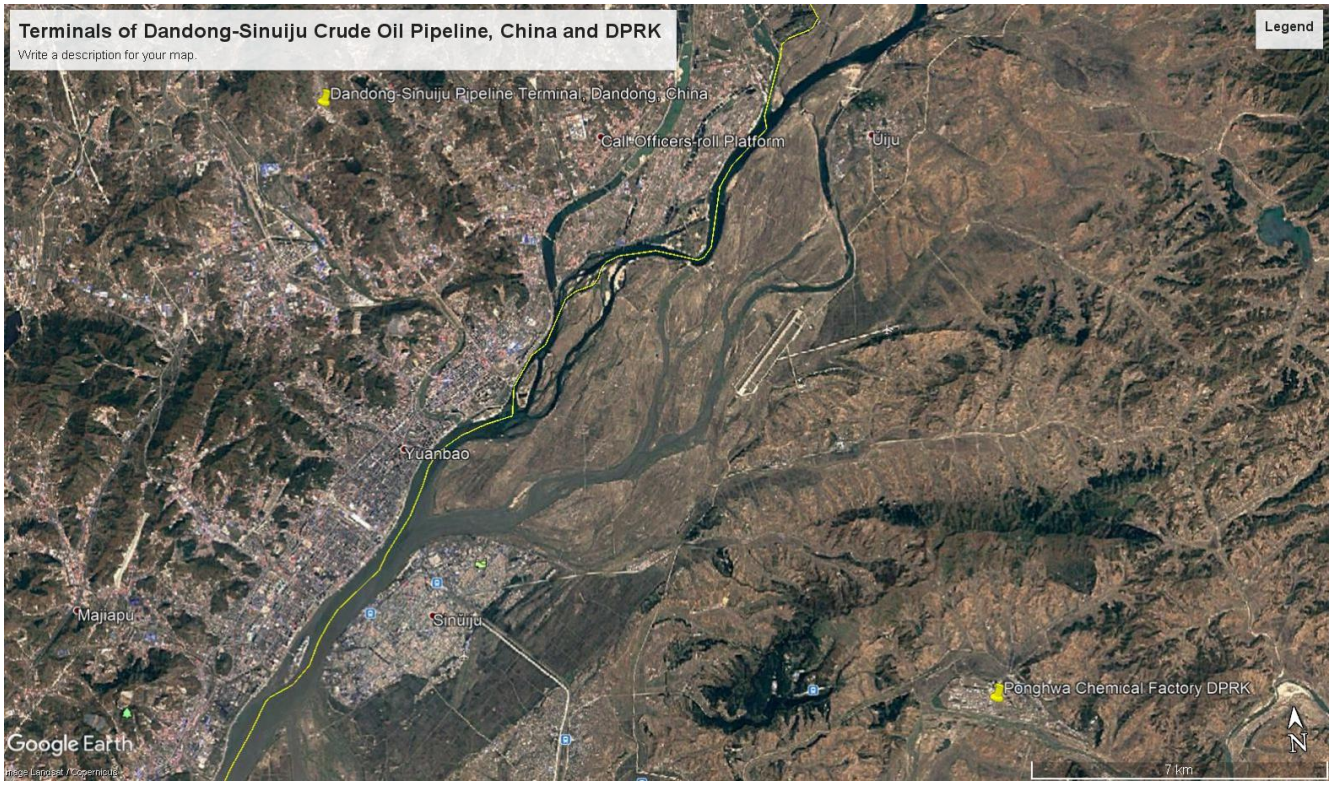
The Google Earth Pro image below shows the terminal of the Dandong-Sinuiju pipeline near Dandong. The train cars shown sitting in the yard in in other images taken on different days at this location have a volume of about 30 *cubic meters, and thus probably a capacity of about* 30 *tonnes per tank car. This implies that about* 25,000 *train cars of crude oil, or, if each train averaged* 50 *cars, about* 500 *trainloads of crude oil per year would be needed if the volume of crude oil that we assume for 2020 was shipped from Daqing to Dandong for transfer to the DPRK. This implies on the order of* 1.37 *train loads are received each day at the Dandong terminal. Location of the terminal is approximately 40.211, 124.38.*

An example of the type of train car that may be used for transfer of the crude oil is shown below, from Alibaba.com (available as https://www.alibaba.com/product-detail/Oil-Tank-Wagon-car-railway-trailer_60279470959.html?spm=a2700.7724857.normalList.53.2226bb38wqFZh4)

There are four large tanks on the premises of the terminal, six that are somewhat smaller, and approximately seven of various much smaller sizes, the largest of which, at about 12 meters in diameter, are located next to the tracks where train cars are unloaded. We estimate the volume of the ten larger tanks as follows. Wikipedia (2020), "List of crude oil products", available as https://en.wikipedia.org/wiki/List_of_crude_oil_products, lists the *API gravity of Daqing crude oil as* 32.2 , which, based on a conversion formula, also from Wikipedia ("API gravity", available *as https://en.wikipedia.org/wiki/API_gravity), implies an average density of* 0.86 *tonnes per cubic meter.*
The results below suggest that storage at the terminal, when full, is enough to supply the pipeline for more than a month at full pipeline capacity of over one million tonnes per year (possibly up to 1.5 million), and for nearly two months or possibly more at the rate that we estimate the China has been sending crude oil to the DPRK in recent years. Note that the estimates below are good to approximately one or two significant figures only. Although we do not have the resources to do so, we assume it would be possible for an organization with access to regular (daily or more frequent) satellite images of Dandong to estimate the number of trains unloaded during a given year and thus the volume sent to the DPRK. Obesrvation of the levels of the larger tanks may also be helpful. Given, however, that images from some days will be obscured by cloudy weather, it may not be possible to determine volumes accurately enough to confirm for certain whether the volumes supplied are greater than the 525,000 tonnes annually that China reports to the UNSC Panel of Experts.

Number	Estimated Diameter (meters)	Estimated Height (meters)	Estimated Volume (cubic meters)	Estimated Full Capacity (tonnes crude oil)
4	40	22.5	113,097	97,760
2	20	18	11,310	9,776
2	28	24.75	30,480	26,346
TOTAL OF ABOVE				**133,882**

The Google Earth Pro image below, dated December of 2016, provides an overview of the area between the terminals of the oil pipeline on the China and DPRK sides. We do not know exactly what route the pipeline takes, though it must be obliged to take a somewhat indirect routing in the DPRK to circumvent hills that lie between the Yalu River and the DPRK terminal at the Pongwha Chemical factory.



We are not entirely sure where the pipeline crosses the Yalu River from China to the DPRK, but the Google Earth Pro image below, located at about 40.154, 124.44, shows what could be the pipeline crossing the Yalu diagonally from upper left to lower right. Image date 2.19-2020.

57 *We assume that there were at least some oil product imports to the DPRK that are not captured in any of the statistics or estimates of "off-books" trade above These imports may come from Russia, China, or other international vendors, and may be coming in by land or sea. They may be barter trades or products imported via the black market. Our assumptions as to imports by product, from 2014 on, are as follows (tonnes):*

Product	2014	2015	2016	2017	2018	2019	2020
Gasoline	15,000	-	15,000	-	35,000	35,000	-
Diesel	85,000	60,000	20,000	120,000	110,000	110,000	100,000
Kerosene/ Jet Kerosene	-	-	-	15,000	15,000	20,000	1,000

For 2017, when UN Security Council restrictions on oil imports were in full force, our assumption is that without a significant amount of fuel--likely diesel, beyond imports described in customs statistics and off-books imports from Russia described in notes 53 thourgh 55 above, signs of fuel shortages, particularly for diesel fuel would have been more evident in the DPRK than visitors describe. We therefore assume that there were modest reductions in fuel use across the board, but also that the amounts of fuels shown above made their way into the country. For example, the 120,000 additional tonnes of diesel fuel we assume were imported "off-books" is more or less consistent with the (sanctions-evading) shipments recorded as received or planned through a Taiwanese company, as reported by the UNSC "Panel of Experts" in paragraphs 71 and 72 of UNSC (2018), ***Note by the President of the Security Council****, number S/2018/171, "Annex: Letter dated 1 March 2018 from the Panel of Experts established pursuant to resolution 1874 (2009) addressed to the President of the Security Council, available as http://www.un.org/ga/search/view_doc.asp?symbol=S/2018/171&referer=/english/&Lang=E.*

For 2018, our assumption is that once again the DPRK must have imported a significant amount of fuel, mostly diesel, through off-books means, otherwise domestic fuel prices would have been much higher and a much greater contraction in petroleum-fueled transport services would have been observed, even anecdotally. The March 5, 2019 **Report of the Panel of Experts established pursuant to resolution 1874 (2009)***, includes an analysis of potential ship-to-ship oil transfers allegedly used by the DPRK to circumvent UNSC sanctions restricting imports of refined products. The Panel of Experts analysis remotely tracked the berthing of relatively small (approximately 900 to 5000 deadweight tonnes) tankers at DPRK ports, most notably Nampo, but also including Chongjin, Najin, Wonsan, and others. The Panel of Experts analysis calculated the volume of oil that would have been delivered by those vessels over the period from Janulary 1 through August 18 of 2018 under assumptions that the vessels were 33 percent, 50 percent, and 90 percent full when they docked (and delivered that quantity of fuel). Under these three assumptions, the total fuel delivered would have been* 108,230.43 | 163,985.50 *and* 295,173.90 *tonnes of oil products respectively. Official reviewers of this analysis from the Russian Federation did not find the analysis acceptable, for reasons not fully specified. It seems possible to us that in counting all of the vessels docking at these ports, the analysis may have included some transfers of oil products purchased under the allowed UNSC 500,000 barrel limit, and/or some transfers of refined product from DPRK refineries (most notably the refinery at Sinuiju) to one or more of these ports. And/or some of these shipments might have represented transfers from port to port, and thus be effectively double-counting oil shipments. Still, we take the Panel of Expert's point that even if these vessels were a third full, they would represent oil transfers greater than the 500,000 bbl limit, and thus is it improbable that all of the transfers viewed by these ships were of oil obtained through transactions that allowed under sanctions. Further, the volumes calculated by the Panel of Experts did not cover all of 2018. Starting with the Panel of Experts estimate of the amount of oil that would have been delivered by the observed tankers if they were on average half full, and assuming that the deliveries continued at about the same pace through the rest of 2018, the tankers would have delivered about* 260,238 tonnes of oil products. We use this as an upper limit on off-books oil product imports to the DPRK,
Figures above from Panel of Experts Table 1 of Annex 2, starting on page 74 of referenced document, available at https://www.undocs.org/S/2019/171.

58 *Leo Byrne, then of NK News, brought to our attention an addition to the DPRK's refinery at Sinuiju, apparently made in 2016, that appears to be a fluid catalytic cracker unit (see photo at right). Based on conversations with Dr. David Fridley, formerly of Caltex, it seems likely that this unit is being used to convert some of the heavy fuel oil produced by the refinery into lighter products. Based on input from Fridley, we assume that the unit is sized to use approximately* 50% *of the HFO produced by the refinery into lighter products. This would imply a capacity of about 250,000 tonnes per year for the cracker unit. The product slate for the throughput of the cracker is estimated to be as follows:*

Heavy Fuel Oil	0%
Gasoline	55%
Diesel Oil (light cycle oil)	20%
Kerosene/Jet Fuel (light cycle oil)	
LPG/other gases/Refinery Gas	18%
Bottoms and Coke (non-energy)	7%

We assume that the proportions of kerosene and jet fuel relative to diesel produced using the light cycle oil coming out of the cracker unit would be similar to those in produced by the refinery before the installation of the cracker unit, about 16.7%. *We further assume that the cracker unit's output as a weight fraction of the heavy fuel oil input is about* 97% *based on data from table 2 of the USDOE (2006) document Energy Bandwidth for Petroleum Refining Processes, available as https://www.energy.gov/sites/prod/files/2013/11/f4/bandwidth.pdf. These figures imply that the output of the refinery after addition of the cracker unit is roughly as follows, assuming a rough split in fuel use for the cracker unit between refinery gas and coke produced by the unit.*

Fuel/Fuel Category	Output as weight fraction of input
Heavy Fuel Oil	19.0%
Gasoline	32.1%
Diesel Oil (light cycle oil)	23.1%
Kerosene/Jet Fuel (light cycle oil)	4.6%
LPG/other gases/Refinery Gas	12.0%
Bottoms and Coke (non-energy)	4.7%
Implied overall Refinery efficiency with Fluid Catalytic Cracker Unit	**95.4%**

59 *The publication "China's Sanctions Enforcement and Fuel Prices in North KoreaWhat the Data Tells Us", by Benjamin Katzeff Silberstein, 38N Special Report dated February 2019, and available as https://www.38north.org/wp-content/uploads/pdf/38-North-SR-1902-BKS-China-NK-Fuel.pdf, suggests that on average, diesel prices were somewhat higher in 2018 than in 2017, and gasoiline prices were somewhat lower, though both had considerable variation over the year. As these data are derived from a limited number of locations in the DPRK, they should be considered at best indicative.*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60 The DPRK imported the following non-energy petroleum products from countries other than China and Russia:

Imports to DPRK from UN Comtrade Database

	Commodity Code 381121: Additives for lubricating oils containing petroleum			
	Volume (te)	Value	$/Tonne	Countries
1990	0.60	$1,329	$ 2,226	Singapore
1996	543.31	$1,241,024	$ 2,284	France
2000	10.48	$23,873	$ 2,278	Singapore, Japan
2001	-	$0	$ -	
2002	174.52	$362,946	$ 2,080	Canada
2003	302.65	$643,803	$ 2,127	Canada, Austria, UK
2004	405.86	$875,755	$ 2,158	Canada
2005	363.11	$927,885	$ 2,555	Canada
2006	189.16	$516,705	$ 2,732	Canada, Brazil
2007	16.00	$56,032	$ 3,502	
2008	-	$0	$ -	
2009	-	$0	$ -	
2010	0.03	$205	$ 8,200	
2011	-	$0	$ -	
2012	-	$0	$ -	
2013	-	$0	$ -	
2014	-	$0	$ -	
2015	-	$0	$ -	
2016	-	$0	$ -	
2017	-	$0	$ -	
2018	-	$0	$ -	

61 The UN Panel of Experts document referenced in note 57, above includes (as Table 14, of Annex 21) a table of oil product exports reported to the Panel by China and Russia by Month in 2018. These figures are from the UNSC document "Supply, sale or transfer of all refined petroleum products to the DPRK", undated, but apparently 2020, available as https://www.un.org/securitycouncil/sanctions/1718/supply-sale-or-transfer-of-all-refined-petroleum. The figures below (from the referenced document) do not split out sales of petroleum product by type, and thus are difficult to reconcile with the UN Comtrade data for Chinese and Russian oil exports to the DPRK summarized above, but the total of the two sources seem comparable, depending on which products are assumed included. We use the Comtrade figures in the accounting above.

Month	**Amounts received by the Committee (tons)**	
	Source country	
	China	Russian Federation
Jan-18	201.38	368.24
Feb-18	1,392.35	1,882.56
Mar-18	2,438.99	1,897.58
Apr-18	437.46	4,293.47
May-18	1,451.41	1,286.14
Jun-18	1,507.90	1,570.44
Jul-18	903.87	576.13
Aug-18	2,725.81	1,369.50
Sep-18	1,814.60	1,859.28
Oct-18	1,886.89	3,777.73
Nov-18	2,928.87	3,377.24
Dec-18	1,510.87	6,983.12
Total of Above	19,200.40	29,241.44

62 *The UN Panel of Experts document referenced in note 57, above includes (on page 152) a note on ROK exports of oil products to the DPRK: "among 338,737 kg of petroleum products used for the implementation of the joint projects from January 2018 to November 2018, 4,039 kg were unused and brought back to the ROK." This means the ROK provided a net of* 334.70 *tonnes of oil products to the DPRK in 2018. We assume that these products were all diesel fuel.*

The UN Panel of Experts document referenced in note 57, above includes (on page 153) a note on China's exports of crude oil to the DPRK: "....and China reported that the amount of the supply of crude oil by China to the Democratic People's Republic of Korea was 150,500 tons from December 2017 to February 2018; 147,900 tons from March to May 2018; 108,500 tons from June to August 2018; and 118,100 tons from September to November 2018." These figures total 525,000 *tonnes, which is the maximum allowed under the UNSC sanctions regime. Although these periods in total do not quite match up to the 2018 calendar year, we assume that they are approximately the same as a calendar year total. We feel that the higher estimate of crude oil provision based on the physical limitations of the China-DPRK pipeline operation may be a better figure than the reported total here, thus we use the total estimated in* ***Note 56***.

63 *The UNSC "Panel of Experts" in UNSC (2020),* ***Note by the President of the Security Council*** *, number S/2020/151, dated 2 March 2020, and including "Annex: Letter dated 26 February 2020 from the Panel of Experts established pursuant to resolution 1874 (2009) addressed to the President of the Security Council", available as https://undocs.org/S/2020/151, includes information on both recorded petroleum product exports by member states (China and the Russian Federation) to the DPRK that are allowed under sanctions, and a range of estimates of suspected volumes of ship-to-ship transfers of oil products ultimately delivered to the DPRK that would have been in evasion of sanctions. The reported exports of refined products by China and Russia over the period from January 1 through October 31 2019 was* 408,576 *barrels (bbl), which converts to* 53,626 tonnes using the conversion factor used in the UNSC document (see footnote 3, page 8). Assuming that this rate of exports to the DPRK *continued over the 12 months of 2019, the total volume delivered would have been* 64,351 tonnes. The UNSC document provides *no information on the volumes of specific oil products supplied by Russia and China, and no specifics on the products supplied were apparently provided to the UNSC. We assume that this total of extrapolated "on-books" exports would be similar in composition (division between products) to that recorded in 2018. Paragraph 5, page 9 of the March 2020 document lists reported (10-month) exports from Russia as* 30,886.33 *tonnes, and reported exports from China were* 22,739.24 *tonnes. Lacking information on which oil products were included in these exports to the DPRK, we assume that the exports coming from China were distributed between gasoline and diesel as they were in Comtrade statistics in 2017, roughly 50 percent for each, and for refined products coming from Russia, we assume that the same fraction used above for off-books trades applies, that is,* 10% *gasoline. For 2020, we assume that on an annual basis these "on-UNSC-books" exports to the DPRK will be reduced to about* 35% *of 2019 levels due to delivery restrictions related to coronavirus responses in the DPRK and other nations. This value is reasonably close to the year-on-year 2020 versus 2019 January through June reported shipments of oil from China and Russia to the DPRK. Quoting a UNSC document of 7/22/20 that was not immediately available, Yonghap News Agency, in "Chinese, Russian oil shipments to N. Korea plunge amid coronavirus pandemic", dated 7/22/20 and available as https://en.yna.co.kr/view/AEN20200722008000325, lists total deliveries from China and Russia to the DPRK of* 14302 tonnes of refined products, compared with an approximate reported 29,602 *tonnes in the first half of 2019 (rough estimate, as we do not have at hand monthly figures for Russian exports during 2019), which would be about* 48% *of 2019 deliveries. This represents, however, only the "on books" trades reported in the first half of 2020, and the impact of COVID-19 on all trades is likely to have been different.*

In addition to these reported volumes of exports to the DPRK, the UNSC document above includes descriptions, provided by a Member State (the US), of 64 deliveries of oil products (or, at least, visits to oil terminals) by foreign-flagged tankers to the DPRK (paragraph 10, page 9), and another "at least" 157 suspected deliveries (paragraph 33, page 20) from DPRK-flagged tankers. Some or many of the oil products that made up these deliveries were apparently obtained through ship-to-ship transfers at sea, either from foreign-flagged to DPRK-flagged vessels, or from foreign-flagged to other foreign-flagged vessels. The US report to the UNSC Panel of Experts estimated the total deliveries of petroleum products over the first 10 months of 2019 under three scenarios, as follows: Tankers providing deliveries averaged of 1/3rd full: 1,436,412 *bbl, if averaging 50% full,* 2,164,113 *bbl, and if averaging 90% laden* 3,894,426 *bbl. The tankers used in these shipments appear to vary in capacity from about 8000 to 44,000 tonnes of oil products (first Table in Annex 1 of UNSC report, totals on page 86). It is not clear whether these recorded deliveries include those "on-books" transfers recorded in the (roughly) 409,000 bbl from Russia and China, and it seems possible to us that some of these port visits could have been intra-DPRK transfers from its Sinuiju refinery (via transfer from train cars or tanker trucks, or from an oil product pipeline connected to the Ponghwa Chemical factory, if such a pipeline exists). Assuming that the deliveries described above continued through 2019 and were at the 50 percent level on average, and the average bbl per tonne was* 8.0 *, the total deliveries reported by the US in the UNSC report would be* 324,616.93 *tonnes. If the "on-books" deliveries are included in this total (we cannot tell whether they are or are not), the total additional "off-books" imports, at least via ship (which is highly likely to be most, perhaps nearly all, of total off-books imports) would be* 260,266.25 *tonnes in 2019. The figure before subtracting on-books trade (if it is included) is somewhat higher than the corresponding figure for 2018 (see Note 57). To what extent this reflects a real increase in off-books imports by the DPRK or is simply the result of better methods of/more complete detection of deliveries is unknown.*

64 *Pending publishing of export and import data for 2019 or 2020, assumes imports LPG/non-energy petroleum products in 2019 were* 100% *of reported imports for 2018. For 2020, due to COVID-19 responses, we assume imports of these fuels were* 35% *of 2018 levels.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ADDITIONAL BACK-UP CALCULATIONS AND DATA: OIL IMPORTS AND EXPORTS

ESTIMATE OF THE MATERIALS REQUIREMENT FOR SURFACING NEW SUPERHIGHWAY BETWEEN PYONGYANG AND NAMPO, DPRK

Prepared By David Von Hippel, 10/19/00, Modified 6/8/02

ASSUMPTIONS:

Asphalt paving is:	5%	to 8%	by weight Asphalt Cement *(see Note 1)*.	
Paving on the Pyongyang--Nampo road will ultimately be:		15	cm thick *(see Note 2)*	
Length of the Pyongyang--Nampo road recently constructed:		43	km *(Note 3)*	
Pavement Width of the Pyongyang--Nampo road	50		meters (DVH on-site estimate)	
Specific gravity of pavement mixture (asphalt cement plus aggregate):		2.3	*(Note 4)*	

RESULTS:

Estimated volume of asphalt mixture used on road:	**322,500**	cubic meters, and			
Estimated mass of asphalt mixture used on road:	**741,750**	tonnes			
Estimated quantity of asphalt cement needed to make above quantity of asphalt mixture:					
37,088 to **59,340** tonnes, or, by comparison, about			**10%**	to	**16%**
of our estimate that 1996 DPRK refinery output of heavy oil was about:			379,000	tonnes.	

NOTES AND SOURCES:

1 *The National Asphalt Pavement Association (NAPA), on its web site, defines Asphalt Cement (AC) as follows: "This is the black, sticky stuff produced by petroleum refineries. It is the "glue" that holds the pavement together. Generally, it makes up about less than 8%, by weight, of the total pavement mixture." Another asphalt-related site provided an estimate that AC was 5% of the weight of asphalt paving (a mixture of AC and aggregate). Information on the "FAQ" page of the Asphalt Institute WWW site (http://www.asphaltinstitute.org/faq/apcfaqs.htm#temp) suggests an intermediate concentration of 400 lbs of asphalt cement to 6000 lbs of asphalt paving (or about 6.7%).*

2 *Another asphalt www site visited suggested that 8 to 12 inches of asphalt paving (applied in at least two layers) was standard for roads used by heavy duty trucks. Where paving was observed being applied to the Pyongyang--Nampo road, the paving seemed to be thinner (perhaps 2-3 inches, or 5 to 7.5 cm), so it is assumed both A) that a second layer would be applied, and B) that the ultimate thickness will be somewhat less than would be recommended in the US for a highway of similar size.*

3 *In DPRK YOUTH BUILD PYONGYANG-NAMPO SUPERHIGHWAY by Jang Yong Chol, First Secretary, Pyongyang City Committee, Kim Il Sung Socialist Youth League, for the Korean Central News Agency, Pyongyang, 28 August, 2000, reference is made to the Pyongyang-Nampo having a "40-odd km-long roadbed, scores of metres wide.." 43 km is a guess, based on the assumption that longer than 45 km would likely be referred to as "nearly 50".*

4 *Density and specific gravity of asphalt will depend on the air void volume in the mix (typically 5 to 8 percent, as based on documents reviewed) and the density and shape of the aggregate used. An example given in a document on the Asphalt Institute's WWW site has a specific gravity of 2.363. http://www.infratech.com/technical_corner/tables_calculators/metric/density_asphalt_materials.htm provides a table entitled "DENSITY AND SPECIFIC GRAVITY FOR VARIOUS TYPES OF COMPACTED ASPHALT PAVEMENTS", which gives a specific gravity range of 2.1 to 2.5 for (combined) several types of asphalt pavements. The estimate of 2.3 for DPRK asphalt is a rough guess based on this range.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
BIOMASS AND WOOD PRODUCTION AND IMPORTS

Prepared By David Von Hippel
Date Last Modified: 7/22/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

					Sources/Notes:
Fuelwood Consumption (Residential and Industrial)					
Residential Fuelwood	6.00E+06	cu.m.			*1*
Industrial Fuelwood	1.50E+05	cu.m.			*1*
Conversion Factor	1.69	cu.m./te			*9*
Conversion Factor	16.00	GJ/te			*2*
Total Fuelwood Production	5.82E+07	GJ			
Charcoal Production					
Wood Input	9.30E+05	cu.m.			*1*
Conversion Factor	1.50	cu.m./te			*10*
Conversion Factor	16.00	GJ/te			*2*
Process Efficiency	30%				*Rough Estimate*
Total Wood used for Charcoal	9.92E+06	GJ			
Total Charcoal Production	2.98E+06	GJ			
Wood for Non-Energy Products					
Building Materials	1.00E+06	cu.m.			*13*
Pulp and Paper	5.00E+05	cu.m.			*1*
Conversion Factor	2.00	cu.m./te			*Assumed to be mostly softwood*
Conversion Factor	16.00	GJ/te			*2*
Total Wood, Non-Energy Products	1.20E+07	GJ			
Wood Imports					
Imports of wood from Russia in exchange for labor	1.50E+06	cu.m.			*3*
Conversion Factor	2.00	cu.m./te			*Assumed to be mostly softwood*
Conversion Factor	16.00	GJ/te			
Sum of Other Recorded Wood/Wood Product Imports	3.43E+03	te			
Wood Imports, Total	1.21E+07	GJ			
Wood Exports					
Sum of Recorded Wood/Wood Product Imports	1.51E+05	GJ			
Pulp and Paper Imports					
Imports of Pulp, all countries	5.01E+04	GJ			*Derived from UN Comtrade Statistics*
Imports of Paper, all countries	7.79E+04	GJ			*Derived from UN Comtrade Statistics*
Exports of Paper, all countries	1.83E+03	GJ			*Derived from UN Comtrade Statistics*
Total Domestic Wood Production	6.80E+07	GJ			
Other Biomass/Crop Wastes Production for Fuel					
Crop Wastes Used in Agriculture:	3.10E+06	te			*4*
Crop Wastes for Other Uses	2.55E+06	te			*Est. based on needs*
Conversion Factor	14.5	GJ/te			*2*
Total Biomass/Crop Wastes Production	8.19E+07	GJ, or	5.65E+06	tonnes	
TOTAL WOOD/BIOMASS PRODUCTION	1.50E+08	GJ			

ESTIMATE OF CURRENT AND FUTURE WOOD/BIOMASS SUPPLY

Category	1996	2000	2005	2008	2009	2010	
Domestic wood production relative to 1990	137.09%	139.30%	171.35%	197.28%	203.05%	206.28%	*6*
Domestic wood production (GJ)	9.33E+07	9.48E+07	1.17E+08	1.34E+08	1.38E+08	1.40E+08	
Wood used to make charcoal relative to 1990	79.8%	61.0%	62.0%	59.2%	60.2%	61.2%	*6*
Wood Used to make charcoal (GJ)	7.92E+06	6.05E+06	6.15E+06	5.87E+06	5.97E+06	6.07E+06	
Charcoal production (GJ)	2.37E+06	1.82E+06	1.85E+06	1.76E+06	1.79E+06	1.82E+06	
Recorded charcoal imports (GJ)	-	3.24E+03	6.51E+02	8.33E+02	5.66E+02	9.54E+01	*18*
Recorded charcoal exports (GJ)	-	3.84E+02	1.06E+04	1.57E+01	0.00E+00	4.99E+01	*18*
Wood imports from Russia in exchange for labor relative to 1990	100%	100%	50%	35%	33%	31%	*5*
Wood imports from Russia in exchange for labor (GJ)	1.21E+07	1.21E+07	6.03E+06	4.22E+06	3.98E+06	3.74E+06	
Recorded wood/wood products imports (GJ)	1.53E+06	3.83E+05	9.86E+05	7.21E+05	4.12E+05	3.62E+05	*18*
Recorded wood/wood products exports (GJ)	3.57E+06	2.52E+06	1.98E+06	1.38E+06	1.43E+06	5.14E+05	*18*
Biomass/crop wastes production relative to 1990	67.2%	68.1%	80.1%	80.0%	78.0%	78.5%	*6*
Biomass/crop wastes production (GJ)	5.50E+07	5.58E+07	6.56E+07	6.55E+07	6.39E+07	6.43E+07	
Pulp and Paper Imports from China (through 2005) or all nations (from 2008) (tonnes)	4.8	772.7	43.9	67,718	23,682	10,585	*7, 17*
Pulp and Paper Imports from China (through 2005) or all nations (from 2008) (GJ)	7.68E+01	1.24E+04	7.02E+02	1.08E+06	3.79E+05	1.69E+05	
Pulp and Paper Exports to China (through 2005) or all nations (from 2008) (tonnes)	225.2	49.2	1,211.6	1,394	2,141	4,314	*7, 17*
Pulp and Paper Exports to China (through 2005) or all nations (from 2008) (GJ)	3.60E+03	7.87E+02	1.94E+04	2.23E+04	3.43E+04	6.90E+04	

Category	2014	2015	2016	2017	2018	2019	
Domestic wood production relative to 1990	193.49%	182.33%	189.59%	157.99%	150.55%	152.26%	*6*
Domestic wood production (GJ)	1.32E+08	1.24E+08	1.29E+08	1.07E+08	1.02E+08	1.04E+08	
Wood used to make charcoal relative to 1990	66.8%	69.4%	72.0%	71.6%	72.7%	73.8%	*6*
Wood Used to make charcoal (GJ)	6.63E+06	6.88E+06	7.14E+06	7.10E+06	7.21E+06	7.32E+06	
Charcoal production (GJ)	1.99E+06	2.06E+06	2.14E+06	2.13E+06	2.16E+06	2.20E+06	
Recorded charcoal imports (GJ)	1.07E+04	6.37E+02	6.74E+02	4.68E+02	2.69E+03	0.00E+00	
Recorded charcoal exports (GJ)	0.00E+00	1.31E+03	5.69E+03	1.04E+04	9.01E+02	0.00E+00	
Wood imports from Russia in exchange for labor relative to 1990	30%	30%	30%	30%	30%	30%	*5*
Wood imports from Russia in exchange for labor (GJ)	3.62E+06	3.62E+06	3.62E+06	3.62E+06	3.62E+06	3.62E+06	
Recorded wood/wood products imports (GJ)	7.26E+05	8.38E+05	2.20E+05	1.72E+05	1.85E+05	0.00E+00	
Recorded wood/wood products exports (GJ)	1.55E+06	2.10E+06	1.67E+06	9.73E+05	2.10E+05	0.00E+00	
Biomass/crop wastes production relative to 1990	90%	95%	80%	75.0%	72.0%	70.0%	*6*
Biomass/crop wastes production (GJ)	7.37E+07	7.78E+07	6.55E+07	6.14E+07	5.89E+07	5.73E+07	
Pulp and Paper Imports from all nations (tonnes)	18,155	20,967	21,014	358	17,694	-	*(See Note 17)*
Pulp and Paper Imports from all nations (GJ)	2.90E+05	3.35E+05	3.36E+05	5.73E+03	2.83E+05	0.00E+00	
Pulp and Paper Exports to all Nations (tonnes)	2,579	2,773	1,653	1,128	253	-	*(See Note 17)*
Pulp and Paper Exports to all nations (GJ)	4.13E+04	4.44E+04	2.64E+04	1.81E+04	4.05E+03	0.00E+00	

Category	2020	
Domestic wood production relative to 1990	156.04%	*6*
Domestic wood production (GJ)	1.06E+08	
Wood used to make charcoal relative to 1990	75.0%	*6*
Wood Used to make charcoal (GJ)	7.44E+06	
Charcoal production (GJ)	2.23E+06	
Recorded charcoal imports (GJ)	-	
Recorded charcoal exports (GJ)	0.00E+00	
Wood imports from Russia in exchange for labor	15%	*5*
Wood imports from Russia in exchange for labor (GJ)	1.81E+06	
Recorded wood/wood products imports (GJ)	0.00E+00	
Recorded wood/wood products exports (GJ)	0.00E+00	
Biomass/crop wastes production relative to 1990	68.0%	*6*
Biomass/crop wastes production (GJ)	5.57E+07	
Pulp and Paper Imports from all nations (tonnes)	-	*(See Note 17)*
Pulp and Paper Imports from all nations (GJ)	0.00E+00	
Pulp and Paper Exports to all Nations (tonnes)	-	*(See Note 17)*
Pulp and Paper Exports to all nations (GJ)	0.00E+00	

	1990	1996	2000	2005	2008	2009	2010
Total Implied Domestic Wood Harvest, tonnes	4.25E+06	5.83E+06	5.92E+06	7.29E+06	8.39E+06	8.63E+06	8.77E+06
Total Implied Domestic Wood Harvest, cu. meters	7.19E+06	9.86E+06	1.00E+07	1.23E+07	1.42E+07	1.46E+07	1.48E+07

	2014	2015	2016	2017	2018	2019	2020
Total Implied Domestic Wood Harvest, tonnes	8.23E+06	7.75E+06	8.06E+06	6.72E+06	6.40E+06	6.48E+06	6.00E+06
Total Implied Domestic Wood Harvest, cu. meters	1.39E+07	1.31E+07	1.36E+07	1.14E+07	1.08E+07	1.10E+07	1.01E+07

Note: Totals above not adjusted for pulp and paper imports and exports (which are minor)

Summary of Information on Wood Stocks and Productivity in the DPRK

For 1996, Prof. Lee Seung-ho (see Note 8, below) estimates from remote sensing and other data that the growing stock of trees--including all above-ground biomass, was in the range of 251 to 293 million tonnes. The lower of these two estimates uses an average specific gravity for Korean hardwoods (0.65 versus 0.80) that appears to be more realistic for typical Korean hardwood species. This lower estimate implies average specific gravity of 1.37 cubic meters stem biomass per tonne above-ground biomass. Based on growth rates for forests in areas of the ROK that have forests similar to the types of forests found in the DPRK, and using data from three sources, Prof. Lee calculates a weighted-average annual growth rate of 3.06%, which implies an annual production from growing tree stocks in the DPRK of 7.68E+06 tonnes per year. Note that this figure includes all above-ground biomass, some of which (small twigs and leaves, for example) would likely not be used as fuel, and likely some of which would be lost during harvesting. Prof. Lee cites ratios of total above-ground biomass to tree stem volume ranging from 1.22 (for hardwoods) to 1.29 (for conifers). This implies that leaf and twig biomass might be on the order of 5 to 15 percent of total above-ground biomass. The table below, originally from the UNEP document cited in ***Note 11***, below, is included in Prof. Lee's presentation, and appears to paint a rosier picture of DPRK forest stocks (Table 3.1 from UNEP document--shaded row and column are values calculated from data in table), at least as of 1990.

Classification	Area (1000 hectares)	Biomass stock (ton/hectare)	Implied stock (million tonnes)
TOTAL Forested land	**8,201**	**62.3**	510.92
Forest of timber industry	5,440	74.55	405.55
Economic forest	1,436	48.3	69.36
Firewood forest	196	40.95	8.03
Protected forest	1,129	66.15	74.68
Non-timber forest land	436	3.15	1.37
Unforested area	383	-	-
Grass field	170	18	3.06
Total of Above	**9,190**	**61.16**	**562**

Professor Lee cites several different sources for surveys of the DPRK's forest area, as follows:

Estimate (Mha)	Date	Source
9.77	1970	DPRK
8.97	1987	FAO
8.45	1994	KFRI: Satellite Image Analysis
7.53	1997	DPRK: UNDP Round Table Meeting
7.53	1999	KFRI: Satellite Image Analysis

In addition, the UN FAO Global Forest Resource Assessment 2005 (see ***note 12***, below) offers the following estimated timeline of assessments of forest area

Estimate (Mha)	Date
8.20	1990
6.82	2000
6.19	2005

A June, 2011 report by KFRI includes the following estimate of forest area in the DPRK, based on an English-language summary (***see Note 15***):

Estimate	Date
8.20	1990
6.99	2000
6.29	2005
5.66	2010

A newer version of the UN FAO Global Forest Resource Assessment (2020 see ***note 19***, below) offers the following estimated timeline of assessments of forest and "other woodland" area

Estimate (Mha)			
Forest	Other Woodland	Year	Growth Rates, Forest
6.912	1.864	1990	
6.455	2.172	2000	**-0.68%**
6.242	2.301	2010	**-0.33%**
6.136	2.366	2015	**-0.17%**
6.030	2.430	2020	**-0.17%**

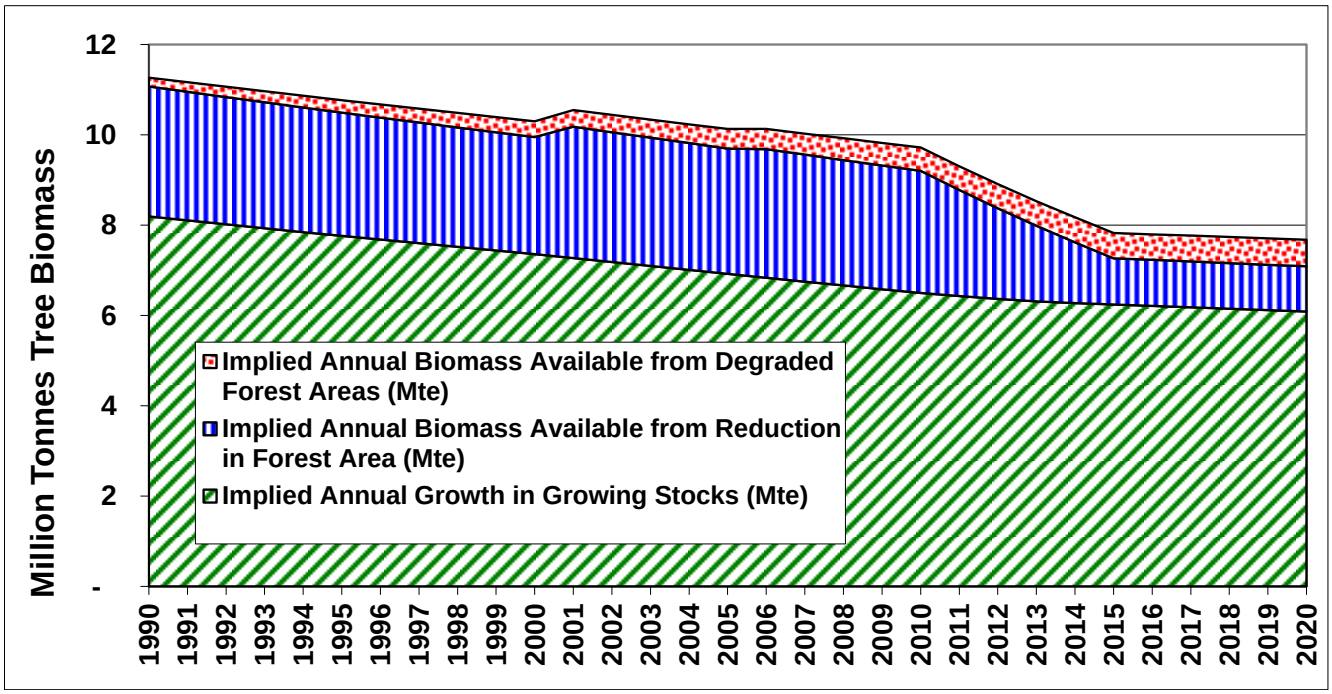
From the data above, the implied rates of change in forest lands in the DPRK were:

-1.45%	per year, 1987 to 1999, using the multi-survey timeline cited by Prof. Lee,		
-0.68%	per year, 1990 to 2000, and	-0.33%	per year, 2000 to 2005, using the 2020 FRA estimates, and
-1.59%	per year, 1990 to 2000, and	-2.09%	per year, 2000 to 2005, and
-2.18%	per year, 2005 to 2010, based on the average of the 2005-2010 data in the summary of the 2011 KFRI report and of the two later-period (2000-2010 and 1998-2008) studies referenced in the article described in *Note 16*.		

Based roughly on the information above, we make the following estimate of forest area, wood stocks, and wood production over time.

Key Assumptions:

Estimate of forest area in 1990:	**8.20**	Million ha (DPRK State of Environment Report, 2003, and UN FAO FRA)
Change in extent of forest lands, 1990 to 2000:	**-1.06%**	per year (average of rates estimated above).
Change in extent of forest lands, 2000 to 2005:	**-1.21%**	per year (average of 2020 FRA and KFRI estimates).
Change in extent of forest lands, 2005 to 2010:	**-1.26%**	per year (average of 2020 FRA with average of KFRI and other estimates--see above).
Change in extent of forest lands by 2015:	**-0.50%**	per year, estimate, and about three times 2020 UNFAO FRA estimates for the period. but which likely takes into account reported DPRK reforestation efforts and improved availabilty of non-biomass fuels as the DPRK economy has grown, while still resulting in estimates for the wood harvest by year consistent with demand-based estimates described above.
Growing wood stocks on forest lands, 1996:	**251**	million tonnes (estimate above by Prof. Lee)
Average annual growth on stocked forest lands:	**3.06%**	per year (estimate above by Prof. Lee)
Average growth per ha on forest lands	**0.94**	te/ha-yr, based on estimates above.
Total degraded forest lands as of about 1997:	**1.6317**	Million ha (from Prof. Lee presentation, slide 34; includes "denuded forest", "unstocked forest", and "converted farmland", of which the latter is 59% of the total.
Average fraction of annual stocked-forest growth per hectare in degraded forests:	20%	(placeholder estimate).



Year	Mha Forest Lands	Growing Stocks (million te)	Implied Annual Growth in Growing Stocks (Mte)	Implied Annual Biomass Available from Reduction in Forest Area (Mte)	Implied Annual Woody Biomass Available from Forest Lands and Clearing (Mte)	Estimated Degraded Forest Lands or "Other Woodland" (Mha)	Implied Annual Biomass Available from Degraded Forest Areas (Mte)	Implied Annual Woody Biomass Available from all Stocked and Degraded Forests (Mte)
1990	8.20	268	8.19	2.88	11.07	1.04	0.19	11.27
1991	8.11	265	8.10	2.85	10.95	1.13	0.21	11.16
1992	8.03	262	8.02	2.82	10.84	1.21	0.23	11.06
1993	7.94	259	7.93	2.79	10.72	1.30	0.24	10.96
1994	7.86	256	7.85	2.76	10.61	1.38	0.26	10.87
1995	7.77	254	7.76	2.73	10.49	1.47	0.27	10.77
1996	7.69	251	7.68	2.70	10.38	1.55	0.29	10.67
1997	7.61	248	7.60	2.67	10.27	1.6317	0.31	10.58
1998	7.53	246	7.52	2.64	10.16	1.71	0.32	10.48
1999	7.45	243	7.44	2.62	10.05	1.79	0.34	10.39
2000	7.37	240	7.36	2.59	9.95	1.87	0.35	10.30
2001	7.28	238	7.27	2.91	10.18	1.96	0.37	10.55
2002	7.19	235	7.18	2.88	10.06	2.05	0.38	10.44
2003	7.10	232	7.09	2.84	9.94	2.14	0.40	10.34
2004	7.02	229	7.01	2.81	9.82	2.22	0.42	10.23
2005	6.93	226	6.92	2.77	9.70	2.31	0.43	10.13
2006	6.85	223	6.84	2.85	9.68	2.39	0.45	10.13
2007	6.76	221	6.75	2.81	9.56	2.48	0.46	10.03
2008	6.67	218	6.67	2.78	9.44	2.57	0.48	9.92
2009	6.59	215	6.58	2.74	9.32	2.65	0.50	9.82
2010	6.51	212	6.50	2.71	9.21	2.73	0.51	9.72
2011	6.44	210	6.43	2.35	8.78	2.81	0.53	9.30
2012	6.37	208	6.37	2.01	8.37	2.87	0.54	8.91
2013	6.32	206	6.31	1.67	7.99	2.92	0.55	8.53
2014	6.28	205	6.27	1.34	7.62	2.96	0.55	8.17
2015	6.25	204	6.24	1.03	7.27	2.99	0.56	7.83
2016	6.22	203	6.21	1.02	7.23	3.02	0.57	7.80
2017	6.19	202	6.18	1.01	7.19	3.05	0.57	7.77
2018	6.16	201	6.15	1.01	7.16	3.08	0.58	7.74
2019	6.13	200	6.12	1.00	7.12	3.11	0.58	7.71
2020	6.10	199	6.09	1.00	7.09	3.14	0.59	7.68

Notes:

1 Documents in authors' files provide estimates that cover a wide range. One source [FC1, p. 11] cites production of 8 - 10 million cubic meters of fuelwood, while other sources suggest total wood production of 4.7 to 7 million cubic meters. Professor Lee Seung-ho (see Note 8, below) provides an estimate of somewhat less than 4 million cubic meters of fuelwood in 1990, rising to 4 million by 1996, and increasing steeply to 5.5 million cubic meters by 1999. Lee cites UN FAO statistics as the source for these data. The UN FAO (2005, see Note 12, below) cites a fuelwood production figure of just over 5 million cubic meters. We use a figure roughly in the middle of this overall range for fuelwood. Most other quantities linked to this note are from the document that provided the higher-range estimate for fuelwood use. Wood input for charcoal falls within a range quoted by a document in the authors files, but was adjusted to roughly match UN FAO production estimate for 1990 shown in Note 7.

2 From document in authors' files [FC1, p. 7].

3 Annual imports from Russia. Document in authors' files lists imports of 2.5 million cubic meters [TP1, p. 4]. Note: other sources list these imports at 230 kcu.m./yr, and also list the number of DPRK workers sent to Russian forests at 16-20,000 annually. An abstract from a 1990s report on the Russian Far East forestry sector (C I N T R A F O R Working Paper Abstract, "The Forest Sector in the Russian Far East: Status and Near-Term Development", by Ekaterina Gataulina and Thomas R. Waggener, 1998, available as http://www.cintrafor.org/research_tab/links/WP/WP63.htm) suggests that the average productivity of Russian forest workers as of 1994 was "360 m^3 per worker (roundwood equivalent)", presumably per annum. This suggests, if the productivity of DPRK work crews were similar, that the DPRK crews might harvest up to about 7 million cubic meters per year, assuming the same rate of production (and the same access to harvesting equipment--which may well not be a given) as Russian crews. If, as has been reported, DPRK harvesting crews brought home approximately a quarter or a third of their harvest (the rest remaining in Russia), annual imports of wood back to the DPRK would be in the range from 1.9 to 2.4 million cubic meters. We assume that 1990 imports of wood to the DPRK from the RFE was somewhat below the lower end of this range, based on an assumption of lower productivity.

4 Use of straw and bran in Agriculture from document in authors' files [HT1, p. 10].

5 Assumptions. Artyom Lukin (2020), "North Korea Stuck between a Rock and a Hard Place: One Year after the Hanoi Summit", dated March 10, 2020, published by Foreign Policy Research Insitute, and available https://www.fpri.org/article/2020/03/north-korea-stuck-between-a-rock-and-a-hard-place-one-year-after-the-hanoi-summit/, suggests that the use of DPRK labor for forest operations in (for example) Siberia has declined to near-zero due to changes in the Russian timber industry: "...virtually stopped hiring them in the 2000s when the industry shifted to the use of highly efficient harvester machines." Based on this finding, we assume that the use of DPRK labor for forestry, and thus related off-books imports of Russian timber, declinded after 2000, with some timber exports possibly continuing in partial payment for DPRK labor working in other sectors, such as construction, which apparently continued until UNSC sanctions prohibiting most imports of DPRK labor went into force. For 2020, we assume that these imports were on the order of half of those in previous years, due to restrictions on trade movements due to the DPRK (and Russian) efforts to reduce the impacts of the COVID-19 pandemic, and the likely resulting further reduction of DPRK labor working in the Russian Far East.

6 Adjusted to meet demand; crop biomass availabiltiy use is assumed to generally, though not directly, track production of cereal crops (see Agriculture worksheet).

7 *China Customs Statistics reported exports "woodpulp, etc" from the DPRK to China in 2005 of (HS #47) of* 1,098 *tonnes. No shipments in this category were reported in 2000, and 1996 shipment were* 80 *tonnes.*

China also imported 726 and 145 tonnes of "paper and paperboard" (HS # 48) from the DPRK in 2003 and 2004 (no DPRK paper and paperboard exports to China were recorded in 2005). In 1996, exports from the DPRK were 145.35 *tonnes in this category, and exports in 2000 were* 49.215 *tonnes.*

An additional 114 *tonnes of paper and paperboard were recorded, however, as exported to Hong Kong from the DPRK in 2005, down from 566 tonnes in 2003 and 136 tonnes in 2004.*

China exported modest amounts of paper and paperboard to the DPRK: about 9.9, and 11.4 tonnes in 2003 and 2004, respectively, and 12.9 *tonnes in 2005,* 6.7 *tonnes in 2000, and* 4.8 *tonnes in 1996, along with a tonne or less of wood pulp in each of those years.*

Hong Kong also exported modest amounts of paper and paperboard to the DPRK: about 42, 38, and 31 *tonnes in 2003, 2004, and 2005, respectively, plus* 766 *tonnes of wood pulp (but no paper) in in 2000.*

Import/export data as compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf.

United Nations Food and Agriculture Organization estimates for DPRK wood and wood products imports and exports are available from http://faostat.fao.org/site/381/DesktopDefault.aspx?PageID=381, and suggest imports and exports of wood and wood products from thousands to tens of thousands of cubic meters (or tonnes) per year over the period from 2000 to 2005. These data have not yet been directly used in the estimates prepared as above because A) in some cases, the use of a value for several consecutive years suggests primary data have not been used, and B) these quantitities have little effect on the overall wood supply/demand balance estimated above. Sample FAO data tables (from the FAOSTAT site) are provided below (for "Korea, Dem People's Rep").

Item	Element	Unit	2000	2001	2002	2003	2004
Sawlogs+Veneer Logs (C)	Imports - Qty	Cum	0	0	0	0	0
Chips and Particles	Imports - Qty	Cum	950	0	0	0	0
Wood Residues	Imports - Qty	Cum	0	600	600	600	600
Wood Charcoal	Imports - Qty	Mt	0	700	700	700	700
Sawnwood (C)	Imports - Qty	Cum	1000	200	200	200	200
Sawnwood (NC)	Imports - Qty	Cum	200	300	300	300	300
Veneer Sheets	Imports - Qty	Cum	100	300	300	300	300
Plywood	Imports - Qty	Cum	1100	3000	3000	3000	3000
Particle Board	Imports - Qty	Cum	200	200	200	200	200
Hardboard	Imports - Qty	Cum	0	100	100	100	100
MDF	Imports - Qty	Cum	0	5500	5500	5500	5500
Fibreboard, Compressed	Imports - Qty	Cum	0	0	0	0	0
Insulating Board	Imports - Qty	Cum	0	0	0	0	0
Ind Rwd Wir (C)	Imports - Qty	Cum	10100	0	0	0	0
Mechanical Wood Pulp	Imports - Qty	Mt	0	100	100	100	100
Semi-Chemical Wood Pulp	Imports - Qty	Mt	0	0	0	0	0
Chemical Wood Pulp	Imports - Qty	Mt	11500	44700	44700	44700	44700
Ind Rwd Wir (NC) Tropica	Imports - Qty	Cum	0	0	0	0	0
Dissolving Wood Pulp	Imports - Qty	Mt	0	0	0	0	0
Other Fibre Pulp	Imports - Qty	Mt	0	200	200	200	200
Recovered Paper	Imports - Qty	Mt	800	2000	2000	2000	2000
Ind Rwd Wir (NC) Other	Imports - Qty	Cum	1100	0	0	0	0
Newsprint	Imports - Qty	Mt	400	5400	5400	5400	5400
Printing+Writing Paper	Imports - Qty	Mt	2900	16900	16900	16900	16900
Other Paper+Paperboard	Imports - Qty	Mt	1300	2200	2200	2200	2200

Item	Element	Unit	1990	1996	2000	**2005**	**2006**	**2007**	**2008**	**2009**
Chemical Wood Pulp	Production	tonnes	43000	43000	43000	43000	43000	43000	43000	43000
Mechanical Wood Pulp	Production	tonnes	13000	13000	13000	13000	13000	13000	13000	13000
Other Fibre Pulp	Production	tonnes	50000	50000	50000	50000	50000	50000	50000	50000
Other Paper+Paperboard	Production	tonnes	80000	80000	80000	80000	80000	80000	80000	80000
Wood Charcoal	Production	tonnes	102729	131226	141339	149939	151258	152600	153900	155286
Other Indust Roundwd(C)	Production	CUM	300000	300000	500000	500000	500000	500000	500000	500000
Sawlogs+Veneer Logs (C)	Production	CUM	400000	450000	600000	600000	600000	600000	600000	600000
Sawlogs+Veneer Logs (NC)	Production	CUM	200000	250000	400000	400000	400000	400000	400000	400000
Sawnwood (C)	Production	CUM	185000	185000	185000	185000	185000	185000	185000	185000
Sawnwood (NC)	Production	CUM	95000	95000	95000	95000	95000	95000	95000	95000

8 Data from presentation entitled "Forest and Other Biomass Production in the DPRK: Current Situation and Recent Trends as Indicated by Remote Sensing Data - Status of Forest Resources, Degradation & Biomass in North Korea using Remote Sensing Data" by Professor Lee Seung-ho of the Remote Sensing Laboratory, KOREA FOREST RESEARCH INSTITUTE. as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Prof. Lee's paper is available as http://www.nautilus.org/DPRKEnergyMeeting/papers/Lee.ppt.

9 Calculated from data in Source 8 (slide 59) as weighted average: 1.69

10 Input to charcoal production assumed to be largely hardwood.

11 The report DPR KOREA : STATE OF THE ENVIRONMENT 2003, published by the United Nations Environment Programme, lists (table 3.2) oak as the dominant hardwood tree species in the DPRK (52.4 percent in deciduous forests).

12 The UN FAO Global Forest Resource Assessment 2005 (FRA) provides forest extent, forest stock, and other data over time for most nations, including the DPRK. DPRK data are available from www.fao.org/forestry/site/32086/en/prk. Key tables from this source are reproduced below.

Extent of forest and other wooded land	**Area (1000 hectares)**		
FRA 2005 categories	**1990**	**2000**	**2005**
Forest	8,201	6,821	6,187
Other wooded land	-	-	-
Forest and other wooded land	8,201	6,821	6,187
Other land	3,840	5,220	5,854
...of which with tree cover	-	-	-
Total land area	12,041	12,041	12,041
Inland water bodies	13	13	13
Total area of country	12,054	12,054	12,054

Data source: FAO, Global Forest Resources Assessment 2005.

Designated functions of forest and other wooded land

FRA 2005 categories/designated function	Area (1000 hectares)					
	Primary function			Total area with function		
	1990	2000	2005	1990	2000	2005
Forest						
Production	7,072	5,882	5,335	7,072	5,882	5,335
Protection of soil and water	-	-	-	8,201	6,821	6,187
Conservation of biodiversity	1,129	939	852	1,129	939	852
Social services	-	-	-	1,129	939	852
Multiple purpose	-	-	-	not appl.	not appl.	not appl.
No or unknown function	-	-	-	not appl.	not appl.	not appl.
Total forest	**8,201**	**6,821**	**6,187**	**not appl.**	**not appl.**	**not appl.**

Note--Table above only part of that provided in source, but the remainder of the table includes no data.

Growing stock in forest and other wooded land						
FRA 2005 categories	Volume (million cubic meters over bark)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Growing stock in forest and other wooded land	504	429	395	-	-	-
Commercial growing stock	-	-	-	-	-	-

Data source: FAO, Global Forest Resources Assessment 2005.

Biomass stock in forest and other wooded land						
FRA 2005 categories	Biomass (million metric tonnes oven-dry weight)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Above-ground biomass	434	369	340	-	-	-
Below-ground biomass	159	136	125	-	-	-
Total living biomass	593	505	464	-	-	-
Dead wood	87	74	68	-	-	-
Total	680	579	532	-	-	-

Data source: FAO, Global Forest Resources Assessment 2005.

Carbon stock in forest and other wooded land

FRA 2005 categories	Carbon (million metric tonnes)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Carbon in above-ground biomass	217	185	170	-	-	-
Carbon in below-ground biomass	80	68	62	-	-	-
Carbon in living biomass	297	252	232	-	-	-
Carbon in dead wood	43	37	34	-	-	-
Carbon in litter	-	-	-	-	-	-
Carbon in dead wood and litter	43	37	34	-	-	-
Soil carbon	-	-	-	-	-	-
Total	340	289	266	-	-	-

Data source: FAO, Global Forest Resources Assessment 2005.

Removals of wood products						
FRA 2005 categories	Volume (1000 cubic meters over bark)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Industrial roundwood	690	1,725	1,725	-	-	-
Woodfuel	5,055	6,318	6,967	-	-	-
Total	5,745	8,043	8,692	-	-	-

Data source: FAO, Global Forest Resources Assessment 2005.

This document also lists the area of forest lands affected by forest fires in the DPRK at 46 kha/yr.

13 A document in the authors' file lists "building materials" (assumed to be similar to "industrial roundwood", though the latter may also include wood for pulp) consumption at "3 to 5 million cubic meters/yr". By way of comparison, at this level, the DPRK would be using approximately twice as much roundwood per capita as China in 1990. We assume that the range above is an over-estimate, and that the UN FAO FRA value (see above) is more reasonable, though possibly still a bit of an under-estimate. We therefore use 1 million cubic meters for building materials as an estimate for 1990.

14 The following is a rough calculation of the annual availablity of livestock manures in 2005:

Animal Type	Number	kg VS/day	te VS/yr
Cattle	578000	2.2	464,134
Pigs	3200000	0.3	350,400
Chickens	21000000	0.01	76,650
Ducks	5500000	0.024	48,180
Goats	2750000		
Sheep	172000		
TOTAL			939,364

Note: VS = "volatile solids", essentially a measure of the amount of dry organic matter in the manure.
Animal numbers from UN Food and Agriculture Organization FAOSTAT, available as http://faostat.fao.org/site/568/default.aspx.
Estimates of manure production per animal are derived from data in Rural Energy Production: Biogas Plant, a Sustainable Source of Energy for Cooperative Farms, by Arthur Wellinger, dated December 12, 2003, and published by ADRA (Adventist Development and Relief Agency International) and Nova Energie. The Wellinger report provides case studies of the application of manure-fed biogas digesters in the DPRK.

15 The following is a summary of a Korea Foreast Research Institute Report, copied from
http://www6.lexisnexis.com/publisher/EndUser?Action=UserDisplayFullDocument&orgId=574&topicId=100007194&docId=l:1438898309&start=8:

Asia Pulse, June 17, 2011 Friday 11:09 AM EST, NATIONWIDE INTERNATIONAL NEWS
N. KOREA'S DEFORESTATION PROCEEDING RAPIDLY: REPORT
SEOUL June 17
Deforestation in North Korea is taking place at a rapid pace as people cut down trees for fuel and turn forest into farmland, a report by a state think tank here said Friday.
An average of 127,000 hectares of forest in North Korea have been destroyed on average every year for the past two decades, the Korea Forest Research Institute (KFRI) said in the report based on data by the United Nations Food and Agriculture Organization.
Total forest area in North Korea stood at 5.66 million hectares as of 2010, which was less than the 6.22 million hectares tallied for South Korea.
The institute under the farm ministry said that the pace of deforestation is even faster than that of rainforests around the world.
"The size of forest lost every year is equal to 150 times the land area of Yeouido in Seoul," the KFRI said. Yeouido in central Seoul, an island-turned-business district, is home to many South Korean securities firms, the stock exchange and the National Assembly.
The report said North Korean forests are probably being destroyed to provide wood for heating and cooking and to make new farmland to grow more food.
The report, meanwhile, showed that North Korea's forest size decreased from slightly over 8.20 million hectares in 1990 to 6.99 million hectares 10 years later and 6.29 million in 2005.

16 The article "Estimation of future carbon budget with climate change and reforestation scenario in North Korea", by Damin Kim, Chul-Hee Lim, Cholho Song, Woo-Kyun Lee ⁄\, Dongfan Piao, Seongbong Heo, and Seongwoo Jeon, ***Advances in Space Research*** *58 (2016) 1002–1016, includes a table with the following summaries of deforestation extents in the DPRK over different periods:*

References (refers to references in article)	Decrease in Forested Area (million ha)	Period	Implied loss of forest lands per year (million ha)	Implied loss of forest area relative to beginning of period
KFS (2011)	1.7	1999–2008	0.1889	2.67%
FAO (2010)	2.5	1990–2010	0.1250	1.52%
Lee et al. (2007)	1.2	Late 1980s–early 2000s	0.0857	1.05%
Park and Yu (2009)	1.9	1989–2008	0.1000	1.22%
Park et al. (2014)	1.7	2000–2012	0.1417	2.04%
This study	1.8	Late 1980s (1987–89)–2010	0.0818	1.00%

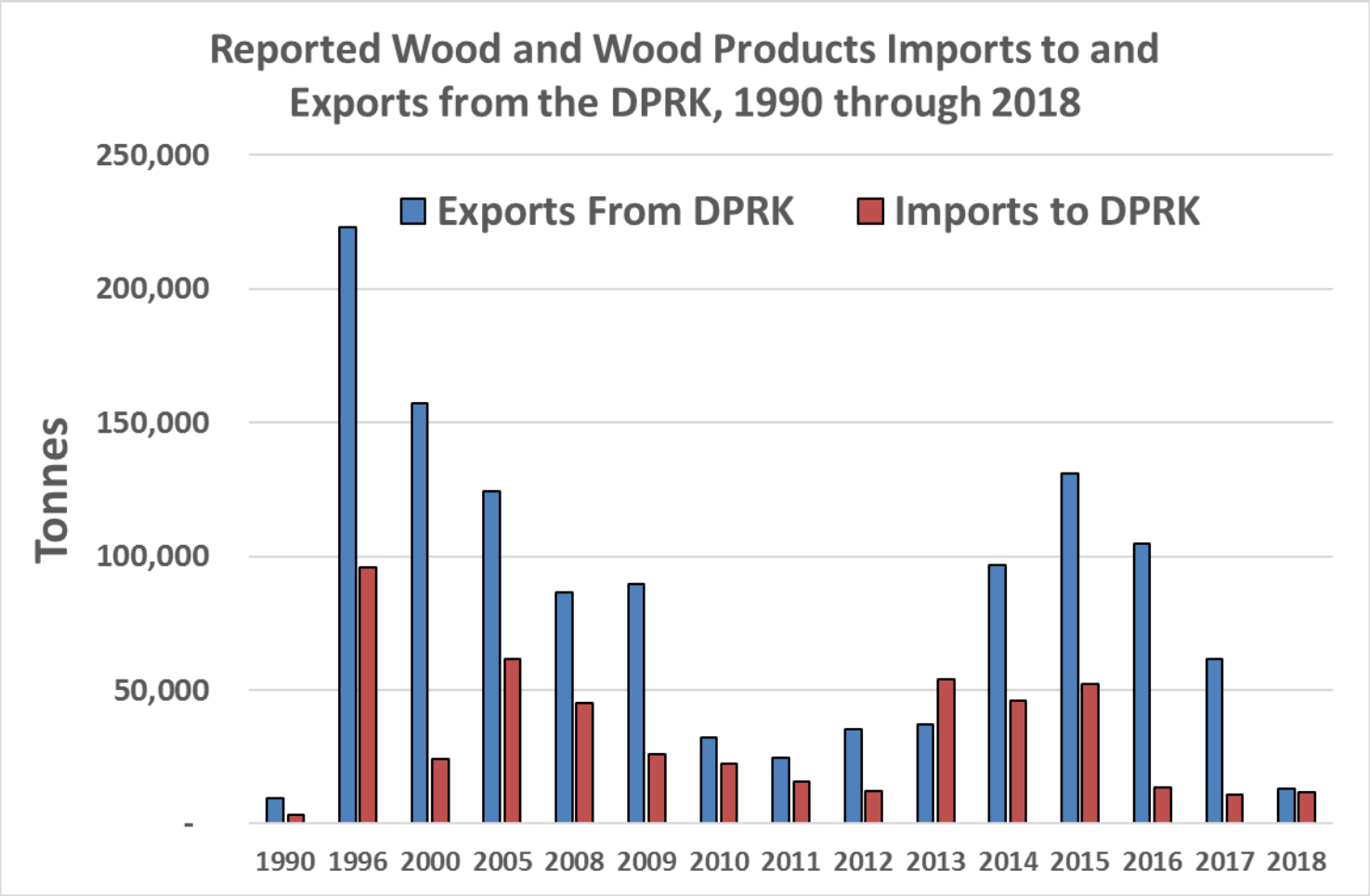
17 The following summarizes data on pulp and paper (HS 47 and 48) imports from and exports to the DPRK from all trade partners for the period from 2008 through 2018 from Comtrade (accessed 6/13/18 and 2/2020):

Year	Import from/Export to DPRK	Products	Total Value (USD)	Total Weight (te)	Implied cost per tonne
2008	Import	All 470X	$ 168,400	845	$ 199.38
2008	Export	All 470X	$ 25,632,705	61,395	$ 417.51
2009	Import	All 470X	$ 41,318	93	$ 443.87
2009	Export	All 470X	$ 6,750,550	19,600	$ 344.42
2010	Import	All 470X	$ 1,765,547	2,091	$ 844.28
2010	Export	All 470X	$ 3,334,609	4,838	$ 689.25
2011	Import	All 470X	$ 352,193	625	$ 563.80
2011	Export	All 470X	$ 3,371,192	3,492	$ 965.46
2012	Import	All 470X	$ 86,704	443	$ 195.57
2012	Export	All 470X	$ 981,797	1,240	$ 791.87
2013	Import	All 470X	$ 38,722	107	$ 360.32
2013	Export	All 470X	$ 4,661,918	7,920	$ 588.64
2014	Import	All 470X	$ 328,319	501	$ 654.96
2014	Export	All 470X	$ 2,708,540	5,412	$ 500.46
2015	Import	All 470X	$ 13,201	88	$ 149.37
2015	Export	All 470X	$ 1,454,085	2,298	$ 632.67
2016	Import	All 470X	$ 332,024	629	$ 527.56
2016	Export	All 470X	$ 962,044	1,370	$ 702.25
2017	Import	All 470X	$ 66,764	368	$ 181.31
2017	Export	All 470X	$ 150,618	312	$ 482.75
2018	Import	All 470X	$ -	-	$ -
2018	Export	All 470X	$ 854,887	1225.463	$ 697.60
2019	Import	All 470X	$ -	-	$ -
2019	Export	All 470X			#DIV/0!
2020	Import	All 470X	$ -	-	$ -
2020	Export	All 470X			#DIV/0!

Year	Import from/Export to DPRK	Products	Total Value (USD)	Total Weight (te)	Implied cost per tonne
2008	Import	All 480X	$ 393,260	550	$ 715.27
2008	Export	All 480X	$ 4,658,978	6,323	$ 736.79
2009	Import	All 480X	$ 1,581,640	2,048	$ 772.24
2009	Export	All 480X	$ 3,265,465	4,082	$ 800.05
2010	Import	All 480X	$ 1,520,691	2,223	$ 684.22
2010	Export	All 480X	$ 4,238,072	5,747	$ 737.43
2011	Import	All 480X	$ 1,671,082	2,369	$ 705.50
2011	Export	All 480X	$ 10,369,411	11,950	$ 867.72
2012	Import	All 480X	$ 1,242,413	1,324	$ 938.71
2012	Export	All 480X	$ 5,861,840	7,569	$ 774.50
2013	Import	All 480X	$ 1,466,483	1,634	$ 897.22
2013	Export	All 480X	$ 6,877,692	8,201	$ 838.63
2014	Import	All 480X	$ 2,079,345	2,077	$ 1,000.89
2014	Export	All 480X	$ 11,274,610	12,743	$ 884.77
2015	Import	All 480X	$ 2,166,414	2,685	$ 807.00
2015	Export	All 480X	$ 16,102,244	18,669	$ 862.51
2016	Import	All 480X	$ 890,082	1,023	$ 869.65
2016	Export	All 480X	$ 15,767,756	19,644	$ 802.67
2017	Import	All 480X	$ 535,116	760	$ 704.19
2017	Export	All 480X	$ 34,423	46	$ 742.16
2018	Import	All 480X	$ 204,634	253	$ 807.90
2018	Export	All 480X	$ 14,482,950	16,468	$ 879.45
2019	Import	All 480X			#DIV/0!
2019	Export	All 480X			#DIV/0!
2020	Import	All 480X			#DIV/0!
2020	Export	All 480X			#DIV/0!

18 The following summarizes data on wood and wood products (HS 44) imports from and exports to the DPRK from all trade partners for the period from 2008 through 2018 from Comtrade (accessed 3/10/2020):

Year	Import from/Export to DPRK	Products	Total Value (USD)	Total Weight (te)	Implied cost per tonne	Total Weight Charcoal Only (4402, te)	Implied cost per tonne	Total Weight without Charcoal (te)	Implied cost per tonne
1990	Import	All 44XX	$ 1,162,903	9,425	$ 123.39	0.70	$ 4,446	9,424	$ 123.07
1990	Export	All 44XX	$ 1,469,403	3,428	$ 428.61	-	#DIV/0!	3,428	$ 428.61
1996	Import	All 44XX	$ 19,458,724	223,148	$ 87.20	-	#DIV/0!	223,148	$ 87.20
1996	Export	All 44XX	$ 6,696,266	95,803	$ 69.90	-	#DIV/0!	95,803	$ 69.90
2000	Import	All 44XX	$ 10,731,155	157,273	$ 68.23	24	$ 629	157,249	$ 68.15
2000	Export	All 44XX	$ 3,073,836	24,143	$ 127.32	202	$ 105	23,941	$ 127.51
2005	Import	All 44XX	$ 14,990,785	124,413	$ 120.49	661	$ 105	123,752	$ 120.57
2005	Export	All 44XX	$ 7,880,662	61,684	$ 127.76	41	$ 701	61,643	$ 127.38
2008	Import	All 44XX	$ 7,686,204	86,322	$ 89.04	1	$ 350	86,321	$ 89.04
2008	Export	All 44XX	$ 6,715,446	45,126	$ 148.81	52	$ 268	45,074	$ 148.68
2009	Import	All 44XX	$ 8,611,239	89,503	$ 96.21	-	#DIV/0!	89,503	$ 96.21
2009	Export	All 44XX	$ 4,064,759	25,786	$ 157.63	35	$ 384	25,751	$ 157.32
2010	Import	All 44XX	$ 3,581,731	32,152	$ 111.40	3	$ 160	32,149	$ 111.39
2010	Export	All 44XX	$ 4,480,108	22,616	$ 198.10	6	$ 1,538	22,610	$ 197.74
2011	Import	All 44XX	$ 4,181,473	24,752	$ 168.93	0	$ 160	24,752	$ 168.93
2011	Export	All 44XX	$ 5,349,302	15,775	$ 339.10	45	$ 726	15,730	$ 337.98
2012	Import	All 44XX	$ 7,026,099	35,396	$ 198.50	-	#DIV/0!	35,396	$ 198.50
2012	Export	All 44XX	$ 2,938,213	12,237	$ 240.11	439	$ 288	11,798	$ 238.31
2013	Import	All 44XX	$ 5,545,142	37,066	$ 149.60	-	#DIV/0!	37,066	$ 149.60
2013	Export	All 44XX	$ 5,966,771	54,151	$ 110.19	2,633	$ 363	51,518	$ 97.27
2014	Import	All 44XX	$ 14,685,712	96,657	$ 151.94	-	#DIV/0!	96,657	$ 151.94
2014	Export	All 44XX	$ 7,417,262	46,060	$ 161.03	668	$ 250	45,392	$ 159.73
2015	Import	All 44XX	$ 18,619,881	131,066	$ 142.07	82	$ 1,283	130,984	$ 141.35
2015	Export	All 44XX	$ 9,373,916	52,426	$ 178.80	40	$ 742	52,386	$ 178.38
2016	Import	All 44XX	$ 15,029,669	104,867	$ 143.32	355	$ 224	104,511	$ 143.05
2016	Export	All 44XX	$ 3,389,305	13,770	$ 246.14	42	$ 1,217	13,728	$ 243.16
2017	Import	All 44XX	$ 9,626,060	61,477	$ 156.58	647	$ 181	60,830	$ 156.33
2017	Export	All 44XX	$ 5,131,112	10,758	$ 476.97	29	$ 1,337	10,729	$ 474.62
2018	Import	All 44XX	$ 1,953,551	13,171	$ 148.32	56	$ 170	13,115	$ 148.23
2018	Export	All 44XX	$ 6,665,391	11,737	$ 567.88	168	$ 1,983	11,569	$ 547.32
2019	Import	All 44XX			#DIV/0!		#DIV/0!	-	#DIV/0!
2019	Export	All 44XX			#DIV/0!		#DIV/0!	-	#DIV/0!
2020	Import	All 44XX			#DIV/0!		#DIV/0!	-	#DIV/0!
2020	Export	All 44XX			#DIV/0!		#DIV/0!	-	#DIV/0!



19 The UN FAO Forest Resource Assesment (FRA) for 2020, Desk Study Democratic People's Republic of Korea, available as http://www.fao.org/3/ca9858en/ca9858en.pdf, provides details of FAO estimates of DPRK forest area and related data. The methods and categorizations for forest area appear to be slightly different than those in earlier versions of the FRA.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION IN 1990

Prepared By David Von Hippel
Date Last Modified: 3/1/2007

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Electricity Generation: Output by Fuel Type:			
Total Gross Generation	4.60E+04	GWhe	*1*
Fraction in Hydro Plants	46.3%		*2*
Fraction in Thermal Plants	53.7%		*2*
Generation in largest Oil-fired plant	1.28E+03	GWhe	*3*
Fraction of Oil Generation in Largest Plant	100%		*4*
Gross Generation, Hydro Plants	2.13E+04	GWhe	
Gross Generation, Oil Plants	1.28E+03	GWhe	
Gross Generation, Coal Plants	2.34E+04	GWhe	
Conversion Factor	3.60E+03	GJ/GWhe	
Gross Generation, Hydro Plants	7.66E+07	GJ	
Gross Generation, Oil Plants	4.61E+06	GJ	
Gross Generation, Coal Plants	8.44E+07	GJ	
Own Use Rate, Hydro Plants	0.3%		*5*
Own Use Rate, Oil Plants	8.00%		*5*
Own Use Rate, Coal Plants	9.00%		*5*
Own Use, Hydro Plants	6.39E+01	GWhe	
Own Use, Oil Plants	1.02E+02	GWhe	
Own Use, Coal Plants	2.11E+03	GWhe	
Own Use, Hydro Plants	2.30E+05	GJ	
Own Use, Oil Plants	3.69E+05	GJ	
Own Use, Coal Plants	7.59E+06	GJ	
Net Generation, Hydro Plants	2.123E+04	GWhe	
Net Generation, Oil Plants	1.178E+03	GWhe	
Net Generation, Coal Plants	2.132E+04	GWhe	
Net Generation, Hydro Plants	7.64E+07	GJ	
Net Generation, Oil Plants	4.24E+06	GJ	
Net Generation, Coal Plants	7.68E+07	GJ	
MW of hydro capacity in shared dams used by China	700	MW	*11*
Fraction of 1990 DPRK hydro generation represented by Chinese border hydro plants	16%		*12*
Exports of electricity to China (does not count shared border dams)	0.00E+00	GWhe	
Exports of electricity to China via shared dams	1.19E+07	GJ	*14*
"Emergency Losses" Rate, Coal Plants	5.0%		*6*
"Emergency Losses", Coal Plants	1.17E+03	GWhe	
"Emergency Losses", Coal Plants	4.22E+06	GJ	
Total Net Generation factoring in emergency losses, Coal Plants	7.25E+07	GJ	
Total Net Generation factoring in emergency losses, All Plants	4.26E+04	GWhe	
Total Net Generation, All Plants	1.53E+08	GJ	
Transmission and Distribution Losses			
Transmission Losses	10%		*7*
Distribution Losses	6%		*7*
Delivered Electricity	3.60E+04	GWhe	
Delivered Electricity	1.30E+08	GJ	
Fuel Requirements for Electricity Generation			
"Heat Rate" (Efficiency) Hydro Plants	100.00%		*8*
Gross Generation Efficiency, Oil-Fired Plants	29.5%		*9*
Gross Generation Efficiency, Coal-Fired Plants	28.0%		*10*
Input Energy, Hydro Plants	7.66E+07	GJ	
Input Energy, Oil Plants	1.56E+07	GJ	
Input Energy, Coal Plants	3.01E+08	GJ	
Fraction of energy input to Coal plants as residual oil	2.1%		*Assumption*
Oil input to coal plants	6.33E+06	GJ	
Total Input Energy, Electricity Generation	3.94E+08	GJ	

Sources/Notes:

1 Somewhat lower than value cited by Choi Su Young, Study of the Present State of Energy Supply in North Korea, P. 49 (55.5 TWh) as "Official NK Figures", compiled by RINU. Other estimates, published and otherwise place 1990 DPRK electricity output between about 28 TWh (RINU estimate) and 60 TWh.

2 Figures from document in authors' files [EE1, p. 15].

3 For Oung gi plant, one of (possibly) 2 grid-connected oil-fired plants. From document in authors' files [EE1, p. I-2].

4 The Oung gi plant is 200 MW. The second oil-fired plant listed by some sources must be quite small, if indeed it exists. Other sources claim that there is only one oil-fired plant in the DPRK, which we have assumed.

5 ROK rates in 1970. From p. 129,E-W.Kim et al, "The Electric Future of Korea" East-West Center, September, 1983. Own use rates for Chinese coal-fired plants are very slightly higher.

6 Rough estimate. A note in document in authors' files [EE1, p. 26] put the loss from "frequent emergencies" at Pyongyang power station at 7%. It is not clear whether this value is typical for the DPRK system as a whole.

7 Official Estimates. From document in authors' files [EP1, p. 3]. This source notes that these estimates may be optimistic.

8 As used in United Nations Energy Statistics Yearbook.

9 Author's estimate. Official rate of approximately 35% (as presented in UNDP (1994), Studies in Support of Tumen River Area Development Programme. Prepared by KIEP, Seoul, ROK for the UNDP, July, 1994) seems somewhat high given the reported condition of the power plant at Sonbong.

10 This rate is somewhat lower than that given for the Chongjin plant in source 9, and similar to the heat rates in Chinese coal plants in the late 1970's.

11 See "Energy Generation Facilities" sheet.

12 Assumes that exported electric energy is proportional to the fraction of capacity earmarked for Chinese use.

*13 The DPRK's Yongbyon nuclear plant, though frequently described as having a capacity of "5 MWe", 5 MW electrical output) is not configured to produce electricity (see, for example, North Korea's Nuclear Weapons Programme, by the International Institute for Strategic Studies, 2006, http://www.iiss.org/publications/strategic-*dossiers/north-korean-dossier/north-koreas-w eapons-programmes-a-net-asses/north-koreas-nuclear-w eapons-programme#w eapons
The Yongbyon reactor does, however, provide some heat to buildings in the area. The reactor is said to have a rated output of about 25 *MWth (a range of 20 - 30 MWth is often cited). Capacity factors of about 80 percent for this reactor have been cited, but other observers suggest that a capacity factor of* 60% *is "more realistic". For 1990, and pending the addition of "heat" as a separate balance category, we place the heat produced by the Yongbyon reactor, estimated at* 4.73E+05 *GJ. In the "Hydro/Nuclear" and the "non-specified" row of the energy balance, as well as in the "domestic production" row under supplies. See "Yongbyon 5-MW(e) Reactor" from http://www.globalsecurity.org/wmd/world/dprk/yongbyon-5.htm for estimates of Yongbyon capacity factor.*

14 Not counted as exports in energy balances because these plants are owned and operated by China.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION FACILITIES

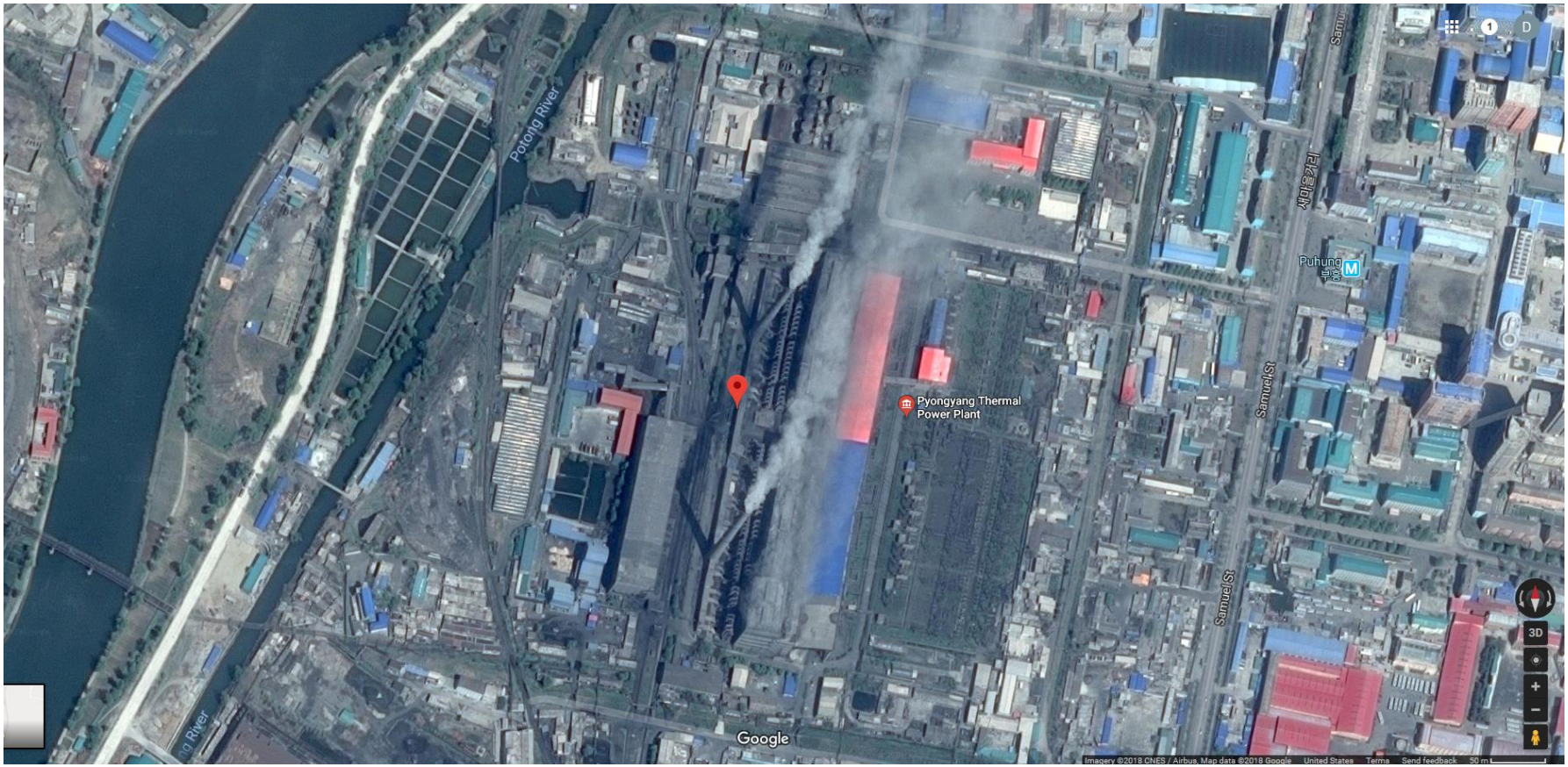
MAJOR THERMAL GENERATING FACILITIES

#	Name		Capacity (MW)	Fuel	Year Completed	Latitude	Longitude	***Sources/Notes:***
1	Pyongyang		500	Coal	1968	39.009548	125.71097	*1*
2	Bukchang		1600	Coal	1985			*1,2,7*
3	Chongjin		150	Coal	1984			*1,2*
4	Chonchonang		200	Coal	1979			*1,2*
5	Oungi		200	Oil	1973			*2*
6	Sunchon		200	Coal	1988			*1*
7	East Pyongyang		50	Coal	1992	38.969045	125.68841	*3, 18*
TOTAL OF LISTED PLANTS			**2900**					

THERMAL GENERATING FACILITIES REPORTEDLY UNDER CONSTRUCTION OR RECENTLY COMPLETED AS OF 1996

#	Name	Capacity (MW)	Fuel	Year Started	Year Completed	***Sources/Notes:***
1	Pyunghung(?)	200	Coal			*8*
2	Suncheon(?)	200	Coal			*8,12*
3	Dongpyungyang	600	Coal		1993 - 1996	*13*
4	Kimchaek	150	Coal	1988		*2*
5	Hamhyng central	100	Coal	1994		*2*
6	12wol	150	Coal		1993?	*13*
7	Haeju	11	Coal	1990		*13, 19*
8	Ahnju	1200	Coal	1989		*13*
9	Hamheung	150	Coal	1989		*13, 14*
TOTAL OF LISTED PLANTS		**2,761**				

Google Earth Image of Pyongyang Power Plant, Probably summer, 2018



Google Earth Image of East Pyongyang Power Plant, Probably summer, 2018

MAJOR HYDRO GENERATING FACILITIES

#	Name	Capacity (MW)	Year Completed	Year Refurbished	***Sources/Notes:***
1	Supung	400			*1,2,4*
2	Kymgansang cascade	13.5	1930	1958	*2*
3	Puren cascade	28.5	1932		*2*
4	Puch'on-gang	260	1932	1956	*2,11*
5	Chanjin-gang	390	1936	1958	*2*
6	Hoch'on-gang	394	1942	1958	*2*
7	Tonno-gang	90	1959		*2*
8	Kangae	246	1965		*2*
9	Ounbong	200	1970		*2,5*
10	Sodusu-1	180	1974		*2,9*
11	Sodusu-2	230	1978		*2,9*
12	Sodusu-3	45	1982		*2,9*
13	Taedong-gang	200	1982		*2*
14	Mirim	32	1980		*2*
15	Ponhwa	32	1983		*2*
16	Hwan-gang	20	198?		*2*
17	Tonhwa	20	198?		*2*
18	T'aep'enmang	90	1989		*2,6*
19	Weewong	200	1989		*2,10*
20	Nam-gang	200	1994		*2*
21	Dokro river	36			*2,8*
TOTAL OF LISTED PLANTS		**3,307**			

HYDRO GENERATING FACILITIES REPORTEDLY UNDER CONSTRUCTION OR RECENTLY COMPLETED AS OF 1996

#	Name	Capacity (MW)	Year Started	Year Completed	***Sources/Notes:***
1	Taechun	750	1983		*2, 8, 15*
2	Kumgang Mountain	800	1985	1996 (1st Phase)	*2,8,13,16*
3	Sodusu-4	200	1990		*2*
4	Namkang	Unknown	1983		*13*
5	Youngwon	Unknown	1986		*13*
6	Ehrangcheon	Unknown	1986		*13*
7	Jabgjakang	240			*13*
8	P'och'on	820			*2*
9	Oranch'on	180			*2*
10	Heech'on	Unknown	1989		*2*
11	Kymyan-gang	Unknown			*2*
TOTAL OF LISTED PLANTS		**2,990**			

PARTIAL LISTING OF SUBSTATIONS IN THE DPRK

#	Name	Capacity MVA	Units	***Sources/Notes:***
1	Changjingang	48	1x28, 1x20	*1*
2	Chongjin	165	1x100, 1x5, 1x60	*1*
3	Pyongyang No. 2	100	2x50	*1*
4	Vynalon	200	2x50, 1x100	*1*
5	Pyongyang No. 1			*1*
6	Undok			*1*
7	Munsan			*1*
8	Kilju			*1*
9	Hamhung			*1*
10	Songchon			*1*
11	Sepo			*1*
12	Nampo			*1*
13	Kusong			*1*
14	Sinuiju			*1*
15	Pyongsong			*1*
16	Sin-Anju			*1*

LISTING OF PROVINCIAL CONTROL CENTERS FOR THE DPRK T&D GRID

Source 1

#	Name	Location (city)
1	North Kamgyong	Chongzin
2	Ryanggang	Hyesan
3	Chagang	Kanggye
4	South Hamgyong	Hamhung
5	South Pyongan	Pyongsong
6	Kangwon	Wonsan
7	North Hwanghae	Sariwon
8	Nampo	Nampo
9	South Hwanghae	Haeju
10	Kaesong	Kaesong
11	North Pyongan	Siniju

Annual Load Curve for 1989

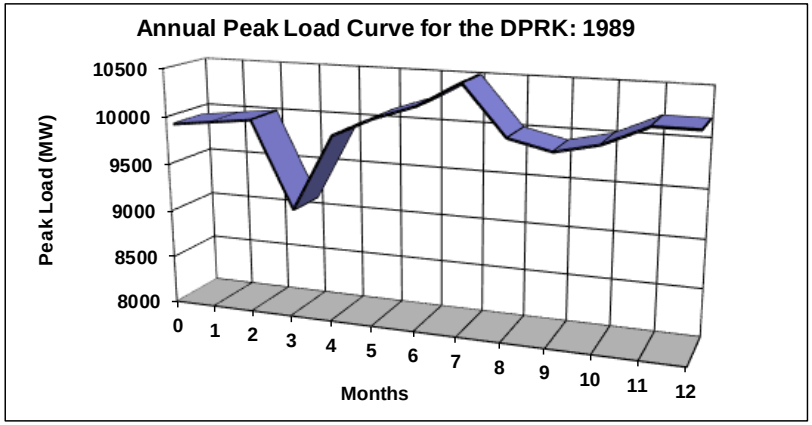
(Source 1)

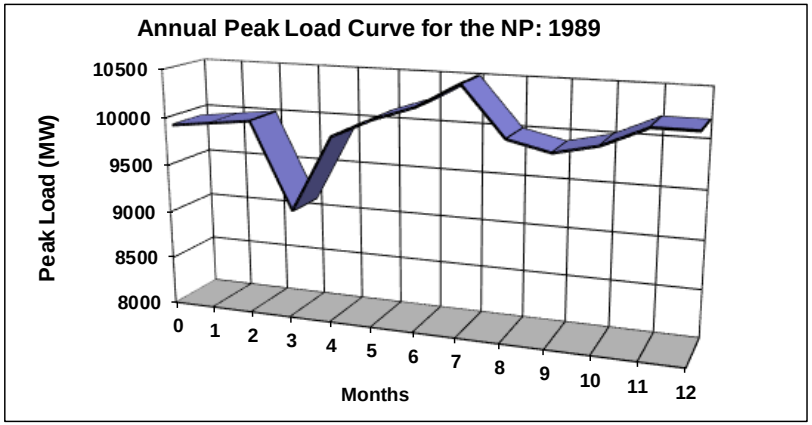
Month	Load (MW)
0	9900
1	9950
2	10000
3	9100
4	9900
5	10100
6	10250
7	10500
8	10000
9	9900
10	10000
11	10200
12	10200

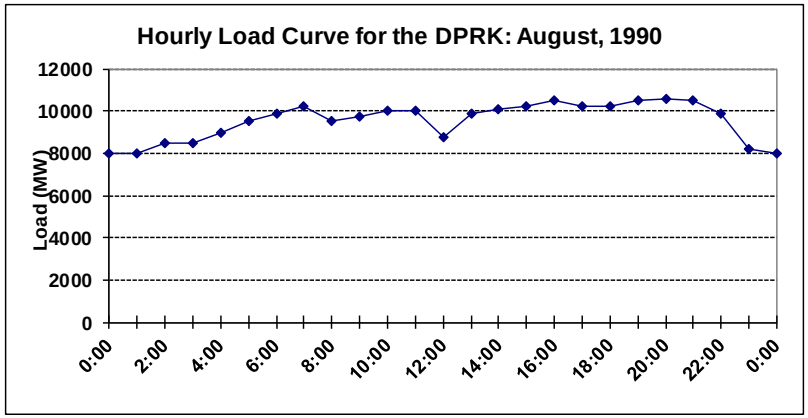
Daily Load Curve for August, 1990

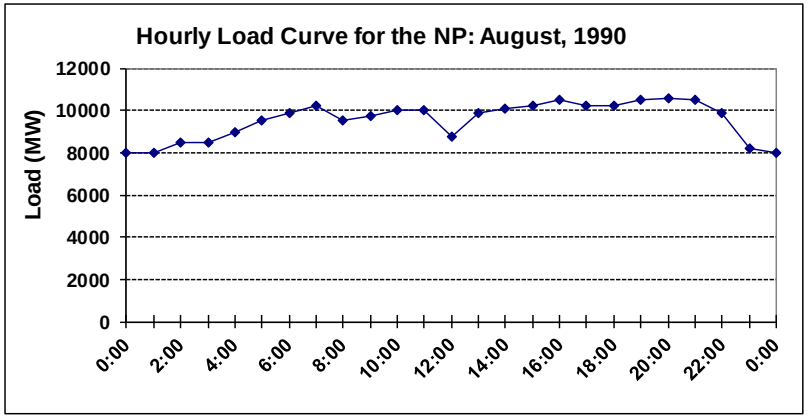
(Source 1)

Time	Load (MW)
0:00	8000
1:00	8000
2:00	8500
3:00	8500
4:00	9000
5:00	9550
6:00	9900
7:00	10200
8:00	9500
9:00	9750
10:00	10000
11:00	10000
12:00	8750
13:00	9900
14:00	10100
15:00	10200
16:00	10500
17:00	10250
18:00	10250
19:00	10500
20:00	10600
21:00	10500
22:00	9900
23:00	8200
0:00	8000


Annual Peak Load Curve for the DPRK: 1989
Peak Load (MW)
10500
10000
9500
9000
8500
8000
0 1 2 3 4 5 6 7 8 9 10 11 12
Months


Annual Peak Load Curve for the NP: 1989
Peak Load (MW)
10500
10000
9500
9000
8500
8000
0 1 2 3 4 5 6 7 8 9 10 11 12
Months


Hourly Load Curve for the DPRK: August, 1990
Load (MW)
12000
10000
8000
6000
4000
2000
0
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00


Hourly Load Curve for the NP: August, 1990
Load (MW)
12000
10000
8000
6000
4000
2000
0
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00

Sources/Notes:

1 *Documents in authors' files [EP1, EE1]*

2 *Moiseyev, V. (1996), The Electric Energy Sector of the DPRK. Paper presented at the workshop on "Security on the Korean Peninsula," November 21, 1996, Diplomatic Academy, Moscow, sponsored by the Center for Nonproliferation Studies at the Monterey Institute of International Studies (with funding from the Rockefeller Foundation).*

3 *Source 1 reports 50 MW of East Pyongyang plant completed in 1992. Source 2 suggests that the ultimate capacity of the plant will be (or was to have been) 400 MW*

4 *Source 2 lists the "Supun" plant as having a total capacity of 735 MW, with 210 MW of that capacity used to produce power for China.*

5 *Source 2 lists this plant as having a total capacity of 400 MW, with 200 MW going to China.*

6 *Source 2 lists this plant as having a total capacity of 190 MW, with 100 MW going to China.*

7 *Source 1 lists the in-service date of the Bukchang station as 1973. This may be the in-service date for the first of the units. (Plant name may also be translated as "Pukchang".)*

8 *Choi Su Young (1993), Study of the Present State of Energy Supply in North Korea, Research Institute for National Unification (RINU), Seoul, (ROK).*

9 *Source 8 lists the total capacity of the three phases of the Sodusu plant at 510 MW. Source 17 lists the plant capacity as 420 MW.*

10 *Source 2 lists this plant as having a total capacity of 390 MW, with 190 MW going to China.*

11 *Capacity listed by source 8 as 226 MW*

12 *Source 8 seems to indicate that this plant will be associated with an industrial facility making vinalon.*

13 *Dongseok Roh, Electricity Policy Division, Korea Energy Economics Institute (KEEI). Personal Communication, 1996.*

14 *This plant may well be the same as the project listed by source 2 as "Hamhyng central".*

15 *Source 8 lists the total capacity of this project at 800 MW. Source 13 describes the "first phase" as having a capacity of 660 MW.*

16 *Source 2 lists the capacity of this project at 810 MW. The first phase of the project, reportedly in the range of 100 to 200 MW, was reportedly brought on line in late 1996.*

17 *UNDP (1994), Studies in Support of Tumen River Area Development Programme. Prepared by KIEP, Seoul, ROK for the UNDP, July, 1994.*

18 *According to one report, the East Pyongyang power plant was built to use lignite coal of relatively low heating value (2000 - 3000 kcal/kg).*

19 *Document in Authors' files [ELE-93] lists capacity for this plant, which perhaps was to have been associated with a nearby cement plant, of 11 MW. Its construction was reportedly postponed as of 1994.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION AND FUEL REQUIREMENTS IN 1996 THROUGH 2020

Prepared by David Von Hippel
Date Last Modified: 5/15/2020

ESTIMATE OF ELECTRICITY GENERATION IN 1996

	Hydro Plants	Coal Plants	HFO Plants	*Sources/Notes:*
Electricity Generating Capacity as of 1990 (MW)	4,500	3,200	200	*4*
Estimated Gross Generation in 1990 (GWHe)	2.129E+04	2.34E+04	1.280E+03	*Based on 1990 est.*
Implied Capacity Factor, 1990	54.0%	83.6%	73.1%	
Changes in Capacity, 1990 to 1996 (MW):	-3250	50	0	*5*
Average 1996 Capacity Factor Relative to 1990 Est.	90%	69.80%	71.2%	*3*
Estimated Gross Generation in 1996 (GWHe)	5.322E+03	1.661E+04	9.114E+02	
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Does not include output of*
Fraction of 1990 Exports to China in 1996	0%			*Supung hydro plants*
Estimated Power Exports to China, 1996 (GJ)	0.00E+00			*controlled by China*
Gross Generation Efficiency, 1996	100%	27.0%	28.00%	*2*
Fuel Input to generation, 1996 (GJ)	1.92E+07	2.21E+08	1.17E+07	
Fraction of fuel input as HFO	N/A	6.20%	100%	*1*
HFO Input to generation, 1996 (GJ)	N/A	1.37E+07	1.17E+07	
Other Petrol Products (tires) input to gen., 1996 (GJ)	N/A	1.69E+04		
Own Use Fractions, 1996	0.30%	9.00%	8.00%	*Based on 1990 est.*
Own Use of Electricity (GJ)	5.75E+04	5.38E+06	2.62E+05	
"Emergency Loss" Fractions, 1996	0%	7.5%	0%	*50% higher than 1990*
Emergency Losses, 1996 (GJ)	0	4.48E+06	0	
Implied Net Electricity Output (GWhe)	5.306E+03	1.387E+04	8.385E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 1996	23.10%			*50% higher than 1990*
Transmission and Distribution Losses, 1996 (GJ)	1.66E+07			

ESTIMATE OF ELECTRICITY GENERATION IN 2000

	Hydro Plants	Coal Plants	HFO Plants	
Changes in Capacity, 1990 to 2000 (MW):	-1400	150	69.8	*Total capacity, not just operable*
Average 2000 Capacity Factor Relative to 1990 Est.	71%	10.8%	8.57%	*CF based on total capacity*
Estimated Gross Generation in 2000 (GWHe)	1.047E+04	2.641E+03	1.480E+02	
Gross Generation Efficiency, 2000	100%	21.0%	20.54%	
Fuel Input to generation, 2000 (GJ)	3.77E+07	4.53E+07	2.59E+06	
Fraction of fuel input as HFO	N/A	28.36%	100%	
HFO Input to generation, 2000 (GJ)	N/A	1.28E+07	2.59E+06	
Other Petrol Products (tires) input to gen., 2000 (GJ)	N/A	7.71E+05		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Excluding Chinese-controlled*
2000 Exports to China (GWh)	22.66			*Based on reported exports*
Estimated Power Exports to China, 2000 (GJ)	8.16E+04			
Imports of Electricity from China (GJ)	0.00E+00			
Own Use Fractions, 2000	0.30%	9.00%	8.00%	*Same as in 1990*
Own Use of Electricity (GJ)	1.13E+05	8.56E+05	4.26E+04	
"Emergency Loss" Fractions, 2000	0%	9.4%	0%	*30% higher than in 1996*
Emergency Losses, 2000 (GJ)	0	8.91E+05	0	
Implied Net Electricity Output (GWhe)	1.044E+04	2.156E+03	1.362E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2000	27.72%			*20% higher than 1996*
Transmission and Distribution Losses, 2000 (GJ)	1.27E+07			

ESTIMATE OF ELECTRICITY GENERATION IN 2005

	Hydro Plants	Coal Plants	HFO Plants	
Changes in Capacity, 1990 to 2005 (MW):	-383.6	150	69.8	
Average 2005 Capacity Factor Relative to 1990 Est.	57.24%	21.00%	10%	*See Note 12*
Estimated Gross Generation in 2005 (GWHe)	1.1146E+04	5.1511E+03	1.727E+02	
Gross Generation Efficiency, 2005	100%	21.0%	21.00%	
Fuel Input to generation, 2005 (GJ)	4.01E+07	8.83E+07	2.96E+06	
Fraction of fuel input as HFO	N/A	3.59%	100%	
HFO Input to generation, 2005 (GJ)	N/A	3.17E+06	2.96E+06	
Other Petrol Products (tires) input to gen., 2005 (GJ)	N/A	8.91E+05		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Excluding Chinese-controlled Based on reported exports.*
2005 Exports to China (GWh)	90.15			*See Note 11*
Estimated Power Exports to China, 2005 (GJ)	3.25E+05			
Own Use Fractions, 2005	0.30%	9.00%	8.00%	*Same as in 1990*
Own Use of Electricity (GJ)	1.20E+05	1.67E+06	4.97E+04	
Imports of Electricity from China (GJ)	2.37E+03			*See Note 10 Discussions, but no*
Imports of Electricity from Russia (GJ)	0.00E+00			*evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	2.62E+05			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	2.65E+05			
"Emergency Loss" Fractions, 2005	0%	9%	0%	*25% higher than in 1996*
Emergency Losses, 2005 (GJ)	0	1.67E+06	0	
Implied Net Electricity Output (GWhe)	1.111E+04	4.224E+03	1.589E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2005	27.72%			*20% higher than in 1996; See Note 9*
Transmission and Distribution Losses, 2005 (GJ)	1.55E+07			

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	100.00	9.7%	22%	*All rough assumptions;*
	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Diesel Fuel Use (GJ)	*see Note 16*
	8.50E+04	3.06E+05	1.39E+06	

ESTIMATE OF ELECTRICITY GENERATION IN 2008

	Hydro Plants	Coal Plants	HFO Plants		
Changes in Capacity, 1990 to 2008 (MW):	-255.46	150	69.8		
Average 2008 Capacity Factor Relative to 1990 Est.	58.89%	20.86%	10%	*See Note 14*	
Estimated Gross Generation in 2008 (GWHe)	1.183E+04	5.117E+03	1.727E+02		1.7116E+04
Gross Generation Efficiency, 2008	100%	21.0%	21.00%		
Fuel Input to generation, 2008 (GJ)	4.26E+07	8.77E+07	2.96E+06		
Fraction of fuel input as HFO	N/A	8.92%	100%		
HFO Input to generation, 2008 (GJ)	N/A	7.82E+06	2.96E+06		
Other Petrol Products (tires) input to gen., 2008 (GJ)	N/A	0.00E+00			
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Excluding Chinese-controlled Based on reported exports.*	
GWhe Electricity Exports to China in 2008	143.54			*See Note 11*	
Estimated Power Exports to China, 2008 (GJ)	5.17E+05				
Own Use Fractions, 2008	0.30%	9.00%	8.00%		
Own Use of Electricity (GJ)	1.28E+05	1.66E+06	4.97E+04		
Imports of Electricity from China (GJ)	6.46E+04			*See Note 10 Discussions, but no*	
Imports of Electricity from Russia (GJ)	0.00E+00			*evidence of transfers as yet*	
Imports of Electricity from ROK (GJ)	8.09E+05			*For Kaesong; See Note 8*	
Total Electricity Imports (GJ)	8.74E+05				
"Emergency Loss" Fractions, 2008	0%	9%	0%		
Emergency Losses, 2008 (GJ)	0	1.66E+06	0		
Implied Net Electricity Output (GWhe)	1.179E+04	4.196E+03	1.589E+02	for use in LEAP	
Transmission and Distribution Loss rate (overall), 2008	27.72%			*Based on 1990 est.*	
Transmission and Distribution Losses, 2008 (GJ)	1.61E+07				

		Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel		155.00	8.5%	22%	*All rough assumptions;*
On-site generation with Gasoline generators		6.00	2%	12%	*see Notes 16 and 17*
		Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)	
	Diesel	1.154E+05	4.15E+05	1.89E+06	
	Gasoline	1.051E+03	3.78E+03	3.15E+04	

ESTIMATE OF ELECTRICITY GENERATION IN 2005

	Hydro Plants	Coal Plants	HFO Plants	
Changes in Capacity, 1990 to 2005 (MW):	-383.6	150	69.8	
Average 2005 Capacity Factor Relative to 1990 Est.	57.24%	21.00%	10%	*See Note 12*
Estimated Gross Generation in 2005 (GWHe)	1.1146E+04	5.1511E+03	1.727E+02	
Gross Generation Efficiency, 2005	100%	21.0%	21.00%	
Fuel Input to generation, 2005 (GJ)	4.01E+07	8.83E+07	2.96E+06	
Fraction of fuel input as HFO	N/A	3.59%	100%	
HFO Input to generation, 2005 (GJ)	N/A	3.17E+06	2.96E+06	
Other Petrol Products (tires) input to gen., 2005 (GJ)	N/A	8.91E+05		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Excluding Chinese-controlled*
				Based on reported exports.
2005 Exports to China (GWh)	90.15			*See Note 11*
Estimated Power Exports to China, 2005 (GJ)	3.25E+05			
Own Use Fractions, 2005	0.30%	9.00%	8.00%	*Same as in 1990*
Own Use of Electricity (GJ)	1.20E+05	1.67E+06	4.97E+04	
Imports of Electricity from China (GJ)	2.37E+03			*See Note 10*
				Discussions, but no
Imports of Electricity from Russia (GJ)	0.00E+00			*evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	2.62E+05			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	2.65E+05			
"Emergency Loss" Fractions, 2005	0%	9%	0%	*25% higher than in 1996*
Emergency Losses, 2005 (GJ)	0	1.67E+06	0	
Implied Net Electricity Output (GWhe)	1.111E+04	4.224E+03	1.589E+02	for use in LEAP
				20% higher than in 1996;
Transmission and Distribution Loss rate (overall), 2005	27.72%			*See Note 9*
Transmission and Distribution Losses, 2005 (GJ)	1.55E+07			

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	100.00	9.7%	22%	*All rough assumptions;*
	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Diesel Fuel Use (GJ)	*see Note 16*
	8.50E+04	3.06E+05	1.39E+06	

ESTIMATE OF ELECTRICITY GENERATION IN 2008

	Hydro Plants	Coal Plants	HFO Plants		
Changes in Capacity, 1990 to 2008 (MW):	-255.46	150	69.8		
Average 2008 Capacity Factor Relative to 1990 Est.	58.89%	20.86%	10%	*See Note 14*	
Estimated Gross Generation in 2008 (GWHe)	1.183E+04	5.117E+03	1.727E+02		1.7116E+04
Gross Generation Efficiency, 2008	100%	21.0%	21.00%		
Fuel Input to generation, 2008 (GJ)	4.26E+07	8.77E+07	2.96E+06		
Fraction of fuel input as HFO	N/A	8.92%	100%		
HFO Input to generation, 2008 (GJ)	N/A	7.82E+06	2.96E+06		
Other Petrol Products (tires) input to gen., 2008 (GJ)	N/A	0.00E+00			
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			*Excluding Chinese-controlled*	
				Based on reported exports.	
GWhe Electricity Exports to China in 2008	143.54			*See Note 11*	
Estimated Power Exports to China, 2008 (GJ)	5.17E+05				
Own Use Fractions, 2008	0.30%	9.00%	8.00%		
Own Use of Electricity (GJ)	1.28E+05	1.66E+06	4.97E+04		
Imports of Electricity from China (GJ)	6.46E+04			*See Note 10*	
				Discussions, but no	
Imports of Electricity from Russia (GJ)	0.00E+00			*evidence of transfers as yet*	
Imports of Electricity from ROK (GJ)	8.09E+05			*For Kaesong; See Note 8*	
Total Electricity Imports (GJ)	8.74E+05				
"Emergency Loss" Fractions, 2008	0%	9%	0%		
Emergency Losses, 2008 (GJ)	0	1.66E+06	0		
Implied Net Electricity Output (GWhe)	1.179E+04	4.196E+03	1.589E+02	for use in LEAP	
Transmission and Distribution Loss rate (overall), 2008	27.72%			*Based on 1990 est.*	
Transmission and Distribution Losses, 2008 (GJ)	1.61E+07				

		Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel		155.00	8.5%	22%	*All rough assumptions;*
On-site generation with Gasoline generators		6.00	2%	12%	*see Notes 16 and 17*
		Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)	
	Diesel	1.154E+05	4.15E+05	1.89E+06	
	Gasoline	1.051E+03	3.78E+03	3.15E+04	

ESTIMATE OF ELECTRICITY GENERATION IN 2010

	Hydro Plants	Coal Plants	HFO Plants	***Sources/Notes:***
Changes in Capacity, 1990 to 2010 (MW):	-179.1	150	69.8	
Average 2010 Capacity Factor Relative to 1990 Est.	58.25%	14.0%	8%	*See Notes 13, 15*
Estimated Gross Generation in 2010 (GWHe)	1.191E+04	3.437E+03	1.381E+02	
Gross Generation Efficiency, 2010	100%	21.0%	21.00%	
Fuel Input to generation, 2010 (GJ)	4.29E+07	5.89E+07	2.37E+06	
Fraction of fuel input as HFO	N/A	2.00%	100%	
HFO Input to generation, 2010 (GJ)	N/A	1.18E+06	2.37E+06	
Other Petrol Products (tires) input to gen., 2010 (GJ)	N/A	9.72E+03		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2010	151.71			
Estimated Power Exports to China, 2010 (GJ)	5.46E+05			
Own Use Fractions, 2010	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.29E+05	1.11E+06	3.98E+04	
Imports of Electricity from China (GJ)	1.20E+04			*See Note 10 Discussions, but no evidence of transfers as yet For Kaesong; See Note 8*
Imports of Electricity from Russia (GJ)	0.00E+00			
Imports of Electricity from ROK (GJ)	1.04E+06			
Total Electricity Imports (GJ)	1.05E+06			
"Emergency Loss" Fractions, 2010	0%	9%	0%	
Emergency Losses, 2010 (GJ)	0	1.11E+06	0	
Implied Net Electricity Output (GWhe)	1.187E+04	2.818E+03	1.271E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2010	27.72%			*6*
Transmission and Distribution Losses, 2010 (GJ)	1.48E+07			

		GWhe	GJ
Nuclear Generating Capacity as of 2010 (MWe)	0		
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	250.00	10%	23%	*All rough assumptions;*
On-site generation with Gasoline generators	32.00	1.6%	12%	*see Notes 16 and 17*
On-site generation with Solar PV Panels	0.51	11.0%	100%	*See* ***Note 18***
Tidal Power Generation	0.50	4.2%	100%	*See* ***Note 20***
Wind power generation	0.04	25.0%	100%	*See* ***Note 19***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	2.190E+05	7.88E+05	3.43E+06
Gasoline	4.485E+03	1.61E+04	1.35E+05
Solar PV	4.879E+02	1.76E+03	1.76E+03
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	8.278E+01	2.98E+02	2.98E+02

ESTIMATE OF ELECTRICITY GENERATION IN 2014

	Hydro Plants	Coal Plants	HFO Plants	***Sources/Notes:***
Changes in Capacity, 1990 to 2014 (MW):	215.9	150	69.8	
Average 2010 Capacity Factor Relative to 1990 Est.	47.31%	24.3%	7%	*See Notes 13, 15*
Estimated Gross Generation in 2014 (GWhe)	1.056E+04	5.967E+03	1.209E+02	
Gross Generation Efficiency, 2014	100%	21.0%	21.00%	
Fuel Input to generation, 2014 (GJ)	3.80E+07	1.02E+08	2.07E+06	
Fraction of fuel input as HFO	N/A	1.84%	100%	
HFO Input to generation, 2014 (GJ)	N/A	1.88E+06	2.07E+06	
Other Petrol Products (tires) input to gen., 2014 (GJ)	N/A	6.91E+04		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2014	222.43			*From Comtrade Database*
Estimated Power Exports to China, 2014 (GJ)	8.01E+05			
Own Use Fractions, 2014	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.14E+05	1.93E+06	3.48E+04	
Imports of Electricity from China (GJ)	1.67E+05			*See Note 10 Discussions, but no evidence of transfers as yet For Kaesong; See Note 8*
Imports of Electricity from Russia (GJ)	0.00E+00			
Imports of Electricity from ROK (GJ)	1.26E+06			
Total Electricity Imports (GJ)	1.43E+06			
"Emergency Loss" Fractions, 2014	0%	9%	0%	
Emergency Losses, 2014 (GJ)	0	1.93E+06	0	
Implied Net Electricity Output (GWhe)	1.052E+04	4.893E+03	1.112E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2014	27.72%			*6*
Transmission and Distribution Losses, 2014 (GJ)	1.55E+07			

		GWhe	GJ
Nuclear Generating Capacity as of 2014 (MWe)	0		
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	607.37	9.5%	25%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions (diesel use somewhat lower than in 2010);*
On-site generation with Gasoline generators	197.25	2.0%	13%	
On-site generation with Solar PV Panels	10.42	11.0%	100%	*See **Note 18***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	0.66	25.0%	100%	*See **Note 19***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	5.055E+05	1.82E+06	7.28E+06
Gasoline	3.456E+04	1.24E+05	9.57E+05
Solar PV	1.000E+04	3.60E+04	3.60E+04
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	1.439E+03	5.18E+03	5.18E+03

ESTIMATE OF ELECTRICITY GENERATION IN 2015

	Hydro Plants	Coal Plants	HFO Plants	***Sources/Notes:***
Changes in Capacity, 1990 to 2015 (MW):	280.9	150	69.8	
Average 2010 Capacity Factor Relative to 1990 Est.	49.65%	20.7%	7%	*See Notes 13, 15*
Estimated Gross Generation in 2015 (GWhe)	1.123E+04	5.080E+03	1.209E+02	
Gross Generation Efficiency, 2015	100%	21.0%	21.00%	
Fuel Input to generation, 2015 (GJ)	4.04E+07	8.71E+07	2.07E+06	
Fraction of fuel input as HFO	N/A	1.94%	100%	
HFO Input to generation, 2015 (GJ)	N/A	1.69E+06	2.07E+06	
Other Petrol Products (tires) input to gen., 2015 (GJ)	N/A	8.10E+03		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2015	118.74			*From Comtrade Database*
Estimated Power Exports to China, 2015 (GJ)	4.27E+05			
Own Use Fractions, 2015	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.21E+05	1.65E+06	3.48E+04	
Imports of Electricity from China (GJ)	1.64E+05			*See Note 10 Discussions, but no evidence of transfers as yet For Kaesong; See Note 8*
Imports of Electricity from Russia (GJ)	0.00E+00			
Imports of Electricity from ROK (GJ)	1.58E+06			
Total Electricity Imports (GJ)	1.74E+06			
"Emergency Loss" Fractions, 2015	0%	9%	0%	
Emergency Losses, 2015 (GJ)	0	1.65E+06	0	
Implied Net Electricity Output (GWhe)	1.120E+04	4.166E+03	1.112E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2015	27.72%			*6*
Transmission and Distribution Losses, 2015 (GJ)	1.54E+07			

		GWhe	GJ
Nuclear Generating Capacity as of 2015 (MWe)	0		
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	789.91	10.5%	26%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions (diesel use somewhat higher than in 2010);*
On-site generation with Gasoline generators	315.59	4.0%	14%	
On-site generation with Solar PV Panels	19.28	11.0%	100%	*See **Note 18***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	0.79	25.0%	100%	*See **Note 19***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	7.266E+05	2.62E+06	1.01E+07
Gasoline	1.106E+05	3.98E+05	2.84E+06
Solar PV	1.851E+04	6.66E+04	6.66E+04
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	1.729E+03	6.23E+03	6.23E+03

ESTIMATE OF ELECTRICITY GENERATION IN 2016

	Hydro Plants	Coal Plants	HFO Plants	***Sources/Notes:***
Changes in Capacity, 1990 to 2016 (MW):	345.9	150	-130.2	*Sonbong plant convered to coal use (but not completed)*
Average 2010 Capacity Factor Relative to 1990 Est.	50.02%	22.2%	25%	*See Notes 13, 15*
Estimated Gross Generation in 2016 (GWhe)	1.147E+04	5.437E+03	1.117E+02	
Gross Generation Efficiency, 2016	100%	21.0%	21.00%	
Fuel Input to generation, 2016 (GJ)	4.13E+07	9.32E+07	1.91E+06	
Fraction of fuel input as HFO	N/A	1.915%	100%	
HFO Input to generation, 2016 (GJ)	N/A	1.78E+06	1.91E+06	
Other Petrol Products (tires) input to gen., 2016 (GJ)	N/A	2.68E+04		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2016	167.23			*From Comtrade Database*
Estimated Power Exports to China, 2016 (GJ)	6.02E+05			
Own Use Fractions, 2016	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.24E+05	1.76E+06	3.22E+04	
Imports of Electricity from China (GJ)	1.14E+05			*See Note 10*
Imports of Electricity from Russia (GJ)	0.00E+00			*Discussions, but no evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	1.93E+05			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	3.07E+05			
"Emergency Loss" Fractions, 2016	0%	9%	0%	
Emergency Losses, 2016 (GJ)	0	1.76E+06	0	
Implied Net Electricity Output (GWhe)	1.143E+04	4.458E+03	1.027E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2016	27.72%			*6*
Transmission and Distribution Losses, 2016 (GJ)	1.60E+07			

		GWhe	GJ
Nuclear Generating Capacity as of 2016 (MWe)	0		
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	898.37	12.6%	27%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions*
On-site generation with Gasoline generators	373.16	3.4%	15%	
On-site generation with Solar PV Panels	31.25	11.0%	100%	*See **Note 18***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	0.97	25.0%	100%	*See **Note 19***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	9.916E+05	3.57E+06	1.32E+07
Gasoline	1.111E+05	4.00E+05	2.67E+06
Solar PV	3.000E+04	1.08E+05	1.08E+05
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	2.128E+03	7.66E+03	7.66E+03

ESTIMATE OF ELECTRICITY GENERATION IN 2017

	Hydro Plants	Coal Plants	HFO Plants	***Sources/Notes:***
Changes in Capacity, 1990 to 2017 (MW):	420.9	150	-130.2	
Average 2010 Capacity Factor Relative to 1990 Est.	44.34%	21.6%	8%	*See Notes 13, 15*
Estimated Gross Generation in 2017 (GWhe)	1.032E+04	5.292E+03	3.574E+01	
Gross Generation Efficiency, 2017	100%	21.0%	21.00%	
Fuel Input to generation, 2017 (GJ)	3.72E+07	9.07E+07	6.13E+05	
Fraction of fuel input as HFO	N/A	1.237%	100%	
HFO Input to generation, 2017 (GJ)	N/A	1.12E+06	6.13E+05	
Other Petrol Products (tires) input to gen., 2017 (GJ)	N/A	1.41E+04		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2017	269.28			*From Comtrade Database*
Estimated Power Exports to China, 2017 (GJ)	9.69E+05			
Own Use Fractions, 2017	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.11E+05	1.71E+06	1.03E+04	
Imports of Electricity from China (GJ)	7.17E+04			*See Note 10*
				Discussions, but no
Imports of Electricity from Russia (GJ)	0.00E+00			*evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	0.00E+00			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	7.17E+04			
"Emergency Loss" Fractions, 2017	0%	9%	0%	
Emergency Losses, 2017 (GJ)	0	1.71E+06	0	
Implied Net Electricity Output (GWhe)	1.029E+04	4.340E+03	3.288E+01	for use in LEAP
Transmission and Distribution Loss rate (overall), 2017	27.72%			*6*
Transmission and Distribution Losses, 2017 (GJ)	1.46E+07			

		GWhe	GJ
Nuclear Generating Capacity as of 2017 (MWe)	0		
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	965.75	6.0%	27%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions. Diesel use down relative to 2016 due to lower availability, better grid electricity.*
On-site generation with Gasoline generators	404.05	3.5%	15%	
On-site generation with Solar PV Panels	46.10	11.0%	100%	*See **Note 18***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	1.15	25.0%	100%	*See **Note 19***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	5.076E+05	1.83E+06	6.77E+06
Gasoline	1.242E+05	4.47E+05	2.98E+06
Solar PV	4.425E+04	1.59E+05	1.59E+05
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	2.527E+03	9.10E+03	9.10E+03

ESTIMATE OF ELECTRICITY GENERATION IN 2018				
				Sources/Notes:
	Hydro Plants	**Coal Plants**	**HFO Plants**	
Changes in Capacity, 1990 to 2018 (MW):	460.9	150	-130.2	
Average 2010 Capacity Factor Relative to 1990 Est.	44.68%	17.7%	8%	*See Notes 13, 15*
Estimated Gross Generation in 2018 (GWhe)	1.049E+04	4.341E+03	3.574E+01	
Gross Generation Efficiency, 2018	100%	21.0%	21.00%	
Fuel Input to generation, 2018 (GJ)	3.77E+07	7.44E+07	6.13E+05	
Fraction of fuel input as HFO	N/A	1.87%	100%	
HFO Input to generation, 2018 (GJ)	N/A	1.39E+06	6.13E+05	
Other Petrol Products (tires) input to gen., 2018 (GJ)	N/A	5.91E+03		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2018	279.35			*From Comtrade Database*
Estimated Power Exports to China, 2018 (GJ)	1.01E+06			
Own Use Fractions, 2018	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.13E+05	1.41E+06	1.03E+04	
Imports of Electricity from China (GJ)	4.01E+05			*See Note 10 Discussions, but no evidence of transfers as yet*
Imports of Electricity from Russia (GJ)	0.00E+00			
Imports of Electricity from ROK (GJ)	0.00E+00			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	4.01E+05			
"Emergency Loss" Fractions, 2018	0%	9%	0%	
Emergency Losses, 2018 (GJ)	0	1.41E+06	0	
Implied Net Electricity Output (GWhe)	1.045E+04	3.559E+03	3.288E+01	for use in LEAP
Transmission and Distribution Loss rate (overall), 2018	27.72%			*6*
Transmission and Distribution Losses, 2018 (GJ)	1.40E+07			

Nuclear Generating Capacity as of 2018 (MWe)	0	GWhe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	974.72	5.92%	27%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions*
On-site generation with Gasoline generators	408.55	3.54%	15%	
On-site generation with Solar PV Panels	62.19	11.0%	100%	*See **Notes 18, 24***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	1.33	25.0%	100%	*See **Notes 19, 24***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	5.055E+05	1.82E+06	6.74E+06
Gasoline	1.267E+05	4.56E+05	3.04E+06
Solar PV	5.971E+04	2.15E+05	2.15E+05
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	2.921E+03	1.05E+04	1.05E+04

ESTIMATE OF ELECTRICITY GENERATION IN 2019				***Sources/Notes:***
	Hydro Plants	**Coal Plants**	**HFO Plants**	
Changes in Capacity, 1990 to 2019 (MW):	490.9	150	-130.2	
Average 2010 Capacity Factor Relative to 1990 Est.	44.83%	17.7%	8%	*See Notes 13, 15*
Estimated Gross Generation in 2019 (GWhe)	1.059E+04	4.341E+03	3.574E+01	
Gross Generation Efficiency, 2019	100%	21.0%	21.00%	
Fuel Input to generation, 2019 (GJ)	3.81E+07	7.44E+07	6.13E+05	
Fraction of fuel input as HFO	N/A	1.85%	100%	
HFO Input to generation, 2019 (GJ)	N/A	1.38E+06	6.13E+05	
Other Petrol Products (tires) input to gen., 2019 (GJ)	N/A	5.91E+03		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2019	279.35			*Assumes same as recorded value for 2018*
Estimated Power Exports to China, 2019 (GJ)	1.01E+06			
Own Use Fractions, 2019	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.14E+05	1.41E+06	1.03E+04	
Imports of Electricity from China (GJ)	1.72E+05			*See Note 10*
Imports of Electricity from Russia (GJ)	0.00E+00			*Discussions, but no evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	0.00E+00			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	1.72E+05			
"Emergency Loss" Fractions, 2019	0%	9%	0%	
Emergency Losses, 2019 (GJ)	0	1.41E+06	0	
Implied Net Electricity Output (GWhe)	1.055E+04	3.559E+03	3.288E+01	for use in LEAP
Transmission and Distribution Loss rate (overall), 2019	27.72%			*6*
Transmission and Distribution Losses, 2019 (GJ)	1.41E+07			

		GWhe	GJ	
Nuclear Generating Capacity as of 2019 (MWe)	0			See ***Note 27***
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00	
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00	
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00	
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00	
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00	
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00	

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	981.46	6.7%	27%	See ***Notes 16 and 17*** *for capacity estimates, others rough assumptions*
On-site generation with Gasoline generators	411.64	3.50%	15%	
On-site generation with Solar PV Panels	78.19	11.0%	100%	See ***Notes 18, 24***
Tidal Power Generation	0.50	4.2%	100%	See ***Note 20***
Wind power generation	1.51	25.0%	100%	See ***Notes 19, 24***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	5.760E+05	2.07E+06	7.68E+06
Gasoline	1.262E+05	4.54E+05	3.03E+06
Solar PV	7.507E+04	2.70E+05	2.70E+05
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	3.315E+03	1.19E+04	1.19E+04

ESTIMATE OF ELECTRICITY GENERATION IN 2020				***Sources/Notes:***
	Hydro Plants	**Coal Plants**	**HFO Plants**	
Changes in Capacity, 1990 to 2020 (MW):	510.9	150	-130.2	
Average 2010 Capacity Factor Relative to 1990 Est.	44.96%	10.5%	8%	*See Notes 13, 15*
Estimated Gross Generation in 2020 (GWhe)	1.066E+04	2.578E+03	3.574E+01	
Gross Generation Efficiency, 2020	100%	21.0%	21.00%	
Fuel Input to generation, 2020 (GJ)	3.84E+07	4.42E+07	6.13E+05	
Fraction of fuel input as HFO	N/A	2.80%	100%	
HFO Input to generation, 2020 (GJ)	N/A	1.24E+06	6.13E+05	
Other Petrol Products (tires) input to gen., 2020 (GJ)	N/A	5.91E+03		
Estimated Power Exports to China, 1990 (GJ)	0.00E+00			
GWhe Electricity Exports to China in 2020	279.35			*Assumes same as recorded value for 2018*
Estimated Power Exports to China, 2020 (GJ)	1.01E+06			
Own Use Fractions, 2020	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.15E+05	8.35E+05	1.03E+04	
Imports of Electricity from China (GJ)	1.72E+05			*See Note 10*
Imports of Electricity from Russia (GJ)	0.00E+00			*Discussions, but no evidence of transfers as yet*
Imports of Electricity from ROK (GJ)	0.00E+00			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	1.72E+05			
"Emergency Loss" Fractions, 2020	0%	9%	0%	
Emergency Losses, 2020 (GJ)	0	8.35E+05	0	
Implied Net Electricity Output (GWhe)	1.063E+04	2.114E+03	3.288E+01	for use in LEAP
Transmission and Distribution Loss rate (overall), 2020	27.72%			*6*
Transmission and Distribution Losses, 2020 (GJ)	1.27E+07			

Nuclear Generating Capacity as of 2020 (MWe)	0	GWhe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	95%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	5%	0.00E+00	0.00E+00
Implied Nuclear Fuel Use (GJ) at assumed efficiency of	33%	0.00E+00	0.00E+00

	Capacity (MW)	Average Capacity Factor	Average Efficiency	
On-site generation with Diesel Fuel	982.81	6.1%	27%	*See **Notes 16 and 17** for capacity estimates, others rough assumptions*
On-site generation with Gasoline generators	412.26	4.50%	15%	
On-site generation with Solar PV Panels	86.19	11.0%	100%	*See **Notes 18, 24***
Tidal Power Generation	0.50	4.2%	100%	*See **Note 20***
Wind power generation	1.59	25.0%	100%	*See **Notes 19, 24***

	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Fuel Use (GJ)
Diesel	5.252E+05	1.89E+06	7.00E+06
Gasoline	1.625E+05	5.85E+05	3.90E+06
Solar PV	8.275E+04	2.98E+05	2.98E+05
Tidal Power Generation	1.823E+02	6.56E+02	6.56E+02
Wind power generation	3.473E+03	1.25E+04	1.25E+04

Calculations of expected exports from Simpo Reactors if built			
Nuclear Generating Capacity when/if built (MWe)	1050	GWHe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	6.439E+03	2.32E+07
Own Use of Electricity at Nuclear Plants	7%	4.507E+02	1.62E+06
Net Nuclear Generation Exported	90%	5.389E+03	1.94E+07
Transmission and Distribution Losses, Exports	5%	2.695E+02	9.70E+05
Net Nuclear Generation Used Domestically	10%	5.988E+02	2.16E+06
Nuclear Generating Capacity as of 2nd unit completion (MWe)	2100	GWHe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	70%	1.288E+04	4.64E+07
Own Use of Electricity at Nuclear Plants	7%	9.014E+02	3.25E+06
Net Nuclear Generation Exported	90%	1.078E+04	3.88E+07
Transmission and Distribution Losses, Exports	5%	5.389E+02	1.94E+06
Net Nuclear Generation Used Domestically	10%	1.198E+03	4.31E+06
Nuclear Generating Capacity 10 years later (MWe)	2100	GWHe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	85%	1.564E+04	5.63E+07
Own Use of Electricity at Nuclear Plants	7%	1.095E+03	3.94E+06
Net Nuclear Generation Exported	75%	1.091E+04	3.93E+07
Transmission and Distribution Losses, Exports	5%	5.453E+02	1.96E+06
Net Nuclear Generation Used Domestically	25%	3.636E+03	1.31E+07

Rough estimates of cost of generation for small generators (in 2017)

	Diesel	Gasoline	Solar PV	Wind power	
Fuel Cost ($/kg)	$ 0.85	$ 1.24	N/A	N/A	*23*
Efficiency	27%	15%	N/A	N/A	
Generation per kg fuel (kWh)	3.241	1.832	N/A	N/A	
Implied fuel cost $/kWh	$ 0.262	$ 0.677	N/A	N/A	
Average annual Generation per Unit (kWh)	31,536	3,022	N/A	N/A	*Fort diesel, smaller-size category for 2018 (60 kW) is assumed*
Implied annual average fuel costs	$ 8,272	$ 2,046	N/A	N/A	
Assumed Unit Lifetime (years)	20	12	15	20	
Assumed Annual Interest/ Discount Rate	15%	15%	15%	15%	
Estimated cost/kW	$ 76.23	$ 70.83	$ 638.83	$ 632.03	
Assumed Capacity Factor	6%	3.5%	11.0%	25.0%	
Implied Annualized Capital Cost ($/kW-yr)	$15.83	$16.99	$142.03	$131.27	
Annualized Capital Cost, $/kWh	$0.030	$0.055	$0.148	$0.060	

Assumed Wholesale (import cost) to retail mark-up: 30%

Conversion Factor:	1.000	N/A	N/A
Conversion Factor:	41.87	GJ/toe	

Plant	Rating (MWe)	Assumed Gross Generation Eff.	Implied Max. fuel use (GJ/mo.)	Max. Listed HFO (te/mo.)	Max. Fract. HFO	***Sources/Notes:***
Pyongyang						
as start-up fuel	500	27.0%	4.87E+06	2,500	2.15%	*1*
as supplement	500	27.0%	4.87E+06	17,000	14.63%	*1*
Ch'ongjin	150	27.0%	1.46E+06	10,000	28.68%	*1*
Pukchang	1600	27.0%	1.56E+07	20,000	5.38%	*1*
Sunchon	200	27.0%	1.95E+06	2,000	4.30%	*1*
East-Pyongyang	150	30%	1.31E+06	3,000	9.56%	*1*
TOTAL	2600		2.52E+07	52,000	8.65%	*2*

Back-up Calculation: Actual KEDO Fuel Input to Power Facilities in 1996 (11/95 through 10/96)

Chongjin	3,755	te		*3*
Pyongyang	44,842	te		*3*
Pukchang	20,065	te		*3*
Estimated KEDO HFO used, nominally coal-fired plants:		68,662	te	
Estimated KEDO HFO used, nominally coal-fired plants:		2.87E+06	GJ	
Sonbong	279,891	te		*3*
Estimated KEDO HFO used, Sonbong oil-fired plant:		1.17E+07	GJ	
Implied average capacity factor at Sonbong plant, 1996:		52.0%		*4*

Sources/Notes:

1 Assumes start-up and fuel supplement use of HFO in coal plants at over 6 percent of total thermal input.

2 Hydro set at 100 percent for accounting purposes. Coal and oil as described in estimates made for 1990, except efficiency reduced to reflect deterioration of infrastructure.

3 Figures of 75 percent and 100 percent of 1990 capacity factors for oil-fired plants and hydroelectric plants are assumptions. Factor for coal-fired stations is used to balance demand with net generation.

4 Assumes 90 percent of UN (1992 Energy Statistics Yearbook) estimate of 5000 MW hydro (thus we use 4500 MW hydro) and estimates 3500 MW thermal. For reference, the sum of the capacities of the seven largest thermal plants was reported to be 2900 MW. There is by at least one report of one other oil-fired, grid-connected plant in addition to Sonbong, but other reports state that the plant at Sonbong is the only active oil-fired plant of any size in the DPRK--which has been our working assumption.

5 Information from one source is that "one or two" "small to medium" (less than 10 MW) hydro plants were damaged in the floods of 1995 and 1996. Another source states that there has without doubt been substantial flood damage, including reservoir siltation and other problems. We assume that the net impact of flood damage and opening of a new hydro facility at Kumgang Mountain has been the effective reduction in hydro capacity shown. For thermal facilities, we assume (and have been told) that the addition of one 50 MW unit of the 150 MW plant under construction at East Pyongyang is the only recent major change.

6 Assumes a slight improvement as a result, for example, of lessons learned in ongoing UNDP program.

7 Year 2000 losses assumed to be an additional 5 percent higher than in 1996, due to continuing deterioration of electricity transmission and distribution system. Year 2005 losses assumed to be about the same as in 2000, as improvement of grids in some areas with improving economies is balanced by continued deterioration in other areas.

8 *Electricity exports from the ROK to the Kaesong (Gaesung) industrial region of the DPRK started from about mid-March, 2005, over a line with a capacity of* 15 *MW. Assuming an average capacity factor of* 70% *(rough estimate, based on consideration of baseload power needs of industry, and seconded by ROK experts) for the supplies to this industrial area, and that supplies were available for 9 months of 2005, implied exports of power from the ROK to the DPRK during 2005 were about* 72.82 GWh.

Capacity of line from ROK from several sources, including KERI ("Analysis of Present Status and Future Supply /Demand Prospects for the DPRK Power System", by J.Y. Yoon, presented at the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Yoon's presentation is avaialble as http://www.nautilus.org/DPRKEnergyMeeting/Papers/Yoon.ppt.

We assume that the power line to Kaesong operated at the same capacity factor estimated above for the full 12 months of 2006, implying energy provision of 97.09 *GWh.*

A sample of the news reports on the initiation of power flows from the ROK to the DPRK is Agence France-Presse (AFP), dated: 16 Mar 2005, "South Korea supplies power to North for first time in five decades". Accessed at http://www.reliefweb.int/rw/RWB.NSF/db900SID/KHII-6AJ9J5?OpenDocument.

In mid-2007, a second, larger power connection to the Kaesong area was completed. This line, capable of carrying 100 MW, would, at the same 70% capacity factor assumed above, *have potential output on the order of* 613.2 GWh/yr.

(Data on line capacity and date from Congressional Research Serice, The Kaesong North-South Korean Industrial Complex, by Dick K. Nanto and Mark E. Manyin, dated June 1, 2010, and available as www.opencrs.com/document/RL34093/2010-06-01/download/1013/.

*An article quoting the KEPCO manager of the power line running into Kaesong, however, indicates that while the capacity of the substation feeding Kaeosong is 100 MW, the power delivered to Kaesong averaged 30 to 50 MW, presumably in early 2013 when the complex was operating at a "normal" level (see, for example, Kang Tae-ho and Ha Eo-young, "Electricity use at Kaesong hums along at bare minimum", **The Hankyoreh,** dated, May.7,2013 , and available as http://english.hani.co.kr/arti/english_edition/e_northkorea/586276.html.*

The total value of goods from the Kaesong complex was 251.4 *million USD in 2008, and* 256.5 *million USD in 2009, up from* 14.9 *million USD in 2005 (source, Nanto and Manyin).*

In 2010, the value of goods from the Kaesong complex was 323.3 *million USD (source, Congressional Research Service, The Kaesong North-South Korean Industrial Complex, by Dick K. Nanto and Mark E. Manyin, dated April 18, 2011, and available as http://www.fas.org/sgp/crs/row/RL34093.pdf)*

More than half of this output value was from textile/apparel firms. In the ROK in 2007, the approximate electricity intensity of the textile industry was 1.379 *kcal per ROK Won, or about* 1.67 *kWh per USD*

This would imply electricity consumption at Kaesong of about 419.44 *GWh in 2008,* 427.95 *GWh in 2009, and* 539.40 *GWh in 2010. These figures are rough estimates, but close enough to the capacity of the line to be plausible. The ROK textile industry, however, is probably more energy-intensive on average than the textile industry in Kaesong, since the latter is mostly smaller businesses involved in assembling garments, not, for example, in making cloth or fiber. We therefore assume that, based on news reports above, the average capacity factor for the 100 MW substation providing power to the complex was* 33% in 2010, and estimate electricity use based on *the reported value of output (although this is not ideal, as output value is an indirect measure of required energy input at best) and estimate electricity delivery from the ROK to Kaesong accordingly.*

In 2007, we assume that total electricity provision over the 15 and then 100 MW lines were mid-way between the totals estimated to be provided in 2006 and 2008, or 193.09 *GWh.*

In 2008, based on the output above, we estimate the electricity provision to Kaesong at 224.79 GWh, with *2009 electricity use estimated at* 229.35 GWh, and *2010 electricity use estimated at* 289.08 GWh.

In 2014, the value of the output of the Kaesong industrial complex was reported as $470 million
by Kim Myong-song in "Output at Kaesong Soars Despite Friction" in Chosonilbo dated July 10, 2015, and
available as http://english.chosun.com/site/data/html_dir/2015/07/10/2015071000808.html.
Adjusting this value downward somehat to account for the difference in exchange rates between the ROK Won and USD
in 2014 versus 2010 (roughly 10% based on Xe.com data), and USD inflation between 2010 and 2014
about 9% yields an equivalent output in 2014 of $ 391.99 million, which suggests that
ROK electricity provision to Kaesong in 2014 might have been in the range of 350.50 *GWh,*

In 2015, the value of the output of the Kaesong industrial complex was reported as $563.3 million
by "KH Digital 2" in "Kaesong industrial park output reached $3.23 bln in 11 years of operation: white paper" in ***The Korea Herald***
dated May 12, 2016, and available as http://www.koreaherald.com/view.php?ud=20160512000863.
Adjusting this value downward somehat to account for the difference in exchange rates between the ROK Won and USD
in 2015 versus 2010 (roughly 5% based on Xe.com data), and USD inflation between 2010 and 2014
about 9.5% yields an equivalent output in 2014 of $ 489.93 million, which suggests that
ROK electricity provision to Kaesong in 2015 might have been in the range of 438.08 *GWh,*

In 2016, ROK electricity supplies to the Kaesong industrial complex were cut off on approximately February 11
(see, for example, NK Economy Watch, "Archive for the 'Kaesong Industrial Complex (KIC)' Category", available
as http://www.nkeconwatch.com/category/economic-reform/special-economic-zones/kaesong-industrial-park/. No figures
Based on data from "North Korea in the World", available as https://www.northkoreaintheworld.org/inter-korean/kaesong-industrial-complex,
DPRK trade volume associated with Kaesong (imports plus exports) fell from about $ 2.70 billion in 2015 to
about $ 0.33 billion in 2016, meaning 2016 trade was about 12% of 2015, which is roughly
consistent with the fraction of the year that Kaesong operated in that year. We therefore assume that this fraction also applies
to the relative amount of electricity used in (and exported by the ROK to) Kaesong in the two years, thus 2016 export
from the ROK to Kaesong (and thus the DPRK in total) are estimated at 53.54 *GWh,*

The Kaesong complex has been closed since early 2016, though apparently some services, including water, were restored in
2018. We assume that in 2017 through 2020, the complex did not/will not receive any electricity from the ROK (
0 GWh.)
As of 2019/2020, the reopening of the complex is under discussion. See, for example, Hankyoreh, dated June 13, 2019,
"Kaesong Industrial Complex business owners visit Washington to argue for complex's reopening",
available as http://english.hani.co.kr/arti/english_edition/e_northkorea/897775.html, and
Elizabeth Shim (2020), "South Koreans call for reopening of Kaesong Industrial Complex", ***UPI****, March 16, 2020,*
available as https://www.upi.com/Top_News/World-News/2020/03/16/South-Koreans-call-for-reopening-of-Kaesong-Industrial-Complex/2781584370425/.

9 *The presentation by Dr. Yoon referenced in Note 9, above, estimates DPRK transmission and distribution losses at "about 20%" and "above 20%". Other, anecdotal estimates of losses, particularly in areas away from large cities, suggest that losses could be considerably higher. The value used for this analysis for 2000 and 2005 is intended as a rough weighted average.*

10 *China Customs Statistics from World Trade Atlas lists 2005 exports of electricity from China to the DPRK as* 657,068 *kWh. As compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf. Electricity exports from the DPRK to China, as indicated by the same source and updates in 2008 and 2010, are as follows for other years throiugh 2009, after 2009 data are from the UN Comtrade database:*

Year	kWh	$/MWh	
1999	115,200		
2000	-		
2001	63,250		
2002	8,845,890		
2003	11,107,121		
2004	8,568,657		
2005	657,068		
2006	1,178,774		
2007	1,710,409		
2008	17,937,327		
2009	6,896,090		
2010	3,345,000		
2011	11,366,000	$ 116.63	
2012	13,146,000	$ 121.27	
2013	15,420,000	$ 122.48	
2014	46,421,000	$ 106.47	
2015	45,583,000	$ 107.83	
2016	31,804,000	$ 100.24	
2017	3,160,000	$ 41.84	
2018	111,306,000	$ 3.42	
2019	47,654,800		Assumed same as
2018	47,654,800		average 2014-2018
Average from 2002:	19,908,961		
Average from 2014:	47,654,800	$ 71.96	

2010 through 2018 values from UN Comtrade Database

11 From China Customs Statistics; see "ELECTRICITY GENERATION IN 2005" Worksheet in this workbook, Note 2.

12 Output from hydroelectric plants based on data and assumptions presented in "ELECTRICITY GENERATION IN 2005 AND BEYOND" Worksheet. Output of oil-fired power plants assumes little change since 2000, and output of (mostly) coal-fired power plants is adjusted to reach total DPRK-wide output as reported in "ELECTRICITY GENERATION IN 2005 AND BEYOND" worksheet by adjusting capacity factor.

13 For 2009, we assume that there was a decrease in overall gross generation approximately equal to that estimated by J.Y. Yoon in his presentation for the 2010 Energy and Minerals Experts Working Group Meeting in Beijing, September 2010, "Analysis on DPRK Power Industry & Interconnection Options". In the presentation, Yoon quotes ROK analysts as estimating that the DPRK's generation in 2008 was 25.5 *TWh, and generation in 2009 was* 23.5 *TWh. We do not use these absolute generation estimates, because we believe that they are too high (Mr. Yoon agrees that a "minimum" value could be closer to 16 TWh for 2007, for which ROK analysts estimate output of 23.7 TWh), but we use a value slightly higher than the ratio of these 2009 and 2008 estimates,* 94.0% *, to estimate a target value for 2009 output. The target value for overall generation is assumed to be composed of the hydroelectric output estimated for 2009 in the worksheet "Electric--2005_2008" in this workbook, the oil-fired capacity estimated for 2009 as above, and the coal-fired capacity, which is estimated by difference from the target value less the output of hydroelectric and oil plants.*

For 2010, reliable figures for total DPRK electricity output remain unavailable, and as a result we again use proxy values to try and estimate the electricity output in 2010 relative to 2009. The Bank of Korea, in a news release dated November 3, 2011, estimated the economic output of the DPRK's electricity sector to have declined by 0.80% between 2009 and 2010, stating *"Electricity, gas & water production fell by 0.8% owing to a drop in thermal power generation." (press release available from (http://www.nkeconwatch.com/nk-uploads/GDP_of_North_Korea_in_2010.pdf). Given that the Bank of Korea figure is nominally a measure of economic output based, in part but not entirely, on the physical output of the power sector, and assuming that the price of electricity (to the limited extent it is priced at all) did not go down in 2010, the implication is that at a minimum, power output fell at least slightly in 2010 relative to 2009.*

As an alternative estimate, indexmundi (http://www.indexmundi.com/g/g.aspx?c=kn&v=79), purportedly based on the CIA World Factbook, provides the following listing for historical electricity production in the DPRK:

Country	2000	2001	2002	2003	2004	2005
North Korea	31.98	28.6	33.4	30.01	30.01	33.62
	2006	**2007**	**2008**	**2009**	**2010**	**2011**
	18.75	21.71	21.72	21.72	20.9	22.5

We assume that these totals do not include on-site generation by backup diesel generators and similar devices. This listing suggests that electricity generation in 2010 was 96.2% *of that in 2009. Although the original sources of this estimate is not entirely clear to us, it seems consistent with anecdotal reports of the power sector in the DPRK, thus we use this factor to scale our estimate of total DPRK power production 2010 relative to 2009.*

14 As an alternative perspective on the capacity factor assumed for coal-fired thermal generation, dprkguidebook.org (probably c. 2006/7), "III - MAIN INDUSTRIAL SECTORS & BUSINESS OPPORTUNITIES", available as http://dprkguidebook.org/contents_3.htm, contains the the assertion "Around 23% of the country's thermal (Coal-fired) power generation facilities are operational [and] [a]round 80% of the country's hydro-electric (water-generated) power generation facilities are operational". No specific source is provided for these data, but comparing our assumed capacity factor for coal-fired generation for 2009 (about 12 percent) with the 23 percent operable value cited by dprkguidebook suggests a capacity factor of about 50 percent for the fraction of thermal capacity that remains operable, which seems plausible.

15 *Several sources suggest that the 200 MW oil-fired power plant associated with the oil refinery at Sonbong has operated relatively little since the oil refinery has been off-line due to lack of crude to process (possibly compounded with maintenance issues). The oil-fired power plant generated power when heavy fuel oil was available from KEDO and, we assume probably when HFO was shipped to the DPRK as a part of the Six-Party Talks agreements, but absent those inputs, has probably operated little, if at all. The website NK Economy Watch, in a posting dated November 7, 2011, under "Choson Exchange October trip findings" (available as part of http://www.nkeconwatch.com/category/energy/oil/) includes the following text:*

> **"Sonbong Power**
> This power plant was originally designed to take fuel oil from Victory Petrochemical as feedstock and generate power to feed back to Victory. Since the refinery has been offline, Sonbong Power has at times provided electricity to the region, but with fuel oil prices close to $700/metric ton and current electricity prices at 6.5 eurocents/kwh, the economics of running the plant do not work leaving the 800 workers employed here largely idle."

Based on this anecdotal information, we reduce the capacity factor for HFO-fired power generation in the DPRK somewhat from 2009 through 2018. For 2017, based on the report that the Sonbong power plant was actively being refurbished to be fueled with coal instead of heavy fuel oil (See Joseph S. Bermudez Jr. (2017), "Conversion of North Korea's Sonbong Thermal Electric Power Plant to Burn Coal Nears Completion", 38 North, dated December 5, 2017, and avaialble as https://www.38north.org/2017/12/sonbong120517/), we assume that the Sonbong plant operated very little or not at all in 2017 or 2018, so we reduce the 2017/18 capacity for oil-fired power accordingly. We assume a capacity factor of 25 percent for the remaining (smaller) oil-fired units, which leaves 2017/18 oil-fired generation somewhat lower than in previous years.

The image below is from Google Maps, coordinates 42.3279749,130.3795243, and dated February of 2019. It shows the formerly HFO-fired plant with new coal storage and coal feed buildings and equipment in place, as well as new roofs on nearby administration buildings. There is no smoke coming out of the stack, so it is not clear whether the plant is operating, and it is not clear whether coal was being handled in the storage facility as yet. There are smaller piles of coal visible to the east of the plant, near a wharf (and outslde of the image below), but they may be for a different purpose (for example, local use). Historical Google Earth Pro images show that coal handling facilities were added to the site in about 2015-2016.

16 China Customs Statistics (as compiled by N. Aden, 10/2/1012) lists the following imports of diesel generators to the DPRK:

		Number of Units		Value ($/million)	
HS Code	Description	2010	2011	2010	2011
850211	Dsl Genr Set=<75Kva	736	1108	$ 1.834	$ 2.569
850212	Dsl Gn Set>75=<375K	176	245	$ 1.688	$ 2.089
850213	Gn Set Com-lg>375Kv	37	27	$ 2.047	$ 1.171
850220	Sp-lg In Com Gn Set	10152	17062	$ 1.241	$ 2.531
850230	Oth Generating Sets	0	0	$ -	$ -
850231	Wind-Powered	10	7	$ 0.011	$ 0.035
850239	Other 8502	259	93	$ 0.197	$ 0.106
850240	El Rotary Converter	0	0	$ -	$ -

These values imply the following cost per unit:

HS Code	Description	2010	2011
850211	Dsl Genr Set=<75Kva	$ 2,491.85	$ 2,318.59
850212	Dsl Gn Set>75=<375K	$ 9,590.91	$ 8,526.53
850213	Gn Set Com-lg>375Kv	$ 55,324.32	$ 43,370.37
850220	Sp-lg In Com Gn Set	$ 122.24	$ 148.34
850230	Oth Generating Sets	#DIV/0!	#DIV/0!
850231	Wind-Powered	$ 1,100.00	$ 5,000.00
850239	Other 8502	$ 760.62	$ 1,139.78
850240	El Rotary Converter	#DIV/0!	#DIV/0!

Assuming the following average capacity for generators in each category implies the indicated cost per kW:

		Average capacity assumed		Cost per kW ($) implied	
HS Code	Description	2010	2011	2010	2011
850211	Dsl Genr Set=<75Kva	20.00	25.00	$ 124.59	$ 92.74
850212	Dsl Gn Set>75=<375K	100.00	100.00	$ 95.91	$ 85.27
850213	Gn Set Com-lg>375Kv	500.00	500.00	$ 110.65	$ 86.74
850220	Sp-lg In Com Gn Set	1.00	1.00	$ 122.24	$ 148.34
850230	Oth Generating Sets	N/A	N/A		
850231	Wind-Powered	1.00	5.00	$ 1,100.00	$ 1,000.00
850239	Other 8502	N/A	N/A		
850240	El Rotary Converter	N/A	N/A		

Based on the data/assumptions above, the Implied total capacity imported from China is:

		Total capacity imported (kW)	
HS Code	Description	2010	2011
850211	Dsl Genr Set=<75Kva	14,720	27,700
850212	Dsl Gn Set>75=<375K	17,600	24,500
850213	Gn Set Com-lg>375Kv	18,500	13,500
850220	Sp-lg In Com Gn Set	10,152	17,062
850230	Oth Generating Sets		
850231	Wind-Powered	10	35
850239	Other 8502		
850240	El Rotary Converter		
Total of Diesels above		50,820	65,700
Total spark ignition		10,152	17,062
Total Wind		10	35

From the Comtrade Database, Imports (number of units) by year, from China, were reportedly:

YEAR	HS 850211, (Diesel, < 75 kW)	HS 850212 (Diesel, 75 - 375 kW)	HS 850213 (Diesel, > 375 kW)	HS 850220 (Spark Ignition Units)	HS 850231 (Wind Power)	HS 850239 (Other Generator Sets)	
1993				9			
1994	289	54					
1995	5	1	2				
1996	26	4	1				
1997	21	3	1				
1998	21	8	3		3		
1999	29	5		6			
2000	131	40	5				
2001	63	15	4	56			
2002	422	33		4	1		
2003	157	52	2	43			
2004	142	38	1	222			
2005	594	74	2	264			
2006	185	66	6	334			
2007	169	111	10	425			
2008	324	92	18	4170	27		
2009	716	149	12	15614	8	9	
2010	736	176	37	10157	10	259	
2011	1,108	244	27	17,062	7	93	
2012	1,143	371	24	16,383	175	1,107	
2013	1,259	341	46	12,734	8	847	
2014	1,883	509	61	26,873	75	7953	
2015	2,955	319	81	53,299	65	*4,697*	Includes other nations where applicable (but non-China volumes are small)
2016	2,006	805	45	25,998	127	*223*	
2017	476	162	6	12,430	90	919	
2018	58	17	0	470	0	-	Zero values indicate no data in Comtrade as of 5/5/20
2019	-	-	-	-	-	-	Zero values indicate no data in Comtrade as of 5/5/20
2020							
Totals of Above	14,918	3,689	394	196,553	596	16,107	

Figures in *red italics* estimated based on reported weight of shipments (number of units not reported)

2014 - 2017 Figures include shipments from other nations where applicable (but non-China volumes are very small).

Total Cost of Imports from China from Comtrade Database, and Implied Cost per Unit

Cost of Imports

YEAR	850211	850212	850213	850220	850231	850239	TOTAL	
2008	$ 1,992,773	$ 1,078,139	$ 787,486	$ 462,407	$ 16,615		$ 4,337,420	
2009	$ 1,083,580	$ 1,695,084	$ 663,922	$ 1,456,146	$ 9,539	$ 222,003	$ 5,130,274	
2010	$ 1,834,752	$ 1,687,058	$ 2,047,142	$ 1,238,564	$ 11,000	$ 197,000	$ 7,015,516	
2011	$ 2,567,847	$ 2,084,131	$ 1,170,492	$ 2,531,289	$ 30,730	$ 105,466	$ 8,489,955	
2012	$ 3,008,899	$ 3,492,843	$ 1,009,783	$ 2,775,750	$ 280,571	$ 672,622	$ 11,240,468	
2013	$ 2,929,385	$ 2,743,737	$ 2,703,770	$ 2,655,330	$ 16,229	$ 754,501	$ 11,802,952	
2014	$ 3,936,437	$ 3,808,660	$ 2,846,269	$ 4,626,594	$ 175,690	$ 2,083,345	$ 17,476,995	
2015	$ 5,429,958	$ 6,293,394	$ 3,557,928	$ 8,758,030	$ 92,554	$ 1,634,075	$ 25,765,939	Includes other nations where applicable (but non-China volumes are small)
2016	$ 2,810,805	$ 3,616,395	$ 1,177,789	$ 3,734,714	$ 83,860	$ 762,353	$ 12,185,916	
2017	$ 2,849,095	$ 2,593,480	$ 368,648	$ 2,025,047	$ 56,785	$ 329,636	$ 8,222,691	
2018	$ 74,525	$ 56,350	$ -	$ 106,807	$ -	$ -	$ 237,682	Zero values indicate no data in Comtrade as of 2/18/20

Weight of Imports (kg)

YEAR	850211	850212	850213	850220	850231	850239	
2008							
2009							
2010							
2011							
2012							
2013	269,692	255,480	206,300	153,409	1,273	-	
2014	363,325	385,542	227,551	321,358	14,285	91,097	
2015	499,536	615,592	276,369	529,835	7,594	67,696	Includes other nations where applicable (but non-China volumes are small)
2016	293,342	393,069	100,087	256,122	8,419	-	
2017	-	297,823	34,022	122,552	5,956	13,249	
2018				5,919			

Implied Cost per kg

YEAR	850211	850212	850213	850220	850231	850239
2008						
2009						
2010						
2011						
2012						
2013	$ 10.86	$ 10.74	$ 13.11	$ 17.31	$ 12.75	#DIV/0!
2014	$ 10.83	$ 9.88	$ 12.51	$ 14.40	$ 12.30	$ 22.87
2015	$ 10.87	$ 10.22	$ 12.87	$ 16.53	$ 12.19	$ 24.14
2016	$ 9.58	$ 9.20	$ 11.77	$ 14.58	$ 9.96	#DIV/0!
2017	#DIV/0!	$ 8.71	$ 10.84	$ 16.52	$ 9.53	$ 24.88
2018				$ 18.04		

Implied Cost per Unit

YEAR	850211	850212	850213	850220	850231	850239
2008	$ 6,151	$ 11,719	$ 43,749	$ 111	$ 615	
2009	$ 1,513	$ 11,376	$ 55,327	$ 93	$ 1,192	$ 24,667
2010	$ 2,493	$ 9,586	$ 55,328	$ 122	$ 1,100	$ 761
2011	$ 2,318	$ 8,542	$ 43,352	$ 148	$ 4,390	$ 1,134
2012	$ 2,632	$ 9,415	$ 42,074	$ 169	$ 1,603	$ 608
2013	$ 2,327	$ 8,046	$ 58,778	$ 209	$ 2,029	$ 891
2014	$ 2,091	$ 7,483	$ 46,660	$ 172	$ 2,343	$ 262
2015	$ 1,838	$ 19,729	$ 43,925	$ 164	$ 1,424	$ 348
2016	$ 1,401	$ 4,492	$ 26,173	$ 144	$ 660	$ 3,419
2017	$ 5,985	$ 16,009	$ 61,441	$ 163	$ 632	$ 359
2018	$ 1,285	$ 3,315	#DIV/0!	$ 227	#DIV/0!	#DIV/0!

Average Capacity Per Unit Assumed (kW)

YEAR	850211	850212	850213	850220	850231	850239
2008	50.00	100.00	500.00	1.00	0.50	
2009	15.00	100.00	500.00	1.00	1.00	200.00
2010	20.00	100.00	500.00	1.00	1.00	8.00
2011	25.00	100.00	500.00	1.50	5.00	10.00
2012	25.00	100.00	500.00	1.60	1.50	6.00
2013	22.00	100.00	600.00	2.00	2.00	8.00
2014	22.00	100.00	500.00	2.00	2.70	2.50
2015	20.00	260.00	500.00	2.00	1.70	2.50
2016	15.00	75.00	400.00	2.00	0.80	25.00
2017	60.00	210.00	800.00	2.30	0.80	2.50
2018	15.00	80.00	800.00	3.00	0.80	2.50

Implied Cost, $/kW

YEAR	850211	850212	850213	850220*	850231	850239**
2008	$ 123.01	$ 117.19	$ 87.50	$ 110.89	$ 1,230.74	
2009	$ 100.89	$ 113.76	$ 110.65	$ 93.26	$ 1,192.38	$ 123.34
2010	$ 124.64	$ 95.86	$ 110.66	$ 121.94	$ 1,100.00	$ 95.08
2011	$ 92.70	$ 85.42	$ 86.70	$ 98.91	$ 878.00	$ 113.40
2012	$ 105.30	$ 94.15	$ 84.15	$ 105.89	$ 1,068.84	$ 101.27
2013	$ 105.76	$ 80.46	$ 97.96	$ 104.26	$ 1,014.31	$ 111.35
2014	$ 95.04	$ 74.83	$ 93.32	$ 86.08	$ 867.60	$ 104.78
2015	$ 91.88	$ 75.88	$ 87.85	$ 82.16	$ 837.59	$ 139.16
2016	$ 93.41	$ 59.90	$ 65.43	$ 71.83	$ 825.39	$ 136.74
2017	$ 99.76	$ 76.23	$ 76.80	$ 70.83	$ 790.03	$ 143.43
2018	$ 85.66	$ 41.43	#DIV/0!	$ 75.75	#DIV/0!	#DIV/0!

*As anecdotal points of comparison, bulk prices for gasoline-fueled small generators on alibaba.com are in the range of $100 per kW (and less, as of 2018), as are the prices for small gasoline-fueled generating sets imported from China and sold by Harbor Freight (see http://www.harborfreight.com/catalogsearch/result?q=generator, for example). When generator units are imported to the DPRK in large quantities, one would expect the unit price to be lower, but on the other hand, the additional costs of delivering units to the DPRK may make the unit price higher. In any case, the assumed capacity values above should be treated as rough estimates. See below for example prices on Chinese-origin diesel generator sets.

** Although the fuel type for traded category 850239 is unspecified, we assume based on their likely size that the units imported are largely spark-ignition units for the purposes of the compilation below.

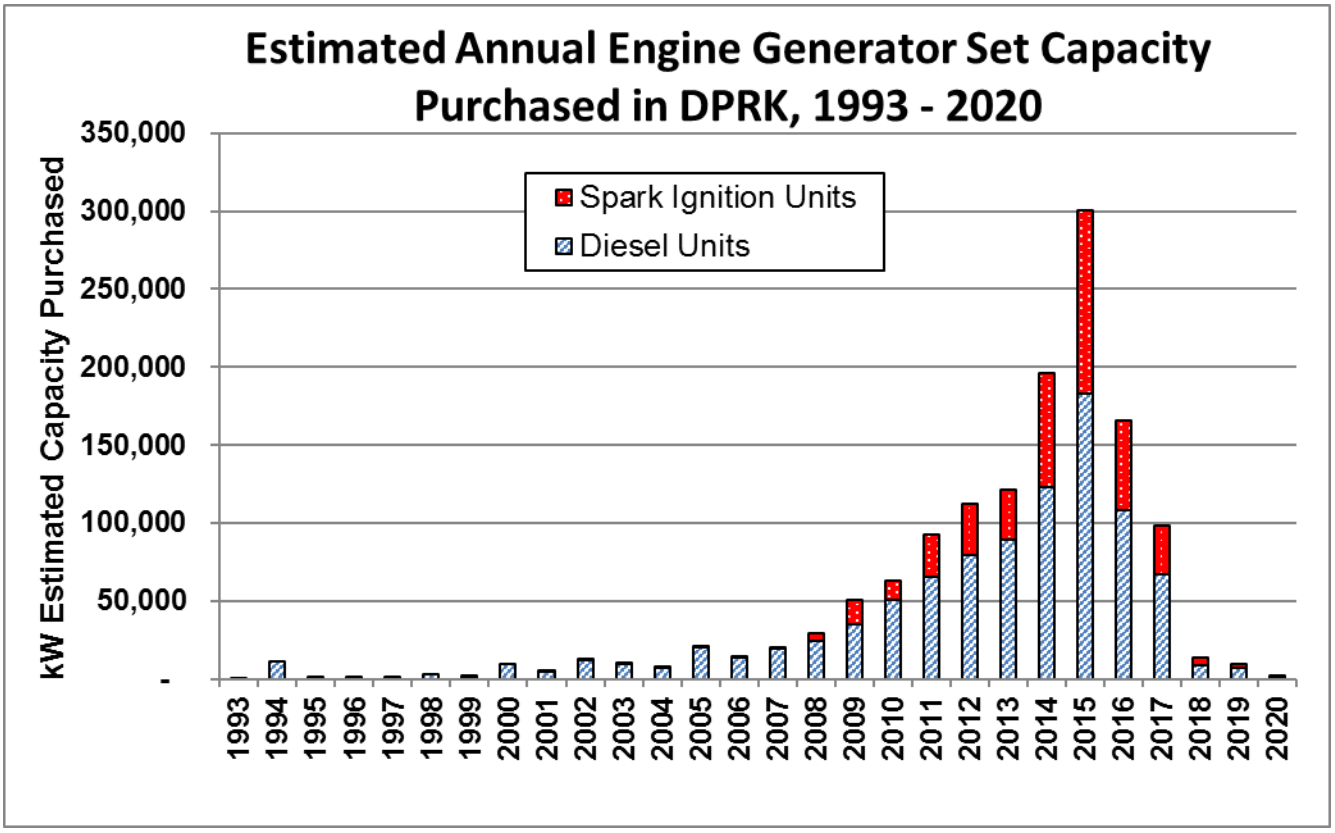
Although there were a number of other trades of diesel and gas generators between the DPRK and nations other than China between 2011 and 2018, the only ones of significant volume was with Russia, as follows (there were no trades in these categories reported in Comtrade statistics in 2018):

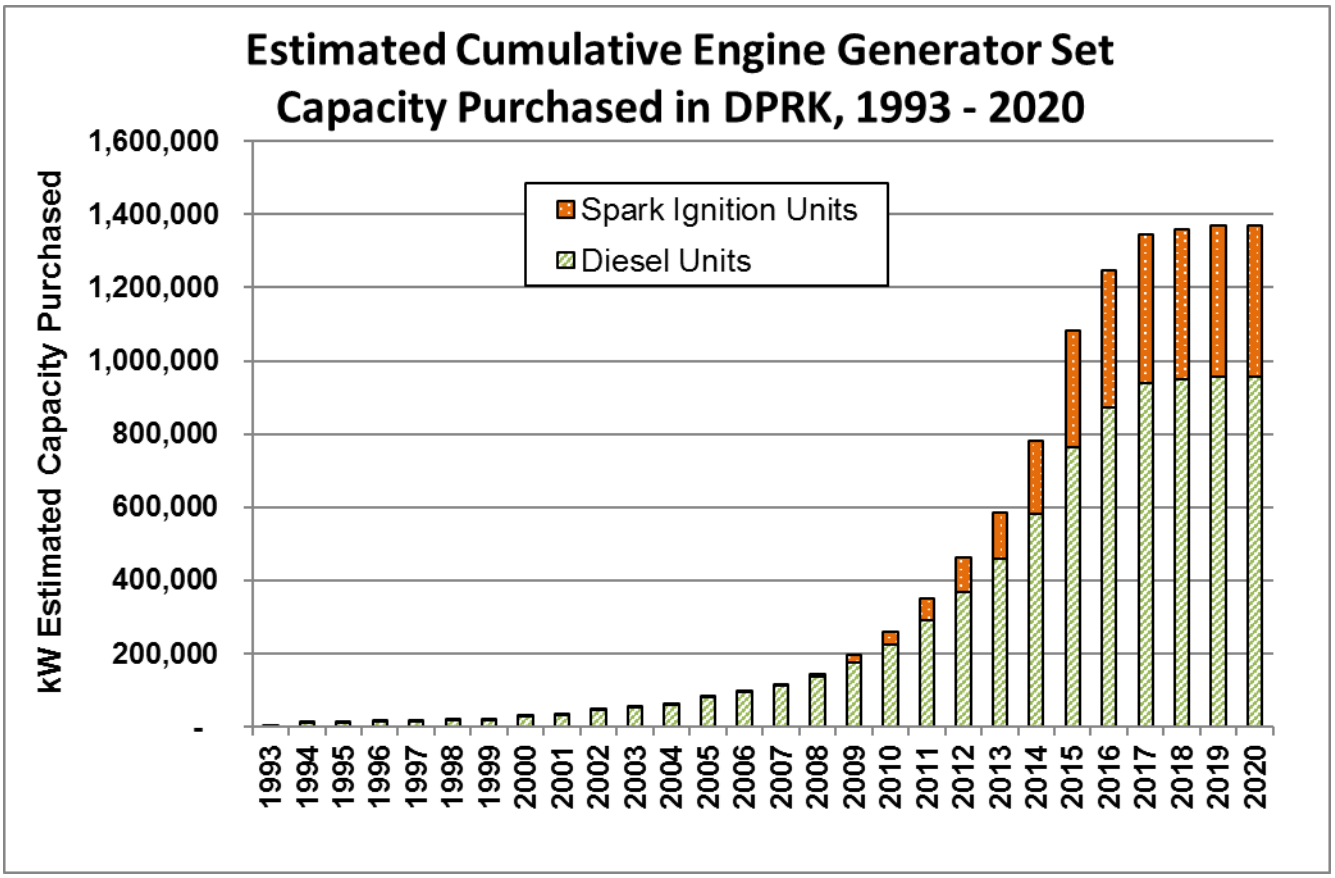
Period	Trade Flow	Reporter	Partner	Code	Trade Value	NetWeight (kg)	Quantity Unit	Trade Quantity
2012	Export	Russian Federation	Dem. People's Rep. of Korea	850213	$1,687,938	90,000	Number of items	6
2015	Export	Russian Federation	Dem. People's Rep. of Korea	850211	$19,073	2,340	Number of items	2
2016	Export	Russian Federation	Dem. People's Rep. of Korea	850211	$18,867	1,560	Number of items	1
2017	Export	Russian Federation	Dem. People's Rep. of Korea	850220	$2,102	103	Number of items	1
2018	Export	Russian Federation	Dem. People's Rep. of Korea				Number of items	

The 2012 transaction appears to be an order for 6 large diesel gensets. If one assumes an average co- $150 per kW of capacity, these trades imply a total capacity of 11,253 kW, or an average of 1,875 kW per unit. This estimate is added to the estimated capacity of Chinese units shown below.

	Implied capacity (kW) added, based on 2010 estimate of capacity per unit above through 2010, then on annual estimates of capacity per unit through 2018.		Implied estimated cummulative capacity (kW) added, based on estimates above	
YEAR	Diesel Units	Spark Ignition Units	Diesel Units	Spark Ignition Units
1993	-	9	-	9
1994	11,180	-	11,180	9
1995	1,200	-	12,380	9
1996	1,420	-	13,800	9
1997	1,220	-	15,020	9
1998	2,720	-	17,740	9
1999	1,080	6	18,820	15
2000	9,120	-	27,940	15
2001	4,760	56	32,700	71
2002	11,740	4	44,440	75
2003	9,340	43	53,780	118
2004	7,140	222	60,920	340
2005	20,280	264	81,200	604
2006	13,300	334	94,500	938
2007	19,480	425	113,980	1,363
2008	24,680	4,170	138,660	5,533
2009	35,220	15,614	173,880	21,147
2010	50,820	12,229	224,700	33,376
2011	65,600	26,523	290,300	59,899
2012	79,550	32,855	369,850	92,754
2013	89,398	32,244	459,248	124,998
2014	122,820	73,629	582,069	198,626
2015	182,540	118,341	764,609	316,967
2016	108,465	57,571	873,074	374,538
2017	67,380	30,888	940,454	405,426
2018	8,968	4,499	949,422	409,925
2019	6,738	3,089	956,160	413,013
2020	1,348	618	957,507	413,631

For 2018 and 2019, we assume that there must have been at least some imports of generators beyond the volumes reported in official statistics. We assume that the total additional "off-books" trade in generators was approximately 10% *of Reported 2017 trade in 2018 and 2019. For 2020, due to restrictions on cross-border trade due to measures in the DPRK to prevent the spread of coronavirus, we assume that only a total of* 2% *of the 2017 volume of generators was imported* off-books to the DPRK.


Estimated Annual Engine Generator Set Capacity Purchased in DPRK, 1993 - 2020
kW Estimated Capacity Purchased
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
Spark Ignition Units
Diesel Units
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020


Estimated Cumulative Engine Generator Set Capacity Purchased in DPRK, 1993 - 2020
kW Estimated Capacity Purchased
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Spark Ignition Units
Diesel Units
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

The following price list for new generators from a Chinese company (downloaded 10/5/2012) is from http://www.china-power-contractor.cn/Perkins-Diesel-Generator-Price-List.html.
These prices are about twice as high as the implied costs calculated above for DPRK imports, but the units imported to the DPRK may be mostly used units.

Perkins Diesel Generator Price List

Perkins Diesel Generator Price List (in USD)

Type	Diesel Engine	Rated Power KW	Unit Price in USD with different Generator			
			Chinese	Stamford	Siemens	Marathon
7KW	403C-11G	9.4/8.5	5,074.63	/B>	/B>	/B>
10KW	403C-15G	13.3/12	5,552.24	/B>	/B>	/B>
15KW	404C-22G	20.4/18.5	6,567.16	/B>	/B>	/B>
24KW	1103A-33G	30.4/27.7	7,014.93	/B>	/B>	/B>
50KW	1104A-44TG1	59/53	11,343.28	12,029.85	11,686.57	11,791.04
75KW	1104C-44TAG2	98/89	13,880.60	15,074.63	14,776.12	14,686.57
120KW	1006TAG2	143/129.5	19,253.73	20,835.82	20,626.87	20,447.76
150KW	1106D-E66TAG4	174/156.7	23,582.09	25,268.66	24,925.37	24,820.90
200KW	1306C-E87TAG6	239/218	33,134.33	35,000.00	34,328.36	34,626.87
250KW	2306C-E14TAG1A	304/261	35,223.88	37,611.94	36,567.16	37,059.70
300KW	2306C-E14TAG2	344/304	36,567.16	39,253.73	37,313.43	38,686.57
320KW	2306C-E14TAG3	387/344	40,597.01	43,134.33	41,194.03	42,552.24
350KW	2506C-E15TAG1	435/396	49,850.75	52,238.81	51,194.03	52,089.55
400KW	2506C-E15TAG2	478/435	52,537.31	55,671.64	54,328.36	55,537.31
500KW	2806A-E18TAG1	556/482	73,731.34	77,358.21	74,776.12	76,895.52
520KW	2806A-E18TAG2	611/556	80,746.27	84,776.12	82,089.55	84,328.36
800KW	4008TAG2A	947/861	138,059.70	145,373.13	139,402.99	145,074.63
1000KW	4012-46TWG2A	1154/1044	202,985.07	210,597.01	204,328.36	209,402.99

The following was downloaded 1/4/2016 from http://www.china-power-contractor.cn/MTU-Cummins-Perkins-Volvo-Diesel-Generator-from-6kw-to-2400kw.html and suggests that prices may have fallen on units of most sizes over the past five years.

Item	Genset model	Capacity	Engine brand\Model	Generator brand\Model	FOB unit price in USD
10-25KVA	ZIPM8.6P	10.75KVA	Perkins\403D-15G	Marathon\GM-8.6-4	$5,680
	ZIPM16P	20KVA	Perkins\403D-22G	Marathon\GM-8.6-4	$6,260
	ZCM20P	25KVA	Cummins\4B3.9-G2	Marathon\GM-20-4	$6,110
100KVA	ZIPM80P	100KVA	Perkins\1006TG2A	Marathon\MP-80-4	$12,890
	ZCM80P	100KVA	Cummins\6BT5.9-G2	Marathon\MP-80-4	$8,870
350KVA	ZIPM280P	350KVA	Perkins\2206C-E13TAG2	Marathon\MP-280-4	$38,120
	ZCM280P	350KVA	Cummins\NTA855-G2A	Marathon\MP-280-4	$26,550
500KVA	ZIPM400P	500KVA	Perkins\2506C-E15TAG2	Marathon\MP-400-4	$45,998
	ZCM400P	500KVA	Cummins\KTA19-G4	Marathon\MP-400-4	$45,260
750KVA	ZGBM640P	800KVA	MTU\12V2000G65	Marathon\MX-700-4	$89,200
	ZIPM640P	800KVA	Perkins\4006-23TAG3A	Marathon\MX-700-4	$96,984
	ZCM600P	750KVA	Cummins\KTA38-G2	Marathon\MX-630-4	$84,620
1000KVA	ZGBM800P	1000KVA	MTU\16V2000G65	Marathon\MX-850-4	$125,286
	ZIPM800P	1000KVA	Perkins\4008TAG2A	Marathon\MX-850-4	$119,380
	ZCM800P	1000KVA	Cummins\KTA38-G5	Marathon\MX-850-4	$118,168

17 As a rough estimate of the efficiency of small gasoline-fired generators, http://www.electricgeneratorsdirect.com/Honeywell-6064-Portable-Generator/p6685.html gives a fuel consumption of 0.5 *gallons in* 3.6 hours at 50% *load for a Honeywell generator rated at* 800 *Watts. This would imply fuel consumption of approximately* 0.139 gal/hr at 121 MJ/gal (LHV) or 16.81 MJ/hr to produce 400 *Whr/hr or* 1.44 *MJ of electricity. This implies a net efficiency of* 8.6%

We assume that the average efficiency of these units is somewhat higher than calculated here, and rises over time as the average stock of gasoline generators in the DPRK becomes newer over time with increasing sales. The efficeincy of diesel generators is likewise assumed to rise over time as the average stock becomes newer. Diesel generator efficiencies are rough estimates.

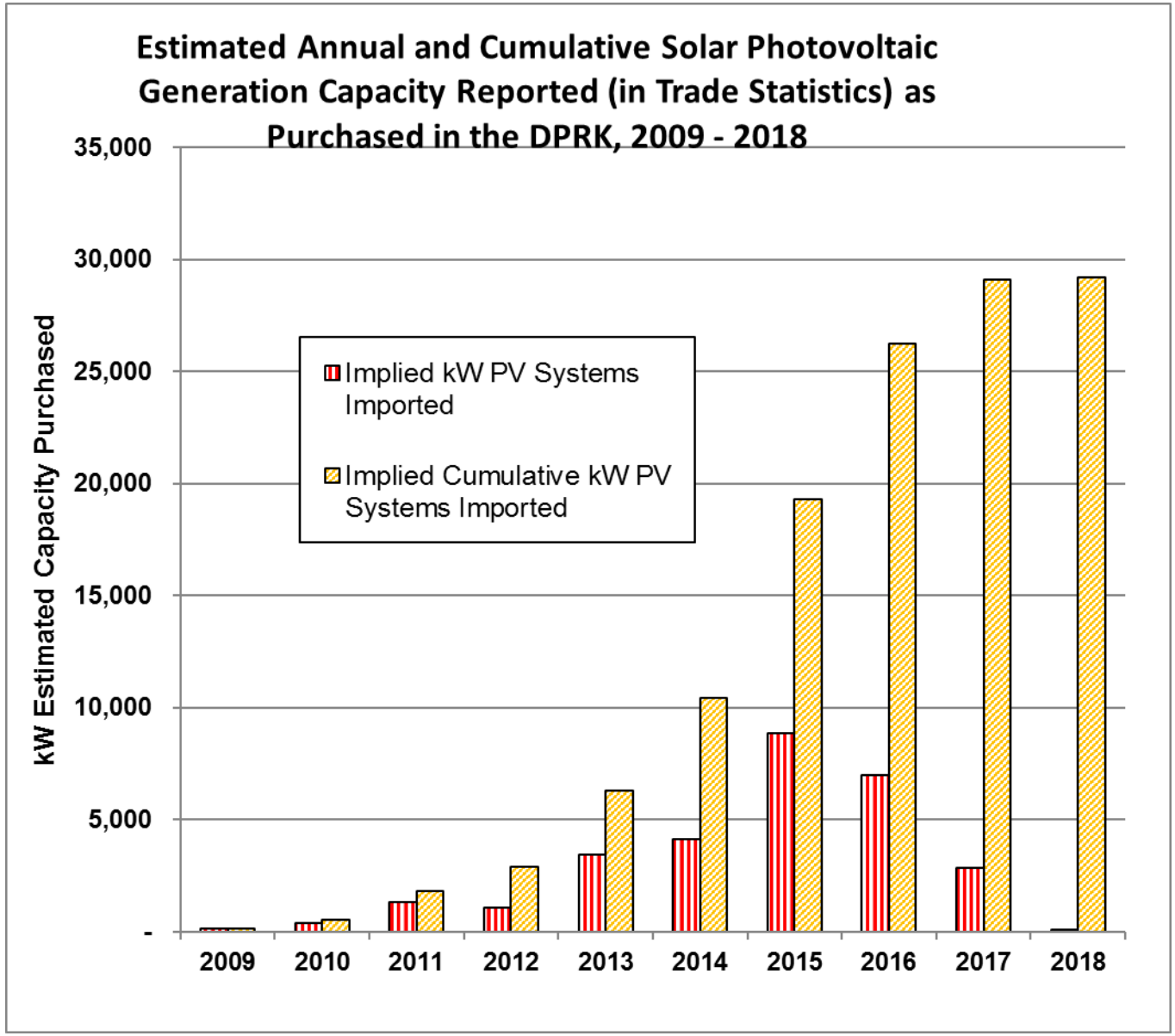
18 The UN Comtrade database provides the following information regarding trades in solar photovotaic equipment from China to the DPRK since 2009 in trade category "854140" = "Name: Photosensitive/photovoltaic/LED semiconductor devices; Description: Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes"
We use these data to estimate the implied volume of imported solar photovoltaic panels into the DPRK.

YEAR	Value (USD)	Quantity	Weight (kg)	Implied $/piece	Assumed $/watt* (Wholesale)	Solar PV system price trend (index)*	Implied kW PV Systems Imported	Implied Cumulative kW PV Systems Imported	Implied Watts per Unit	Implied kg per kW
2009	$476,898	120,037	Not Provided	$ 3.97	$ 4.09	3.75	116.49	116.49	0.97	N/A
2010	$1,069,042	1,334,010	94,108	$ 0.80	$ 2.73	2.50	391.71	508.20	0.29	240.25
2011	$2,986,229	2,494,441	297,735	$ 1.20	$ 2.29	2.09	1,306.50	1,814.70	0.52	227.89
2012	$1,401,307	185,491	97,533	$ 7.55	$ 1.31	1.20	1,066.92	2,881.62	5.75	91.42
2013	$3,899,887	424,450	644,336	$ 9.19	$ 1.14	1.05	3,412.46	6,294.08	8.04	188.82
2014	$4,501,019	856,380	Not Provided	$ 5.26	$ 1.09	1.00	4,123.07	10,417.15	4.81	N/A
2015	$8,524,920	716,670	1,397,045	$ 11.90	$ 0.96	0.88	8,859.05	19,276.20	12.36	157.70
2016	$6,146,408	533,294	Not Provided	$ 11.53	$ 0.88	0.81	6,973.30	26,249.50	13.08	N/A
2017	$1,819,988	183,198	377,759	$ 9.93	$ 0.64	0.59	2,848.95	29,098.45	15.55	132.60
2018	$60,720	1,114	11,052	$ 54.51	$ 0.64	0.59	95.05	29,193.50	85.32	116.28

2017 value for quantity was not provided in Comtrade statistics, and has been estimated based on watts per unit and kg per watt estimated for previous years.
The only Comtrade data available for trades in this category involving the DPRK for the year 2019 (as of 5-15-20) was a small export shipment from the DPRK to Poland.

* DPRK Solar Panel and Battery Prices from *Daily NK* article
by Seol Song Ah (2014), "Solar Panels Shine New Light on NK", Daily NK, dated 2014-10-24, and available as http://www.dailynk.com/english/read.php?cataId=nk01500&num=12465/.
suggest an average PV panel price over several sizes of systems of $1.31 per watt. We assume that the average mark-up from customs values to DPRK retail prices is 20%, and further assume that the average costs changed consistent with international solar module costs, for example, as described in http://www.nrel.gov/docs/fy14osti/62558.pdf, Photovoltaic System Pricing Trends, Historical, Recent, and Near-Term Projections, 2014 Edition, dated September 22, 2014, by authors from the National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory (USA). See, for example, slides 5 and 26.
The 2015 version of the same report is available here http://www.nrel.gov/docs/fy15osti/64898.pdf.
Index from 2015 on is based roughly on trend in residential module plus inverter plus balance of system costs from https://www.nrel.gov/docs/fy17osti/68925.pdf, Appendix A.
2018 costs are assumed similar to 2017 costs (see, for example, https://www.nrel.gov/docs/fy19osti/72399.pdf, page 21.

We assume that an unshaded PV system in the DPRK will produce 1200 *kWh annually per kW of capacity, but that the average small PV system is only approximately* 80% *unshaded, though the latter is a very rough estimate.*
Solar PV "efficiency" set at 100% *by definition.*

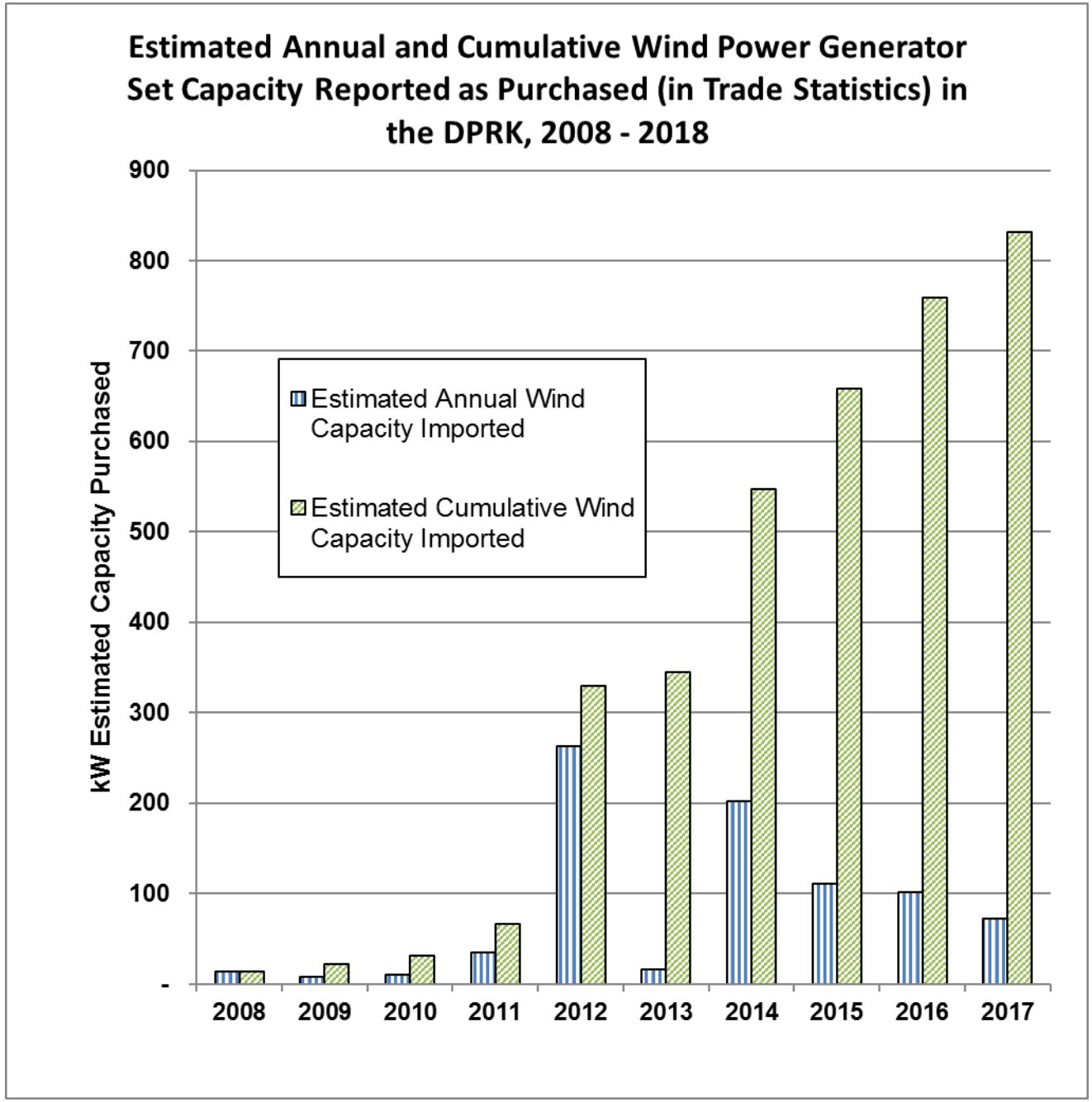

Estimated Annual and Cumulative Solar Photovoltaic Generation Capacity Reported (in Trade Statistics) as Purchased in the DPRK, 2009 - 2018
kW Estimated Capacity Purchased
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
Implied kW PV Systems Imported
Implied Cumulative kW PV Systems Imported
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

19 Based on data from the UN Comtrade database, and the assumptions above, the estimated capacity of imported wind power systems in the DPRK, starting in 2008, were approximately as follows:

YEAR	Estimated Annual Wind Capacity Imported	Estimated Cumulative Wind Capacity Imported
2008	13.50	13.50
2009	8.00	21.50
2010	10.00	31.50
2011	35.00	66.50
2012	262.50	329.00
2013	16.00	345.00
2014	202.50	547.50
2015	110.50	658.00
2016	101.60	759.60
2017	71.88	831.48
2018	-	831.48

The implied average size of these units is quite small, so we assume that they are mostly not grid-connected. We assume an average capacity factor of 25% *, which may well be somewhat higher than is realistic for average DPRK applications, though it would be low for typical applications.*
Wind power "efficiency" set at 100% *by definition.*

The DPRK produces some domestic wind turbines, although these appear to be mostly quite small. See, for example, North Korean Economy Watch (2015), "DPRK's domestic sales of wind turbines", dated October 28th, 2015, identifying a factory producing wind turbines of 100 to 300 W capacity. Original source is Pyongyang Times. Zoom in Korea (2018), includes a reference to "The Pyongsong Automated Equipment Factory, which mass-produces wind turbines, used to only produce small turbines with an output of 1.5 kilowatts, but it now produces 100- and 250-kilowatt turbines." ("N Korea Science and Technology Part 4: Advances in Sustainable Farming and Renewable Energy", dated July 10, 2018, and available as http://www.zoominkorea.org/part-4-advances-in-sustainable-farming-and-renewable-energy/, but no information is available on the volume of wind turbines produced by the factory. A DPRK expert was quoted as follows in North Korea Economy Watch ("Progress in North Korea's renewable energy production", dated February 15th, 2016, and available as https://www.nkeconwatch.com/2016/02/15/progress-in-north-koreas-renewable-energy-production/), "In 2014, Natural Energy Research Institute Director Lee Myong Son revealed that, 'among the wind turbine currently in use, 71.4 percent are in the 300w range while 28.6 percent are above that range,' indicating that most products used in solar and wind power generation are domestically produced." We have no specific information on the volume of wind turbines produced in the DPRK, but assuming that most are small, probably are mounted relatively low, may not be optimally located, and thus probably have low capacity factors, we assume that the output of domestic wind turbines in any given year is about 20% *of the total output we estimate for turbines imported from China. This is of course a rough estimate only.*


Estimated Annual and Cumulative Wind Power Generator Set Capacity Reported as Purchased (in Trade Statistics) in the DPRK, 2008 - 2018
kW Estimated Capacity Purchased
900
800
700
600
500
400
300
200
100
-
Estimated Annual Wind Capacity Imported
Estimated Cumulative Wind Capacity Imported
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

20 *The DPRK has one completed tidal power plant, part of the West Sea Barrage, near Nampo. This plant has a nominal capacity of* 500 *kW (as described to Nautilus delegation by West Sea Barrage Visitor Center staff in 1998). As a point of comparison, The article "The Sihwa Lake Tidal Power Plant: The World's Largest Tidal Power Station", by Moataz Abdelmegid, available as http://www.bibalex.org/psc/en/home/sciplanetdetails.aspx?id=76 The Sihwa Lake Tidal Power Station in South Korea has the following parameters:*

Capacity 254 *MW*

Stated displacement of oil for power generation 862,000 bbl, which at 5.86 GJ/bbl *would be* 5,051,320 *GJ. Assuming a power generation efficiency of* 33% *for the displaced generation yields an output of* 1,666,936 *GJ, or* 463.04 *GWhe/yr.*

The implied capacity factor is thus 20.8% for the Sihwa plant. We take this figure as the maxium capacity factor for the DPRK's West Sea Barrage plant, but assume that it is probable that due to maintenance problems and/or substation issues, it is likely that the plant operated no more than 20% *of this maximum by 2000 and after, yielding output from 2000-on of* 182.30 *MWh/yr. This is a very rough estimate. Based on our observation of the condition of the plant in 1998, it is possible that the plant is not operating at all.* 100% *by definition.*

21 *As usual, hard data on the output of the DPRK electricity generation system is not publically available, and as a result, proxy measures and assumptions must be employed to try and estimate output for 2014. The Index Mundi series of electricity production estimates, purportedly based on the CIA World Factbook was as follows as of 5/5/2020 (from Index Mundi, http://www.indexmundi.com/g/g.aspx?c=kn&v=79):*

Country	2000	2001	2002	2003	2004	2005	2006	2007
North Korea	31.98	28.6	33.4	30.01	30.01	33.62	18.75	21.71
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2017**
	21.72	21.72	20.9	22.5	22.52	20.45	21.04	17
	2018	**2019**	**2020**					
	16.57	16.57						

This trend suggests that there was little difference between the output of the DPRK electricity system in 2010 and 2014. The cited source of this information, however, gave a lower estimate of 18.76 *TWh for 2012, which is less than the value provided by Index Mundi, and* 13.41 TWh for 2015. *(CIA World Factbook entry for Korea, North, available as https://www.cia.gov/library/publications/the-world-factbook/geos/kn.html.) Considering a number of factors, including the apparent lack of substantial imports of electricity generating equipment (boilers and generators, for example) from China during 2010 through 2014, the higher (but stabilizing, as of 2015) coal exports to China over 2010 through 2015, indicating at least ongoing activitiy in coal mining (though perhaps focused on export revenues), and the overall reported poorer availability of power in 2014 relative to the few previous years, plus the apparent lack of any new coal-fired generation coming on line, we provisionally conclude that any increase in coal-fired generation between 2010 and 2014 would have had to have come from improved fuel availability and output, We assume that 2014 coal-fired generation was* 73.6% *higher than in 2010 in this low-hydro year in order to balance electricity output with estimated requirements.*

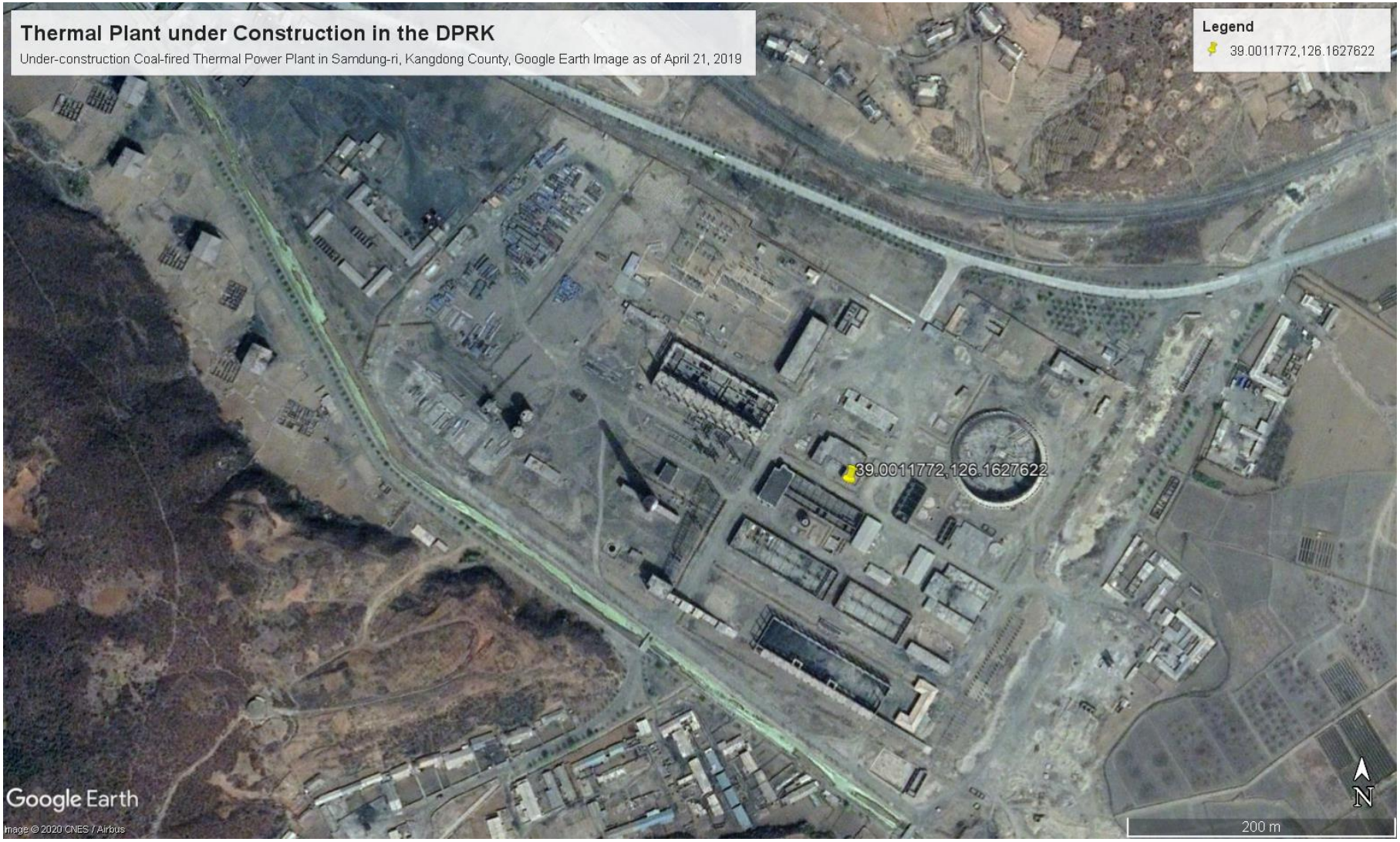
For 2015, we assume that coal-fired generation was 47.8% higher than in 2010 (as 2015 was a more normal hydro year) to balance estimated required generation.
For 2016, we assume that coal-fired generation was 58.2% higher than in 2010 to balance estimated required generation.
For 2017, we assume that coal-fired generation was 54.0% higher than in 2010 to balance estimated required generation.
For 2018, we assume that coal-fired generation was 26.3% higher than in 2010 to balance estimated required generation.
For 2019, we assume that coal-fired generation was 26.3% higher than in 2010 to balance estimated required generation.
For 2020, we assume that coal-fired generation was 25.0% **lower** than in 2010 to balance estimated required generation, in part due to production *difficulties at DPRK mines due to restrictions on imports of equipment parts and other inputs for mining, and in part due to movement restrictions within the DPRK to address the COVID-19 epidemic. It is also possible that domestic and international restrictions on transport and movement have reduced the availability of parts and parts and maintenance supplies for thermal (mostly coal-fired) power plants, which may have also limited their use during 2020.*

There does appear to be one new coal-fired generator being built, as reported by Curtis Melvin for ***38 North, in "Pyongyang's Perpetual Power Problems",*** *dated 25 November, 2014, and available as http://38north.org/2014/11/cmelvin112514/. This article shows satellite imagery of "a new coal-powered thermal power plant in Samdung-ri, Kangdong County, in eastern Pyongyang", that was mostly finished (but apparently not yet operational) as of late-2014. The article estimates the size of the power plant, which it refers to as the Kangdong plant, as between 100 and 300 MW, though no capacity figures have apparently been announced by the DPRK. Our guess, based on comparison of photos of the plant (see below) with photos of the 50 MW (but possibly designed to be 100 or 150 MW) East Pyongyang power plant, is that the actual capacity is/will be toward the lower end of that range.*

In the photo below, likely, based on vegetation, taken in late summer or fall of 2015, the power plant looks largely complete, but does not seem to be in operation.
Photo from Google Earth, https://www.google.com/maps/place/Kangdong,+Pyongyang,+North+Korea/@39.0011772,126.1627622,565m/data=!3m1!1e3!4m2!3m1!1s0x5fd5e2124d7020a7:0x1e266ba7812ffe4e,
Coordinates 38.999085 N, 126.162468 E.

By way of comparison, a photo from Google Earth of the East Pyongyang plant in operation, probably from about the same time, is shown below
(Source, Google Maps, https://www.google.com/maps/search/east+pyongyang+power+plant,+North+Korea/@38.9694907,125.6877455,426m/data=!3m1!1e3.)

Sourcewatch (2018) indicates that the "Kangdong power station is a 300 megawatt (MW) coal plant under construction near Pyongyang, North Korea", but suggests that little progress has been made in construction between 2013 and 2018. The following photo, from Google Earth, probably in mid 2018, suggests that, indeed, not much progress has occurred relative to the 2015 photo above. In fact, the site looks as though it has not been kept up much in the last few years, judging from what appear to be drifts of sand in some places, although a set of what may be vehicles, trailers, or storage containers at the northwestern edge of the site may indicate pending activity. Google Earth Pro Image from April 2019, coordinates approximately 39.00, 126.163. The Google Earth image at right shows the same site in June of 2017.
The 2017 and 2019 image show relatively little progress on construction since the earlier (2015) image was taken.


Thermal Plant under Construction in the DPRK
Under-construction Coal-fired Thermal Power Plant in Samdung-ri, Kangdong County, Google Earth Image as of April 21, 2019
Legend
39.0011772,126.1627622
39.0011772,126.1627622
Google Earth
Image © 2020 CNES / Airbus
N
200 m

Sunchon Thermal power plant, probably early 2016, from Google Earth,
https://www.google.com/maps/place/39%C2%B024'04.0%22N+125%C2%B058'03.0%22E/@39.4005487,125.966141,847m/data=!3m1!1e3!4m5!3m4!1s0x0:0x0!8m2!3d39.4011111!4d125.9675

Sunchon Thermal power plant, probably mid=2018, from Google Earth,
https://www.google.com/maps/place/39%C2%B024'04.0%22N+125%C2%B058'03.0%22E/@39.4000188,125.9658967,657m/data=!3m1!1e3!4m5!3m4!1s0x0:0x0!8m2!3d39.4011111!4d125.9675

22 Leo Byrne of NK News provided the following China Customs Statistics for 2016 and 2017 (the latter partial) on 11-13-17:

Year 2016			
Month	Value	Quantity (Number)	Implied value/unit
1월	$ 801,048	33,818	$ 23.69
2월	$ 366,161	27,626	$ 13.25
3월	$ 456,637	31,325	$ 14.58
4월	$ 982,459	82,290	$ 11.94
5월	$ 136,172	20,803	$ 6.55
6월	$ 160,959	4,399	$ 36.59
7월	$ 35,508	1,356	$ 26.19
8월	$ 349,966	15,971	$ 21.91
9월	$ 683,397	156,203	$ 4.38
10월	$ 361,421	37,962	$ 9.52
11월	$ 352,970	17,582	$ 20.08
12월	$ 715,510	39,832	$ 17.96
Total	**$ 5,402,208**	**469,167**	**$ 11.51**
Comtrade figures for 2016	$5,239,526	473,058	**$ 11.08**

Year 2017			
Month	Value	Quantity (Number)	Implied value/unit
1월	$ 532,555	27,673	$ 19.24
2월	$ 37,294	2,290	$ 16.29
3월	$ 263,947	48,659	$ 5.42
4월	$ 42,956	386	$ 111.28
5월	$ 24,284	491	$ 49.46
6월	$ 108,074	39,750	$ 2.72
7월	$ 32,769	1,537	$ 21.32
8월	$ 95,482	1,868	$ 51.11
9월	$ 62,133	1,294	$ 48.02
Total of Above	$ 1,199,494	123,948	$ 9.68
Full Year Extrapolated Total	**$ 1,599,325**	**165,264**	**$ 9.68**

23 A July 24, 2018 Reuters article entitled "Exclusive: North Korean fuel prices drop, suggesting U.N. sanctions being undermined", by Hyonhee Shin, and available as https://www.reuters.com/article/us-northkorea-economy-exclusive/north-korean-fuel-prices-drop-suggesting-u-n-sanctions-being-undermined-idUSKBN1KE15F, includes the following passage:

> "China said on Tuesday it strictly abided by U.N. sanctions, but indicated it may have resumed some fuel shipments to North Korea in the second quarter of this year. Gasoline was sold by private dealers in the North Korean capital Pyongyang at about $1.24 per kg as of Tuesday, down 33 percent from $1.86 per kg on June 5 and 44 percent from this year's peak of $2.22 per kg on March 27, according to Reuters analysis of data compiled by the Daily NK web site. Diesel prices are at $0.85 per kg, down about 17 percent from March. The website [that collects price data] is run by North Korean defectors who collect prices via phone calls with multiple traders in the North after cross-checks to corroborate their information, offering a rare glimpse into the livelihoods of ordinary North Koreans."

24 Despite the dramatic reduction in reported exports of wind and solar PV systems to the DPRK since 2016, several articles have described the trend toward continuing purchases and installation of these systems, including larger-sized PV systems, not only by residential consumers, but by commercial, institutional, and even industrial consumers as well. See, for example, Kang Mi Jin (2019), "Massive increase in solar panel use in North Korea", Daily NK, dated 2019-04-12, and available as https://www.dailynk.com/english/massive-increase-in-solar-panel-use-in-north-korea/.
We therefore assume that additional wind and solar PV systems have been imported into the DPRK, likely from China, without being documented. In the case of solar PVs, at least some panels are likely assembled in the DPRK from parts imported from China. Some DPRK-made wind turbines, at least in small sizes, are probably also coming into the market in the DPRK. We assume that the following volumes (kW) of wind and solar PV systems went into use in the DPRK in 2017 and 2018 from a mixture of off-books imports and domestic production. The Daily NK article referenced above includes the following passage: "the Daily NK estimates that almost 50% of households in North Korea have solar panels ". Given that this estimate is based on anecdotal reports of observations in just some DPRK cities, we feel that the Daily NKs estimate is probably somewhat overstated. If it were accurate, and "households" refers to both urban and rural households, then the total solar PV capacity by early 2019 would be on the order of 100 to 200 MW, assuming that the average household owning a PV panel has one in the range of 30 to 60 watts. The assumed values below are roughly consistent with pre-2016 growth trends, tempered increasingly in 2017 and 2018 by the impact of UNSC sanctions on imports availability.

	kW of assumed additional renewable generation capacity (domestic or unreported imports)		Implied total cumulative kW of renewable capacity (including reported imports)	
	Wind Power	Solar PV	Wind Power	Solar PV
2016	50	5,000	810	31,250
2017	80	12,000	961	46,098
2018	150	16,000	1,111	62,194
2019	150	16,000	1,261	78,194
2020	60	8,000	1,321	86,194

25 A UPI article, "North Korea recovering power plants, state media says", by Elizabeth Shim, dated March 9, 2020, and available as https://www.upi.com/Top_News/World-News/2020/03/09/North-Korea-recovering-power-plants-state-media-says/5081583777107/, says that DPRK media has reported that crews of workers have been sent to the major thermal and hydro power plants to "restore" the plants: "...working hard to restore the original performance of power generation facilities," We assume that without improved access to spare parts and other products for plant maintenance, the improvments made in performance will be modest in 2020, and any improvements may be offset by problems associated with the transport of needed goods and fuels due to the the COVID-19 panedmic, as well as due to problems obtaining spare parts and other material due to ongoing UNSC sanctions on the DPRK.

*26 KCNA Watch, reporting on an article from the **Pyongyang Times**, describes a rural installation of a 1 kW micro-hydro system by a rural family. "Family builds mini hydropower plant", dated 07/05/2020, and available as as https://kcnawatch.org/newstream/1588845669-773171530/Family-builds-mini-hydropower-plant/. The installation on a "brooklet" seems to use mostly local materials.*

27 The Experimental Light Water Reactor (ELWR) has been under construction since 2010 or earlier. Although it appears complete, and there have been recent additions of landscaping, new buildings, and modifications to the berms and dam in the adjacent river in the last few years, the ELWR apparently has not run yet as of early 2020. See, for example,
"North Korea's Yongbyon Nuclear Center: Rail Activity at the Radioisotope Production and Uranium Enrichment Plants", dated February 14, 2020, and available as https://www.38north.org/2020/02/yongbyon021420/. It is possible that the ELWR is being readied for operation in the near future, but we assume that it will not operate, or at least will not provide electricity to the grid, in 2020.
The image below, from Google Earth Pro, shows the Yongbyon ELWR as of October 13, 2019, apparently not operating, as indicated by the lack of steam from the smokestack. Some stains on the dome of the reactor have appeared in recent years, but we do not know what their significance is, if any.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION IN 2000

Prepared by David Von Hippel
Date Last Modified: 2/24/2011

Estimate of Status of Electricity Generating Plants as of 2000 *(see Note 1)*

Plant Name/Group	Design Fuel	Original Capacity (MW)	Operable Capacity as of 2000	Capacity Factor (fraction of operable capacity)	Estimated 2000 output (GWh)	Notes
Thermal Power Plants				***(Note 3)***		
Oungi (Sonbong refinery)	HFO	200	-	0%	-	Not in operation since 1999
(Plant associated with small W Coast Refinery)	HFO	60	*60*	*20%*	105	Operable capacity not from Source 1--estimate assuming full capacity available, but plant may have heat exchanger problems. Much of output may be dedicated to nearby refinery.
Pukchang	Coal	1,600	180	*45%*	710	3x100 MW units in operation, further 40% reduction in capacity due to heat exchanger problems.
Pyongyang	Coal	500	190	*45%*	749	*See also Note 16*
East Pyongyang	Coal	100	40	*45%*	158	*See also Note 16*
Taechon	Coal	200	50	*45%*	197	
Songlim (internal combustion)	HFO/diesel	9.8	9.8	*50%*	43	Capacity factor rough estimate
Songlim	Coal	100	-	0%	-	Plant reportedly not operating
Sariwon	Coal	100	-	0%	-	Plant reportedly not operating
Sunchon	Coal	100	-	0%	-	Plant reportedly not operating
Total of Above		2,970	530		1,961	
Thermal Capacity included in 1996 estimate but not in the above:	Coal	350	*210*	*45%*	828	Operable capacity not from Source 1--estimate assuming full capacity available, but down-rated by 40% because plants likely have heat exchanger problems.
Total of Large Thermal		3,320	740	43%	2,789	

Plant Location/Category	Design Fuel	Original Capacity (MW)	Operable Capacity as of 2000	Estimated Capacity Factor (fraction of operable capacity)	Estimated 2000 output (GWh)	Notes
Hydro Power Plants						
Plants on Chinese Border	Hydro	700	700	*17.5%*	1,073	*See Note 2*
Other Hydro Plants as of 1996	Hydro	3,925	2,944	36%	9,401	Assumes about 75% of non-border-region capacity is operable (or that the average available capacity is 75% of nameplate), and capacity factor is 75% of 1996 estimate.
Total Estimated Operable Hydro Capacity		4,625	3,644	33%	10,474	Excludes portion of capacity at Chinese border used exclusively by China.
TOTAL IMPLIED DPRK ELECTRICITY OUTPUT, 2000					**13,263**	GWH ***(see Note 4)***

Recorded Electricity Exports to China	22.66	GWh ***(see Note 5)***
Recorded Electricity Imports from China	0.00	GWh ***(see Note 5)***

Input of used tires as fuel for electricity generation 7.71E+05 GJ ***(See Notes 6 and 7)***

Sources/Notes:

1 Information on status of electricity generating facilities from an industry source, except as noted below.

2 An industry source with knowledge of operating procedures for the hydroelectric power plants along the China/DPRK border estimates that there are approximately 700 MW of capacity providing power to the DPRK from the 4 hydroelectric cascades on the rivers that form the border between the DPRK and China. Further, this capacity, if it was damaged in the floods of the mid-1990s, is now operational. Standard procedures for operating the shared hydro capacity on the DPRK/China border is to run the plants on a peaking basis (low capacity factor) except for August, when rivers are full and the plants are run at full capacity. Availability of water thus limits output. As 2000 was reportedly a relatively low water year (perhaps 70% of normal), we assume that the average capacity factor for these plants was 10% for all months except August, and thus the overall annual average capacity factor was approximately 17.5%.

3 An estimated 50% capacity factor for the operable thermal units is roughly consistent with the level of output we assumed for 1996, with some reduction to account for difficulties in obtaining coal supplies. Still, 50 percent may be a generous estimate. By way of comparison, the KEEI data set provided to Nautilus (workbook titled "DPRK Energy Data", based on information from the ROK National Statistics Office) suggests total (probably not all operable) thermal capacity of 2960 MW, and output of 9200 GWh, for an average capacity factor of 35 percent. The average hydroelectric capacity factor from the same source for 2000 is 25%.

4 This total is lower than the 19.3 TWh quoted by The Wall Street Journal (Jay Solomon, "EUROPE ENGINEERS WAIT FOR U.S. MOVE TO OFFER ENERGY HELP TO NORTH KOREA," Seoul, 03/21/01) as having been estimated by Siemens AG, and is also lower than the 19.4 TWh estimated production in 2000 as provided in the KEEI data set described in Note 3. The total, however, does not seem unreasonable given the difficult status of the power generation and fuel supply infrastructure in the DPRK described by recent visitors. The total calculated also is similar to the value (apparently) attributed to "ROK Officials" by the Associated Press in a 1998 article focusing on potential South-North Power Transfers ("KOREA ELECTRIC POWER CHIEF OFFERS SURPLUS POWER TO N. KOREA," Seoul, 06/08/98) as "most of the DPRK's power plants are fossil-fired and only produce about 1.5 million kilowatts daily, about one- fifth of their total capacity, because of fuel shortages". If the reference here, which is not entirely clear, is interpreted to mean that the average output of DPRK electricity plants was 1500 MW as of mid-1998, the implied total annual generation would be about 13 TWh.

5 Exports from the DPRK to China from China Customs Report 2000, pp. 1483-1495 (in Chinese).

6 *Source from the industry reports that the DPRK likely received a total of 25,000 tonnes of used auto tires from Japan and Taiwan in 2000 for use as a supplemental boiler fuel. The DPRK has reportedly been requesting similar cargoes from Europe. This estimate corresponds well with data from Japan Customs Statistics (data from files downloaded from http://www.customs.go.jp/toukei/download/index_d012_e.htm) that lists year 2000 exports from Japan to the DPRK in a category (HS # 400400000) that is defined as "Waste, parings and scrap of rubber (other than hard rubber) and powders and granules obtained therefrom" at a total level of* 22,156 *tonnes. We use this value as the estimated input of waste tires to electricity generation in the DPRK in 2000. For 2005, exports from Japan to the DPRK in the same category were recorded as* 25,599 *tonnes. The reported value of cargoes of this product averaged about 3600 Yen/tonne in 2000, and was about 3000 Yen per tonne from 2003 through 2005. By way of comparison these per-tonne value were less, sometimes significantly less, than the amount paid by Japan for coal exported from the DPRK to Japan in those years. Exports of this waste-rubber product were higher in all of the other years between 2000 and 2005, peaking at over 110,000 tonnes in 2003.*

UN Comtrade data available for exports of this product from Japan to the DPRK are as follows:

Period	Trade Value	Net Weight (kg)	Implied Cost per tonne
1988	$102,675	920,312	$ 111.57
1989	$80,735	631,125	$ 127.92
1990	$22,169	189,910	$ 116.73
1991	$368,796	926,937	$ 397.87
1992	$16,346	88,050	$ 185.64
1993	$2,693	14,000	$ 192.36
1995	$6,324	237,359	$ 26.64
1996	$5,117	486,250	$ 10.52
1997	$20,383	328,875	$ 61.98
1998	$37,169	1,385,812	$ 26.82
1999	$185,892	6,047,750	$ 30.74
2000	$733,051	22,156,316	$ 33.09
2001	$1,600,014	78,881,812	$ 20.28
2002	$2,207,715	112,927,562	$ 19.55
2003	$1,633,181	63,311,953	$ 25.80
2003	$7,736	100,500	$ 76.98
2004	$1,781,644	62,972,308	$ 28.29
2004	$4,338	50,000	$ 86.76
2005	$692,654	25,599,116	$ 27.06
2006	$221,617	8,557,974	$ 25.90

7 Oxford Recycling Inc. (http://www.oxfordrecycling.com/product.html#5, visited 6/8/02) lists a fuel energy content of 15,000 *Btu/lb, or* 34.82 *GJ/tonne, for fuel from shredded tires. the same source lists a sulfur content of* 1.30% *for the same fuel.*

8 An article entitled "Defector from Pyonyang: 'Thirty thousand constructing soldires were died (sic) in Guemgangsan Plant'", by Han Yo'ng-chin, published 14 Feb, 2006, in The Daily NK WWW (Seoul), includes a reference to the Anbyun Youth Power Plant, near Mount Guemgang (Kumgang) as having a second step of construction completed in 2000, with final construction completed in 2003, and having a capacity of 200 MW.

9 An article in KCNA in English (Pyongyang), dated 14 December, 2004, and entitled "Leader Gives Field Guidance to Construction of Power Station", refers to the under-construction Orangch'on (hydro) Power Plant in North Hamgyong Province. The generating room of "Power Station No. 1" is described as "entering the construction stage".

10 An article in KCNA in English (Pyongyang), dated 26 May, 2005, and entitled "Kim Jong Il Visits Wo'nsan Power Station", refers to the under-construction Wo'nsan Youth Power Station (hydro) in Kangwo'n Province. This plant seems to be in the construction phase, with the dam at least partially completed. No figures on capacity are given.

11 An article in KCNA in Korean (Pyongyang), dated 19 September, 2005, and entitled "DPRK Leader Visits Moranbong Theater Under Reconstruction", includes a reference to the construction of a series of "10 small- and medium-sized power plants in tiers along [the] To'kchi River", with the implication that construction of the dam and related elements are complete or nearly so. The article also references the completion and starting of the To'kchinggang No.9 power plant, and refers to an under-construction No. 4 power plant. No information on plant capacity is provided.

12 An broadcast by KCNA in Korean (Pyongyang), dated 20 December, 2005, and on the subject "DPRK TV on Leader's Inspiring People to Build New Power Plants on 'Large Scale'", includes reference to the Naep'yo'ng No. 2 Kunmin Power Plant and the Wo'nsan Youth Power Plant, and notes that "Kim Jong Il visited all the power plant construction sites in the country for the last 10 years." The transcript of the broadcast also refers to the volume of the dam at the Wo'nsan Youth Power Plant as 1.7 million cubic meters, with 16 km of aqueducts, and refers to assembly of generators No. 2 through 5. There is also a reference to the Ku'mjingang Hu'ngbong Youth Power Plant in South Kamgyo'ng Province on the Ku'mjin River, to "large scale hydraulic power plants" such as the Orangch'o'n Power Plant and the Paektusan So'ngun Youth Power Plant, plus "scores of" small and medium-scale power plants including the "(Word Indistinct) No. 2 Railway Youth Power Plants, the Naso'n Youth Power Plant, the Singye Kunmin power plant, the (Word Indistinct) Mine No. 2 Power plant, [and the] (? Taegak) Youth Power Plant." There is a reference to a photo of "one or a power plant of the Susongch'o'n Second-stage Five Powr Plants".

13 An article in Korea Today (Pyongyang, via Naenara Internet, in English), dated 12 January, 2006, includes an interview with Kim Su Nam, "Bureau Director of the Ministry of Electric and Coal Industries". In the interview, Kim states, in part, "A large number of hydroelectric power stations have been built, including the Taedonggang, Namgang, Anbynon Youth, Thaechon, and Kanggye Youth Power Stations. Hydroelectric generating capacity has steadily grown with the builiding of many minor hydropower stations on the principle of combining large, medium, and small power plants. Along with this, thermal power plants have been erected in Pyongyang, Pukchang, Sunchon, and other parts of the country to meet the growing demand for electricity." The interview also refers to the completed construction of a dam of the Nyongwon Power Station, and to medium and (smaller) power stations in Jagang, South Haymgyyong, Ryanggang, and other provinces. Kim also refers to efforts to increase capacity at existing hydro and thermal power stations.

14 The article in Nodong Sinmun (Pyongyang, in Korean), dated 29 December, 2002, page 1, by Chong Yong-ch'ol, "At North Hwanghae Province: Power Plants Wherever the Water Flows", refers to power plants including the Yosonggang Power Plant in North Hwanghae Province, power plants in Yont'an and Unp'a County, a power plant in P'yongsan County, a power plant in Koksan County (on the stream of the same name), a plant at Taech'on-ri in Insan County, plants under construction in Singye and Yonsan Counties (Singye Power Plant No. 1, and Hwangdaech'on Power Plant, respectively, with the latter apparently in early construction phases, and the former more advanced). There is a reference to "power plant constructed at Holdong Mine".

15 From China Customs Statistics. See Note 10 in "Electric--96-on" Worksheet in this workbook.

16 A set of figures from a 2001 document in the authors' files [NKES-01], citing a DPRK source, provided the following information about the Pyongyang Thermal Power plant. The coal consumption figure shown corresponds to a relatively high efficiency if it is interpreted as referring to average heat-content coal, and an efficiency of about 26% *when converted from grams of coal equivalent per kWh. The same source also includes the following information: "The Pyongyang area has 600MW of thermal power plants (Pyongyang Thermal Plant 500MW, East Pyongyang Thermal Plant 100 MW), which receive coal supplies from the Chikdong Mine and the Chonsong Mine. Electric power production these days is only 1,700,000 MWh (Pyongyang Thermal Plant 1,225,000 MWh, East Pyongyang Thermal Plant 475,000 MWh)." The latter figures, if true, suggest that year 2000 electricity output was somewhat higher than estimated above, at least for these plants. It should be noted that the Pyongyang and in particular, East Pyongyang plants are among the most recent additions to the DPRK fleet of thermal power plants.*

Pyongyang Thermal Power Facilities*

Thermal Condensing Turbine	50 MW x 7 (USSR)
Extraction Steam Condensing Turbine	50 MW x 1 (German)
Steam Condensing Turbine	100 MW x 1 (German)
Steam Boiler	12 Unit
Heating Boiler (210t) 100Gcal/h	2 Unit
Total Operating Hours	300,000
Consumption of Anthracite	470g/kwh (approximately)

Based on a very rough calculation, 2 boilers of this size could supply space heat and hot water for tens of thousands of households (perhaps 25,000 to 100,000)

* *This table has been edited slightly for clarity.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION IN 2005 AND BEYOND

Prepared by David Von Hippel
Date Last Modified: 5/6/2020

Estimates of Status of Electricity Generating Plants as of 2005-2017 *(see Note 1)*

Plant Name/Group	Design Fuel	Original Capacity (MW)	Operable Capacity as of 2005	Capacity Factor (fraction of operable capacity)	Estimated 2005 output (GWh)	Notes
Thermal Power Plants				***(Note 3)***		
Oungi (Sonbong refinery)	HFO	200	-	0%	-	Reportedly not in operation since 1999 as of 2000. Assumed not to have operated since 2000, as associated refinery remains inactive.
(Plant associated with small W Coast Refinery)	HFO	60	*60*	*20%*	105	Assumed same as 2000. May be the same as the "December (nampo) Powerplant" listed in source ***23***, which in turn is listed as having a capcity of 50 MW in source ***12***. Recent news articles suggest that this plant is a mainstay of the current DPRK electricity system, and has been upgraded recently, but an estimate of currently operable capacity is not available. See also *Note 13*.
Pukchang	Coal	1,600	*??*	*??*		
Pyongyang	Coal	500	*??*	*??*		
East Pyongyang	Coal	100	*??*	*??*		
Taechon	Coal	200	*??*	*??*		
Songlim (internal combustion)	HFO/diesel	9.8	9.8	*50%*	43	Assumed same as 2000
Songlim	Coal	100	*??*	*??*		Plant reportedly not operating
Sariwon	Coal	100	*??*	*??*		Plant reportedly not operating
Sunchon	Coal	100	*??*	*??*		Plant reportedly not operating
Total of Above		2,970	70		148	
Thermal Capacity included in 1996 estimate but not in the above:	Coal	350	*??*	*??*		
Total of Large Thermal		3,320	2,040	30.2%	5,400	Operable capacity and output from data reported by KERI (for 2004)--see source in *Note 1*. Total capacity roughly consistent with data in *Note 12*.

Plant Location/Category	Design Fuel	Original Capacity (MW)	Operable Capacity as of 2005	Estimated Capacity Factor (fraction of operable capacity)	Estimated 2005 output (GWh)	Notes
Hydro Power Plants						
Plants on Chinese Border	Hydro	700	864	37%	2,800	Estimated based on 2004 figures for plants shared with China as provided in source listed in *Note 1*.
Other Hydro Plants as of 1996	Hydro	3,925	3,066	30%	8,100	Estimated based on 2004 figures for plants other than those shared with China as provided in source listed in *Note 1*.
Total Estimated Operable Hydro Capacity as of end-2004	Hydro	4,625	3,930	32%	10,900	Excludes portion of capacity at Chinese border used exclusively by China. Total capacity roughly consistent with data in *Notes 12, 16*.
New large hydro capacity added in 2005			100	15%	132	Rough estimate. New reports in the last few years such as those described in *Notes 6 - 11* list several new large hydro facilities in different stages of construction, but few quantitative details are available.
New medium hydro capacity added in 2005	Hydro		86.4	15%	114	See *Note 14*. Capacity factor for medium and large hydro plants added in 2005 assumed half of average for existing plants not shared with China (to roughly account for operation starting at different times of the year).
TOTAL IMPLIED DPRK ELECTRICITY OUTPUT, 2005					**16,546**	GWh (See ***Note 15***)

Estimate of Status of Electricity Generating Plants as of 2008 *(see Note 1)*

Plant Name/Group	Design Fuel	Original Capacity (MW)	Estimated Operable Capacity as of 2008	Estimated Capacity Factor (fraction of operable capacity)	Estimated 2008 output (GWh)	Notes
Thermal Power Plants				***(Note 3)***		
Oungi (Sonbong refinery)	HFO	200	-	0%	-	Reportedly not in operation since 1999 as of 2000. Assumed not to have operated since 2000, as associated refinery remains inactive.
(Plant associated with small W Coast Refinery)	HFO	60	*60*	*20%*	105	Assumed same as 2000. This may be the power plant identified as "December (nampo) Powerplant" in reference 23, below.
Pukchang	Coal	1,600	*??*	*??*		Recent information from visitors to the DPRK indicate that updates to this plant are planned, but have not yeat been carried out. See also *Note 13*.
Pyongyang	Coal	500	*??*	*??*		
East Pyongyang	Coal	100	*??*	*??*		
Taechon	Coal	200	*??*	*??*		
Songlim (internal combustion)	HFO/diesel	9.8	9.8	*50%*	43	Assumed same as 2000
Songlim	Coal	100	*??*	*??*		Plant reportedly not operating
Sariwon	Coal	100	*??*	*??*		Plant reportedly not operating
Sunchon	Coal	100	*??*	*??*		Plant reportedly not operating
Total of Above		2,970	70		148	
Thermal Capacity included in 1996 estimate but not in the above:	Coal	350	*??*	*??*		
Total of Large Thermal		3,320	2,040	30.2%	5,400	Operable capacity and output from data reported by KERI (for 2006)--see source in *Note 1*. Total capacity roughly consistent with data in *Note 12.*

Plant Location/Category	Design Fuel	Original Capacity (MW)	Operable Capacity as of 2008	Estimated Capacity Factor (fraction of operable capacity)	Estimated 2008 output (GWh)	Notes
Hydro Power Plants						
Plants on Chinese Border	Hydro	700	864	37%	2,800	Estimated based on 2004 figures for plants shared with China as provided in source listed in *Note 1*.
Other Hydro Plants as of 1996	Hydro	3,925	3,066	31%	8,300	Slightly higher than 2004 figures for plants other than those shared with China as provided in source listed in *Note 1*.
Total Estimated Operable Hydro Capacity as of end-2004	Hydro	4,625	3,930	32%	11,100	Excludes portion of capacity at Chinese border used exclusively by China. Total capacity roughly consistent with data in *Notes 12, 16*.
New large hydro capacity added from 2005 through 2008			200	30%	526	Rough estimate. News reports in the last few years such as those described in *Notes 6 - 11, 19, and 22* list several new large hydro facilities in different stages of construction, but few quantitative details are available.
New medium hydro capacity added between 2006 and 2008	Hydro		114.54	20.0%	201	See *Note 14*. Capacity factor for medium-sized hydro plants added from 2006 through 2008 assumed somewhat lower than capacity factor for larger hydro plants, and also reduced somewhat because plants completed in 2008 are assumed to average only half of a full year's output during that year. Capacity total for 2006-2008 extrapolates trend of capacity additions from 2000-2005 through 2008, and thus is a very rough estimate.
New medium hydro capacity added during 2009	Hydro		38.18	12%	40	See *Note 14*. Capacity factor for medium-sized hydro plants added during 2009 assumed somewhat lower than capacity factor for larger hydro plants, and also reduced somewhat because plants completed in 2009 are assumed to average only half of a full year's output during that year. Capacity total for 2009 extrapolates trend of annual capacity additions from 2000-2005, and thus is a very rough estimate.

Plant Location/Category	Design Fuel	Original Capacity (MW)	Operable Capacity as of Completion	Estimated Capacity Factor (fraction of operable capacity)	Estimated Output (GWh)	Notes
New medium hydro capacity added during 2010	Hydro		38.18	12%	40	See *Notes 14 and 24*. Capacity factor for medium-sized hydro plants added during 2010 assumed somewhat lower than capacity factor for larger hydro plants, and also reduced somewhat because plants completed in 2010 are assumed to average only half of a full year's output during that year. Capacity total for 2010 extrapolates trend of annual capacity additions from 2000-2005, and thus is a very rough estimate.
New medium hydro capacity added from 2010 through 2014	Hydro		95	29.6%	247	Capacity addition is a rough estimate, and may in fact be high. Includes 60 MW plus 35 MW explicitly listed in DPRK UNFCCC filings--see ***Note 27***. Capacity factor shown is intended to be an estimated average for 2010 through 2013, and is certainly also a very rough estimate.
New large hydro capacity added from 2010 through 2014	Hydro		300	25%	657	Huichon power station #2, reportedly brought on line in 2012, though it apparently has a number of problems--see ***Note 26***.
New medium hydro capacity added during 2015	Hydro		35	20%	61	Rough estimate. Includes the five power stations on the Chongchon River reportedly brought on line in 2015 in reference ***30***, plus perhaps one or two more. Capacity factor assumes plants are phased in relateively evenly over the year, and have a full-year capacity factor of about 40%.
New large hydro capacity added during 2015	Hydro		30	20%	53	Rough estimate. Includes the Paektusan power station identified in DPRK UNFCCC (see note ***27***), plus perhaps one more of a similar size. Capacity factor assumes plants are phased in relateively evenly over the year, and have a full-year capacity factor of about 40%.
New medium hydro capacity added during 2016	Hydro		35	22%	66	Assumes similar to 2015, and consistent with additions reported as a part pf UNFCCC CDM projects in recent years. Capacity factor somewhat higher than 2015 based on trend in output of UNFCCC-registered plants.
New large hydro capacity added during 2016	Hydro		30	22%	57	Rough estimate. Includes the Paektusan power station #3 (see Note ***31***), which is assumed to be similar in size to the #2 station on the same river (the latter identified in DPRK UNFCCC filings--see note ***27***), plus perhaps one more of a similar size. Capacity factor somewhat higher than 2015 based on trend in output of UNFCCC-registered plants.

Plant Location/Category	Design Fuel	Original Capacity (MW)	Operable Capacity as of Completion	Estimated Capacity Factor (fraction of operable capacity)	Estimated Output (GWh)	Notes
New medium hydro capacity added during 2017	Hydro		35	19%	58	Assumes similar to 2015, and consistent with additions reported as a part pf UNFCCC CDM projects in recent years. Capacity factor somewhat lower than 2016 based on trend in output of UNFCCC-registered plants.
New large hydro capacity added during 2017	Hydro		40	19%	67	Rough estimate. Could include, for example, one or more of the Wonsan hydro plants coming on line. See notes ***32*** through ***35***.
New small, medium and large hydro capacity added during 2018	Hydro		40	19%	67	Rough estimate. Could include, for example, one or more of the Wonsan hydro plants coming on line. See notes ***32*** through ***35***.
New small, medium and large hydro capacity added during 2019	Hydro		30	19%	50	Rough estimate. Could include, one or more of the hydro plants under construction in various areas. See notes ***32*** through ***35***.
New small, medium and large hydro capacity added during 2020	Hydro		20	19%	33	Rough estimate. Could include, one or more of the hydro plants under construction in various areas, but assumes less progress than in previous years due to coronavirus pandemic and response. See notes ***32*** through ***35***.
Kangdong power station	Coal-fired		300	0%	-	Power station about 20 km east of Pyongyang has been under construction since 2010. Sourcewatch (see reference ***29***) indicates that construction appears to have been halted for many years.

Recorded 2005 Electricity Exports to China	90.15	GWh	***(see Note 2)***
Recorded 2008 Electricity Exports to China	143.54	GWh	***(see Note 2)***
Recorded 2009 Electricity Exports to China	128.89	GWh	***(see Note 2)***
Recorded 2010 Electricity Exports to China	151.71	GWh	***(see Note 2)***
Recorded 2014 Electricity Exports to China	222.43	GWh	***(see Note 2)***
Recorded 2015 Electricity Exports to China	118.74	GWh	***(see Note 2)***
Recorded 2016 Electricity Exports to China	167.23	GWh	***(see Note 2)***
Recorded 2017 Electricity Exports to China	269.28	GWh	***(see Note 2)***
Recorded 2018 Electricity Exports to China	279.35	GWh	***(see Note 2)***
Recorded 2019 Electricity Exports to China	279.35	GWh	***(see Note 2)***
Recorded 2020 Electricity Exports to China	279.35	GWh	***(see Note 2)***

Input of used tires as fuel for electricity generation, 2005	8.91E+05	GJ	***(See Notes 3 and 4)***
Input of used tires as fuel for electricity generation, 2008	0.00E+00	GJ	
Input of used tires as fuel for electricity generation, 2009	5.74E+02	GJ	
Input of used tires as fuel for electricity generation, 2010	9.72E+03	GJ	
Input of used tires as fuel for electricity generation, 2014	6.91E+04	GJ	
Input of used tires as fuel for electricity generation, 2015	8.10E+03	GJ	
Input of used tires as fuel for electricity generation, 2016	2.68E+04	GJ	
Input of used tires as fuel for electricity generation, 2017	1.41E+04	GJ	
Input of used tires as fuel for electricity generation, 2018	5.91E+03	GJ	
Input of used tires as fuel for electricity generation, 2019	5.91E+03	GJ	(Assumes same as 2018)
Input of used tires as fuel for electricity generation, 2020	5.91E+03	GJ	(Assumes same as 2018)

Sources/Notes:

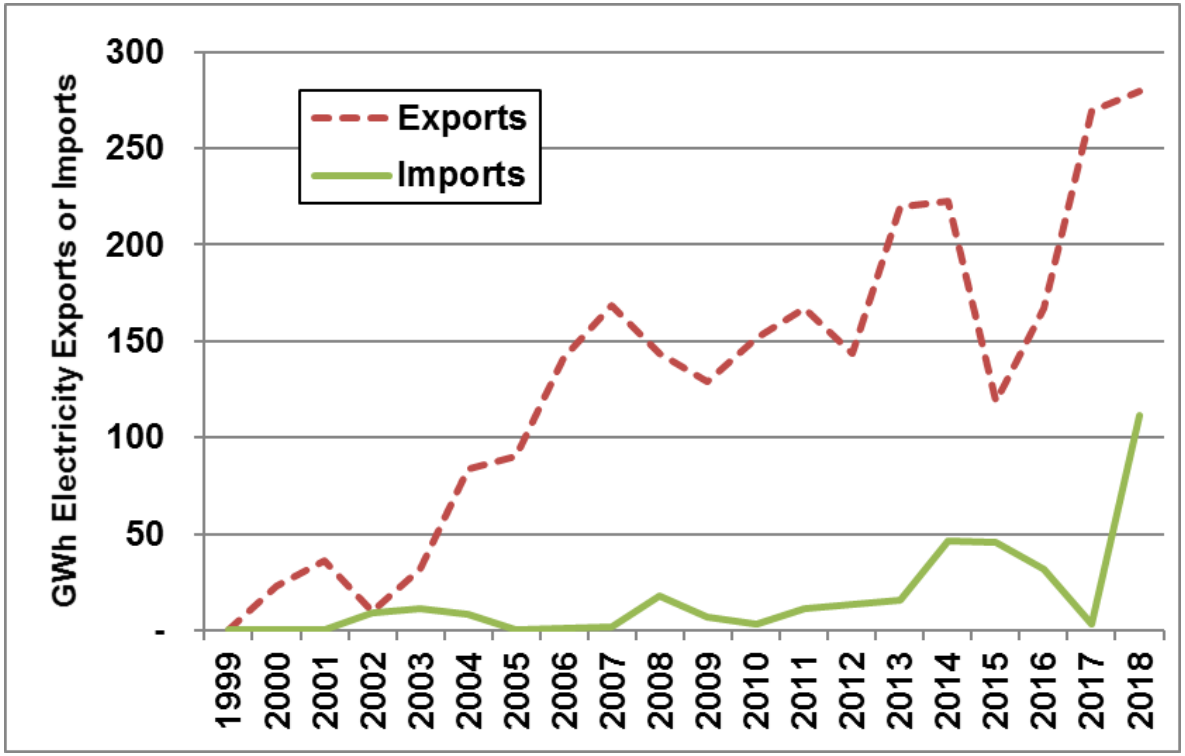
1 For 2005, we do not yet have the same estimates of plant-by-plant operational status that we had in 2000. We therefore use as a rough guide the overall estimates of capacity and capacity factor for thermal and hydroelectric power plants as reportedly provided by DPRK engineers to KERI (Korea Electrotechnical Research Institute) staff (and as cited in "Analysis of Present Status and Future Supply /Demand Prospects for the DPRK Power System", by J.Y. Yoon, presented at the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Yoon's presentation is available as http://www.nautilus.org/DPRKEnergyMeeting/Papers/Yoon.ppt. A similar table also appear in the presentation "Analysis on DPRK Power Industry & Interconnection Options", by the same author, dated September 21, 2010, prepared for the DPRK Energy and Minerals Experts Working Group Meeting, Beijing, China, September, 2010, and available as http://nautilus.wpengine.netdna-cdn.com/wp-content/uploads/2011/12/01.-Yoon.ppt. Note, however, that the estimates presented here are slightly different than those derived for 2005 in the "Electic--96-on" worksheet in this workbook, and the latter are used in the 2005 energy balance.

2 Exports from the DPRK to China from China Customs World Trade Atlas As compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf. Electricity imports to China from the DPRK, as indicated by the same source and 2008 and 2010 updates, but from the UN Comtrade database from 2010-on, are as follows for other years:

Year	MWh	$/MWh	
2000	22,665		
2001	36,289		
2002	9,979		
2003	31,838		
2004	83,350		
2005	90,146		
2006	141,129	$ 27.00	
2007	168,502	$ 28.23	
2008	143,535	$ 30.65	
2009	128,886	$ 32.20	
2010	151,710	$ 32.37	
2011	167,013	$ 33.85	
2012	143,292	$ 35.95	
2013	219,445	$ 37.01	
2014	222,425	$ 37.88	
2015	118,743	$ 39.96	
2016	167,233	$ 34.42	
2017	269,284	$ 40.78	
2018	279,352	$ 40.78	No quantity reported, estimated based on 2017 price
2019	279,352		No electricity trade reported in Comtrade as of 5/5/2020, assumed same as 2018.
2020	279,352		Assumed same as 2018
Average, 2006-2018	178,504	$ 35.45	

2010 through 2018 values from UN COMTRADE, HS Code 2716.

No data for electricity exports from the DPRK to China are available for 1990 - 1999.


GWh Electricity Exports or Imports
300
250
200
150
100
50
-
Exports
Imports
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

3 *Source from the industry reports that the DPRK likely received a total of 25,000 tonnes of used auto tires from Japan and Taiwan in 2000 for use as a supplemental boiler fuel. The DPRK has reportedly been requesting similar cargoes from Europe. This estimate corresponds well with data from Japan Customs Statistics (data from files downloaded from http://www.customs.go.jp/toukei/download/index_d012_e.htm) that lists year 2000 exports from Japan to the DPRK in a category (HS # 400400000) that is defined as "Waste, parings and scrap of rubber (other than hard rubber) and powders and granules obtained therefrom" at a total level of* 22,156 *tonnes. We use this value as the estimated input of waste tires to electricity generation in the DPRK in 2000. For 2005, exports from Japan to the DPRK in the same category were recorded as* 25,599 *tonnes. The reported value of cargoes of this product averaged about 3600 Yen/tonne in 2000, and was about 3000 Yen per tonne from 2003 through 2005. By way of comparison these per-tonne value were less, sometimes significantly less, than the amount paid by Japan for coal exported from the DPRK to Japan in those years. Exports of this waste-rubber product were higher in all of the other years between 2000 and 2005, peaking at over 110,000 tonnes in 2003. UN Comtrade statistics include these trades of scrap rubber in this HS category from Japan, and also include smaller trades from other countries to the DPRK, as well as some trades from the DPRK to other countries, mostly to China, mostly in years when the DPRK imported these products from Japan, and at prices higher than the DPRK paid Japan for the rubber imports. The table below summarizes mostly larger (greater than ~100 te) trades in this commodity through 2019.*

Year	Tonnes of Imports from Japan	Tonnes Imports from Other Nations Net of Exports	Net GJ Waste Rubber Fuel Use Implied	GJ fuel input to coal-fired power plants	Implied fraction input as tires
1990	190		6.61E+03	3.01E+08	0.002%
1991	927		3.23E+04	2.88E+08	0.011%
1992	88	135.4	7.78E+03	2.75E+08	0.003%
1993	14		4.87E+02	2.61E+08	0.000%
1994	-	78.2	2.72E+03	2.48E+08	0.001%
1995	237		8.26E+03	2.35E+08	0.004%
1996	486	235.1	2.51E+04	2.21E+08	0.011%
1997	329	121.8	1.57E+04	1.77E+08	0.009%
1998	1,386		4.82E+04	1.33E+08	0.036%
1999	6,048		2.11E+05	8.93E+07	0.236%
2000	22,156	73.5	7.74E+05	4.53E+07	1.709%
2001	78,882	418.5	2.76E+06	5.39E+07	5.124%
2002	112,928	200.3	3.94E+06	6.25E+07	6.303%
2003	63,312	(2,122.8)	2.13E+06	7.11E+07	2.996%
2004	62,972	(3,020.0)	2.09E+06	7.97E+07	2.619%
2005	25,599	(3,862.0)	7.57E+05	8.83E+07	0.857%
2006	8,558	(36.8)	2.97E+05	8.83E+07	0.336%
2007	-	79.0	2.75E+03	8.83E+07	0.003%
2008	-	-	0.00E+00	8.77E+07	0.000%
2009	-	16.5	5.74E+02	6.94E+07	0.001%
2010	-	279.2	9.72E+03	5.89E+07	0.016%
2011	-	1,058.6	3.69E+04	5.89E+07	0.063%
2012	-	105.4	3.67E+03	5.89E+07	0.006%
2013	-	611.7	2.13E+04	5.89E+07	0.036%
2014	-	1,984.3	6.91E+04	5.89E+07	0.117%
2015	-	232.6	8.10E+03	8.71E+07	0.009%
2016	-	769.0	2.68E+04	9.32E+07	0.029%
2017	-	404.7	1.41E+04	9.07E+07	0.016%
2018	-	169.7	5.91E+03	7.44E+07	0.008%
2019	-	169.7	5.91E+03	7.44E+07	0.008%
2020	-	169.7	5.91E+03	4.42E+07	0.013%

No trades reported in Comtrade statistics for 2019 as of 5/5/2020. Values for 2019 assumed similar to 2018

4 Oxford Recycling Inc. (http://www.oxfordrecycling.com/product.html#5, visited 6/8/02) lists a fuel energy content of 15,000 *Btu/lb, or* 34.82 *GJ/tonne, for fuel from shredded tires. the same source lists a sulfur content of* 1.30% *for the same fuel.*

5 An article entitled "Defector from Pyonyang: 'Thirty thousand constructing soldires were died (sic) in Guemgangsan Plant'", by Han Yo'ng-chin, published 14 Feb, 2006, in The Daily NK WWW (Seoul), includes a reference to the Anbyun Youth Power Plant, near Mount Guemgang (Kumgang) as having a second step of construction completed in 2000, with final construction completed in 2003, and having a capacity of 200 MW.

6 An article in KCNA in English (Pyongyang), dated 14 December, 2004, and entitled "Leader Gives Field Guidance to Construction of Power Station", refers to the under-construction Orangch'on (hydro) Power Plant in North Hamgyong Province. The generating room of "Power Station No. 1" is described as "entering the construction stage".

7 An article in KCNA in English (Pyongyang), dated 26 May, 2005, and entitled "Kim Jong Il Visits Wo'nsan Power Station", refers to the under-construction Wo'nsan Youth Power Station (hydro) in Kangwo'n Province. This plant seems to be in the construction phase, with the dam at least partially completed. No figures on capacity are given.

8 An article in KCNA in Korean (Pyongyang), dated 19 September, 2005, and entitled "DPRK Leader Visits Moranbong Theater Under Reconstruction", includes a reference to the construction of a series of "10 small- and medium-sized power plants in tiers along [the] To'kchi River", with the implication that construction of the dam and related elements are complete or nearly so. The article also references the completion and starting of the To'kchinggang No.9 power plant, and refers to an under-construction No. 4 power plant. No information on plant capacity is provided.

9 An broadcast by KCNA in Korean (Pyongyang), dated 20 December, 2005, and on the subject "DPRK TV on Leader's Inspiring People to Build New Power Plants on 'Large Scale'", includes reference to the Naep'yo'ng No. 2 Kunmin Power Plant and the Wo'nsan Youth Power Plant, and notes that "Kim Jong Il visited all the power plant construction sites in the country for the last 10 years." The transcript of the broadcast also refers to the volume of the dam at the Wo'nsan Youth Power Plant as 1.7 million cubic meters, with 16 km of aqueducts, and refers to assembly of generators No. 2 through 5. There is also a reference to the Ku'mjingang Hu'ngbong Youth Power Plant in South Kamgyo'ng Province on the Ku'mjin River, to "large scale hydraulic power plants" such as the Orangch'o'n Power Plant and the Paektusan So'ngun Youth Power Plant, plus "scores of" small and medium-scale power plants including the "(Word Indistinct) No. 2 Railway Youth Power Plants, the Naso'n Youth Power Plant, the Singye Kunmin power plant, the (Word Indistinct) Mine No. 2 Power plant, [and the] (? Taegak) Youth Power Plant." There is a reference to a photo of "one or a power plant of the Susongch'o'n Second-stage Five Powr Plants".

10 An article in Korea Today (Pyongyang, via Naenara Internet, in English), dated 12 January, 2006, includes an interview with Kim Su Nam, "Bureau Director of the Ministry of Electric and Coal Industries". In the interview, Kim states, in part, "A large number of hydroelectric power stations have been built, including the Taedonggang, Namgang, Anbynon Youth, Thaechon, and Kanggye Youth Power Stations. Hydroelectric generating capacity has steadily grown with the builiding of many minor hydropower stations on the principle of combining large, medium, and small power plants. Along with this, thermal power plants have been erected in Pyongyang, Pukchang, Sunchon, and other parts of the country to meet the growing demand for electricity." The interview also refers to the completed construction of a dam of the Nyongwon Power Station, and to medium and (smaller) power stations in Jagang, South Haymgyyong, Ryanggang, and other provinces. Kim also refers to efforts to increase capacity at existing hydro and thermal power stations.

11 The article in Nodong Sinmun (Pyongyang, in Korean), dated 29 December, 2002, page 1, by Chong Yong-ch'ol, "At North Hwanghae Province: Power Plants Wherever the Water Flows", refers to power plants including the Yosonggang Power Plant in North Hwanghae Province, power plants in Yont'an and Unp'a County, a power plant in P'yongsan County, a power plant in Koksan County (on the stream of the same name), a plant at Taech'on-ri in Insan County, plants under construction in Singye and Yonsan Counties (Singye Power Plant No. 1, and Hwangdaech'on Power Plant, respectively, with the latter apparently in early construction phases, and the former more advanced). There is a reference to "power plant constructed at Holdong Mine".

12 The table below is from http://www.asiatradehub.com/n.korea/power.asp., "Asia Trade Hub: North Korea, Energy (Power)" The year to which these data apply was not recorded, but seems likely to be 2000 or shortly thereafter. The ultimate source of these data is unknown.

Hydraulic Power Plants

	Name	Location	Capacity (Unit: 10,000 kw)	Remarks
Eastern Region	Soedusoo	North Hamkyung	51	A valley-remodeling type
	The Huhchon River	South Hamkyung	39.4	"
	The Changjin River	"	38.1	"
	The Pujon River	"	26.2	"
	Anbyon Youth	Kangwon	10	A dam-type
	Soopung	North Pyongan	70	"
	Taechon	"	40	A valley-remodeling type and a dam type
Western Region	Woonbong	Jagang	40	A dam-type
	Wiwon	"	39	"
	Kanggye Youth	"	24.6	A valley-remodeling type
	The Daedong River	South Pyongan	20	A dam type
	Taepyongman	North Pyongan	19	"
	The Jangja River	Jagang	9	"
TOTAL of Above			426.3	

Thermal Power Plants

	Name	Location	Capacity (Unit: 10,000 kw)	Remarks
Eastern Region	Seonbong	North Hamkyung	20	
	Chongjin	Chongjin	15	
Western Region	Bukchang	South Pyongan	169	A condensed water type
	Pyongyang	Pyongyang	50	A combined heat type
	The Chongchon River	South Pyongan	20	"
	Soonchon	South Pyongan	20	"

13 Note from presentation by DPRK Delegation, "THE PROSPECT OF ELECTRICAL ENERGY DEVELOPMENT IN DPRK AND REGIONAL CO OPERATION IN NORTH EAST ASIA," September 31, 2003. From Nautilus Institute 3rd Workshop on Grid Interconnection in Vladivostok, Russia, September 31, 2003. "Puk Chang thermal power plant at center of electrical system of DPRK has capacity of 1,600,000 kW. All hydro plants connected to Puk Chang through 220kW network."

14 The table below (which has been edited slightly for clarity) was provided in the KERI presentations referenced in Note 1. It lists capacity in small and medium power plants, but notes that "effect of small power plant was not high". A trend toward construction of larger-capacity "medium" hydro plants is noted.

Units: kW

Category	As of 2000	2001	2002	2003	2004	2005	Total
Planned (number)	6,840	370	250	?	100	43	
Number Constructed (under construction)	6,615	98	40	30	10	48(18)	6,841(18)
Capacity (kW)	292,000	24,500	30,000	30,000	20,000	86,400	470900*
kW/unit	31	250	750	1,000	800	1,800	

*Total as shown in presentations appears to be incorrect. Actual total of values through 2005 is 482,900 kW

15 2006 source in Note 1 cites estimates of total DPRK (central station) generation in approxmately 2004 ranging from 16.3 TWh (KERI estimate, based on data provided by DPRK) to 20.4 (ROK government estimate). We feel that the former is likely closer to actual DPRK generation. The year 2010 source in Note 1 cites a range from 16.5 to 25.5 TWh for generation in approximately 2007-2008.

16 A source familiar with the DPRK energy sector suggests that about 3.9 GW of hydroelectric capacity was operable as of 2004, which is consistent with the estimate provided here.

17 Table below is from Some Thoughts on DPRK's Natural Geological Conditions and Their Evaluation - On the Distribution and Development of Hydropower Resources and the Electric Industry, by Professor Sagong Jun, Korea University in Japan, Available as http://www1.korea-np.co.jp/pk/112th_issue/99091601.htm

Hydraulic Resources in DPRK (II)

Name	GWh	(%)
Amrok (Yalu) River	39,635.00	47.9
Tumen River	8,134.61	9.5
Taedon River	7,508.17	9.1
Chongchon River	4,407.00	5.3
Rimjin River (north)	2,806.10	3.4
Pukhang River (north)	3,422.10	4.1
Resong River	701.34	0.8
Songchon River	1,675.00	2.0
Kumya River	1,617.17	2.0
Tanchonnam River	1,692.40	2.0
Orangchon River	1,451.80	1.8
Kiljunam River	7,670.80	0.9
TOTAL OF ABOVE	80,721.49	88.8

Units in original source given as "1,000,000 kwh", but apparently GWh is the intended unit.
Above corresponds to 9.21 *average GW of power.*

18 Li Dunqiu, in his presentation "DRPK's Reform & Sino-DPRK Economic Cooperation", as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA, and available as http://www.nautilus.org/DPRKEnergyMeeting/Papers/Li.ppt, notes the following power exchange project between China and the DPRK, presumably starting in 2005 or 2006:

"Jilin Province has reached "barter" agreement with DPRK, transmitting electricity to DPRK in exchange of exploitation rights of its Youth Copper Mine. The project has a total investment of 0.22 billion RMB and represents DPRK's typical experiment in exchanging electricity with mineral [resources]."

19 NK Economy Watch, in a compilation of recent news and other information releases describing recently completed or under-construction hydroelectric power plants in the DPRK, lists the following plants and units.

Summarized from a search of hydroelectric plant articles, the most recent of which (3/23/2011), is entitled "DPRK to sell carbon credits", and derived from http://www.nkeconwatch.com/2011/03/23/dprk-to-sell-carbon-credits/.

Eight power plants were included in a February, 2011 listing provided to the United Nations Framework Convention on Climate Change: as DPRK projects that might qualify for credits. No additional Information on size or other parameters were provided to the UNFCCC by the DPRK, though an earlier post quoted Bernhard Seliger, "the [Hanns Seidel] foundation's representative in South Korea, [as saying that] North Korea is initially looking at trying to get approval for three hydro power plants of 7-8 megawatts (MW)." We assume this means 7-8 MW each.

Selinger was also quoted as saying "We are talking about eight power plants, with the smallest size about 7.5 megawatts. These are not big projects but small or medium-sized projects," and that none of the projects had been completed.

Name/Location	Location/Google Earth Image	Notes
Stations on UNFCCC List of 2011		
Hamhung Hydropower Plant No.1		
Hamhung 20MW Hydropower Plant No. 2		
Kumya Hydropower Plant	39.574232°, 127.104736°; http://www.nkeconwatch.com/nk-uploads/Kumya-Dam-Construction.jpg	Under construction as of 2008
Paekdusan Songun Youth 14MW Hydropower Project No.2	See "Paektusan…" stations below	
Ryesonggang Hydropower Project No. 3		
Ryesonggang Hydropower Project No. 4		
Ryesonggang Hydropower Project No. 5		
Wonsangunmin 20MW Hydropower Project No. 1		Presumably Project #1 of the 4 Wonsan units below.
Other Stations Described in NK Economy Watch (reference above)		
Kumjingang Power Station	http://www.nkeconwatch.com/nk-uploads/Kumjin-River-Power-Stations.jpg	Started in 2000, complete as of 2011
Kumjingang Hungbong Youth Power Station	Hamju County, South Hamgyong Province	DPRK Economy Watch describes as under construction as of 2011, but "Korea is one" website (http://www.korea-is-one.org/spip.php?mot111), based on a KCNA report, describes plant as completed in April, 2005.
Kumjingang Kuchang Youth Power Station		Complete as of 2011
Wonsan Youth Power Stations No's. 1-4	http://www.nkeconwatch.com/nk-uploads/wonsan-youth-powerstations-3-2011.jpg.	Started construction in 2009. "These projects required the construction of both the Kuryong Reservoir and an appx 8.5 mile (13.69km) tunnel to link the hydro power stations with their power source". At least one unit ("Chungnyun") described as being complete in early 2009 (NK Today 298, 10/2009, No. 293, 8/2009)
Orangchon Power Station No. 1	http://www.nkeconwatch.com/nk-uploads/Orangchon-Power-Station.jpg	Begun by 2007, completed by 2011
Anbyon Youth Power Stations No's 1 & 2	38.954400°, 127.538912°, http://www.nkeconwatch.com/nk-uploads/Orangchon-Power-Station.jpg	Fed by 45 km tunnel from Imnam Reservoir.

Name/Location	Location/Google Earth Image	Notes
Stations on UNFCCC List of 2011		
Ryesonggang Youth Power Stations 1-6	38.367696°, 126.781096°, http://www.nkeconwatch.com/nk-uploads/Ryesonggang-Power-1-6Stations.jpg	Power station 1 completed 2007, #2 and #6 also complete, others presumaby under construction.
Paektusan Songun Youth Power Stations (1 and 2)	41.716931°, 128.786163°, http://www.nkeconwatch.com/nk-uploads/Paektusan-Power-Station-GE.jpg	Also probably called "Mt. Baekdu Military First Power Plant", mentioned as completed (at least one unit) in NK Today, 375, November 2010.
Pukchang Ryongsan Power Station	39.596238°, 126.266478°, http://www.nkeconwatch.com/nk-uploads/Pukchang-Ryongsan-Power-station.jpg	Construction began 2002, apparently continuing as of 2011
Huichon (also "Heecheon") Youth Power Stations (1 - 5). Capacity 300 MW (probably for units 1 or 1 and 2, but not clear)	Jagang Province, upper part of Chung-chun river	Completion of units 1 and 2 apparently scheduled for 2012, with units 3 - 5 scheduled for 2015 (NK Today #297, 9/2009). Armed forces units are heavily involved in construction, and locals residents, North Korean businesses, and Chinese trading companies operating in the DPRK have been asked to provide funds toward its construction (see, for example, NK Today, No. 291, 8/2009).
Other Stations Mentioned in 2007 - July 2011 Issues of North Korea Today		
Urang River Hydroelectric Dam	North Hamgyong Province	Unit 1 apparently complete at 60 MW as of 2007, Units 2-5 (total capacity 23 MW apparently started in 1988, restarted in 2008, and under construction as of 2011
Dae-Ryeng-Gang No. 2 Power plant	Taechun County	Power output down 40% from previous year due to problems with turbine and maintenance. Plant is apparently relatively small (NK Today No 285, 7.2009).
Stations Under Construction on Yalu River mentioned in NK Economy Watch, 4/4/2010, http://www.nkeconwatch.com/2010/04/04/dprk-prc-plan-two-more-yalu-river-dams		
Wangjianglou or Lintu	Yalu River near Jian, Jilin Province, China--see ***Note 25***	Each dam reportedly 40 MW, with planned annual output of 154 GWh (implying a capacity factor of about 44%), total cost of $160 M, apparently paid by China. How the output is to be shared is unclear. Construction apparently began in Spring of 2010, with completion planned for 2013. "The plants will each produce 154 million kilowatt-hours per year. The Wangjianglou dam is 397 metres long and 16 metres high, while Wenyue is 602.7 metres long and 15.5 metres high. They are 36 and 24 km from Ji'an, respectively and are 1.5 and 5.5 km from North Korean railway stations (Rinto린토 and Mun'ak 문악 – these are the Korean names of the dams)." Reference for quote: http://www.nkeconwatch.com/2010/04/04/dprk-prc-plan-two-more-yalu-river-dams/
Wenyue or Changchuan		

20 The following, from North Korea Today No.267 February 2009, describes coal supply to the Pyongyang power plant.

Ryongdae Coalmine in Sungchun City Fails to Supply the Pyongyang Thermoelectric Power Plant
Ryongdae Coal Mine, located in the Workers District, new Sungchun, in Sungchun County of South Pyongan Province, has been supplying its partial production to the Pyongyang Thermoelectric Power Plant. However, there has been a recent failure in supply, due to low productivity volume. The production level has dropped to about 27,000 MT a month. This coal mine had produced over 100,000 MT a month and about 1,000,000 MT a year.

At 500 *MW, and a capacity factor of* 75% *and with coal averaging* 23.35 *GJ/tonne, and an efficiency of* 21% *(all starting assumptions), the implied annual use of coal at the Pyongyang power plant would be* 2,412,086 *If the Ryongdae mine was the main supplier of coal to the Pyongyang plant, the information above implies that the average capacity factor was about* 31% *formerly, and now is about* 8.4%. *As it is unclear that this mine is the only source of coal for the Pyongyang plant, and as some of the coal for the plant goes to heat-only boilers, this calculation is incomplete, but it suggests that there is reason to show a decrease in power output for thermal plants through 2009.*

21 This calculation assumes that the average capacity factor for DPRK hydroelectric capacity in 2009, 2010, and 2014 was similar to that in 2008. In fact, it is clear that hydro output in the DPRK differs, at least in different areas of the DPRK, with the timing and amount of rainfall received (based on anecdotal information from a number of sources), but we have no specific information that would allow us to estimate how the relative hydroelectric output differed in the three years.

22 Several sources in Korean (including NODONG SINMUN, DPRK, 28 OCTOBER 2000, 3 and 8 NOVEMBER 2005, and 22 MAY 2006, and MINJU CHOSON, DPRK, 15 NOVEMBER 2005) refer to a 11 MW power plant called "THE NAEP'YONG NO. 2 ARMY-CIVILIAN HYDROELECTRIC POWERPLANT", in Sep'o County, Kwangwon Province. This plant appears to have begun operation in 2005 or so. It produces power for the Korean People's Army. Information from the photo below includes the following: RIVER BASIN -- 1,021 SQUARE KILOMETERS (SQ KM), MAXIMUM WATER LEVEL -- 177.5 M, EFFECTIVE FALL (hydraulic head) -- 28 m, MAXIMUM WATER CONSUMPTION -- 51.30 CUBIC M PER SECOND, DAM HEIGHT -- 31.30 M, LENGTH OF LEVEE, 41.58 m, *LENGTH OF IRON PIPE CONDUIT -- 83.00 m. Rainfall data from nearby counties suggest that rainfall in the area is 1.2 to 1.5 meters/yr, based on data from county observation stations.*

SOURCE: NODONG SINMUN, P'YONGYANG, NORTH KOREA, 8 NOVEMBER 2005.

23 The table below is from Enipedia, http://enipedia.tudelft.nl/wiki/North_Korea/Powerplants_Without_Power_Conversion_Units, "North Korea/Powerplants Without Power Conversion Units"
The year to which these data apply was not recorded, but the website lists "date last modified" as 2011.
The ultimate source of these data is unknown.

Powerplant	Owner	Fuel type	Output (MWh)
Pukchang Powerplant	Pukchang Thermal Plant Complex		5,017,987
Supung Dam Dprk Powerplant	Korea-china Hydroelec Power	Hydro	1,449,843
Pyongyang Powerplant	Pyongyang Power Plant		1,167,045
Kyosenko Powerplant	Ministry Of Power Industry		961,959
Unbong Powerplant	Korea-china Hydroelec Power	Hydro	920,535
Taechon Hydro Powerplant	Ministry Of Power Industry	Hydro	920,535
Hochon River Powerplant	Ministry Of Power Industry		906,727
Laohushao B Powerplant	Korea-china Hydroelec Power	Hydro	897,522
Wiwon Powerplant	Korea-china Hydroelec Power	Hydro	897,522
Changjin River Powerplant	Ministry Of Power Industry		880,262
Taechon Metal Works Powerplant	Taechon Metal Works		669,489
Pujon River Powerplant	Ministry Of Power Industry		598,348
Taepeungman Powerplant	Korea-china Hydroelec Power	Hydro	575,334
Chonchon River Powerplant	Chonchongang Power Plant		530,121
East Pyongyang Powerplant	Ministry Of Power Industry		516,762
Daedong River Powerplant	Ministry Of Power Industry		460,268
Kanggye Youth Powerplant	Ministry Of Power Industry		434,953
Sodusu (march 17)-1 Powerplant	Ministry Of Power Industry		414,241
Chongjin River Powerplant	Ministry Of Power Industry		390,449
Sodusu (march 17)-2 Powerplant	Ministry Of Power Industry		373,664
Sodusu (march 17)-3 Powerplant	Ministry Of Power Industry		345,201
Shoko Powerplant	Ministry Of Power Industry		331,393
Anbyon Youth Powerplant	Ministry Of Power Industry		230,134
Kokai Powerplant	Ministry Of Power Industry		220,928

Powerplant	Owner	Fuel type	Output (MWh)
Donro-gang Powerplant	Ministry Of Power Industry		207,120
Jangja River Powerplant	Ministry Of Power Industry		207,120
Fusenko Powerplant	Ministry Of Power Industry		180,931
Taechon Youth Hydro-3 Powerplant	Ministry Of Power Industry	Hydro	138,080
Taechon Youth Hydro-4 Powerplant	Ministry Of Power Industry	Hydro	138,080
December (nampo) Powerplant	Ministry Of Power Industry		127,642
Sonbong (unggi) Powerplant	Sonbong (unggi) Power Plant		121,512
Oranchon Powerplant	Ministry Of Power Industry		103,560
Bu-dzan-gan Powerplant	Ministry Of Power Industry		80,547
Mirimkapmun Powerplant	Ministry Of Power Industry		73,643
Pu-ryong Powerplant	Ministry Of Power Industry		59,605
Sunchon Vinalon Powerplant	Sunchon Vinalon Complex		51,080
Bongwhaskapum Powerplant	Ministry Of Power Industry		46,027
Hongnam Fertilizer Powerplant	Hongnam Fertilizer Plant		45,757
Anju Youth Powerplant	Ministry Of Power Industry		34,520
Eogidon Powerplant	Ministry Of Power Industry		34,520
Tongchun Powerplant	Ministry Of Power Industry		32,219
Kumgansan Powerplant	Ministry Of Power Industry		31,068
Heungman Powerplant	Ministry Of Power Industry		30,481
Dprk West Coast Refinery Powerplant	Dprk West Coast Refinery		27,816
Chunma (bui) Powerplant	Ministry Of Power Industry		27,616
Najungri Powerplant	Ministry Of Power Industry		27,616
Kilju Pulp Mill Powerplant	Kilju Pulp Mill		22,851
Chongjin Chemical Powerplant	Chongjin Chemical Fiber Plant		15,228
Songlim Powerplant	Ministry Of Power Industry		2,222
Unhi-ra Powerplant	Korea Peace Committee		27
SUM OF ABOVE			21,978,110

24 In a China CCTV-4 report on the DPRK drought in early 2012, the recently completed (meaning, probably, one of the units has been completed), Hu'ich'o'n Power Plant in Hu'ich'o'n City of Chagang Province, in the northwest part of the DPRK, was listed as having a design capacity of 300 *MW, and a design output of* 980 *GWh/yr. This implies a capacity factor of* 37.3% *, which is in the range of our assumptions for an average DPRK hydroelectric capacity factor. Reference: Beijing CCTV-4 in Chinese, 15 June, 2012.*

25 Photos on these powerplants from Google Maps, https://www.google.com/maps/@40.9002996,125.9717221,1087m/data=!3m1!1e3 for the Wenyue (or Changchuan) dam, and https://www.google.com/maps/@41.3799715,126.5166998,1473m/data=!3m1!1e3
Below probably Weiyuan (or Wiwon) Dam (South of/downriver from Ji'an, China)

Below probably Yunfeng dam (North of Ji'an, China)

Below probably Changchuan dam (North of Ji'an, China)

26 The Huichon power plant, which has a reported capacity of 300 *MW, was reportedly brought on line in April of 2012. The plant is one of several to be developed on the Chongchon River in Northern DPRK, and reportedly improved power supplies in Pyongyang in some periods. See "N. Korea completes new power plant to tackle energy shortage", Yonghap news agency, dated 2012/04/06 , available as http://english.yonhapnews.co.kr/northkorea/2012/04/06/47/0401000000AEN20120406001900315F.HTML. Numerous other articles about this plant exist, but few provide much information about its generation capacity. One blog post states "The dam is reported to be more than 300ft high and 1,800ft wide and capable of storing 850 million cubic metres of water.", but also suggests that it has a serious structural defect (Rich Lennon, May 24, 2013, availabe as https://www.facebook.com/DragonsParadox/posts/4975149101259, though other news stories make the same claim). Rainer (2014) also lists the capacity of the Huichon #2 power plant at 300 MW See http://www.univie.ac.at/koreanologie/fileadmin/user_upload/DigitalNK/Forschungsarbeit/Huichon.pdf. Multiple sources indicate that the drought in 2014 (and 2015) had a siginificant impact on hydroelectric output, but few source offer numerical estimates as to the as to the impact on output. One story, "North Korea Newsletter 368 (June 25, 2015) " by Yonghap News Agency, referencing a Reuters report, indicates that hydroelectric output in 2015 was affected as follows "Reuters reported on May 30 that many hydro power plants in North Korea have suspended operation, reducing the nation's power generation by half." (source, http://english.yonhapnews.co.kr/full/2015/06/24/49/1200000000AEN20150624007300325F.html). We assume that the drought has resulted a significant decrease in 2014 hydroelectric output. We assume that relative to 2008, hydro output in existing dams shared with China (along the Yalu river) decreased by* 20%, *and hydro output in other large and medium hydro plants is also reduced by* 20% *relative to 2008. For the Huichon #2 plant, we assume a capacity factor for 2014 of* 25%, *which is designed to take into account the impacts of the combination of the drought plus reported structural problems in reducing what would be an average 45-50% capacity factor for a DPRK hydroelectric plant. We also assume that a "normal year" output for medium-sized hydro plants added in 2006 through 2010 was about* 30%.

27 The following data describe the size and output of six hydroelectric plants registered with the United Nations Framework Convention on Climate Change (UNFCCC) as DPRK CDM projects. Data obtained from documents on the UNFCCC CDM website https://cdm.unfccc.int/Projects/projsearch.html.

			MWh Annual Net Generation							
Plant	First Operation	Capacity (MW)	2012	2013	2014	2015	2016	2017	Location	
Hamhung Hydro Power Plant #1	Dec-13	10	-	50	24,855	25,392	29,875	30,472	39°39′25′ N	127°15′01″ E
Kumya Hydropower Plant	Dec-13	7.5		48	16,256	17,394	19,462	14,909	39°34′22″N	127°07′08″E
PaekdusanSongun Youth 14 MW Hydropower Project No.2	10/1/2015	14	-	-	-	8,675	52,680	52,263	41°43′18″ N	128°50′15′ E
Ryesonggang Hydropower Plant No.4	11/28/2014	5	-	-	1,303	26,251	24,747	19,100	38°18′02″ N	126°31′42″ E
Ryesonggang Hydropower Plant No.5	11/30/2013	7.5	-	2,646	31,246	32,335	31,645	30,243	38°15′35″ N	126°29′41′ E
Ryesonggang Hydropower Plant No.3	10/11/2013	5	-	1,868	26,397	26,911	29,209	18,924	38°19′42″ N	126°34′03″ E
Totals		**49**	**-**	**4,612**	**100,056**	**136,958**	**187,617**	**165,911**		
Implied aggregate annual capacity factor (for plants while on line)				**29.77%**	**37.55%**	**40.61%**	**43.71%**	**38.65%**		

From the comparison of capacity factors in 2016 and 2017 un the data above, plus news of 2017 and 2018 (and 2019) drought in the DPRK (See, for example, IFRC (2019), "Information bulletin: DPR Korea: Drought and Food Insecurity", dated April 30, 2019, and available as https://reliefweb.int/sites/reliefweb.int/files/resources/IBDPRKDFI04302019.pdf), we assume that hydroelectic capacity factors were reduced in 2017 and 2018 by about 12% *for all hydro in the DPRK, relative to 2016.*

28 What appears to be a large hydroelectric project is underway at Tanchon, with groundbreaking in approximately 2017. Hamish MacDonald (2017), "North Korea begins work on major power station in Tanchon", NK News, dated May 19, 2017, available as https://www.nknews.org/2017/05/north-korea-begins-work-on-major-power-station-in-tanchon/?c=1529546145196
A report by the Korea Friends Association of the UK (on Facebook) as of March 2019 suggests that the project is "at 80 percent", presumably meaning 80 percent complete. See https://www.facebook.com/permalink.php?id=223522167739886&story_fbid=2124476950977722.

Following images from Google Earth, as of April 18, 2019. Coordinates of dam are approximately 40.804905, 128.448379, and length of dam is approximately 130 meters. As of the date of these images, it looks like the dam is complete or near complete, but that the impoundment behind the dam was not yet being filled.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29 Kangdong power station is reported by Sourcewatch (https://www.sourcewatch.org/index.php/Kangdong_power_station) to have been under construction since 2010-2011, but with little progress between 2013 and 2017. The plant does not yet appear to be operational, and based on the Google Maps image below, appears unlikely to have progressed much in recent months. The nominal capacity of the plant is listed as 300 MW.

Following images from Google Earth, as of June 28, 2019. Images are probably from winter of 2019. Coordinates are 39.0019936, 126.1619389. Image of this location in Google Maps as of 2/17/2020 appears identical to that below.

30 *See North Korea Economy Watch (2015 and 2016), "Some Huichon Power Stations go operational on Chongchon River", initial article quoting Rodong Sinmun (2015-11-9), with an undated update in approximately mid 2016.*
Available as https://www.nkeconwatch.com/2015/11/10/some-huichon-power-stations-go-operational-on-chongchon-river/.

There appear to be a number of power stations completed or under construction on the Chongchon river as of mid-2019. An example, from Google Earth, coordinates 40.0290466,126.1781053, appears below, and includes what appears to be a skating rink carved out of river ice, presumably for use by the residents of the adjacent city of Kuwollim. In an article entitled "Progress in North Korea's renewable energy production", dated February 15th, 2016, NK Economy Watch quoted the Institute for Far Eastern Studies as saying "...the recently constructed Chongchon power plant which took three years to complete and has a total output of 430,000 kW". Looking at the hydro plants on the Chongchon river, which seem to have modest head and relatively limited impoundments (thereby more "run-of-river" type plants), our guess is that even assuming this figure is intended to be a total for all 11 (or so) or the plants on the river, the estimate of capacity is likely to be an order of magnitute or so too high, perhaps as a result of a units reporting error. But we have no solid data on the capacity of these plants.


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31 NK Economy Watch (2016), "Uptick in North Korea's Renewable Energy Production", dated November 17th, 2016, and available as http://www.nkeconwatch.com/category/energy/damshydro/.

32 Industry About lists the capacity of the Wonsan #1 hydro plant as 40 MW. Available as https://www.industryabout.com/country-territories-3/2392-north-korea/hydro-energy/51250-wonsan-youth-1-hydro-power-plant.

33 The Business Times, in "Dark nights in power-starved North Korea", dated Oct 04, 2017, lists the rated capacity of Wonsan Hydro Plant # 5, quoting a DPRK engineer, as "...complex's total capacity is 60,000 kW/h, actual production is a fraction of that" and "We have normalised our production rate at 25,000 kilowatts per hour,' he told AFP - little more than 40 per cent.". The units appear incorrect, but assuming what is meant is 60 MW and 25 MW as an actual maximum output, it implies that the Wonsan plants have capacities on the order of a few tens of MW each.

34 CNN (2017), "Secret State A journey into the heart of North Korea", mentions the Wonsan #4 power plant as having been recently completed in Chapter 2 focusing on the city of Wonsan. Available as https://www.cnn.com/interactive/2017/09/asia/north-korea-secret-state/.

35 The report North Korea's Hydroelectric Power – Part I, by Peter Makowsky, Jenny Town and Samantha Pitz of 38 North, dated July 3, 2019 and available as https://www.38north.org/2019/07/hydropower070319/, provides images of a number of recent and under-construction DPRK hydroelectric plants. One of the largest, at about 70-80 meters tall and about 360 meters across, as measured using Google Earth Pro, is the Orangchon Power Station at the Phalhyang Dam on the Orangchon River, has reportedly been under construction since 1981, but has not been completed. A visit by Chairman Kim Jong Un apparently has increased the pace of construction. The images below, respectively for 5/2/2019 and 9/27/2019, are from Google Earth Pro, The later image shows significant additional construction completed, and the reservoir largely full. Water is coming out of the spillway at the top of the dam, and there appear to be spots of seepage lower on the dam, though it is hard to tell for certain. We assume that this power station was not yet on line as of 2019, and is not likely to be on line in 2020, although it does appear to be a priority project for the DPRK.


Orangchon Power Station, DPRK, Image As of 5/2/2019
Write a description for your map.
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Google Earth
Image © 2020 Maxar Technologies
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Orangchon Power Station, DPRK, Image As of 9/27/2019
Write a description for your map.
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Image © 2020 CNES / Airbus
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36 *The article "Samsu Power Plant fails to meet demand, frustrating local residents", by Mun Dong Hui, **Daily NK**, dated 2019.01.31, available as https://www.dailynk.com/english/samsu-power-plant-fails-to-meet-demand-frustrating-local-residents/, suggests that the Samsu plant near Hyesan, south of Mount Paektu, is not performing as designed, and has some leakage problems. The dam measures approximately 50 meters high and 550 meters long, based on measurements from Google Earth Pro. An image of the dam as of October 2018 is provided below (also from Google Earth Pro).*

37 *Another larger hydro project underway since about 2017 is the Tanchon River project, involving several power stations and dams, and large-scale transfer of water, some from other river basins, via a series of tunnels that in aggregate may be on the order of 100 km long. An official interviewed about the project by a DPRK publication described the overall capacity of the project as several hundred megawatts. The project is described in the* ***38 North*** *publication* ***North Korea's Hydroelectric Power – The Tanchon Power Station Project****, dated October 11, 2019, by Peter Makowsky, Jenny Town and Samantha Pitz, and available as https://www.38north.org/2019/10/hydropower101119/. One element of the project, the Sinhong dam, shown below, appears to be about 15-20 meters tall and 130 meters long, and is located at approximatly 40.805, 128.449. The Hochongang power station, with its associated incoming penstocks and substation, located at approxiately 40.782, 128.446, is also shown below.*


Hochongang Power Station, with associated penstocks and substation, part of the under-construction Tanchon hydroelectric sy
Write a description for your map.
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Image © 2020 Maxar Technologies
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35 *The report North Korea's Hydroelectric Power – Part II, by Peter Makowsky, Jenny Town and Samantha Pitz of 38 North, dated August 29, 2019 and available as https://www.38north.org/2019/08/hydropower082919/, provides images of a number of recent and under-construction DPRK hydroelectric plants in the small-medium size range, focusing on the" hydroelectric dams of the Jangja (Changja) and Taeryong Rivers" in the Northwest of the DPRK. This 38 North analysis includes four plants/dams on the Taeryong River, the Taechon power stations, built in 2004 and 2006, and approximately six dams on the Jangja River, which the authors describe as mostly constructed by 2009, except two of more recent vintage, and one that was still under construction as of February 2019, but appeared to be nearing operational status. Although no capacity figures for these dams are provided, we assume that the characterization of "small to medium" suggests that they are in the megawatts to low tens of megawatts capacity range.*

Data on District Heat Use from 2008 DPRK Census

The 2008 DPRK Census (D P R Korea 2008 Population Census National Report, Central Bureau of Statistics Pyongyang, DPR Korea, 2009, available as http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/North_Korea/Final%20national%20census%20report.pdf), includes a table (52) on heating energy use in the DPRK. This table suggests that in 2008, a total of 263,809 households used (presumably primarily) "Central or local heating system[s]". Over 99 percent of these were in urban areas, about 97 percent were in apartment buildings, and 99.2% were in Pyongyang. This suggests that as of 2008, about 7.37%, which seems consistent with both the assumptions above and a supposition that few themal central heating and/or power plants were built after 1990 (the construction of the East Pyongyang plant in the 1990s being a notable exception).

Assumptions for post-1990 District Heat (DH) Production Parameters

We assume generally that district heat production matches district heat usage, which is assumed similar to electricity availabilty in the Urban Residential and Public/Commercial sectors. Beyond that, assumptions related to district heat production are as follows. These assumptions follow the premise that infrastructure related to district heating, similar to electricity generation and T&D infrastructure, has continued to degrade in the years since 1990, but at a decreasing rate since about 2000, and has not been extended substantially over time. Post-2010, the capacity factor of district heating systems is assumed to rise slightly, with better coal availability, with a larger rise in 2017 as more coal is available at reduced prices due to coal export restrictions as a result of UNSC sanctions.

Parameter	1996	2000	2005	2008	2009	2010
District Heat distribution losses	18%	20%	21%	21%	21%	21%
Efficiency of heat-only boilers for DH	65%	62%	62%	62%	62%	62%
Fraction of fuel as HFO for heat-only boilers (assumes same as coal-fired electricity generation)	6.20%	28.36%	3.59%	8.92%	2.0%	2.0%
Capacity Factor of heat-only DH boilers relative to 1990 estimate	70%	35%	50%	45%	45%	45%
Implied gross heat output of heat-only DH boilers (GJ/yr)	1,710,419	855,210	1,221,728	1,099,555	1,099,555	1,099,555
Implied Coal input to heat-only DH boilers (GJ/yr)	2,468,266	988,181	1,899,846	1,615,353	1,737,563	1,738,007
Implied HFO input to heat-only DH boilers (GJ/yr)	163,148	391,189	70,683	158,123	35,913	35,470
Implied DH used from electricity generation boilers as a fraction of total fuel input	2.14%	5.41%	4.26%	4.83%	5.18%	5.69%
1990 --> 2.62%						

Parameter	2014	2015	2016	2017	2018	2019	2020
District Heat distribution losses	21%	21%	21%	21%	21%	21%	21%
Efficiency of heat-only boilers for DH	62%	62%	62%	62%	62%	62%	62%
Fraction of fuel as HFO for heat-only boilers (assumes same as coal-fired electricity generation)	1.8%	1.9%	1.9%	1.2%	1.9%	1.9%	2.8%
Capacity Factor of heat-only DH boilers relative to 1990 estimate	46%	47%	47%	50%	50%	50%	50%
Implied gross heat output of heat-only DH boilers (GJ/yr)	1,123,990	1,148,424	1,148,424	1,221,728	1,221,728	1,221,728	1,221,728
Implied Coal input to heat-only DH boilers (GJ/yr)	1,779,620	1,816,363	1,816,826	1,946,154	1,933,680	1,934,074	1,915,354
Implied HFO input to heat-only DH boilers (GJ/yr)	33,266	35,935	35,471	24,375	36,849	36,455	55,175
Implied DH used from electricity generation boilers as a fraction of total fuel input	2.97%	3.69%	3.65%	3.69%	4.80%	4.07%	10.52%

Workpapers—Energy Demand Sectors

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ESTiMATE OF DISTRICT HEATING USE

Prepared by David Von Hippel
Date Last Modified: 6/23/2020

District heating is used in several DPRK cities, but very little information is available with which to estimate the extent of district heating. The following estimate should therefore be regarded as very rough.

Size of existing heat-only boilers at Pyongyang Power Plant: 2 units at
(see Note 16 in "Electric--2000" worksheet in this workbook). 100 Gcal/hr rating (assumedly, heat output).
Or the equivalent of 7,330,368 GJ/yr (at full capacity for the entire year).

Total MWe of major thermal power plants described as "combined type": 1000 (rated capacity)
(see Note 12 in "Electric--2005_2008" worksheet in this workbook).
Total full-time equivalent months of heat production by both types of plants: 4 months/yr (Assumption)
Average ratio of heat output to electricity output in combine-type plants: 1 Assumption

Implied heat output (as of 1990) in Pyongyang Heat-only boilers: 2,443,456 GJ/yr.

Assuming a capacity factor of 75% for combined heat and power plants over the heating months above, useful
heat output produced by these plants in 1990 would be 7,884,000 GJ/yr.
This is the equivalent of 2.62% of the total heat input to coal-fired power plants in 1990.

Our estimate for the annual 1990 use of coal per urban household is 52.74 GJ/yr
Assuming that 90% of that is for space and water heat, and an average boiler efficiency of
55%, the implied heat delivered per household is 26.11 GJ/yr
Assuming an average rate of losses in district heating systems of 15%, the actual delivery of heat
from district heating boilers and combined heat and power systems would be 8,778,338 GJ/yr
This would be sufficient to supply 336,254 households, or approximately 13%
of Urban households in 1990.

District heat is also used in the Public/Commercial sector. In 1990, our estimate is that coal use for the pubic/commercial sector was
0.82 GJ per square meter, which, assuming that 90% of coal use
was for heating and water heating, and an average boiler efficiency of 60%, the implied heat delivered per
square meter of floorspace would be 0.44. At this rate, the output of the district heating and combined heat and
power plants would be enough to provide heat for 16,812,680 square meters of floorspace, or about
42% of the total estimated Public/Commercial floorspace in the DPRK, if all heat from these systems
were used in the Public/Commercial sectors.

We make the assumption that Public/Commercial space is somewhat more likely than residential space to be served by district heat,
since such space is more likely to be centrally located in a city. We therefore assume that 15% of
Public/Commercial heat demand was met by central heat-only boilers or district heating systems in 1990. This means that the
amount of heat used in the Public/Commercial sector was 2,644,289 GJ/yr of delivered heat, or
3,110,928 GJ/yr of heat at the generator, or 30.1% of heat produced for district heating systems would
be used in the Public/Commercial sector, meaning that 6,134,049 GJ/yr of heat was used in 1990 by the residential sector, or
enough for 234,964 households, or 8.755% of urban households.

We assume that the average efficiency of heat-only district heat boilers was 70% in 1990, and that those boilers were fueled
with 97.9% coal and 2.1% heavy fuel oil (used as a starter fuel) in that year.
These assumptions imply usage of 3,417,348 GJ of coal, and 73,304 GJ of heavy oil in 1990.

Data on District Heat Use from 2008 DPRK Census

The 2008 DPRK Census (D P R Korea 2008 Population Census National Report, Central Bureau of Statistics Pyongyang, DPR Korea, 2009, available as http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/North_Korea/Final%20national%20census%20report.pdf), includes a table (52) on heating energy use in the DPRK. This table suggests that in 2008, a total of 263,809 households used (presumably primarily) "Central or local heating system[s]". Over 99 percent of these were in urban areas, about 97 percent were in apartment buildings, and 99.2% were in Pyongyang. This suggests that as of 2008, about 7.37%, which seems consistent with both the assumptions above and a supposition that few themal central heating and/or power plants were built after 1990 (the construction of the East Pyongyang plant in the 1990s being a notable exception).

Assumptions for post-1990 District Heat (DH) Production Parameters

We assume generally that district heat production matches district heat usage, which is assumed similar to electricity availabilty in the Urban Residential and Public/Commercial sectors. Beyond that, assumptions related to district heat production are as follows. These assumptions follow the premise that infrastructure related to district heating, similar to electricity generation and T&D infrastructure, has continued to degrade in the years since 1990, but at a decreasing rate since about 2000, and has not been extended substantially over time. Post-2010, the capacity factor of district heating systems is assumed to rise slightly, with better coal availability, with a larger rise in 2017 as more coal is available at reduced prices due to coal export restrictions as a result of UNSC sanctions.

Parameter	1996	2000	2005	2008	2009	2010
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Efficiency of heat-only boilers for DH	65%	62%	62%	62%	62%	62%
Fraction of fuel as HFO for heat-only boilers (assumes same as coal-fired electricity generation)	6.20%	28.36%	3.59%	8.92%	2.0%	2.0%
Capacity Factor of heat-only DH boilers relative to 1990 estimate	70%	35%	50%	45%	45%	45%
Implied gross heat output of heat-only DH boilers (GJ/yr)	1,710,419	855,210	1,221,728	1,099,555	1,099,555	1,099,555
Implied Coal input to heat-only DH boilers (GJ/yr)	2,468,266	988,181	1,899,846	1,615,353	1,737,563	1,738,007
Implied HFO input to heat-only DH boilers (GJ/yr)	163,148	391,189	70,683	158,123	35,913	35,470
Implied DH used from electricity generation boilers as a fraction of total fuel input	2.14%	5.41%	4.26%	4.83%	5.18%	5.69%
1990 --> 2.62%						

Parameter	2014	2015	2016	2017	2018	2019	2020
District Heat distribution losses	21%	21%	21%	21%	21%	21%	21%
Efficiency of heat-only boilers for DH	62%	62%	62%	62%	62%	62%	62%
Fraction of fuel as HFO for heat-only boilers (assumes same as coal-fired electricity generation)	1.8%	1.9%	1.9%	1.2%	1.9%	1.9%	2.8%
Capacity Factor of heat-only DH boilers relative to 1990 estimate	46%	47%	47%	50%	50%	50%	50%
Implied gross heat output of heat-only DH boilers (GJ/yr)	1,123,990	1,148,424	1,148,424	1,221,728	1,221,728	1,221,728	1,221,728
Implied Coal input to heat-only DH boilers (GJ/yr)	1,779,620	1,816,363	1,816,826	1,946,154	1,933,680	1,934,074	1,915,354
Implied HFO input to heat-only DH boilers (GJ/yr)	33,266	35,935	35,471	24,375	36,849	36,455	55,175
Implied DH used from electricity generation boilers as a fraction of total fuel input	2.97%	3.69%	3.65%	3.69%	4.80%	4.80%	4.80%

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCE
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
INDUSTRIAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 12/14/2011

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

GENERAL ASSUMPTION:

DPRK Industrial processes assumed to be **10%** more energy intensive than in China when Chinese intensities are used, and **15%** more energy intensive than in Russia when Russian intensities are used

				Notes/Sources:
Coal Consumption, All Industries	6.72E+08			
All Coal Consumption: Iron and Steel				
Annual Steel Production:	6.00E+06	Te		*4, 49*
Coal Use intensity:	1.64	tce/Te Steel		*6*
Total Coal Use:	3.25E+08	GJ coal		
Coking Coal Consumption: Iron and Steel				
Coking Coal Use intensity:	0.79	tce/Te Steel		*5*
Conversion Factor:	29.3	GJ/tce		
Total Coking Coal Use:	1.5277E+08	GJ coal		
Other Coal Consumption: Iron and Steel				
Coal Use intensity:	0.85	tce/Te Steel		*45*
Conversion Factor:	29.3	GJ/tce		
Total Other Coal Use:	1.72E+08	GJ coal		
Coal Consumption: Cement				
Annual Cement Production:	1.10E+07	Te		*1, 48*
Coal/Oil Use intensity:	6.883	GJ/te clinker		*2*
Fraction of fuel needs by coal	90%			*46*
Total Coal Use:	6.81E+07	GJ/yr		
Coal Consumption: Fertilizers				
Annual Fertilizer Consumption:	6.00E+05	Te Nitrogen		*12*
Annual Fertilizer Imports	1.00E+05	Te Nitrogen		*43*
Annual Ammonia prod capacity	5.80E+05	te/yr		*30*
Annual Urea Production capacity	1.35E+06	te/yr		*30*
Ratio of Ammonia Mass to N	1.214			
Ratio of Urea Mass to N	2.50			
Capacity Utilization Factor	49%			
Estimated Ammonia Production	2.853E+05	te/yr		
Estimated Urea Production	6.626E+05	te/yr		
Total coal use/te NH_3	2	te/te		*29*
Fraction coal used as feedstock:	50%			
Conversion factor:	25.1	GJ/te		*29*
Coal Use, Ammonia Production	1.83E+07	GJ/yr for energy		*29*
Coal and Oil Use, Ammonia Production	1.83E+07	GJ/yr as feedstock		
Annual Superphosphate product.	2.466E+05	te		*35*
Fract. Phosphorus in Superphos.	44%			
Energy int., phosphorous prodn.	8.83	tce/te		*36*
Conversion Factor:	29.3	GJ/tce		
Total Coal Use, Superphos prodn.	5.70E+06	GJ/yr (net of elect. use)		*36*
Total Coal and Oil Use, fertilizer prodn.	1.83E+07	GJ/yr--non-energy feedstock		
Total Coal Use, Fertilizer Prod.	2.40E+07	GJ/yr--as fuel		
Coal Consumption: Other Chemicals				
Annual Carbide production:	3.50E+05	te (from coal, Hamhung)		*31*
Coal Use, carbide production:	0.96	te/te Ca Carbide		
Conversion factor:	25.1	GJ/te coal		*29*
Total Coal Use, Carbide Prod:	8.43E+06	GJ/yr		
Caustic Soda Production:	9.86E+04			*33*
Therm. En. Int., caustic soda prod.:	14.64	th GJ/te caustic soda		*44*
Boiler efficiency	60%	thermal GJ/tce		*Assumption*
Total Coal Use, caustic soda prod.:	2.77E+06	GJ/yr		
Total Coal Use, Unspec. Chem:				
Total Coal Use, Other Chem.:	1.12E+07	GJ/yr		

Coal Consumption: Pulp and Paper			
Paper production:	1.82E+05	Te	*7*
Wood Pulp/Unit Paper	0.85	Te/Te	*8*
Fraction of fuel needs by coal	50%		*10*
Ratio of fuel use to electr. use:	0.00106115	tce/kWh	*11*
Conversion factor:	29.3	GJ/tce	
Total Coal Use:	4.03E+06	GJ/yr	
Coal Consumption: Other Metals			
Zinc Production	1.70E+05	Te	*15*
Copper Production	2.90E+04	Te	*15*
Aluminum Production	2.10E+04	Te	*15*
Lead Production	8.40E+04	Te	*15*
Zinc Coal Use intensity:	2.47	tce/te	*27*
Copper Coal Use intensity:	1.705	tce/te	*17*
Aluminum Coal Use intensity:	1.916	tce/te	*16*
Lead Coal Use intensity:	2.693	tce/te	*20*
Coal Use, Zinc Production	4.20E+05	tce	
Coal Use, Copper Production	4.94E+04	tce	
Coal Use, Aluminum Production	4.02E+04	tce	
Coal Use, Lead Production	2.26E+05	tce	
Conversion factor:	29.3	GJ/tce	
Total Coal Use: Other Metals	2.37E+07	GJ	
Coal Consumption: Other Minerals			
Magnesia Production	1.00E+06	Te	*40*
Magnesia Production assumed Oil-based in 1990			
Coal Use, Other Minerals	0.00E+00		
Coal Consumption: Textiles			
Textile Production	5.20E+08	running meters	7
Average textile weight	2.47E-04	te/running meter	*21*
Coal use, printing and dyeing	4.39E-04	tce/running meter	*22*
Coal Use per unit "vinalon" fiber	7.04	te coal/te	*31*
Conversion factor:	25.104	GJ/te coal	29
Conversion factor:	29.3	GJ/tce	
Total Coal Use: Textiles	2.94E+07	GJ	
Coal Consumption: Building Materials			
Glass production in China, 1990	8.07E+07	Cases	*37*
Population of China, 1990	1.14E+09	People	*37*
Per Capita Glass prod., China	7.06E-02	Cases/Person	
DPRK Population, 1990	2.20E+07	People	*38*
Est. Glass production, DPRK	1.55E+06	Cases	
Coal Consumption Intensity/Case	30.85	kgce/case	*20*
Conversion factor:	29.3	GJ/tce	
Total Coal Use: Glass Production	1.40E+06	GJ/yr	
Brick Production in China, 1990	4.49E+11	Pieces	*37*
Per Capita Brick product., China	392	Pieces/Person	
Est. Brick production, DPRK	8630473192	Pieces	
Coal Consumption Intensity	2390	kgce/10,000 pieces	*39*
Total Coal Use:Brick Production	6.04E+07	GJ/yr	
Total Coal Cons., Bldg Materials.	6.20E+07	GJ/yr	
Coal Consumption: Non-specified Industry	1.25E+08	GJ/yr	*26*
Oil Consumption, Cement:			
Fraction of heat input provided by oil	10%		*46*
Heavy Fuel oil use, cement product.	7.57E+06	GJ/yr	
Oil Consumption, Fertilizers:			
See "Industry--96-on" and "Non-energy" worksheets for oil products use as Fertizer Feedstocks			

Oil Consumption, Other Minerals:			
Magnesia Production	1.00E+06	Te	*40*
Magnesia Fuel Use intensity:	12.6	GJ/te	*41*
Hvy Fuel Oil Use, Magnesia Prod.	1.26E+07	GJ	
Oil Consumption: Non-specified Ind. (Diesel):	3.05E+06	GJ	*Placeholder value*
Oil Consumption: Non-specified Ind. (Hvy Oil):	6.00E+05	GJ	*Placeholder value*
Oil Consumption, All Industries	2.38E+07	GJ	
Wood/Biomass Consumption: Pulp and Paper	4.03E+06	GJ *Complements coal consumption noted above*	
Wood Consumption: Non-specified Industry			
Fuelwood consumption	1.50E+05	cu.m.	*23*
Conversion Factor	1.50E+00	cu.m./te	*24*
Conversion Factor	1.60E+01	GJ/te	*24*
Total Fuelwood Consumption	1.60E+06	GJ	
Electricity Consumption, All Industries	7.02E+07		
Electricity Consumption: Iron and Steel			
Electricity Use intensity:	700.0	kWh/te crude steel	*47, 5*
Conversion Factor	3.60E-03	GJ/kWh	
Total Electricity Use:	1.74E+07	GJ/yr	
Electricity Consumption: Cement			
Electricity Use intensity:	100.0	kWh/te cement	*3*
Conversion Factor	3.60E-03	GJ/kWh	
Total Electricity Use:	4.36E+06	GJ/yr	
Electricity Consumption: Fertilizers			
Electricity Use intensity:	5.76	MWh/te Ammonium	*29*
Conversion Factor	3.60E+00	GJ/MWh	
Electricity Use, Ammonium Prod.	1.26E+07	GJ/yr	
Electricity Use intensity:	16.258	MWh/te phosphorous	*36*
Electricity Use, Superphos. Prod.	6.30E+06	GJ/yr	
Total Electricity Use:	1.89E+07	GJ/yr	
Electricity Consumption: Other Chemicals			
Elect. Use, Carbide production:	4571	kWh/te Ca Carbide	*31*
Conversion factor:	3.60E-03	GJ/kWh	
Total Elect. Use, Carbide Prod:	5.76E+06		
Elect. Use, Caustic Soda prod.:	2413	kWh/te	*32*
Total Elect., Caustic Soda Prod:	8.57E+05		
Total Elect. Use, Unspec. Chem:			
Total Elect. Use, Other Chem.:	6.62E+06		
Electricity Consumption: Pulp and Paper			
Electricity Use intensity:	1522	kWh/te pulp	*9*
Conversion Factor	3.60E-03	GJ/kWh	
Total Electricity Use:	9.32E+05	GJ/yr	
Electricity Consumption: Other Metals			
Zinc Elect. Use intensity:	3844	kWh/te	*28*
Copper Elect. Use intensity:	1240	kWh/te	*17*
Aluminum Elect. Use intensity:	16050	kWh/te	*18*
Lead Elect. Use intensity:	184.92	kWh/te	*28*
Elect. Use, Zinc Production	6.53E+08	kWh	
Elect. Use, Copper Production	3.60E+07	kWh	
Elect. Use, Aluminum Production	3.37E+08	kWh	
Elect. Use, Lead Production	1.55E+07	kWh	
Conversion factor:	3.60E-03	GJ/kWh	
Total Elect. Use: Other Metals	4.13E+06	GJ/yr	
Electricity Consumption: Other Minerals			
Magnesia Elect. Use intensity:	100.0	kWh/te Magnesia	*42*
Conversion Factor	3.60E-03	GJ/kWh	
Elect. Use, Magnesia Production	3.96E+05	GJ/yr	
Electricity Consumption: Textiles			
Elect. Use, Vinalon production	5400	kWh/te	*31*
Conversion factor:	3.60E-03	GJ/kWh	
Total Electricity Use: Textiles	2.50E+06	GJ/yr	
Electricity Consumption: Building Materials			
Electricity Int., Glass Production	30.81	kWh/case	*20*
Conversion factor:	3.60E-03	GJ/kWh	
Electricity Use: Glassmaking	1.72E+05	GJ/yr	
Total Elect. Use: Bldg. Materials	1.89E+05	GJ/yr	
Electricity Consumption: Non-specified Industry		1.4850E+07 GJ	*25*

Notes/Sources:

1 The National Report of DPRK to UNCED, 1992, lists 13.9 million tonnes cement output for 1990. See also note 48.

2 Based on document in authors' files [CE1]. which cites 1645 kcal/kg "clinker". This is somewhat higher than a figure given for the Chinese cement industry, but only about 5% higher than the 1980 average for Russian cement plants.

3 Approx 1981 fig., China "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL

4 Document in authors' files [IF1] lists a figure of 7 million tonne figure (as of 1989) for crude steel output.

5 1987 fig. for "Key, Medium, and Small" plants in China is 890 kWhe/te. Source: "The Energy Efficiency of the Steel Industry in China", M. Ross and L. Feng, Energy, 1991. Also see note 6.

6 Note that this figure is about 30% higher than 1987 Average Chinese energy intensities.

7 Economist Intelligence Unit, "China, North Korea Country Profile 1992-93", p.72 (Original Source, "Industry of the DPRK" by M. Trigubenko).

8 Approximation based on author's experience. Remainder of paper weight is chemicals and binders, such as clay.

9 Chinese 1985 value: "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL V. Kalashnikov (personal communication, 9/97) suggests that the Russian historical average for electricity use in papermaking is somewhat lower--671 kWh/te paper (not pulp) as of 1965. We use the Chinese value here.

10 Working assumption, no data. Rest of fuel would probably be wood-derived.

11 For Chinese plants, 1980. Sum of non-electric fuel use (mostly coal) per kWh electricity used. Source: China Energy Databook, 1992 Edition, page IV-30

12 Based on document in authors' files [HA1]. Figure is probably from 1989 or 1990, and is generally consistent with other estimates and official figures for fertilizer production and consumption.

13 Ammonia, med. plants, tot. energy use; and elect. gen. eff. From "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL. Figures are for 1981 Chinese plants.

14 Assumes all non-electric energy use is coal. Subtracts coal input to electric power plants from total energy use.

15 Economist Intelligence Unit, "China, North Korea Country Profile 1992-93", p.72 (Original Source, "Industry of the DPRK" by M. Trigubenko). Data for 1990.

16 For aluminum oxide production (not clear if per te AlOx or Al), China, 1990. [Chinese data compendium provided by J. Sinton], p. 2.

17 Coal use in copper refining, China, 1990, from [Chinese data compendium provided by J. Sinton], p. 2. 1980 Russian figure for electric intensity of copper production (V. Kalashnikov, personal communication, 9/97). Value is substantially higher (3-fold) than estimates for electricity use in copper production in China.

18 1980 Russian figure for electric intensity of aluminum production (V. Kalashnikov, personal communication, 9/97). 1981 China figure for electrolytic aluminum, DC use, (from "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL) is very similar.

19 Document in authors' files [HT1, p. 10]. Reference to oil use is assumed to be all use of refined products in nation.

20 Chinese language spreadsheet of energy intensities obtained from J.Sinton, dated Feb 12, 1993. 1980 data

21 Ratio of textile length to weight as implied by figures in Korea Foreign Trade Association, "Major Economic Indicators for North Korea, 1993". (Page 9).

22 1990 (?) figures for China. P. 23: Energy of China, 1993 (Chinese-lang. compendium provided by J. Sinton, LBL)

23 Industrial Fuelwood, from document in authors' files [TO1, p. 22]. Upper end of range (100 - 150 kte/yr).

24 From document in authors' files [FC1, p. 7]

25 Placeholder value to bring total industrial demand up to approximately 60% of total electricity consumption as estimated in document in authors' files [EP1].

26 Placeholder estimate to bring total industrial/electric generation coal consumption up to (approximately) 75% of coal available, as estimated in document in authors' files [EE1]

27 1980 figures for China, section 8-37 of Chinese language document (1991) provided by J. Sinton, LBL.

28 For zinc, uses Russian electric intensity value from 1980 (V. Kalashnikov, personal communication, 9/97). Zinc figure is about 30% higher than 1990's figures for China, page 369 of Chinese language document ("China Energy ____") (1994) provided by J. Sinton, LBL. Lead intensity figure is from the latter document. Includes electricity used in ore milling (c. 1/3 of total for lead).

29 Based on flow diagram for Hamhung Fertilizer Complex as presented in document in authors' files [HT1, Annex 8].
Assumes that all nitrogen fertilizer starts with ammonia production. Coal is assumed to have a calorific value of 6000 kcal/kg (as specified for Anthracite in Annex 7 of the same document). Electricity consumption is also based on the flow diagram, which shows a total of 200 MW of power input to the process that produces 250 kte/yr ammonia. 7200 operating hours per year assumed, as stated in Annex 7 for the vinalon plant in the same complex. Electricity use is assumed (based on the flow diagram) to also account for conversion of ammonia into other fertilizer products, such as urea.

30 Based on values in Annex 7 of document described in 29. Note that these production capacities are the sum of data provided for specific large complexes in DPRK, and thus probably represent most, but not all, of the productive capacity in the country.

31 Based on values for carbide and vinalon production from flow diagrams presented in Annex 7 of the document described in 29.

32 Chinese 1980 value: "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL

33 from document in authors' files [TX1: Annexure 1].

34 Electricity use in caustic soda (sodium hydroxide) production refining, China, 1990, from [Chinese data compendium provided by J. Sinton].

35 Based on values for superphosphate production from flow diagrams presented in Annex 7 of the document described in 29. Assumes productive capacity of 400 kte/yr at full capacity and actual operation 7200 hours/yr.

36 Assumes that superphosphate is produced from phosphorous, and that the energy/electricity intensities of phosphorous production is as noted in "Chinese Energy Conservation" (1993), a Chinese-language compendium provided by J. Sinton of LBL. This assumption probably overstates the energy use in manufacturing superphosphate.

37 Data on production of glass and bricks in China contained in spreadsheet provided by J.Sinton of LBL.

38 As in "Residential" spreadsheet in this Workbook.

39 Russian value for bricks for 1965 obtained from V. Kalashnikov (personal communication, 9/97). Used without inflator. 1980 value from China (Chinese language spreadsheet of energy intensities obtained from J.Sinton, dated Feb 12, 1993) gives an energy intensity slightly more than half of the 1965 Russian value. We do not know whether the Russian and Chinese bricks are the same size, but assume that DPRK bricks will more closely resemble Russian models.

40 Economist Intelligence Unit, "China, North Korea Country Profile 1992-93", p.72 (Original Source, Industry of the DPRK by M. Trigubenko). Magnesia is MgO, or magnesium oxide.

41 Rough of intensity from US Bureau of Mines publication as relayed by Ms. Deborah A. Kramer of the U.S. Geological Survey is 10 MMBtu/short ton. This estimate is on the same order of magnitude as the energy required to produce chemically similar calcium oxide from calcium carbonate. A separate estimate of DPRK magnesite fuel use intensity (personal communication [QR 9/97]) was slightly higher: 300 kg fuel oil/te. The latter figure was used.

42 Estimated to be similar to electricity requirements for production of cement "clinker" from limestone.

43 Estimated imports of nitrogen fertilizer in 1990. Assumed mostly from the (former) Soviet Union.

44 1980 Russian figure for thermal energy use (assumed to be as heat) in caustic soda production (V. Kalashnikov, personal communication, 9/97).

45 Rough estimate based on 1965 and 1980 Russian figures for coal use in iron making plus steelmaking. (V. Kalashnikov, personal communication, 9/97).

46 It has been reported that some fuel oil is used in cement production. The figure shown here is a guess on our part.

47 Based on 1965 and 1980 Russian figures for electric energy use in steelmaking (V. Kalashnikov, personal communication, 9/97).

48 Data from the Korean National Statistical Office and the Korea Cement Industrial Association suggest a considerably lower figure for DPRK cement output in 1990--6.13 million tonnes. Other sources place DPRK cement production at 10.1 million tonnes in 1986, 10 million tonnes in 1988 (the latter from the Economist Intelligence Unit, "China, North Korea Country Profile, 1992-93", p.79, Original Source, Mining Journal, Mining Annual Review, 1991), 4.75 million tonnes in 1992, 7.5 million tonnes in 1993, and 12 million tonnes in 1993. Of these, our subjective judgement is that the 7.5 million tonnes in 1993 figure may well be the best-informed of the group, and given the substantial decline in all industrial output in the DPRK between 1990 and 1993, we believe that a 1990 figure of about 11 million tonnes is a reasonable estimate.

49 Data from the Korea Iron & Steel Association suggests a considerably lower figure for DPRK steel output in 1990--3.36 million tonnes. Other sources place DPRK steel production at 5.8 million tonnes in 1993, 4.2 million tonnes in 1990, 5.1 million tonnes in 1990 (the latter from the Economist Intelligence Unit, "China, North Korea Country Profile, 1992-93", p.79, Original Source, Mining Journal, Mining Annual Review, 1991), 1.79 million tonnes in 1992, and 5.98 million tonnes in 1993. Of these, our subjective judgement is that a 1990 figure below the 7 million tonne figure cited in Note 4 (for 1989) is likely for 1990 (most observers suggest that 1989 was a peak year for industrial output in many subsectors), but that the Korea Iron and Steel Association figure is probably too low (or represents an incomplete count of output). We therefore adopt an estimate of 6.0 million tonnes of steel output in 1990 for the DPRK.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
INDUSTRIAL SECTOR ENERGY DEMAND IN 1996, 2000, 2005, 2008 THROUGH 2010, AND 2014 THROUGH 2020

Prepared By David Von Hippel
Date Last Modified: **6/23/2020**

ASSUMPTIONS FOR CHANGES IN INDUSTRIAL ENERGY USE, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020

	Production Relative to 1990							Energy Intensity Relative to 1990						
Subsector	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**
Iron and Steel ***(See Notes 1, 17, 22, 25)***	35%	18.05%	14.50%	14.5%	20.92%	21.32%	20.33%	110%	115%	112%	110%	103%	100%	100%
Cement ***(See Notes 2, 23, 24)***	40%	30%	32.0%	40.0%	55.69%	57.08%	60.68%	110%	115%	112%	110%	108%	105%	102%
---- fraction of heat from heavy oil	10%	26.9%	13.2%	9.5%	3.48%	5.02%	5.40%							
Fertilizers ***(See Note 3)***	24.68%	7.5%	11.2%	10.9%	7.2%	7.4%	22.54%	110%	115%	112%	110%	110%	110%	108%
Other Chemicals	30%	18.05%	18.05%	17.0%	15%	14.0%	11.0%	110%	115%	112%	110%	110%	110%	110%
Pulp and Paper	30%	18.05%	18.05%	17.0%	15.0%	14.5%	10.0%	110%	115%	112%	110%	110%	110%	110%
Other Metals ***(See Note 19)***	30%	18%	60%	62%	61%	58.0%	52.0%	110%	115%	112%	110%	110%	110%	110%
Other Minerals ***(See Note 18)***	30%	30.0%	50%	52%	50%	50.0%	50.0%	110%	115%	112%	110%	110%	108%	108%
---- fraction of heat from heavy oil	80%	80%	50%	43.0%	30.5%	35.0%	34.1%							
Textiles	30%	18%	20%	20%	17%	16.0%	12.0%	110%	115%	112%	110%	110%	110%	110%
Building Materials	30%	30%	30%	30%	30%	28.0%	22.0%	110%	115%	112%	110%	110%	110%	110%
Non-Specified Industry--non-oil fuels ***(See Note 20)***	33.00%	17.23%	15.14%	14.78%	11.45%	11.01%	8.00%	110%	115%	112%	110%	110%	110%	110%
Non-Specified Industry--diesel oil	20.0%	18.1%	24.7%	12.0%	13.8%	15.0%	10.0%	110%	115%	112%	110%	110%	110%	110%
Non-Specified Industry--heavy oil	30.0%	36.1%	28.0%	27.5%	24.5%	29.0%	27.9%	110%	115%	112%	110%	110%	108%	108%

	(See Notes 4, 27)													
	Production Relative to 1990							**Energy Intensity Relative to 1990**						
Subsector	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Iron and Steel ***(See Notes 1, 17, 22, 25, 27)***	17.983%	20.300%	18.167%	17.0%	17.0%	14.5%		100%	99%	100%	100%	100%	100%	
Cement ***(See Notes 2, 23, 24, 27)***	60.88%	64.34%	62.16%	58.0%	58.0%	46.0%		102%	100%	101%	101%	101%	101%	
---- fraction of heat from heavy oil	8.00%	8.7%	4.06%	4.93%	4.90%	8.49%								
Fertilizers ***(See Note 3)***	20.95%	23.98%	16.26%	9.10%	9.10%	4.55%		108%	107%	108%	108%	108%	108%	
Other Chemicals	11.0%	11.0%	11.0%	11.0%	11.0%	8.0%		110%	110%	110%	110%	110%	110%	
Pulp and Paper	10.0%	10.0%	10.0%	10.0%	10.0%	8.0%		110%	110%	110%	110%	110%	110%	
Other Metals ***(See Notes 19, 26)***	52.0%	52.0%	49.0%	49.0%	49.0%	37.0%		110%	109%	110%	110%	110%	110%	
Other Minerals ***(See Note 18, 26)***	50.0%	50.0%	45.0%	45.0%	45.0%	35.0%		108%	107%	108%	108%	108%	108%	
---- fraction of heat from heavy oil	37.1%	37.3%	20.0%	20.0%	20.0%	20.0%								
Textiles	12.0%	12.0%	11.0%	11.0%	11.0%	8.0%		110%	110%	110%	110%	110%	110%	
Building Materials	22.0%	22.0%	21.0%	23.0%	23.0%	16.0%		110%	110%	110%	110%	110%	110%	
Non-Specified Industry--non-oil fuels ***(See Note 20)***	8.0%	8.0%	8.5%	12.0%	12.0%	12.0%		110%	110%	110%	110%	110%	110%	
Non-Specified Industry--diesel oil	12.5%	14.0%	7.0%	7.0%	7.0%	7.0%		110%	110%	110%	110%	110%	110%	
Non-Specified Industry--heavy oil	23.0%	23.0%	14.8%	15.2%	15.2%	18.0%		108%	108%	108%	108%	108%	108%	

[Below is same as and linked to table above, but fomatted for reporting]

Subsector	**1996 Production Relative to 1990**	**2000 Production Relative to 1990**	**2005 Production Relative to 1990**	**2008 Production Relative to 1990**	**2009 Production Relative to 1990**	**2010 Production Relative to 1990**	**2014 Production Relative to 1990**	**2015 Production Relative to 1990**	**2016 Production Relative to 1990**	**2017 Production Relative to 1990**	**2018 Production Relative to 1990**	**2019 Production Relative to 1990**	**2020 Production Relative to 1990**
Iron and Steel	35%	18%	15%	15%	21%	21%	20%	18.0%	20.3%	18.2%	17.0%	17.0%	14.5%
Cement	40%	30%	32%	40%	56%	57%	61%	60.9%	64.3%	62.2%	58.0%	58.0%	46.0%
---- fraction of heat from heavy oil	10%	27%	13%	10%	3%	5%	5%	8.0%	8.7%	4.1%	4.9%	4.9%	8.5%
Fertilizers	25%	8%	11%	11%	7%	7%	23%	21.0%	24.0%	16.3%	9.1%	9.1%	4.6%
Other Chemicals	30%	18%	18%	17%	15%	14%	11%	11.0%	11.0%	11.0%	11.0%	11.0%	8.0%
Pulp and Paper	30%	18%	18%	17%	15%	15%	10%	10.0%	10.0%	10.0%	10.0%	10.0%	8.0%
Other Metals	30%	18%	60%	62%	61%	58%	52%	52.0%	52.0%	49.0%	49.0%	49.0%	37.0%
Other Minerals	30%	30%	50%	52%	50%	50%	50%	50.0%	50.0%	45.0%	45.0%	45.0%	35.0%
Textiles	30%	18%	20%	20%	17%	16%	12%	12.0%	12.0%	11.0%	11.0%	11.0%	8.0%
Building Materials	30%	30%	30%	30%	30%	28%	22%	22.0%	22.0%	21.0%	23.0%	23.0%	16.0%
Non-Specified Industry--non-oil fuels	33%	17%	15%	15%	11%	11%	8%	8.0%	8.0%	8.5%	12.0%	12.0%	12.0%
Non-Specified Industry--diesel oil	20%	18%	20%	12%	14%	15%	10%	12.5%	14.0%	7.0%	7.0%	7.0%	7.0%
Non-Specified Industry--heavy oil	30%	36%	28%	28%	25%	29%	28%	23.0%	23.0%	14.8%	15.2%	15.2%	18.0%
Non-Specified Industry--Electricity for Kaesong (GJ), See *Note 8* in "Electric-96-on" worksheet			2.62E+05	8.09E+05	8.26E+05	1.04E+06	1.26E+06	1.58E+06	1.93E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 www.koreascope.com, in "Production of Major Industrial Items and World Ranking" (visited 6/3/02), lists the ROK production of steel in 1999 as 41 million tonnes. In "Economic and Social Comparison between the Two Koreas", on the same WWW site, the ROK's steel production is listed as being 33 times that of the DPRK, implying an annual production of about 1.24 million tonnes. This figure, about 18 percent of 1990 production levels, seems plausible (though possibly high). A figure that is probably from the same ultimate source, the Korea Iron & Steel Association, suggests a value of 1.086 million tonnes in 2000, along with 1.208 million tonnes in 1996, and 1.168 million tonnes in 2005. It is unclear how these figures were derived. Based on consideration of existing estimates, observations of the overall DPRK economy, and trends in iron and steel products trade with China (see notes 13 through 17, below), we adopt iron and steel production estimates of 2.1 million tonnes in 1996, 1.08 million tonnes in 2000, and 0.87 million tonnes in 2005, describing a slow decline, in more recent years, in primary iron and steel production in the DPRK.

2 The source noted above, in the "Economic and Social…" page, lists a DPRK cement production of 4.1 million tonnes, or about 41 percent of year 1990 production, in 1999, which seems plausible. Data that are probably from the same ultimate source, the Korean National Statistical Office and the Korea Cement Industrial Association, suggest that year 2000 cement output was 4.6 million tonnes, output in 1996 was 3.79 million tonnes, and output in 2005 was 5.93 million tonnes. It is unclear how these numbers were derived, and though one would expect the cement industry to decline somewhat less than other industries, as it is/was not largely an export industry, the observed lack of recent construction activity in the DPRK would suggest that the level of 1996 to 2005 increase that the latter source shows is not what one would expect. We assume cement output of 4.4 million tonnes in 1996, 3.3 million tonnes in 2000, and 3.52 million tonnes in 2005, showing a trend of slightly increased construction-sector demand for cement (for example, for hydroelectric dams) in recent years in the DPRK.

3 *www.nis.go.kr/english/democratic/industry07.html, dated 2001, by the ROK National Intelligence Service, suggests that current supplies of fertilizer cover only 40 percent of fertilizer needs in the DPRK. Causes and Lessons of the "North Korean Food Crisis", by Tony Boys of Ibaraki Christian University Junior College (2000), lists total fertilizer supply in the DPRK in 1999 of 200 ktonnes of "NPK", of which 32% was produced domestically, 10% imported, and the remainder provided in aid. This would imply that about* 11% *of 1990 levels of fertilizer production were achieved in 1999. This document is available as "dprke.pdf" on the WWW. The same document shows total fertilizer availability of about* 170 *ktonnes in 1996. Assuming fertilizer aid at that time was minimal, and assuming fertilizer imports were approximately as in 1999, domestic fertilizer production in 1996 can be estimated at* 25% *of 1990 levels.*

As an alternative source, the presentation "Agriculture and Fertilizer Situation in DPR Korea", by R.V. Misra, available as http://www.fertilizer.org/ifa/publicat/PDF/2006_crossroads_misra_slides.pdf (from the International Fertilizer Industry Association), presented as part of the "IFA Crossroads ASIA-PACIFIC 2006 Conference 'Growing markets, nurturing success'", Chiangmai, Thailand, 13-16 November 2006, includes the graph at right. This suggests that 1999 production of fertilizer in the DPRK was 63 *thousand tonnes of nitrogen, which is roughly consistent with the level suggested in the article by Tony Boys that is quoted above. Assuming this figure is correct, we adopt Misra's 2000 fertilizer production figure of* 37.5 *thousand tonnes or nitrogen, or* 7.5% *of 1990 production levels. The analogous figure for 2005 is* 56 *thousand tonnes or nitrogen, or* 11.2% *of 1990 production levels. A companion paper by Misra available from the same source notes that of the* 362.8 *thousand tonnes of annual nitrogen fertilizer production capacity listed (see reproduction of Table 5 from that paper, below),* 27 *kte of capacity use a fuel-oil based fertilizer process, electrolysis is the basis for* 61 *kte of capacity and* 239 *kte of N fertilzer capacity use "coal and naptha" as feedstocks. No information is provided on the relative proportions of these inputs, or on the relative capacity factors typical for the different production complexes. The same paper quotes an estimated energy intensity of fertilzer output of* 50 *GJ/te N to produce ammonia, and an additional* 25 *GJ/te N to produce urea. Which fuels these estimates include are not specified, but these estimates seem reasonably consistent with the estimates we have used for 1990 energy consumption in the fertilizer subsector.*

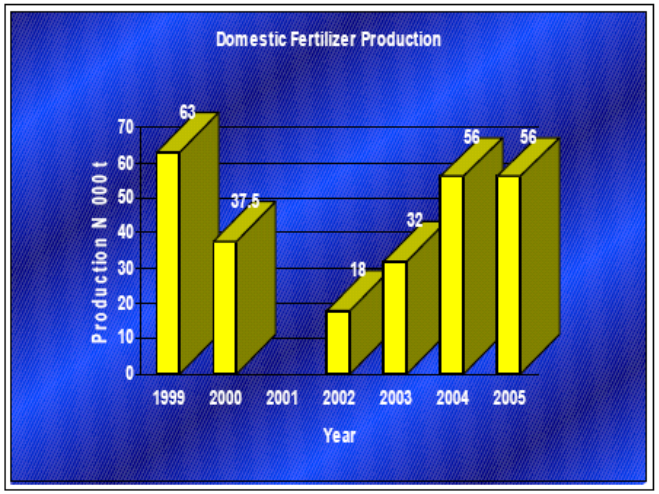


Table 5. Nitrogen Fertilizer Production Units and their Capacity

Production Unit	Product	Capacity ('000 t)	
		Product	Nutrient (N)
Hungnam	Urea	170	78
	Ammonium Nitrate	180	61
	Ammonium Sulphate	170	35
Namhueng	Urea	360	161
	Ammonium Sulphate	4	0.8
July 7 Chemical Complex, Undok	Ammonium Nitrate	80	27

On the basis of these data, and largely as placeholder values, we assume that 5% *of (non-energy) fertilizer feedstocks are heavy oil (in 1990 and beyond), and* 20% *are naptha, relative to the reported coal used as feedstock (at 1 te per tonne ammonia produced). Consumption of these feedstocks is reported in the "non-energy" sheet in this workbook. At this level, the naptha use in the fertilizer sector is still less than half of the 220,000 tonnes of naptha reportedly used in the industrial sector as a whole in 1990 in the report State of the Environment DPR Korea 2003 (Table 3.14) prepared by the DPRK with UNDP, and published by the United Nations Environment Programme. Other figures in the same table, however, appear somewhat overstated relative, at least, to our estimates for 1990.*

For 2008 and 2009 (and 2010), estimates of fertilizer production were obtained from UN Food and Agriculture Organization and World Food Program (2010), SPECIAL REPORT: FAO/WFP CROP AND FOOD SECURITY ASSESSMENT MISSION TO THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA, dated 16 November 2010, and available as URL http://www.fao.org/docrep/013/al968e/al968e00.pdf. The estimate is derived from data in Table 2 of that document (see below).

Table 2: DPRK - Fertilizer statistics for 2008-2010 (tonnes)

	Year	Domestic production	Import	Assistance	Stock from previous year	Application	Remaining stock
N (amm. sulph. equivalent)	2010	174 350	274 580	24 670	3 000	475 100	1 500
	2009	170 090	266 817		900	434 807	3 000
	2008	256 800	180 500	657	1 400	438 457	900
P	2010	11 402				11 402	
	2009	2 776				2 776	
	2008	7 425				7 425	
K	2010	12 314				12 314	
	2009	8 400				8 400	
	2008	10 415				10 415	
Total (N, P, K)	**2010**					**498 816**	
	2009					**445 983**	
	2008					**456 297**	

The most recent update to the above report that was identified as of 1/2016 is UN Food and Agriculture Organization and World Food Program (2013), SPECIAL REPORT: FAO/WFP CROP AND FOOD SECURITY ASSESSMENT MISSION TO THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA, dated 28 November 2013, and available as http://www.fao.org/docrep/019/aq118e/aq118e.pdf. Table 2 of that report reads as follows:

Table 2. DPRK - Fertilizer statistics for 2008-2012 (tonnes)

	Year (August to July)	Application	Domestic production	Import/ Assistance	Stocks	Remaining stocks
N (ammonium sulphate equivalent, approx. 20.5% N)	2013	686,015				
	2012	686,517	202,931	483,586	3,000	3,000
	2011	735,943	189,335	548,108	1,500	3,000
	2010	475,100	174,350	299,250	3,000	1,500
	2009	434,807	170,090	266,817	900	3,000
	2008	438,457	256,800	181,157	1,400	900

Although we could not find, as of this writing, direct information on fertilizer production in the DPRK in 2014, the trends in the table above suggest increasing domestic output, which is consistent with DPRK announcements and the results of a 38 North *analysis ("North Korea's Namhung Youth Chemical Complex: Seven Years of Construction Pays Off", by Joseph S. Bermudez Jr., dated 10 April 2014, and available as http://38north.org/2014/04/jbermudez041014/) that notes increases in fertilizer production in recent years. Coupled with this, imports of nitrogeneous fertilizer from China have declined in recent years, based on information from the UN COMTRADE database as shown below. (The DPRK does imports fertilizer from other countries, but the quantities imported are very small compared with imports from China.)*

The UN FAO document ***GIEWS Update:The Democratic People's Republic of Korea, Food Supply and Demand Outlook in 2017/18 (November/October)****, dated 9 July 2018, and avaialble as http://www.fao.org/3/ca0363en/CA0363EN.pdf, citing DPRK government sources, includes the following table describing recent DPRK fertilizer use:*

Table 1: Democratic People's Republic of Korea - Fertilizer statistics *(tonnes)*

Year	N (ammonium sulphate equivalent, approx. 20.5 % N)	P (superphosphate equivalent, approx. 17% P2O5)	K (KCl-muriate of potash, 48-62%K2O)	Total
Avg *(5-yrs)*	678 180	16 663	6 683	701 526
2016	837 171	11 911	930	850 012
2017	599 017	10 776	2 343	612 136

Source: Ministry of Agriculture (MoA)

For earlier years, the UN FAO document ***GIEWS Update:The Democratic People's Republic of Korea, Food Supply and Demand Outlook in 2015/16 (November/October)****, dated 27 April 2016, and avaialble as http://www.fao.org/3/a-i5572e.pdf, citing DPRK government sources, includes the following table describing DPRK fertilizer use from 2009 thorugh 2015:*

Table 3: DPRK - Fertilizer statistics for 2009-2015 (tonnes)

	N (ammonium sulphate equivalent, approx. 20.5 % N)	P (superphosphate equivalent, approx. 17% P2O5)	K (KCl-muriate of potash, 48-62%K2O)	Total
2015	612 194	7 817	2 595	622 606
2014	727 993	18 977	2 700	749 670
2013	686 015	18 396	2 788	707 199
2012	686 517	21 460	18 650	726 627
2011	735 943	5 545	4 477	745 965
2010	475 100	11 402	12 314	498 816
2009	434 807	2 776	8 400	445 983

Source: Ministry of Agriculture (MoA)

Year	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Imports of Nitrogen fertilizers from China, tonnes	*284,307*	*350,641*	*237,679*	*189,944*	*131,786*	67,381	146,364	117,471	252,690	-	-
Imports of Nitrogen fertilizers from China, value (thousand USD)	$ *40,872*	$ 94,188	$ 62,757	$ 54,514	$ 28,839	$17,926	$ 33,114	$ 28,757	$ 80,744	$ -	$ -
Imports of Nitrogen fertilizers from China, implied $/tonne	$ 144	$ 269	$ 264	$ 287	$ 219	$ 266	$ 226	$ 245	$ 320	#DIV/0!	#DIV/0!
Imports of Urea from China, tonnes	45,075	*95,749*	44,718	117,333	72,501	56,781	140,872	110,155	237,387	-	-
Imports of Ammonium Sulphate from China, tonnes	239,167	254,892	192,945	72,577	59,265	10,580	5,491	7,316	15,303	-	-
Implied total Ammoniium sulphate equivalent tonnes	324,255	435,638	277,360	294,068	196,126	117,766	271,418	215,258	463,422	-	-

The quantities of nitrogen fertilizer shown imply the following domestic production (quantities in thousand tonnes):

Year	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Nitrogen fertilizer as Ammonium Sulphate	256.8	*170.09*	*174.35*	189.335	202.931	391.95	531.87	494.43	565.75	383.76	214.76	214.76	107.38
Nitrogen fertilizer as N	*54.42*	*36.04*	*36.94*	*40.12*	*43.00*	*83.05*	*112.70*	*104.77*	*119.88*	*81.32*	*45.51*	*45.51*	*22.75*
Fraction of 1990 Production	*10.9%*	*7.2%*	*7.4%*	*8.0%*	*8.6%*	*16.6%*	*22.5%*	*21.0%*	*24.0%*	*16.3%*	*9.1%*	*9.1%*	*4.6%*
Fraction of $(NH_4)_2SO_4$ as N			21.2%										
Fraction of Urea as N			*40.0%*										

The relative energy intensity for domestic production of fertilizer is reduced slightly in 2014 through 2017 relative to 2010 to reflect the improvements in the Namhung Chemical Complex reported as above.

One source, "North Korea's largest fertilizer plant reportedly shut down", by Benjamin Katzeff Silberstein for NK Economy Watch, dated November 6th, 2019, available as part of https://www.nkeconwatch.com/category/agriculture/, suggests that persistent problems in DPRK fertilizer factories were continuing as of early 2019.

An article in Daily NK "N. Korea's largest fertilizer complex no longer operational: Sources report that up to 70% of the complex's workers have been reassigned to other work", available as https://www.dailynk.com/english/north-korea-largest-fertilizer-plant-no-longer-operational/, suggests that DPRK fertilizer production must have fallen significantly at least in 2018.

Lacking specific estimates of fertilizer production or use in the DPRK in 2018, we assume that overall fertilizer supplies were about the same in 2018 as in the "five-year average" reported in 2018 in the UN FAO GIEWS report, but given that imports of fertilizer from China were much higher in 2018 than in 2017, implied domestic fertilizer production must have been much lower. This assumption is used to estimate the figures for 2018 production provided in the table above.

No Comtrade data were available for fertilizer trades involving the DPRK in 2019 as of 4/20/20. We assume that fertilizer trades and output in that year were similar to the total estimates for 2018 pending receipt of additionsl data. For 2020, we assume that the restrictions on trade and movement within the DPRK will result in a reduction of both imports of fertilizer and domestic fertilizer production of about 50% percent. This assumes that fertilizer imports *and production are likely deemed crucial, and thus continued to the degree possible, but the combination of domestic and Chinese restrictions due to the pandemic still significantly affected fertilizer provision.*

4 With the exception of "Other Minerals" and "Building Materials", we assume that the level of activity in other industries relative to 1990 in the year 2000 is approximately the same as in the iron and steel sector. The building materials and other minerals subsectors are assumed to have activities relative to 1990 similar to the cement industry. The other minerals subsector includes magnesite (or, when processed like lime for cement, magnesia), which is a valuable export product. An industry source indicates that an 8000 tonne shipment of magnesia (although it may have been magnesite) arrived in Europe in early 2001. Japan imported $3.5 million worth of magnesia in the first half of 2000 (Korea Trade-Investment Promotion Agency data from http://www.kotra.or.kr/main/common_bbs, visited 6/3/02, "Trade Tendencies of the Major Countries"), which, if annualized and assuming a sales price of $US 100 to $200 per tonne (within the range suggested in Queensland Department of Minerals and Energy Mineral Information Leaflet No 5: MAGNESITE, dated January 1998, suggests exports of 35 to 70 thousand tonnes to Japan alone, which in turn suggests relatively active production of the mineral. On our trip to the DPRK in October of 2000 we saw working brick or tile production facilities, some of the very few active industrial facilities we saw during our time in the DPRK. For 2005, with the exception of the subsectors treated explicitly in other notes, we assume that the generally-percieved modest upturn in the DPRK economy has translated in into a small increase, relative to 2000, in activity and energy use in industry, for example, in the cement, building materials, and textiles subsectors, though the upturn in the latter may be mostly due to garment assembly on commission, rather than the much more energy-intensive manufacturing of cloth. We increase non-oil fuels in "unspecified industry" more than other categories to reflect the probable increase in demand for electricity, and also some coal, from development of export-oriented light industry. A Bank of Korea estimate placed the production of cement in the DPRK at 5.6 million tonnes in 2004, which is considerably higher than the 4.1 million tonnes we use for 2000. We assume, in part reflecting information in Note 5, below, that the Bank of Korea figure is probably an over-estimate for 2005.

5 The document Seoul T'ongil Kyongje, dated August 2000, pages 39-48, article by Hong Sun-chik entitled "North Korean Industry (Part II): Cement Industry", suggests that cement output in 1998 was 3.15 million tonnes, but grew substantially in 1999. The capacity factor of DPRK factories was 26.2 percent in 1998, compared with 51 percent in 1990. The article lists a year-2000 capacity of 12.01 *million tonnes, of which 96.3 percent was in the 10 largest factories. The DPRK had 49 kilns, and the average capacity of 0.25 million tonnes each was less than one quarter the average capacity of kilns in the ROK. The article cite DPRK limestone reserves of about 100 billion tonnes. The article references a year-2000 source listing the Ch'onnae-ri Cement plant with "Annual production of 1.1 Million tonnes, the largest on the East Coast". In a discussion of cement quality, the article says that cement made in the DPRK is lower in quality (due to poorer quality control, kiln breakdown due to oil shortages, and lack of input supplies) than ROK cement, but that DPRK cement is similar in quality and price to Chinese cement. Problems in the Cement industry listed in the article include outdated production facilities, with automated facilities in use for only about one sixth of kilns, poor cement quality (due in part to lack of fuels, which prevent kilns from being operated normally), lack of paper for packaging of cement products (leading to difficulties in exporting cement), the presence of wastes in the cement, and "an inefficient use that causes environmental pollution".*

6 The document Seoul T'ongil Kyongje, dated December 2000, pages 36-44, is an article by Hong Sun-chik entitled "North Korean Industries (Part V): Automobile Industry". This article notes a new plant in Nampo, opening 9/2000, to "modif[y] imported secondhand automobiles", with a planned second phase to assemble Fiats. In the 1970s, the DPRK developed production lines for 2.5-, 10-, and 25-tonne trucks. The article states that "most of the key parts that require elector-circuit systems and precision processing such as cylinder heads and starter motors are imported" due to problems with the quality of domestically-produced parts. Although a 90 percent "self-sufficieny rate" is claimed by the DPRK, the author estimates a rate under 60% is more likely. 1999 auto production capacity in the DPRK was estimated at 33,000 units, with production of 7,300 that year. The Sungni Motor General Plant accounts for 80 percent of the DPRK's output of cars and trucks. Starting in 1995, this factory began producing a diesel-fueled passenger car to try and shift transport fuel consumption to lower-cost diesel oil (and away from gasoline). This transition is also (as of 2000) being undertaken for new 2.5-tonne trucks (gasoline-to-diesel). The article contains an estimate that 70 to 90 percent of cars being used in Pyongyang are imported. The article estimates that the DPRK's domestic automobile demand is 20,000 to 30,000 units per year, of which passenger cars account for 30-40 percent. Engines have been imported from Japan, the Czech Republic, and other countries since 1988.

7 China Customs Statistics reported imports of television sets to the DPRK from China increased approximately five-fold, on average, between 1998-2000 and 2003-2005. Televisions (HS #8528) were the number one import in the "electrical equipment" category for the DPRK during the latter years, at an average of about 400,000 sets per year. At the same time, imports to the DPRK from China of the rare earth metal Yttrium (HS # 2846) , which is used in making phosphors for televisions, declined from about 55 tonnes in the mid-1990s to zero by 2000 and 2005. China was (as of the mid-1990s) by far the world leader in production of Yttrium (see http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/741397.pdf). The increase in television imports from China, and the decrease in Yttrium imports, is circumstantial evidence of (though, admittedly, hardly proof of) a decline in the DPRK appliance sector since the mid-1990s. Import data as compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf.

8 Many of the top imports to the DPRK from China, by value, in 2005 in the Machinery (HS # 84) category appear to be tools related to mines, mining, or the mineral industry. These include minerals sorting devices, compressors and pumps (air and liquid), bulldozers and related self-propelled equipment, furnaces, derricks, and cranes. These purchases would appear to point to an upturn in the DPRK metals and minerals subsector (or perhaps an upturn to come in the next few years). In most of these categories, purchases increased significantly in recent years. In the "machinery" category overall, the DPRK's imports from China nearly doubled (in reported value) between 2004 and 2005. Source same as cited in note 7, above.

9 Imports of plastics and plastic goods to the DPRK from China, by weight, in 2005 in the Plastics (HS # 39) category were over 45,000 tonnes, which was an increase of more than 50 percent over year 2004 imports, and about four-fold higher than plastics imports in the mid-1990s. This may indicate a combination of a decline in the DPRK's capacity to produce plastics domestically, plus an increase in the demand for plastic goods, particularly as the non-state economy began to develop. Source same as cited in note 7, above.

10 Imports of iron and steel products (for example, rolled steel and steel bar, not finished goods--"Iron and Steel", HS # 72 category) to the DPRK from China, by weight, averaged about 57,000 tonnes per year from 2003 through 2005. This was an increase of more than 4-fold over 1995-1997 imports, and may indicate a combination of a decline in the DPRK's capacity to produce such products domestically. Source same as cited in note 7, above
A similar pattern exists for finished iron and steel goods ("Iron and Steel Products", HS #73), where year 2005 imports from China (at about 25,000 tonnes) were significantly higher than in previous years, and about five-fold higher than the approximately 4000 - 6000 tonnes level of imports of these goods that prevailed from 1995 through 1999.
Among these products, the DPRK imported over 24,000 tonnes of railway track (HS# 7302) in both 2001 and 2005, far more than imports in other years. Likewise, imports of inorganic chemicals (HS # 28), at about 50,000 tonnes in 2005, were over 50% higher than in 2003 and 2004, and about 3 times imports in the mid-1990s. Aluminum oxides and carbonates (HS# 2818 and 2836, respectively) made up almost 40,000 of the total imports by the DPRK from China in this category in 2005.

11 Similar to the pattern noted in 10, above, Imports of aluminum and aluminum products (HS # 76 category) to the DPRK from China, by weight, averaged about 57,000 tonnes per year from 2003 through 2005 (see data below). This was an increase of about 5-fold over 1995-1997 imports, and, similar to the iron and steel sector, may indicate a combination of a decline in the DPRK's capacity to produce such products domestically.
The most commonly imported products in this category, by weight, were "bar, rod, profiles", "other structures", "plate, sheet, strip > 0.2 mm thick", "household articles", and "foil =< 0.22 mm thick (except backing)" (?).
Imports of aluminum "tubes and pipes" (HS # 7608) were just under 19 tonnes in 2005.
Source same as cited in note 7, above.

	2003	2004	2005	
76 ALUMINUM	1,655	2,286	4,285	*Quantity: tonnes*

12 In 2005, the DPRK exported to China somewhat under 4700 tonnes of lead (HS # 78) and over 9300 tonnes of Zinc and zinc products (HS # 79). Lead exports from the DPRK to China were recorded as zero in 2003 and 2004 (or, possibly, not recorded), but varied from about 1200 to 4200 tonnes per year from 1995 through 2002. Zinc/zinc products exports were much higher in 2004--about 35,000 tonnes, and also higher--about 15,500 tonnes--in 2003.
Source same as cited in note 7, above.

13 In 2003 - 2005, the DPRK exported to China the quantities of ores (HS # 26) noted below.
Only selected ore exports are shown (largely, top exports by volume). Many ore exports to China showed large increases in 2005, and also between the late 1990s and 2005.
Exports from the DPRK to China of 90.54 tonnes of "Uranium, Thorium Ore and Concentrate" was listed for the year 2004, but Uranium exports from the DPRK to China are not listed for other years between 1995 and 2005.
Source same as cited in note 7, above.

Description	HS #	2003	2004	2005	
IRON ORES+CONCENTRATE	2601	270,854	937,159	1,320,458	*Units: Tonnes*
ZINC ORES+CONCENTRATE	2608	5,242	16,109	30,389	
PRECIOUS METAL ORES+C	2616	55,788	60,007	-	
MOLYBDENUM ORE+CONCEN	2613	230	384	619	
LEAD ORES+CONCENTRATE	2607	20,608	14,301	14,090	
COPPER ORES+CONCENTRA	2603	7,298	6,987	7,856	
TUNGSTEN ORE+CONCEN	2611	398	542	1,252	
OT WASTE MANU IRN/STL	2619	-	568	7,169	
OTHER ORES AND CONCENTRATES	2617	-	2	2,962	

14 In 2003 - 2005, the DPRK exported to China the quantities of iron and steel products (HS # 72) noted below. Only selected exports are shown (largely, top exports by volume). Exports to China in this category also, overall, showed large increases between the late 1990s and 2005, particularly in scap exports. In addition to the quantities noted above, smaller amounts of iron and steel products (about 1100 tonnes in 2003, but only 82 and 87 tonnes in 2004 and 2005, respectively) were imported to Hong Kong from the DPRK. Source same as cited in note 7, above.

Description	HS #	2003	2004	2005	
FERROUS WASTE,SCRAP;O	7204	221,719	275,687	358,293	*Units: Tonnes*
PIG IRON,SPIEGELEISEN	7201	118,874	155,377	98,060	
SEMIFINSH IRON,NONAST	7207	69,183	47,767	47,538	
FERROALLOYS	7202	3,318	6,139	9,843	
PRIMARY FORMS,NT 7203	7206	8,084	4,677	2,042	
BAR,ROD,H ROLLD,I/NAS	7214	738	2,485	798	

15 From 1995 - 2005, the DPRK exported to China small quantities of finished iron and steel products (HS # 73) in quantities ranging, by year, from near zero to about 800 tonnes. The largest single year's export of a single product was 707 tonnes of railway track in 2004. Source same as cited in note 7, above.

16 Since 1998, the DPRK has exported to China less than a million USD per year of goods in "machinery" category (HS # 84.) Exports for 1998 and for several other years in the late 1990s were higher, by value. Source same as cited in note 7, above.

17 The data on trade in iron ore and iron and steel goods between China and the DPRK, as described in notes 10, 13, and 14 above, suggest a pattern whereby the DPRK (and/or Chinese businesses operating in the DPRK) are focusing on exporting increasing amounts of raw materials (ore, scrap) from the DPRK to China, and increasing imports of finished and semi-finished iron and steel products into the DPRK from China. Based on this pattern and on reports (and our own observations) of the continued decline of DPRK heavy industry, we assume a continued reduction in output of iron and steel and iron and steel products in the DPRK between 2000 and 2005.

18 Dr. Chung Woo-jin, in his presentation entitled "Mineral Resources in DPRK", as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA), and available as http://www.nautilus.org/DPRKEnergyMeeting/Papers/Chung.ppt. lists 2004 DPRK output of Magnesite of 1 million tonnes, the same as in 1990. What is not known is what fraction of that output might have been simply exported as a raw ore (and thus not processed to Magnesia), and what fraction might of ore processing was fueled with heavy oil versus coal. We make the assumption, for the year 2005, that about 50% *of magnesite was processed to Magnesia, and about* 50% *of the fuel input for that processing was provided by heavy fuel oil (the rest being provided by coal).*

19 In the presentation referenced above, Dr. Chung provides estimates of the production of lead and zinc metal (ingots) in 2004 in the DPRK at levels of 60 *and* 100 *kte, respectively, or about* 71% and 59% *of 1990 output. Copper ingot production was estimated by Dr. Chung at* 13 kte, or 45% of 1990 output as *estimated. The heavy imports of aluminum products (at levels well beyond even the reported output of aluminum in 1990) from China into the DPRK, as reported in Note 11, above, suggest that domestic DPRK production of aluminum in 2005 could have been low (which would also be consistent with electricity shortage, as aluminum manufacture is quite electricity-intensive). Based on these data, we estimate a rough average activity for the overall "other metals" subsector for 2005 at* 60% of 1990 levels.

20 Anecdotal and fragmented evidence of activity in industrial installations include: The Wonsan shipyard has not built a new ship since 1985, and struggles in even repair work due to deteriorated equipment, with only 1/6th of the original workforce even reporting. The "6.4 Wonsan Vehicle Factory" has ceased manufacturing trains due to a shortage of raw materials and electricity, and now occasionally repairs trains, but also makes doors for buildings its reporting workforce about 1/6th of 1990 levels (North Korea Today, No. 298, 10/2009).
NK Today No. 291 (8/2009) report "[p]roduction Rate below Thirty Percent at Lanam Mine Machinery Factory in Chungjin", *despite the pressure of a "150-day battle campaign" (national productivity push).*
Low output (due to lack of electricity and food) at the Duksa Coal Mine (producing "low heat anthracite coal") of Soodong District idled clothing, shoe, and "market" factories in Hamheung, which used to receive 1000 te/month from the mine. NK Today, No.268 March 2009.

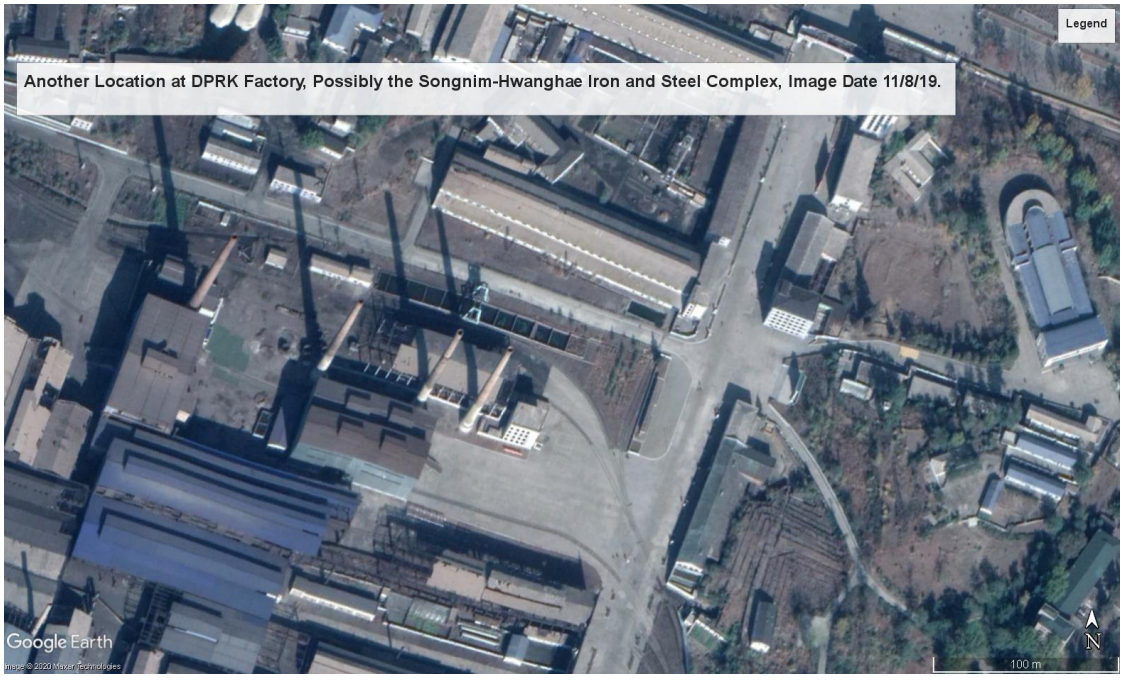
21 A piece in North Korea Today (No.263 January 2009) suggests that DPRK fertilizer output was on the order of 300,000 te, though the units (tonnes of N or of fertilizer in total, for example) of fertilizer output were not specified. Assuming this is a figure for total fertilizer output, it is reasonably consistent with the 2008 value shown in Note 3, above.

22 Quoting the Bank of Korea, the Website "Trading Economics" (https://tradingeconomics.com/north-korea/steel-production) quotes the following figures for DPRK steel production over the years (thousand tonnes): Web page "North Korea Steel Production". In all probability, these figures are rough estimates, but we use them as figures of merit to scale energy use in the DPRK iron and steel industry. Figures for 2018 were not available from this source as of 2/2020.

Year	Thousand tonnes
2009	1255
2010	1279
2011	1225
2012	1222
2013	1210
2014	1220
2015	1079
2016	1218
2017	1090

The following Google Earth Pro images are of a factory, possibly the Songnim-Hwanghae Iron and Steel Complex, along the Taedong River between Nampo and Pyongyang. The image was taken in November, 2019. Coordinates are approximately 38.737, 125.634. An active smokestack is visible in the upper left part of the image, along with a coal port and coal storage, and storage of what appears to be iron and/or steel products at the lower left, near the river.


DPRK Factory, Possibly the Songnim-Hwanghae Iron and Steel Complex, Image Date 11/8/19
Google Earth
Image © 2020 Maxar Technologies
Image © 2020 CNES / Airbus


Legend
Another Location at DPRK Factory, Possibly the Songnim-Hwanghae Iron and Steel Complex, Image Date 11/8/19.
Google Earth
N
100 m

23 Quoting the Bank of Korea, the Website "Trading Economics" (https://tradingeconomics.com/north-korea/cement-production) quotes the following figures for DPRK cement production over the years (thousand tonnes): Web page "North Korea Cement Production". In all probability, these figures are rough estimates, but we use them as figures of merit to scale energy use in the DPRK cement industry. Fractions of heat from heavy oil are estimates used to balance overall heavy fuel oil supply and demand. As of February 2020, this source did not yet include an estimate for cement output in 2018, thus we assume output in 2018 was somewhat lower than in 2017 as a result of the general economic slowdown induced by UNSC sanctions. Although most of the inputs To the DPRK cement industry, with the possible exception of spare parts, are likely of domestic origin (coal, limestone, silica), it seems probable that overall cement use would have declned in 2018 due to a reduction in construction as sanctions affected other industries and the economy in general.

Year	Thousand tonnes
2009	6126
2010	6279
2011	6452
2012	6446
2013	6600
2014	6675
2015	6697
2016	7077
2017	6838

The table that follows, from https://www.cemnet.com/global-cement-report/country/north-korea, provides a listing of 10 cement plants in the DPRK.

Company Name	Facility Name	City
Korea Building Materials Trading Corp.	618 Cement Plant	
Korea Building Materials Trading Corp.	August 2	Changang
Korea Building Materials Trading Corp.	Chonnae-ri	Chonnae
Korea Building Materials Trading Corp.	February 8	Madong
Korea Building Materials Trading Corp.	Haeju	Haeju
Korea Building Materials Trading Corp.	Kyongnam	
Korea Building Materials Trading Corp.	Puraesan	Puraesan
Korea Building Materials Trading Corp.	Sangwon	Pyongyang
Korea Building Materials Trading Corp.	Sunchon	Sunchon
Kumusan Cement Factory	Kumusan	Komusan

The Sangwon Plant listed above, located South and East of Pyongyang, is shown in the Google Maps image below (rough coordinates, 38.876890, 126.036658. What we assume to be limestone is supplied to this plant from a set of mines a few kilometers away, as shown in the second Google Maps image below (coordinates 38.867119, 126.091016). It is unclear why this mine is labeled "Steel Mine" in the image.


Steel Mine
3D
Google
Imagery ©2020 CNES / Airbus, Imagery ©2020 CNES / Airbus, Maxar Technologies, NSPO 2020 / Spot Image, Map data ©2020
United States
Terms
Send feedback
100 m

An image of the Haeju plant listed above follows, from Google Earth Pro. Image date is March, 2018.

24 A summary of UN Comtrade data on cement (HS 2523) trade between the DPRK and other nations follows. Over time, the DPRK appears to have transitioned from being mostly a net exporter fo cement to being mostly a net importer, one explanation for which is that its output is not sufficient to meet domestic demand. Another possibility is that it imports mostly grades of cement that it cannot manufacture. In any case, the volumes of trade are only a few percent, in general, of estimated DPRK cement output, so it is probably difficult to read too much into these statistics.

Unit:Tonnes

	DPRK Imports from		DPRK Exports to	
Year	China	Other Nations	China	Other Nations
1990	-	30	-	232,295
1996	320	30	4,617	340
2000	20,213	7,999	-	1
2001	9,818	7,161	3,565	49,858
2002	20,907	10,375	1,266	-
2003	20,760	13,022	2,791	27,728
2004	20,725	11,907	3,411	89,510
2005	38,710	5,000	658	54,760
2006	52,638	3,799	-	32,879
2007	86,491	57	680	141,796
2008	70,129	-	-	141,796
2009	61,960	4	-	76,360
2010	127,900	1,647	-	162,055
2011	311,562	758	-	184,320
2012	185,921	1,354	182	-
2013	135,527	14,225	-	-
2014	173,221	3,705	-	62
2015	301,407	2,336	0	40,120
2016	228,104	485	-	337
2017	77,372	0	17,836	-
2018	102,454	-	12,907	-

25 A summary of UN Comtrade data on "roasted iron pyrite" (HS 2601) and "unroasted iron pyrite" (HS 2502) follows. Most trades were with China, except as indicated. Volumes of reported exports to China, except for 2018 (due to UNSC sanctions), are comparable in some years (in iron content) to estimated steel production, indicating that these trades account for an important fraction of DPRK iron ore production.

Unit:Tonnes

	DPRK Imports from		DPRK Exports to		
Year	China	Other Nations	China	Other Nations	
2000		4,790,478	48,855		Imports from Brazil and India. The former may be a reporting error.
2005		125,040	1,385,350		Imports from South Africa
2008		1,420,701	1,898,057		Imports from South Africa
2009		1,222,187	1,816,017		Imports from South Africa
2010		2,065,704	2,095,565		Imports from South Africa (most) and Brazil
2011		1,164,633	2,507,309		Imports from South Africa
2012			2,435,330		
2013			3,093,323		
2014			2,832,114		
2015			1,544,353		
2016			1,638,186		
2017		75,888	1,659,773		Imports from India
2018		108,504	456		Imports from India

26 Our understanding is that since the advent of the COVID-19 lockdown measures have gone into effect in the DPRK, the output of some mines, and, we assume the metals and other minerals refining facilities that they feed, have been affected by reduced access to spare parts and other inputs. As a result, we assume that output of these products in the DPRK will have fallen by on the order of a fifth to a third in 2020, relative to 2019, by the time that 2020 is over, with the reduction in output more pronounced in the first half of the year.

27 We assume that since the advent of the COVID-19 lockdown measures have gone into effect in the DPRK, the output of most industries in 2020 has been constrained by a combination of a lack of spare parts, workers staying at home (or sick, although little if any information has been made available as to the impact of COVID-19 on the DPRK population), reduced markets for goods, and other factors. Similarly, we assume that as a result of UNSC sanctions, DPRK output in 2018 and 2019 in most industries was somewhat lower than in previous years, due to reduced access to foreign markets and foreign inputs, although some output may have been redirected to the domestic market.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

BACK-UP CALCULATIONS AND DATA: TRANSPORTATION SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 2/25/2011

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

GENERAL ASSUMPTION:

DPRK transport assumed to be **20%** more energy intensive than in China or Russia

				Notes/Sources:
Oil Use: Road Vehicles				
Freight Transported:	4.20E+07	te		1
Average Distance of transport	75	km	Guess	
Energy Intensity, Diesel Trucks	3.08	MJ/te-km		19
Fract Freight on Diesel Trucks	23.93%		Guess	
Diesel Use, Road Freight	2.32E+06	GJ		
Energy Intensity, Gasoline Trucks	5.77	MJ/te-km		19
Fract Freight on Gasoline Trucks	71.5%		Guess	
Gasoline Use, Road Freight	1.30E+07	GJ		
Total Road Freight Oil Use	1.84E+07	GJ		
Number of Civilian Autos in Use	15,500			11
Average km traveled/yr	8,500		Guess	
Efficiency, Civilian Autos	1.10E+01	km/liter gasoline		11
Conversion factor	0.0325	GJ/liter		
Gasoline Use, Civilian Autos	3.896E+05	GJ		
Economically Active Population	1.38E+07			3
Per capita Trips/yr	300		Guess	
Average Trip Distance	16	km	Guess	
Fract. Trips by Motor Transport	25%		Guess	
Fraction of Trips by Road	30%			10
Fraction of km in Diesel Veh.	50%		Guess	
Energy Intensity, Diesel Oil Transport	75	kgce/kpass-km		4
Conversion Factor	0.0293	GJ/kgce		
Total Passenger Road Diesel Use	5.47E+06	GJ		
Fraction of km in Gasoline Veh.	50%		Guess	
Energy Intensity, Gasoline Transport	98.2	kgce/kpass-km		4
Total Passenger Road Gas Use	7.16E+06	GJ		
Total Oil Use, Pass Vehicles	1.42E+07	GJ		
Total Oil Use, Road Vehicles	3.26E+07	GJ		
Biomass Use, Road Vehicles				
Fract Freight on Biomass-fueled Trucks	4.60%			14
Efficiency of biomass trucks relative to gasoline		50%		13
Biomass use, road freight	1.67E+06	GJ		
Oil Use: Rail Transport				
Freight Transported:	1.69E+08	te		1
Fraction of Freight on Diesel Rail	12.5%			10
Average Distance of transport	250	km	Guess	
Energy Intensity, Diesel Rail	10.5	kgce/kte-km		18
Conversion Factor	0.0293	GJ/kgce		
Total Rail Freight Oil Use	1.95E+06	GJ		
Oil Use: Water Transport				
Freight Transported:	1.80E+07	te		1
Average Distance of transport	200	km	Guess	
Energy Intensity, Diesel/Heavy Fuel Oil Ships	9.9	kgce/kte-km		5
Conversion Factor	0.0293	GJ/kgce		
Total Ship Oil Use	1.25E+06	GJ		
Fraction of Ship Oil Use as Heavy Fuel Oil	50%		Guess	
Total Diesel Oil Use in Ships	6.27E+05			
Total Heavy Oil Use in Ships	6.27E+05			

Oil Use: Air Transport				
Number of Planes (Total)	24			*8*
Number of Planes that are Tu-154 jets	3			*16*
Average Number of Seats/Plane (non-jets)	50			*15, 16*
Average Airspeed During Operation (non-jets)	500	km/hr		*15*
Average Number of Seats/Plane (jets)	166			*15*
Average Airspeed During Operation (jets)	900	km/hr		*15*
Annual Operating Hrs/plane-yr--non-jets	300		*Guess*	
Annual Operating Hrs/plane-yr--jets	750		*Guess*	
Implied total seat-km per year	4.94E+08			
Average Fraction of Seats Occupied	75%		*Guess*	
Implied Air Passenger-km	3.70E+08			
Fuel use per hour (An-24s)	3582	liters/hr		*12*
Fuel use per hour (Tu-154s)	5073	liters/hr		*17*
Conversion factor	0.0321	GJ/liter gasoline		
Conversion factor	0.0350	GJ/liter jet fuel		
Total Domestic Air Aviation Gasoline Use	7.24E+05	GJ		
Total Domestic Air Jet Fuel Use	3.99E+05	GJ		
Total Domestic Oil Products Use	1.12E+06	GJ		
Implied Intensity, all planes	3.03E-03	GJ/passenger-km		
International Aviat. Fuel Supplied by DPRK		0 GJ	*Guess*	
Total Air Transport Oil Use	1.12E+06	GJ		
Oil Use: Non-Specified Transport	1.00E+06	GJ	*Placeholder value*	
Electricity Use: Rail Transport				
Fraction of Freight on Electr. Rail	87.5%			
Average Distance of transport	300	km	*Guess*	
Energy Intensity, Electric Rail	28.6	kWh/kte-km		*18*
Conversion Factor	0.0036	GJ/kWh		
Total Rail Freight Elect Use	5.48E+06	GJ		
Fract. pass. Transp on Elect Rail	70%			
Energy Intensity, Electric Rail	13.2	kgce/kpass-km		*7*
Conversion Factor	0.0293	GJ/kgce		
Total Pass. Rail Elect Use	5.39E+06	GJ		
Total Electricity Use, Rail Transp.	1.09E+07	GJ		
Coal Use: Rail Transport	0	GJ		
Coal Use: Water Transport	0	GJ		
Electricity Use, Non-specified Transport	6.00E+05	GJ	*Placeholder value*	

Notes:

1 Estimated Freight transported. Korea Foreign Trade Association, "Major Economic Indicators for North Korea, 1993". Page 34.

2 Chinese 4-ton truck, "CA-10B", c. 1985, from [Chinese data compendium provided by J. Sinton], p.2.

3 Korea Foreign Trade Association, "Major Economic Indicators for North Korea", page 9.

4 For Pass. Vehicles. From: "Energy and Transport in China" in "Energy Markets and the Future of Energy Demand", LBL, 1988. Chinese data for 1985. Probably high for DPRK.

5 Per 1000 net te-km. From: "Energy and Transport in China" in "Energy Markets and the Future of Energy Demand", LBL, 1988. Chinese data for 1985. Probably a bit low for DPRK.
Russian (1970s) energy intensities for ships fueled with heavy oil are very similar to the Chinese value used.
Russian intensities for marine diesel-fueled ships are lower (about 7 kgce/kte) than the value used, but Russian intensities for inland waterways shipping are higher, about 13 kgce/kte. Russian intensities from V. Kalashnikov (personal communication, 9/97).

6 Electric generation efficiency, China, 1981. From "Physical Intensity of Selected Industrial Products" Spreadsheet printout from J. Sinton, LBL.

7 Very rough estimate based on US value for 1989 for commuter rail. From D. Gordon, Steering a New Course: Transportation, Energy, and the Environment, 1991, p.33. NK fuel efficiency is probably lower than US but passenger-km per seat is probably much higher.

8 Korea Foreign Trade Association, "Major Economic Indicators for North Korea", page 37.

9 Rough estimate: DPRK planes assumed to be twice as energy intensive per seat mile as US commercial commuter airlines in 1989 (US data from reference 7).

10 Economist Intelligence Unit, "China, North Korea Country Profile 1992-93"

11 Estimate by recent visitors of cars in Pyongyang, including 4000 Volvo sedans (of which 3000 are operable), and assuming five years worth of imports of approximately 2500 vehicles per year (used, from Japan, also from former East Bloc). Fuel economy assumed to average 25 miles/gallon.
Other observers estimate less than 10,000 autos total as of approximately 1990.

12 Fuel use and airspeed is as estimated cor An-24 in Aircraft spreadsheet of Military Energy Use workbook.

13 Assumes that efficiency of gasification of biomass for use as motor fuel is about 50 percent.

14 One observer reports that "most trucks outside Pyongyang are fueled with biomass". Other observers, on the other hand, report few or no biomass trucks in use. We assume 5 percent for 1990.

15 Assumes (based on source 16) that planes that are not jets are An-24s. These are reported to carry 48 to 52 passengers (World-wide Web site "Turkish World Russian Aircraft", http://www.rz.uni.franfurt.de/~puersuen/tac.htm).

16 Federal Research Division, US Library of Congress (1993), North Korea, A Country Study, edited by Andrea M. Savada.

17 Assumes Tu-154s, with a range of 5500 km (source 15) have a fuel capacity similar to that of the Boeing 727 (31,000 liters--data from World-wide Web site http://boeing.com/bck_html/Boe727.html), an aircraft similar in size (the 727 is a few percent lighter) and configuration to the Tu-154.

18 Based on energy intensity of Russian rail freight in the 1970s (V. Kalashnikov, personal communication, 9/97).

19 Based on energy intensity of Russian road freight in the 1970s (V. Kalashnikov, personal communication, 9/97). Note that these values are substantially higher (in the case of gasoline trucks, by a factor of 2) than published Chinese values (for example, see note 2).

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
TRANSPORT SECTOR ENERGY DEMAND IN 1996, 2000, 2005, 2008 THROUGH 2010, AND 2014 THROUGH 2020

Prepared By David Von Hippel
Date Last Modified: **6/26/2020**

ASSUMPTIONS FOR CHANGES IN TRANSPORT ENERGY USE, 1996, 2000, 2005, AND 2008 THROUGH 2010, and 2014 through 2017

(See Note 5 for Assumptions for 2000) ***Sources/Notes:***

Population Growth Rate through 2000:	**0.08%**	/yr ***(See Note 20 in "Residential" worksheet)***	
Econ. Active. Population Growth Rate 2000-2008:	**1.02%**	/yr	*(See Note 22 in "Residential" worksheet)*
Econ. Active. Population Growth Rate 2008-2010:	**0.54%**	/yr	
Econ. Active. Population Growth Rate 2010-2014:	**0.50%**	/yr	
Econ. Active. Population Growth Rate after 2014:	**0.39%**	/yr	

	1996	2000	2005	2008	2009	2010	
Economically Active population relative to 1990:	100.5%	100.5%	105.7%	109.0%	109.6%	110.2%	*Calculated*
	2014	2015	2016	2017	2018	2019	
Economically Active population relative to 1990:	112.4%	112.8%	113.3%	113.7%	114.1%	114.6%	*Calculated*
	2020						
Economically Active population relative to 1990:	115.0%						*Calculated*

Sources/Notes:

	1996	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	
Total Road Freight rel. to 1990	32.0%	14.0%	23.3%	23.9%	18.0%	20%	22.3%	
Fraction Road Freight, biomass truck	7.60%	9.90%	9.64%	9.70%	9.80%	9.80%	9.80%	*8*
Fraction Road Freight, diesel truck	23.00%	34.35%	70.00%	47.00%	50.00%	50.0%	52.6%	*9*
Fraction Road Freight, gasoline truck	69.40%	55.75%	20.36%	43.30%	40.20%	40.20%	37.60%	*Calculated*
	2015	**2016**	**2017**	**2018**	**2019**	**2020**		
Total Road Freight rel. to 1990	23.5%	25.5%	23.0%	21.8%	21.6%	16.0%		
Fraction Road Freight, biomass truck	9.5%	9.5%	10%	10%	10%	10%		*8*
Fraction Road Freight, diesel truck	55.0%	57.5%	51.0%	52.5%	54.0%	51.0%		*9*
Fraction Road Freight, gasoline truck	35.50%	33.00%	39.00%	37.50%	36.00%	39.00%		*Calculated*

	Activity Relative to 1990				Energy Intensity Relative to 1990				
Subsector--End Use	**1996**	**2000**	**2005**	**2008**	**1996**	**2000**	**2005**	**2008**	
Road--Freight--Gasoline	31.1%	10.9%	6.6%	14.5%	110%	110.0%	110.0%	105%	*2*
Road--Freight--Diesel	30.8%	20.1%	68.2%	46.9%	110%	100.0%	100.0%	100%	*2*
Road--Freight--Biomass	52.9%	30.1%	48.8%	50.4%	100%	100%	100%	100%	
Road--Civilian Auto Pass-km	100.0%	73.0%	75.0%	111.0%	105%	103.0%	97.0%	95.0%	*10, 11*
Road--Passenger Bus, Diesel	44.4%	37.9%	67.7%	45.6%	110%	106.0%	105.0%	102%	*3*
Road--Passenger Bus, Gasoline	57.9%	15.7%	12.8%	45.0%	110%	100.0%	100.0%	98%	*3*
Rail--Freight, Diesel	40.0%	30.0%	48.0%	31.0%	100%	100%	100%	100%	*2*
Rail--Freight, Electric	40.0%	33.0%	32.0%	39.0%	105%	100%	100%	100%	*2*
Rail--Passenger, Electric	44.41%	26.5%	33.0%	38.0%	105%	100%	100%	100%	*3*
Water--Freight, Diesel and HFO	40.0%	38.0%	42.0%	33.0%	100%	100%	100%	100%	*2*
Air--Passenger: Activity levels (fuel)	80.0%	70.0%	80.0%	87.0%	100%	100%	100%	100%	*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	45.0%	68.0%	70.0%					*4*
Non-Specified Transport (Oil/Elect.)	0.0%	0.0%	0.0%	0.0%	100%	100%	100%	100%	

	Activity Relative to 1990				Energy Intensity Relative to 1990				
Subsector--End Use	**1996**	**2009**	**2010**	**2014**	**1996**	**2009**	**2010**	**2014**	
Road--Freight--Gasoline	31.1%	10.1%	11.2%	11.7%	110%	103%	102%	96%	*2*
Road--Freight--Diesel	30.8%	37.6%	41.8%	49.0%	110%	98%	96.5%	89.0%	*2*
Road--Freight--Biomass	52.9%	38.3%	42.6%	47.5%	100%	100%	100%	100%	
Road--Civilian Auto Pass-km	100.0%	115.5%	122.0%	128.0%	105%	95%	94%	92%	*Assumption*
Road--Passenger Bus, Diesel	44.4%	35.9%	39.6%	40.6%	110%	100%	97%	92%	*3*
Road--Passenger Bus, Gasoline	57.9%	34.2%	40.4%	40.0%	110%	96%	95%	92%	*3*
Rail--Freight, Diesel	40.0%	23.0%	27.0%	27.5%	100%	100%	100%	98%	*2, 12*
Rail--Freight, Electric	40.0%	36.0%	36.0%	40.0%	105%	100%	100%	98%	*2, 12*
Rail--Passenger, Electric	44.4%	36.0%	36.0%	24.0%	105%	100%	100%	100%	*3, 12*
Water--Freight, Diesel and HFO	40.0%	28.0%	30.0%	27.0%	100%	100%	100%	100%	*2*
Air--Passenger: Activity levels (fuel)	75.0%	79.0%	84.0%	84.0%	100%	100%	100%	98%	*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	70.0%	76.0%	76.0%					*3*
Non-Specified Transport (Oil/Elect.)	0.0%	0.0%	0%	0%	100%	100%	100%	100%	

	Activity Relative to 1990					
Subsector--End Use	**1996**	**2015**	**2016**	**2017**	**2018**	
Road--Freight--Gasoline	31.1%	11.7%	11.8%	12.6%	11.4%	*2*
Road--Freight--Diesel	30.8%	54.0%	61.3%	49.0%	47.8%	*2*
Road--Freight--Biomass	52.9%	48.5%	52.7%	50.0%	47.4%	
Road--Civilian Auto Pass-km	100.0%	142.0%	151.0%	150.5%	147.0%	*Assumption*
Road--Passenger Bus, Diesel	44.4%	40.0%	42.7%	37.3%	36.4%	*3*
Road--Passenger Bus, Gasoline	57.9%	41.6%	40.1%	38.0%	37.3%	*3*
Rail--Freight, Diesel	40.0%	28.0%	29.0%	27.0%	25.7%	*2, 12*
Rail--Freight, Electric	40.0%	40.0%	40.0%	30.0%	28.0%	*2, 12*
Rail--Passenger, Electric	44.4%	38.0%	41.0%	40.0%	39.0%	*3, 12*
Water--Freight, Diesel and HFO	40.0%	28.0%	29.0%	27.0%	25.5%	*2*
Air--Passenger: Activity levels (fuel)	75.0%	90.0%	95.0%	84.0%	84.0%	*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	78.0%	79.0%	79.0%	79.0%	*3*
Non-Specified Transport (Oil/Elect.)	0.0%	0.0%	0%	0%	0%	

	Activity Relative to 1990				
Subsector--End Use	**1996**	**2019**	**2020**		
Road--Freight--Gasoline	31.1%	10.9%	8.7%		*2*
Road--Freight--Diesel	30.8%	48.7%	34.1%		*2*
Road--Freight--Biomass	52.9%	47.0%	34.8%		
Road--Civilian Auto Pass-km	100.0%	148.5%	124.0%		*Assumption*
Road--Passenger Bus, Diesel	44.4%	40.1%	28.0%		*3*
Road--Passenger Bus, Gasoline	57.9%	35.0%	28.7%		*3*
Rail--Freight, Diesel	40.0%	26.0%	19.6%		*2, 12*
Rail--Freight, Electric	40.0%	28.0%	28.0%		*2, 12*
Rail--Passenger, Electric	44.4%	39.0%	39.0%		*3, 12*
Water--Freight, Diesel and HFO	40.0%	25.5%	16.0%		*2*
Air--Passenger: Activity levels (fuel)	75.0%	82.2%	52.4%		*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	80.0%	80.0%		*3*
Non-Specified Transport (Oil/Elect.)	0.0%	0%	0%		

	Energy Intensity Relative to 1990					
Subsector--End Use	**1996**	**2015**	**2016**	**2017**	**2018**	
Road--Freight--Gasoline	110%	95%	102%	98%	98%	*2*
Road--Freight--Diesel	110%	88%	88.0%	87%	86.4%	*2*
Road--Freight--Biomass	100%	100%	100%	100%	100%	
Road--Civilian Auto Pass-km	105%	91%	90%	90%	89.5%	*Assumption*
Road--Passenger Bus, Diesel	110%	91%	90%	88%	87.6%	*3*
Road--Passenger Bus, Gasoline	110%	91%	90%	89%	89%	*3*
Rail--Freight, Diesel	100%	98%	98%	98%	98%	*2, 12*
Rail--Freight, Electric	105%	98%	98%	98%	98%	*2, 12*
Rail--Passenger, Electric	105%	100%	100%	100%	100%	*3, 12*
Water--Freight, Diesel and HFO	100%	100%	100%	100%	100%	*2*
Air--Passenger: Activity levels (fuel)	100%	100%	100%	100%	100%	*Assumption*
Air--Passenger: Fraction as Jet Fuel						*3*
Non-Specified Transport (Oil/Elect.)	100%	100%	100%	100%	100%	

	Energy Intensity Relative to 1990			
Subsector--End Use	**1996**	**2019**	**2020**	
Road--Freight--Gasoline	110%	98%	98%	*2*
Road--Freight--Diesel	110%	86.4%	86.4%	*2*
Road--Freight--Biomass	100%	100%	100%	
Road--Civilian Auto Pass-km	105%	89.5%	89.5%	*Assumption*
Road--Passenger Bus, Diesel	110%	87.4%	87.7%	*3*
Road--Passenger Bus, Gasoline	110%	89%	89%	*3*
Rail--Freight, Diesel	100%	98%	98%	*2, 12*
Rail--Freight, Electric	105%	98%	98%	*2, 12*
Rail--Passenger, Electric	105%	100%	100%	*3, 12*
Water--Freight, Diesel and HFO	100%	100%	100%	*2*
Air--Passenger: Activity levels (fuel)	100%	100%	100%	*Assumption*
Air--Passenger: Fraction as Jet Fuel				*3*
Non-Specified Transport (Oil/Elect.)	100%	100%	100%	

See ***Notes 17*** *and* ***18*** *for estimates of truck and aircraft energy intensities used in DPRK energy futures studies.*

Type of Vehicles	Units	2010 (and before)	2011	2012	2013	2014	2015	2016
Electric Scooters* (see ***Notes 15, 21)***	MWh		2	11	249	1,044	1,779	4,741
	GJ		5.66	40.52	898.08	3,757.13	6,403.38	17,068.68
Electric Cars** (see ***Notes 16, 20***)	MWh	9	11	12	13	13	13	33
	GJ	34.15	41.28	42.81	45.36	46.89	48.42	119.02
TOTAL	MWh	**9.49**	**13.04**	**23.15**	**262.07**	**1,056.67**	**1,792.17**	**4,774.36**
	GJ	**34.15**	**46.94**	**83.33**	**943.44**	**3,804.02**	**6,451.79**	**17,187.70**
TOTAL Electric Vehicle-km	Scooters	-	113,150	697,150	17,151,350	57,180,900	110,105,900	323,411,900
	Cars	268,000	324,000	336,000	356,000	368,000	380,000	575,000
	Total	**268,000**	**437,150**	**1,033,150**	**17,507,350**	**57,548,900**	**110,485,900**	**323,986,900**
Cars fraction of total Auto Veh-km		**0.22%**				**0.304%**	**0.203%**	**0.289%**
Cars fraction of total 1990 Auto Veh-km		**0.20%**	**0.25%**	**0.26%**	**0.27%**	**0.28%**	**0.29%**	**0.44%**
Energy Intensity of electric cars	kWh/km	0.0354	0.0354	0.0354	0.0354	0.0354	0.0354	0.0575

Type of Vehicles	Units	2017	2018	2019	2020
Electric Scooters* (see ***Notes 15, 21)***	MWh	11,241	13,822	15,136	15,690
	GJ	40,467.98	49,760.70	54,490.92	56,483.63
Electric Cars** (see ***Notes 16, 20***)	MWh	104	143	182	191
	GJ	374.30	515.51	656.73	689.32
TOTAL	MWh	**11,345.08**	**13,965.61**	**15,318.79**	**15,881.38**
	GJ	**40,842.28**	**50,276.21**	**55,147.65**	**57,172.95**
TOTAL Electric Vehicle-km	Scooters	791,397,981	977,252,331	1,071,856,681	1,111,711,031
	Cars	1,280,000	1,670,000	2,060,000	2,150,000
	Total	**792,677,981**	**978,922,331**	**1,073,916,681**	**1,113,861,031**
Cars fraction of total Auto Veh-km		**0.646%**	**0.862%**	**1.053%**	**1.316%**
Cars fraction of total 1990 Auto Veh-km		**0.97%**	**1.27%**	**1.56%**	**1.63%**
Energy Intensity of electric cars	kWh/km	0.0812	0.0857	0.0886	0.0891

* Includes rough estimates that imports of 50,000 electric scooters occurred but were unreported in 2018, 25,000 scooters were imported but not (or not yet) reported in 2019, and that 10,000 scooters will be imported in 2020.

** Includes rough estimates that imports of 25 electric cars occurred but were unreported in 2018, 25 cars were imported but not (or not yet) reported in 2019, and that 5 electric cars will be imported in 2020.

Sources/Notes:

1 US Central Intelligence Agency, "Korea, North". CIA Factbook, 1995 (World Wide Web Version). USCIA, Washington, D.C., USA. 1996.

2 Consistent with general decrease in industrial production through about 2008, but then intensity declines as new imported vehiicles become more widely used.

3 Assumes that per-capita passenger transport use decreased to 44 to 60 percent of 1990 by 1996 due to austerity measures, with the decrease continuing through 2000 before increasing slightly in 2005 (based on the anecdotal observations of visitors to the DPRK), varying thereafter to roughly follow the estimated availability of refined fuels.

4 Based on general observations of a decline in air travel through 2000, increasing somewhat in 2001 and 2002, as more international visitors came to Pyongyang in those years, but declining somewhat thereafter to a current level that is similar to that in 1990. It is assumed that a larger fraction of travelers are carried on jet aircraft as opposed to the older propellor-driven DPRK planes.

5 No specific data were available for the transport sector for 2000, so estimates of the parameters in these tables are rough figures based on the experiences of Nautilus staff and others in the DPRK. It is assumed that the use of producer-gas-fueled trucks would increase somewhat as a fraction of overall freight transport, but that the increase would be modest. Visitors to the DPRK have generally noted a modest increase in the use of small "private" cars and mini-vans in the last several years. The use of other vehicles, however, seems to have stayed the same or decreased slightly, thus the slight decrease in vehicle use between 1996 and 2000 relative to 1990. No change in the efficiency of vehicles was assumed between 1996 and 2000, as any efficiency gains through the introduction of a few new vehicles seems likely to be counterbalanced by continuing problems with the availability of spare parts. We saw many disabled trucks along the road in areas not far from Pyongyang.

6 The website http://www.answers.com/topic/north-korea, visited 1/15/07, listed the following as the ships in the DPRK merchant marine as of 2005: "total: 238 ships (1,000 GRT or over) 985,108 GRT/1,389,389 DWT by type: bulk carrier 13, cargo 191, container 2, livestock carrier 4, passenger/cargo 5, petroleum tanker 13, refrigerated cargo 5, roll on/roll off 5 foreign-owned: 52 (China 1, Denmark 2, France 1, Greece 4, Italy 1, Lebanon 4, Lithuania 1, Netherlands 1, Pakistan 2, Romania 10, Russia 2, Singapore 2, South Korea 2, Syria 9, Turkey 6, Ukraine 1, UAE 3).

7 China Customs Statistics reported transport vehicles exports from China to the DPRK as follows for 2000 through 2005. As compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf. Values for years after 2005 are from UN Comtrade database, accessed 8/2018.

ROAD VEHICLES IMPORTS TO DPRK FROM CHINA

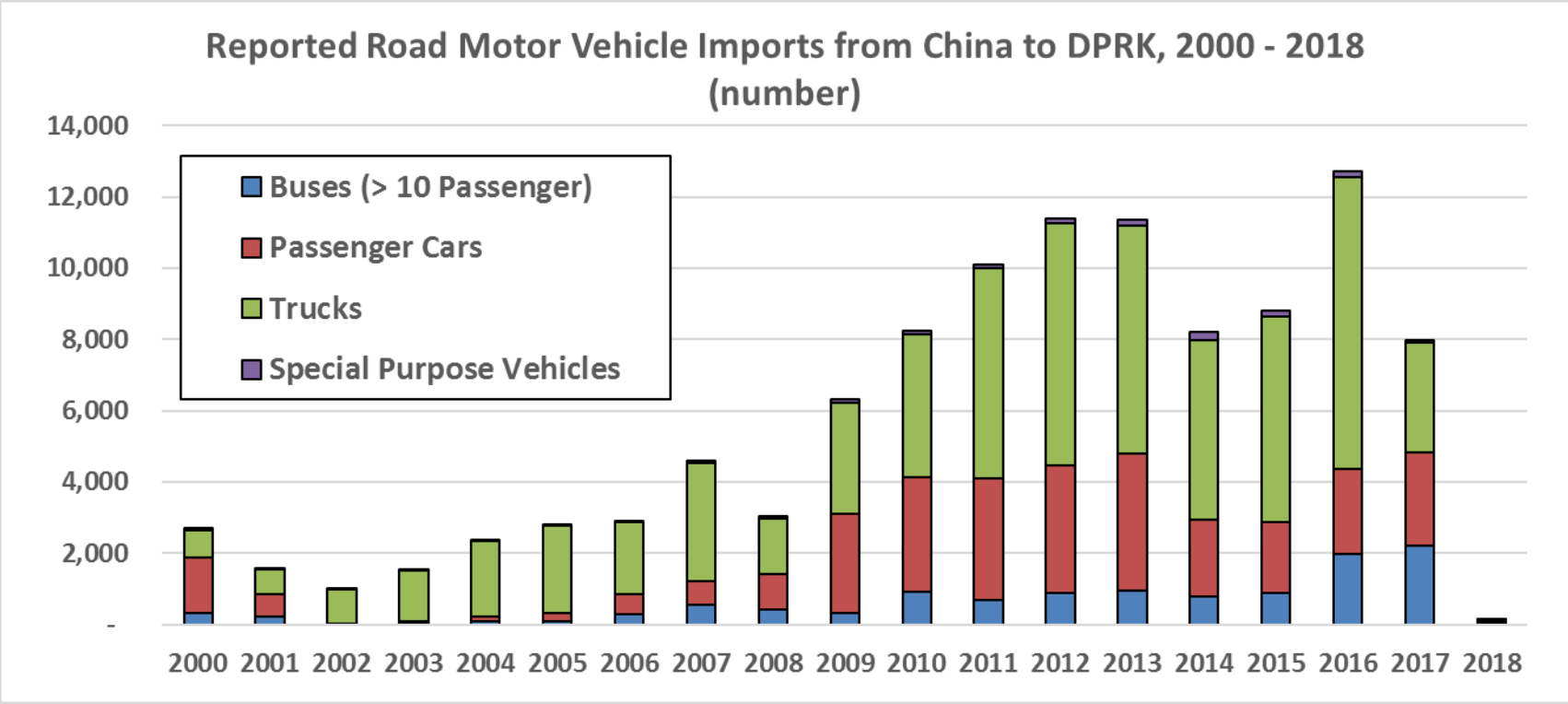
Units: Number of Vehicles

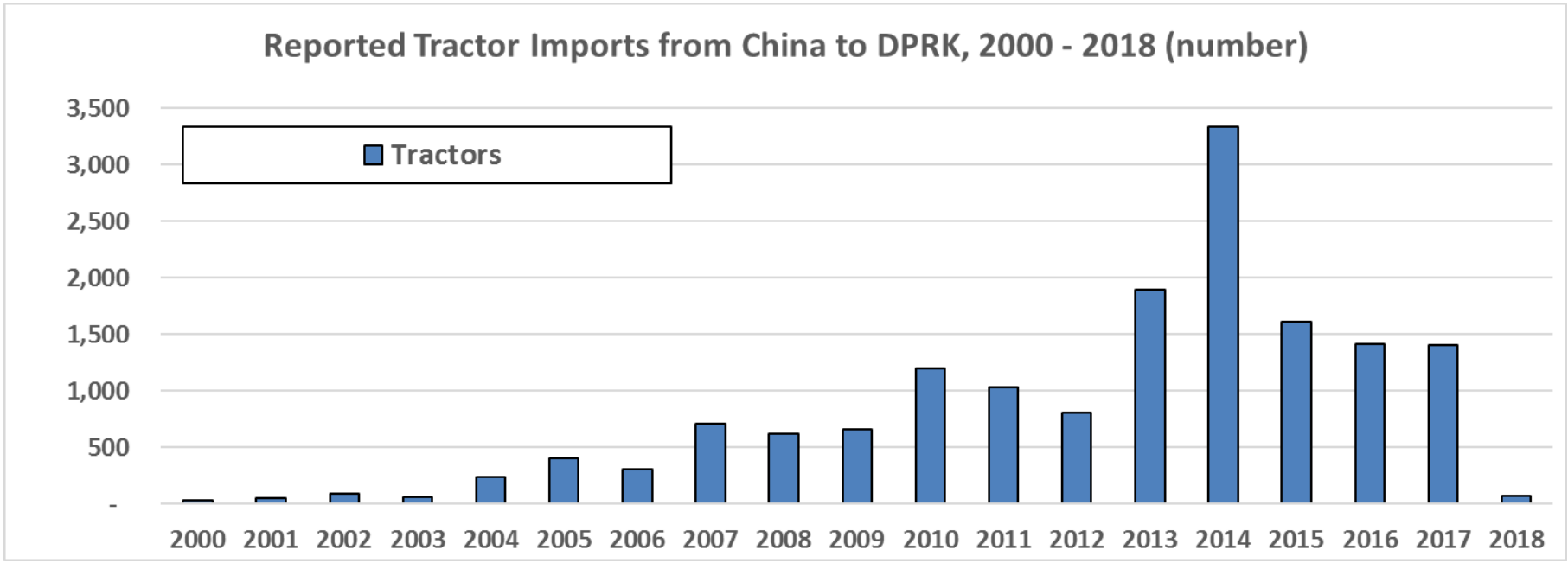
Description	HS (code)	2000	2001	2002	2003	2004	2005
MOTOR TRUCKS	8704	770	677	955	1,409	2,108	2,444
PASSENGER MOTOR	8703	1,529	629	-	65	145	244
OT SPEC PURPOSE M VEH	8705	75	40	9	10	26	29
MOTORCYCLES	8711	1,354	62	30	1	701	3,433
TRACTORS,NOT IN 8709	8701	28	47	86	65	234	401
PUB TRANS MV>10PERS	8702	337	233	14	38	82	89
PART/ACCESS 8701-8705	8708	-	-	-	-	-	-
PART,ACCESS 8711-8713	8714	-	-	-	-	-	-
BICYCLES+OTHER CYCLES	8712	12,400	4,066	53,601	1,020	7,745	12,958
TRAIL,ET,NT MEC PROPL	8716	-	-	-	-	-	-
M VHCL CHASSIS W/ENGN	8706	10	4	16	2	2	24
MOTOR VEHICL BODIES	8707	3	2	6	7	15	38
CARRIAGES FOR DISABLED PERSONS,MOTORIZED OR NOT	8713	200	-	387	132	548	552

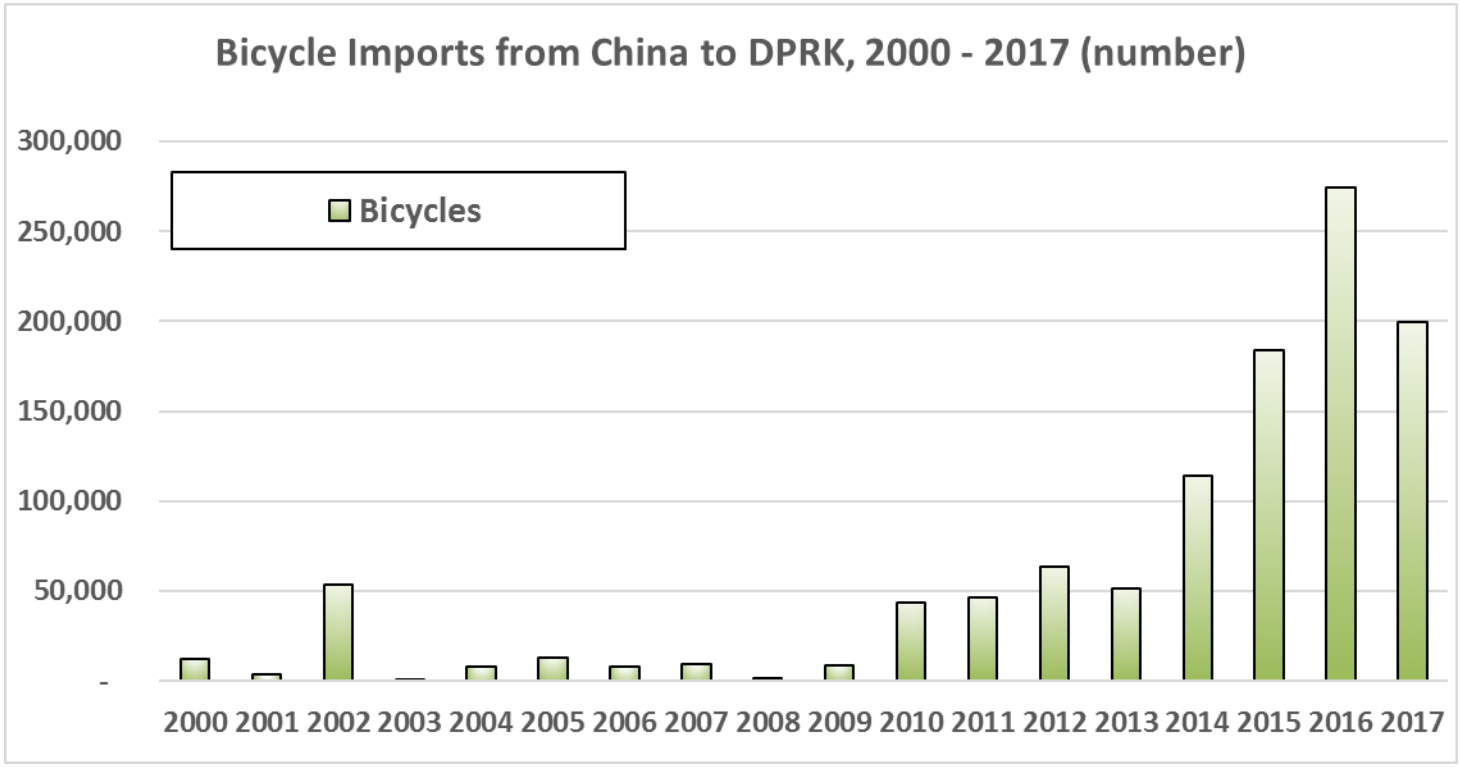
Description	HS (code)	2006	2007	2008	2009	2010	2011	
MOTOR TRUCKS	8704	1996	3,312	1,551	3,111	4,015	5,894	
PASSENGER MOTOR	8703	582	684	980	2773	3183	3,413	
OT SPEC PURPOSE M VEH	8705	29	58	88	92	126	122	
MOTORCYCLES	8711	599	2,633	1,457	1,957	1,736	2,270	
TRACTORS,NOT IN 8709	8701	310	712	621	661	1196	1,028	
PUB TRANS MV>10PERS	8702	286	546	437	330	934	685	
PART/ACCESS 8701-8705	8708	469,951	1,073,187	481,149	417,527	720,248	680,927	Units: kg
PART,ACCESS 8711-8713	8714	701,795	0	0	0	3,081,641	4,325,620	Units: kg
BICYCLES+OTHER CYCLES	8712	7,700	9,191	1,800	9,018	43,802	46,606	
TRAIL,ET,NT MEC PROPL	8716	113,037	185,501	282,925	124,009	188,999	194,118	Units: kg
M VHCL CHASSIS W/ENGN	8706	24	7	9	2	6	1,028	
MOTOR VEHICL BODIES	8707	44	35	115	93	324	114	
CARRIAGES FOR DISABLED PERSONS,MOTORIZED OR NOT	8713	806	805	453	447	223	519	

Description	HS (code)	2012	2013	2014	2015	2016	2017	2018	
MOTOR TRUCKS	8704	6,788	6,381	5,032	5,738	8,203	3,073	20	
PASSENGER MOTOR	8703	3,599	3,860	2,169	1,992	2,365	2,630	46	
OT SPEC PURPOSE M VEH	8705	139	159	233	179	151	72	3	
MOTORCYCLES	8711	2,978	6,772	19,465	16,888	60,119	130,059	919	
TRACTORS,NOT IN 8709	8701	808	1898	3,330	1,607	1,409	1,404	69	
PUB TRANS MV>10PERS	8702	879	946	784	895	1989	2,204	69	
PART/ACCESS 8701-8705	8708	658,840	969,188	791,540	563,252	431,950	1,328,382	49,626	Units: kg
PART,ACCESS 8711-8713	8714	6,028,696	6,557,047	9,384,798	8,354,697	5,860,575	7,158,369	124,884	Units: kg
BICYCLES+OTHER CYCLES	8712	63,506	51,821	113,910	183,781	274,097	199,750	3,349	
TRAIL,ET,NT MEC PROPL	8716	0	351,841	412,629	202,304	311,737	262,182	0	Units: kg
M VHCL CHASSIS W/ENGN	8706	4	4	12	5	6	2	0	
MOTOR VEHICL BODIES	8707	0	174	106	151	139	13	4	
CARRIAGES FOR DISABLED PERSONS,MOTORIZED OR NOT	8713	449	250	493	613	643	376	1	

Note: for category 8710, "Tanks and other armaments….", no trades are listed in Comtrade from China to the DPRK, at least after 2005


Reported Road Motor Vehicle Imports from China to DPRK, 2000 - 2018
(number)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
Buses (> 10 Passenger)
Passenger Cars
Trucks
Special Purpose Vehicles
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018


Reported Tractor Imports from China to DPRK, 2000 - 2018 (number)
Tractors
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

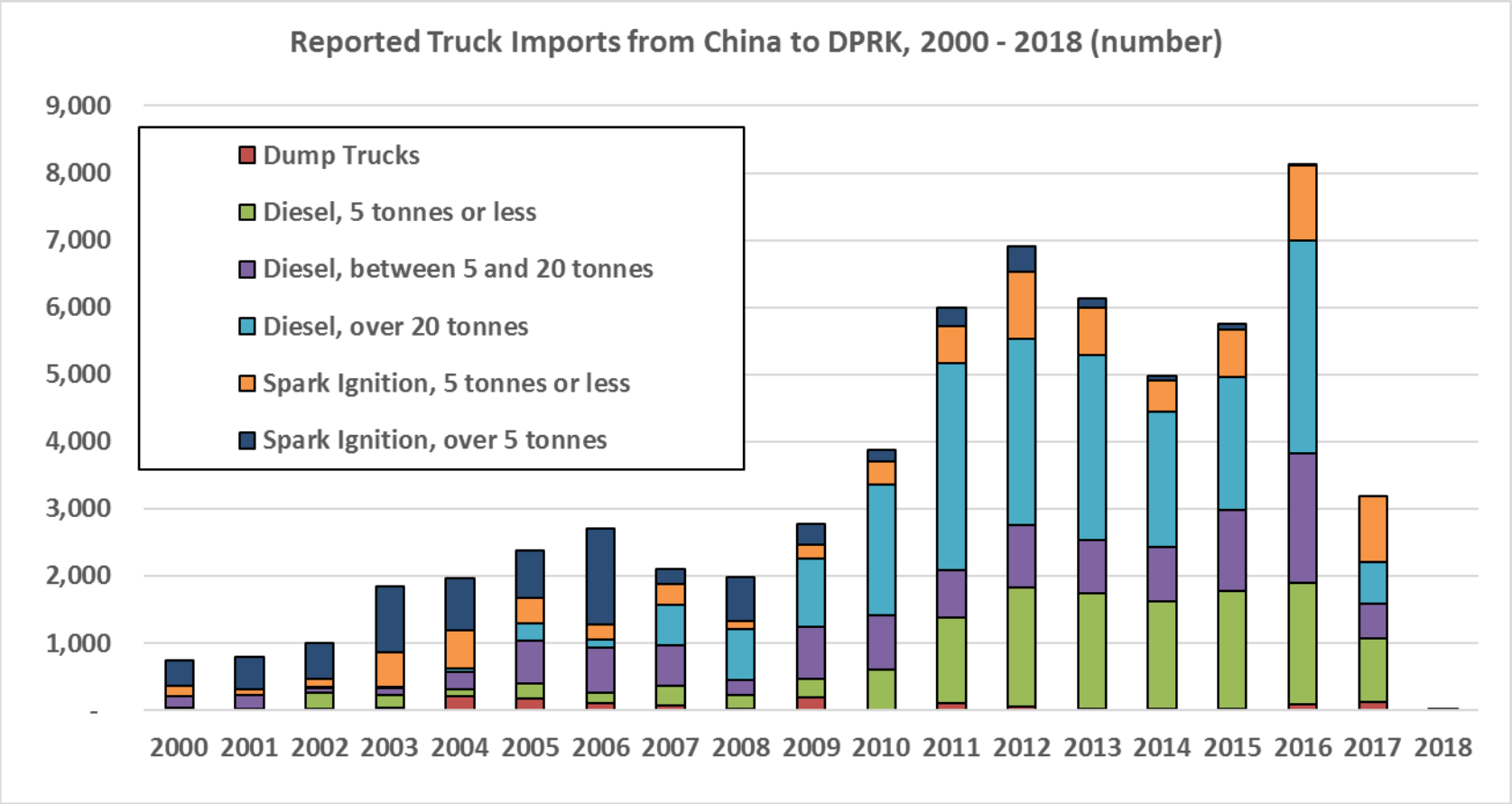

Bicycle Imports from China to DPRK, 2000 - 2017 (number)
300,000
250,000
200,000
150,000
100,000
50,000
-
Bicycles
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

Additional Detail on Motor Trucks (HS 8704)

Description	HS (code)	2000	2001	2002	2003	2004	2005
Vehicles, Dumpers, Designed for off-highway Use	870410	0	4	19	32	211	178
Vehicles for goods transport…diesel.. 5 tonnes or less	870421	33	26	236	199	95	224
Vehicles for goods transport…diesel.. 5 to 20 tonnes	870422	173	201	84	108	273	634
Vehicles for goods transport…diesel.. More than 20 tonnes	870423	0	4	5	18	45	256
Vehicles for goods transport…spark ignition.. 5 tonnes or less	870431	164	72	122	508	572	387
Vehicles for goods transport…spark ignition…over 5 tonnes	870432	400	369	489	536	985	767
Vehicles for goods transport…n.e.s.	870490	-	1	0	0	0	0

Description	HS (code)	2006	2007	2008	2009	2010	2011
Vehicles, Dumpers, Designed for off-highway Use	870410	110	73	28	187	9	110
Vehicles for goods transport…diesel.. 5 tonnes or less	870421	161	299	206	284	591	1,270
Vehicles for goods transport…diesel.. 5 to 20 tonnes	870422	668	589	222	778	813	710
Vehicles for goods transport…diesel.. More than 20 tonnes	870423	120	611	756	1,005	1,951	3,080
Vehicles for goods transport…spark ignition.. 5 tonnes or less	870431	227	314	118	204	338	554
Vehicles for goods transport…spark ignition…over 5 tonnes	870432	695	1,426	221	653	313	170
Vehicles for goods transport…n.e.s.	870490	15	0	0	0	0	0

Description	HS (code)	2012	2013	2014	2015	2016	2017	2018
Vehicles, Dumpers, Designed for off-highway Use	870410	60	26	23	24	86	127	0
Vehicles for goods transport…diesel.. 5 tonnes or less	870421	1,777	1,710	1,596	1,758	1,807	936	7
Vehicles for goods transport…diesel.. 5 to 20 tonnes	870422	919	803	806	1,198	1,926	525	0
Vehicles for goods transport…diesel.. More than 20 tonnes	870423	2,766	2,747	2,012	1,989	3,175	623	2
Vehicles for goods transport…spark ignition.. 5 tonnes or less	870431	998	712	468	699	1,118	976	11
Vehicles for goods transport…spark ignition…over 5 tonnes	870432	268	383	127	70	91	1	0

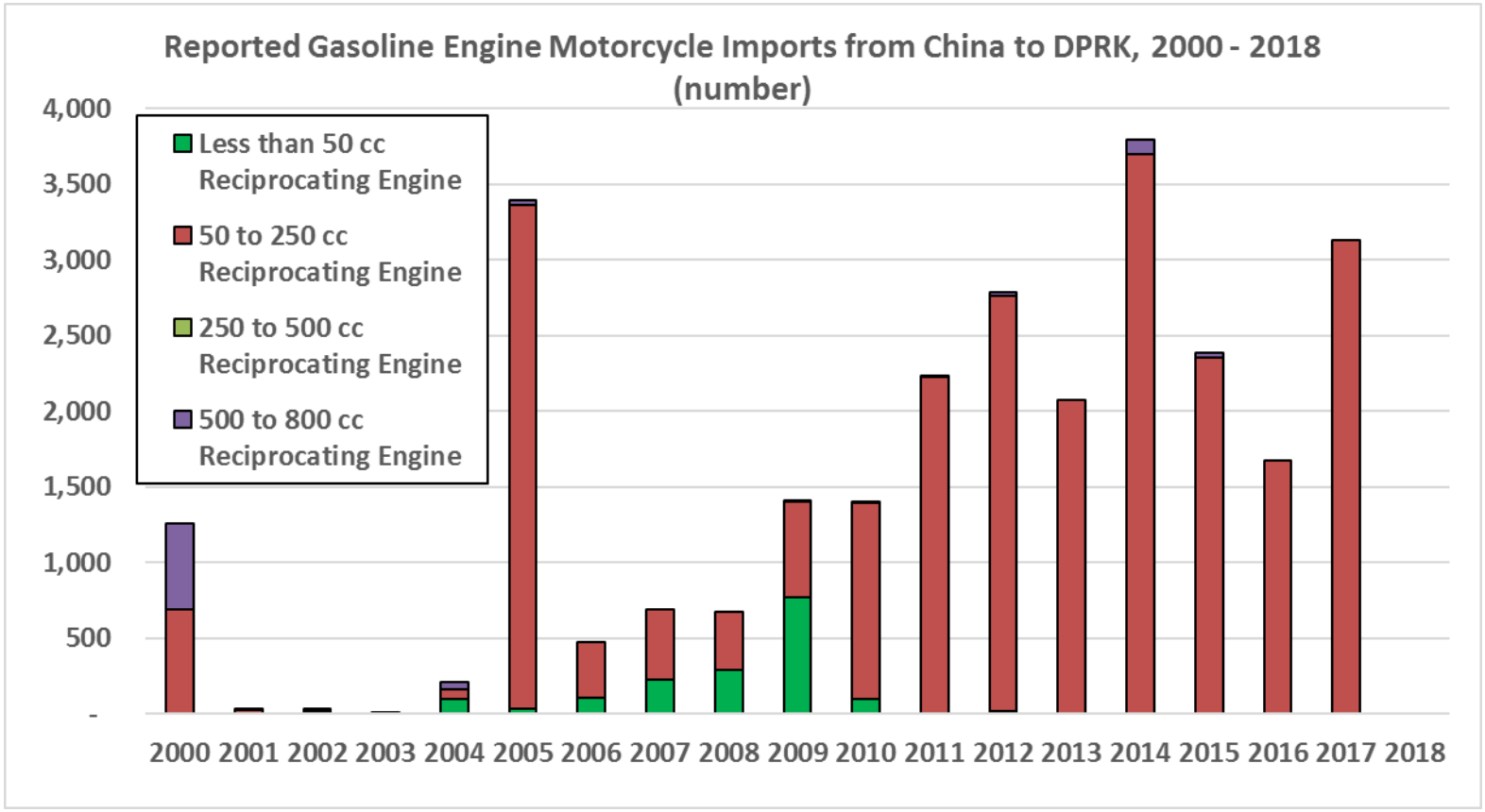

Reported Truck Imports from China to DPRK, 2000 - 2018 (number)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
Dump Trucks
Diesel, 5 tonnes or less
Diesel, between 5 and 20 tonnes
Diesel, over 20 tonnes
Spark Ignition, 5 tonnes or less
Spark Ignition, over 5 tonnes
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

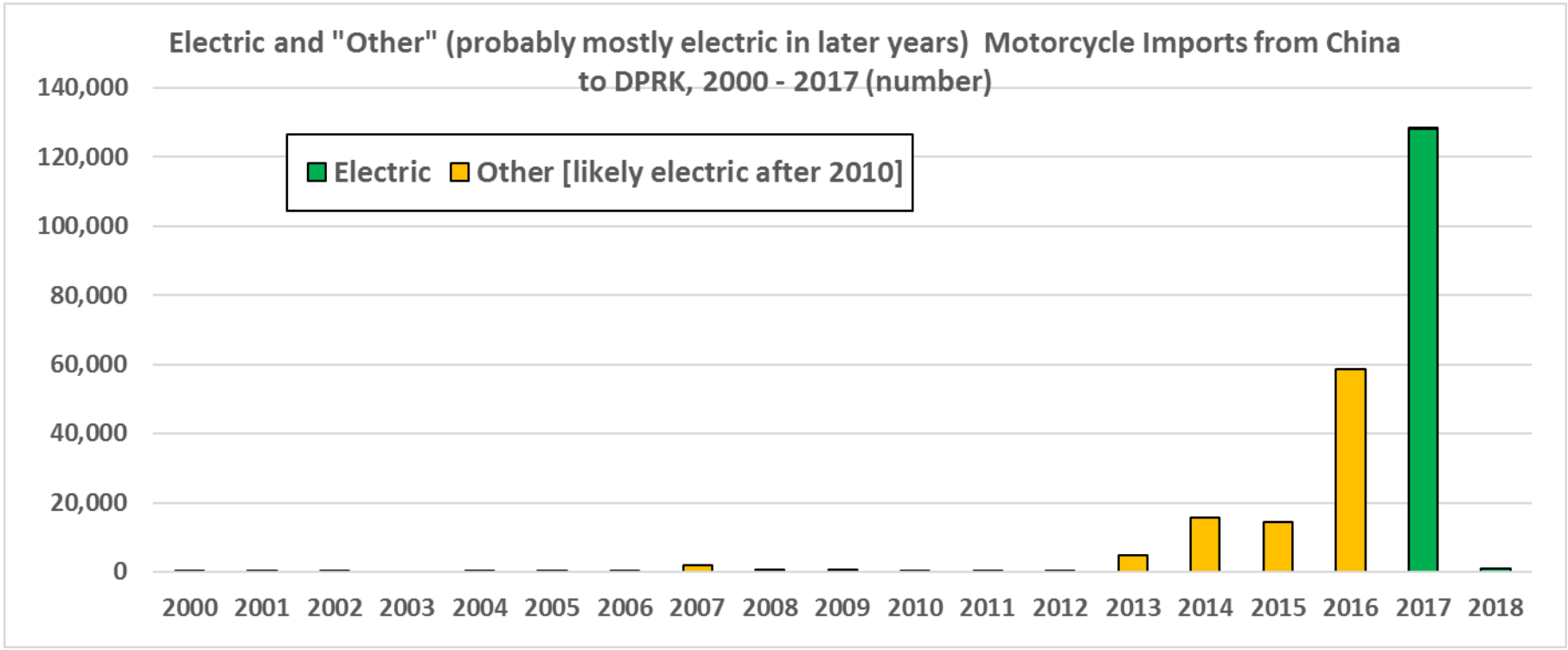
Additional Detail on Motorcycles (HS 8711, "Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars")

Description	HS (code)	2000	2001	2002	2003	2004	2005
With reciprocating internal combustion piston engine of a cylinder capacity not exceeding 50 cc	871110					101	36
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 50 cc but not exceeding 250 cc	871120	692	30	15	1	63	3324
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 250 cc but not exceeding 500 cc	871130			10			
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 500 cc but not exceeding 800 cc:	871140	564	9	3		50	37
Other	871190	98	23	2		487	36

Description	HS (code)	2006	2007	2008	2009	2010	2011
With reciprocating internal combustion piston engine of a cylinder capacity not exceeding 50 cc	871110	105	225	291	771	102	
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 50 cc but not exceeding 250 cc	871120	373	464	381	629	1291	2,229
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 250 cc but not exceeding 500 cc	871130					3	
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 500 cc but not exceeding 800 cc:	871140				5		10
Other	871190	121	1944	785	552	340	31

Description	HS (code)	2012	2013	2014	2015	2016	2017	2018
With reciprocating internal combustion piston engine of a cylinder capacity not exceeding 50 cc	871110	20	2	4	3			
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 50 cc but not exceeding 250 cc	871120	2743	2,071	3695	2351	1,679	3,133	
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 250 cc but not exceeding 500 cc	871130							
With reciprocating internal combustion piston engine of a cylinder capacity exceeding 500 cc but not exceeding 800 cc:	871140	24		100	34			
With electric motor for propulsion	871160						128,145	919
Other	871190	191	4,699	15,666	14,500	58,440	71	


Reported Gasoline Engine Motorcycle Imports from China to DPRK, 2000 - 2018
(number)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
Less than 50 cc Reciprocating Engine
50 to 250 cc Reciprocating Engine
250 to 500 cc Reciprocating Engine
500 to 800 cc Reciprocating Engine
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

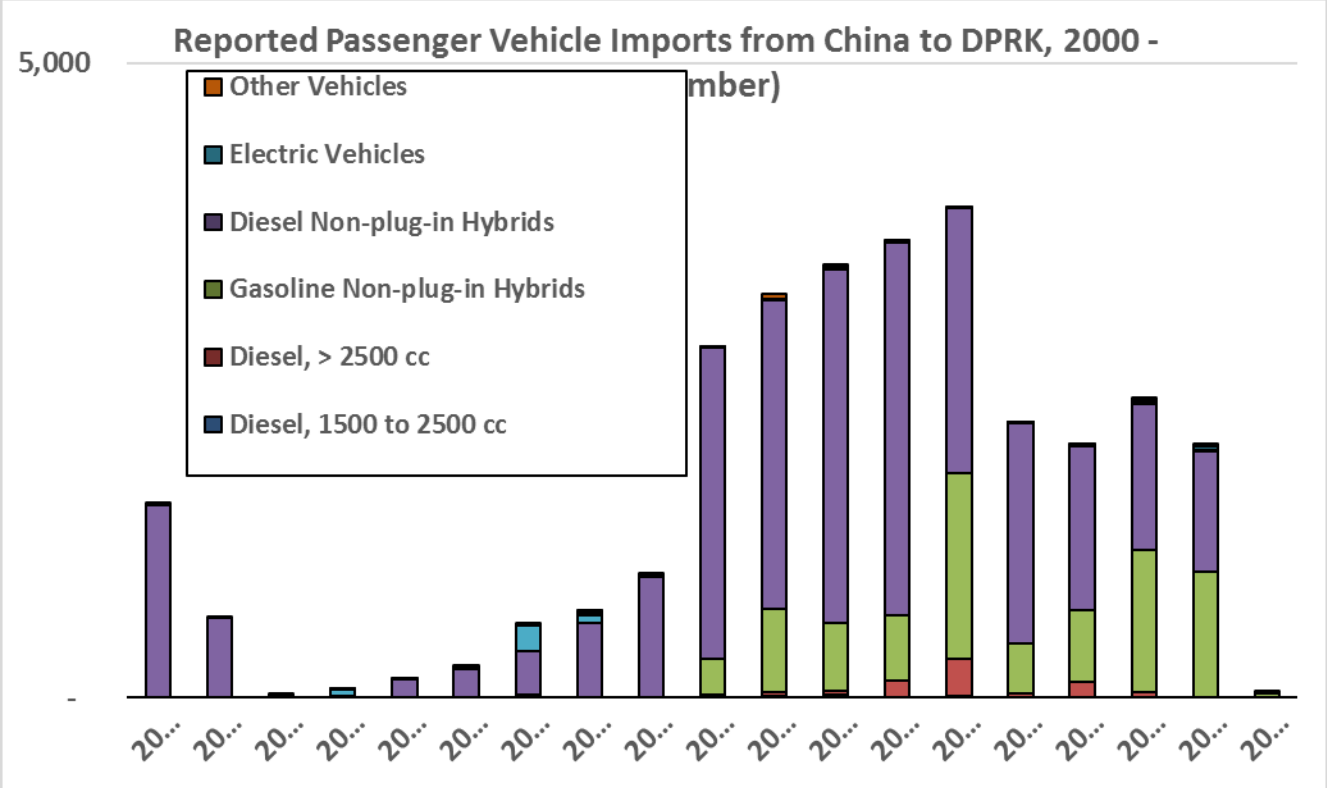

Electric and "Other" (probably mostly electric in later years) Motorcycle Imports from China to DPRK, 2000 - 2017 (number)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Electric
Other [likely electric after 2010]
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Additional Detail on Passenger Cars (HS 8703, "MOTOR CARS AND OTHER MOTOR VEHICLES PRINCIPALLY DESIGNED FOR THE TRANSPORT OF PERSONS (OTHER THAN THOSE OF HEADING 8702), INCLUDING STATION WAGONS AND RACING CARS.")

Description	HS (code)	2000	2001	2002	2003	2004	2005
Classification of Vehicles specially designed for travelling on snow; golf cars and similar vehicles, including the driver	870310					2	
Of a cylinder capacity not exceeding 1000 cc, Spark-ignition	870321					1	
Of a cylinder capacity exceeding 1000 cc but not exceeding 1500 cc, Spark-ignition	870322	3	4		1	5	2
Of a cylinder capacity exceeding 1500 cc but not exceeding 3000 cc, Spark-ignition	870323	1519	623	22	15	133	222
Of a cylinder capacity exceeding 3000 cc, Spark-ignition	870324	4	1		46	4	2
Of a cylinder capacity not exceeding 1500, Diesel-powered	870331				1		1
Of a cylinder capacity exceeding 1500 cc but not exceeding 2500 cc, Diesel-powered	870332	3					
Of a cylinder capacity exceeding 2500 cc, Diesel-powered	870333				1		14
Vehicles with both spark-ignition engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids)	870340						
Vehicles with both diesel engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids, diesel)	870350						
Vehicles with both spark-ignition engines and electric motors, and capbable of being plugged in for charging (plug-in hybrids)	870360						
Vehicles with both diesel engines and electric motors, and capbable of being plugged in for charging (plug-in diesel hybrids)	870370						
Vehicles with only electric motors for propulsion	870380						
Other	870390			1	1	1	3

Description	HS (code)	2006	2007	2008	2009	2010	2011
Classification of Vehicles specially designed for travelling on snow; golf cars and similar vehicles , including the driver	870310	2			13	14	19
Of a cylinder capacity not exceeding 1000 cc, Spark-ignition	870321	6	1		16	27	35
Of a cylinder capacity exceeding 1000 cc but not exceeding 1500 cc, Spark-ignition	870322	12	2		275	654	531
Of a cylinder capacity exceeding 1500 cc but not exceeding 3000 cc, Spark-ignition	870323	346	588	955	2452	2439	2788
Of a cylinder capacity exceeding 3000 cc, Spark-ignition	870324	202	62	6			1
Of a cylinder capacity not exceeding 1500 cc, Diesel-powered	870331		5				
Of a cylinder capacity exceeding 1500 cc but not exceeding 2500 cc, Diesel-powered	870332		19		1	2	9
Of a cylinder capacity exceeding 2500 cc, Diesel-powered	870333	10	6	19	6	1	16
Vehicles with both spark-ignition engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids)	870340						
Vehicles with both diesel engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids, diesel)	870350						
Vehicles with both spark-ignition engines and electric motors, and capbable of being plugged in for charging (plug-in hybrids)	870360						
Vehicles with both diesel engines and electric motors, and capbable of being plugged in for charging (plug-in diesel hybrids)	870370						
Vehicles with only electric motors for propulsion	870380						
Other	870390	4	1		10	46	14

Description	HS (code)	2012	2013	2014	2015	2016	2017	2018
Classification of Vehicles specially designed for travelling on snow; golf cars and similar vehicles , including the driver	870310	4	18	2	3	5		
Of a cylinder capacity not exceeding 1000 cc, Spark-ignition	870321	129	292	31	122	42	7	
Of a cylinder capacity exceeding 1000 cc but not exceeding 1500 cc, Spark-ignition	870322	521	1462	390	565	1113	987	36
Of a cylinder capacity exceeding 1500 cc but not exceeding 3000 cc, Spark-ignition	870323	2936	2081	1735	1290	1153	947	9
Of a cylinder capacity exceeding 3000 cc, Spark-ignition	870324			3	2	19	1	
Of a cylinder capacity not exceeding 1500 cc, Diesel-powered	870331						1	
Of a cylinder capacity exceeding 1500 cc but not exceeding 2500 cc, Diesel-powered	870332	4		2	6	11		
Of a cylinder capacity exceeding 2500 cc, Diesel-powered	870333	2	2	3	1	9	1	
Vehicles with both spark-ignition engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids)	870340						1	
Vehicles with both diesel engines and electric motors, but not capbable of being plugged in to charge batteries (non-plug-in hybrids, diesel)	870350						5	
Vehicles with both spark-ignition engines and electric motors, and capbable of being plugged in for charging (plug-in hybrids)	870360							
Vehicles with both diesel engines and electric motors, and capbable of being plugged in for charging (plug-in diesel hybrids)	870370							
Vehicles with only electric motors for propulsion	870380						30	
Other	870390	3	5	3	3	13	17	1



RAIL EQUIPMENT IMPORTS TO DPRK FROM CHINA

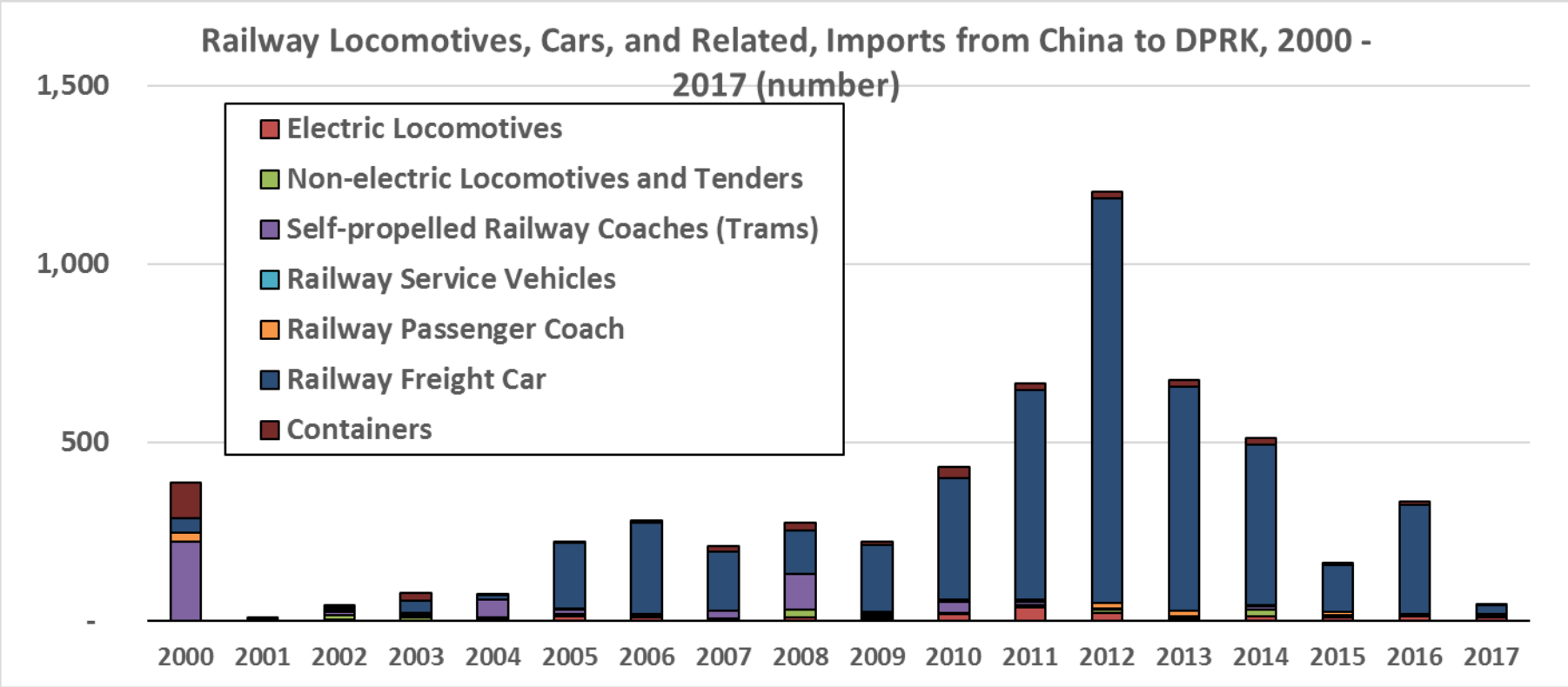
Units: Number of Vehicles except as noted

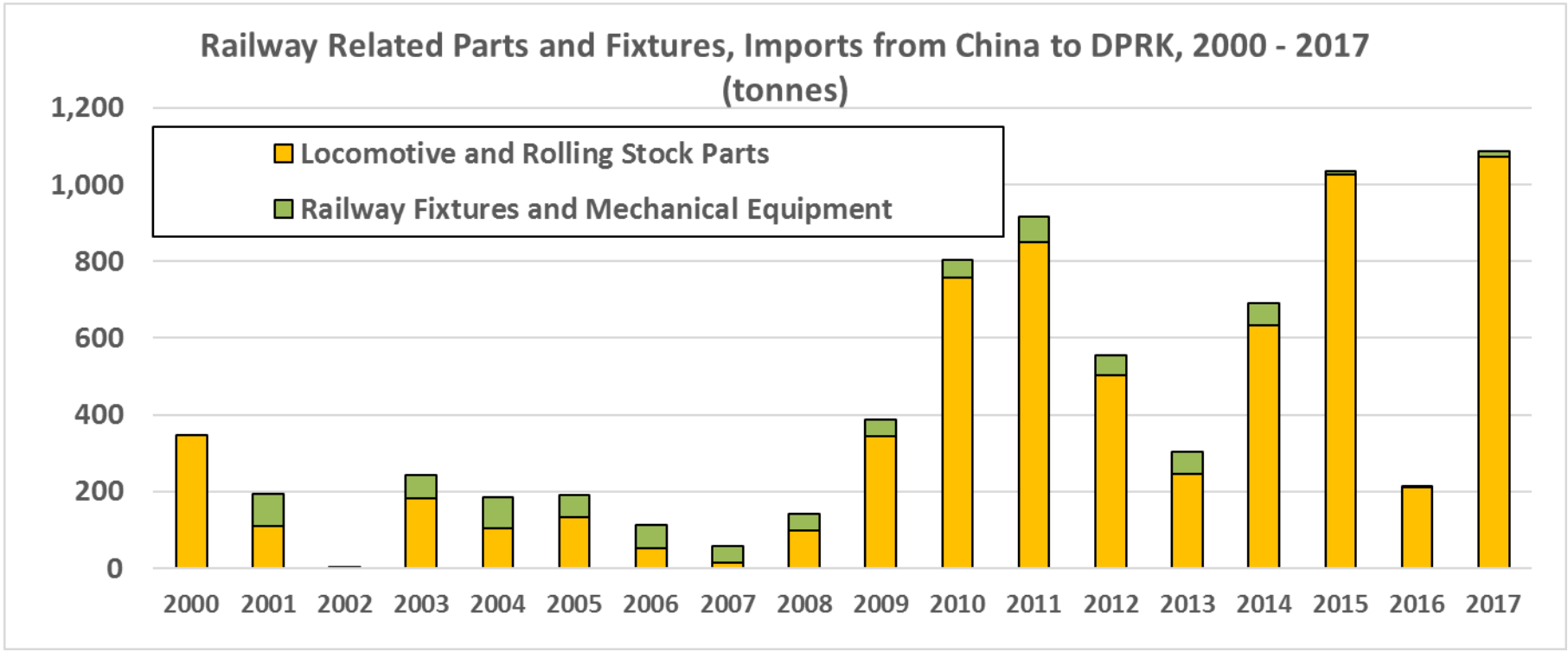
Description	HS (code)	2000	2001	2002	2003	2004	2005	Value of Trades by Category 2000	2001	2002	2003	2004	2005
RAIL LOCOMOTIVE,ELECT	8601	-	-	3	1	3	12	$ -	$ -	$ 81,982	$ 7,101	$ 59,070	$ 153,073
OT N-EL LCMTV;TENDERS	8602	-	5	13	8	6	7		$ 254,555	$ 1,780,787	$ 349,500	$ 226,100	$ 648,744
OT S-PRPL RLWAY COACH	8603	220	-	8	5	50	13	$ 2,036,000		$ 147,500	$ 20,000	$ 232,000	$ 70,000
RLWAY MAINT/SERV VHCL	8604	-	-	-	2		2	$ -	$ -	$ -	$ 1,450		$ 14,000
N-S-P RWAY PASS COACH	8605	26	-	6	5	-		$ 4,564,992	$ -	$ 4,500	$ 1,710,000	$ -	
N-S-P RLWAY FRGHT CAR	8606	42	-	8	36	12	183	$ 116,000	$ -	$ 36,210	$ 13,850	$ 12,684	$ 1,239,113
LOCOMOTV/R STOCK PRTS (Units: kg)	8607	347,698	110,753	2	181,596	104,980	133,615	$ 235,455	$ 75,000	$ 38,620	$ 233,203	$ 119,335	$ 733,731
RLWAY FXTUR; MECH EQP (Units: kg)	8608	-	83,000	5	61,300	80,000	57,472	$ -	$ 65,243	$ 82,272	$ 48,550	$ 76,117	$ 141,944
CONTNR (1+TRANS MODE)	8609	100	1	6	21	4	1	$ 56,000	$ 10,648	$ 20,500	$ 30,600	$ 5,500	$ 17,136
Total Value of Rail Equipment Imports	86	$ 7,008,447	$ 405,446	$ 2,192,371	$ 2,414,254	$ 730,806	$ 3,017,741	$ 7,008,447	$ 405,446	$ 2,192,371	$ 2,414,254	$ 730,806	$ 3,017,741

Description	HS (code)	2006	2007	2008	2009	2010	2011	Value of Trades by Category 2006	2007	2008	2009	2010	2011
RAIL LOCOMOTIVE,ELECT	8601	9	4	10	5	19	38	$ 138,191	$ 45,326	$ 132,711	$ 57,406	$ 318,213	$ 548,932
OT N-EL LCMTV;TENDERS	8602	2	3	21	8	3	6	$ 175,000	$ 180,750	$ 2,497,120	$ 2,512,374	$ 697,000	$ 4,116,374
OT S-PRPL RLWAY COACH	8603	5	20	100	5	31	10	$ 20,000	$ 250,255	$ 1,752,840	$ 65,000	$ 342,000	$ 196,500
RLWAY MAINT/SERV VHCL	8604	1	-	-	-	1	-	$ 6,700	$ -	$ -	$ -	$ 2,850	$ -
N-S-P RWAY PASS COACH	8605	2	-	-	8	5	4	$ 1,000	$ -	$ -	$ 2,510,000	$ 2,256,000	$ 1,280,000
N-S-P RLWAY FRGHT CAR	8606	256	167	123	185	340	588	$ 1,071,279	$ 475,574	$ 829,406	$ 1,635,019	$ 3,380,011	$ 7,521,529
LOCOMOTV/R STOCK PRTS (Units: kg)	8607	52,296	13,755	99,393	343,703	756,845	850,450	$ 260,938	$ 19,010	$ 142,694	$ 493,438	$ 986,003	$ 1,065,457
RLWAY FXTUR; MECH EQP (Units: kg)	8608	60,000	43,055	43,435	42,515	46,095	64,720	$ 33,600	$ 112,323	$ 112,109	$ 117,567	$ 146,440	$ 212,915
CONTNR (1+TRANS MODE)	8609	5	14	22	10	32	18	$ 19,850	$ 25,500	$ 31,036	$ 20,624	$ 69,384	$ 87,433
Total Value of Rail Equipment Imports	86	$ 1,726,558	$ 1,108,738	$ 5,497,916	$ 7,411,428	$ 8,197,901	$ 15,029,140	$ 1,726,558	$ 1,108,738	$ 5,497,916	$ 7,411,428	$ 8,197,901	$ 15,029,140

Description	HS (code)	2012	2013	2014	2015	2016	2017	Value of Trades by Category 2012	2013	2014	2015	2016	2017
RAIL LOCOMOTIVE,ELECT	8601	22	7	12	10	12	10	$ 207,185	$ 95,607	$ 188,164	$ 115,977	$ 141,805	$ 122,738
OT N-EL LCMTV;TENDERS	8602	10	6	20	4	5	3	$ 3,991,884	$ 1,841,638	$ 4,915,809	$ 832,683	$ 674,139	$ 387,402
OT S-PRPL RLWAY COACH	8603	1		8	2	2	3	$ 13,621		$ 62,405	$ 45,600	$ 16,180	$ 21,780
RLWAY MAINT/SERV VHCL	8604	-	-	-	-	-	-	$ -	$ -	$ -	$ -	$ -	$ -
N-S-P RWAY PASS COACH	8605	18	14	5	10	-	1	$ 8,160,000	$ 41,906	$ 1,660,000	$ 1,713,200	$ -	$ 60,000
N-S-P RLWAY FRGHT CAR	8606	1,132	628	447	129	307	25	$ 14,776,198	$ 4,950,479	$ 5,004,249	$ 526,896	$ 1,911,474	$ 610,380
LOCOMOTV/R STOCK PRTS (Units: kg)	8607	501,514	246,788	634,045	1,025,944	211,052	1,073,359	$ 771,785	$ 339,192	$ 871,449	$ 962,044	$ 301,914	$ 1,160,542
RLWAY FXTUR; MECH EQP (Units: kg)	8608	52,435	55,640	55,910	8,938	3,927	13,008	$ 164,631	$ 171,575	$ 168,198	$ 24,004	$ 9,722	$ 64,886
CONTNR (1+TRANS MODE)	8609	19	20	20	7	7	5	$ 64,135	$ 106,315	$ 103,404	$ 70,490	$ 10,710	$ 27,160
Total Value of Rail Equipment Imports	86	$ 28,149,439	$ 7,546,712	$ 12,973,678	$ 4,290,894	$ 3,065,944	$ 2,454,888	$ 28,149,439	$ 7,546,712	$ 12,973,678	$ 4,290,894	$ 3,065,944	$ 2,454,888

Note that no trades from China were reported in the above categories in 2018, and only a handful of small volume trades from elsewhere, mostly Russia.


Railway Locomotives, Cars, and Related, Imports from China to DPRK, 2000 - 2017 (number)
1,500
1,000
500
-
Electric Locomotives
Non-electric Locomotives and Tenders
Self-propelled Railway Coaches (Trams)
Railway Service Vehicles
Railway Passenger Coach
Railway Freight Car
Containers
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

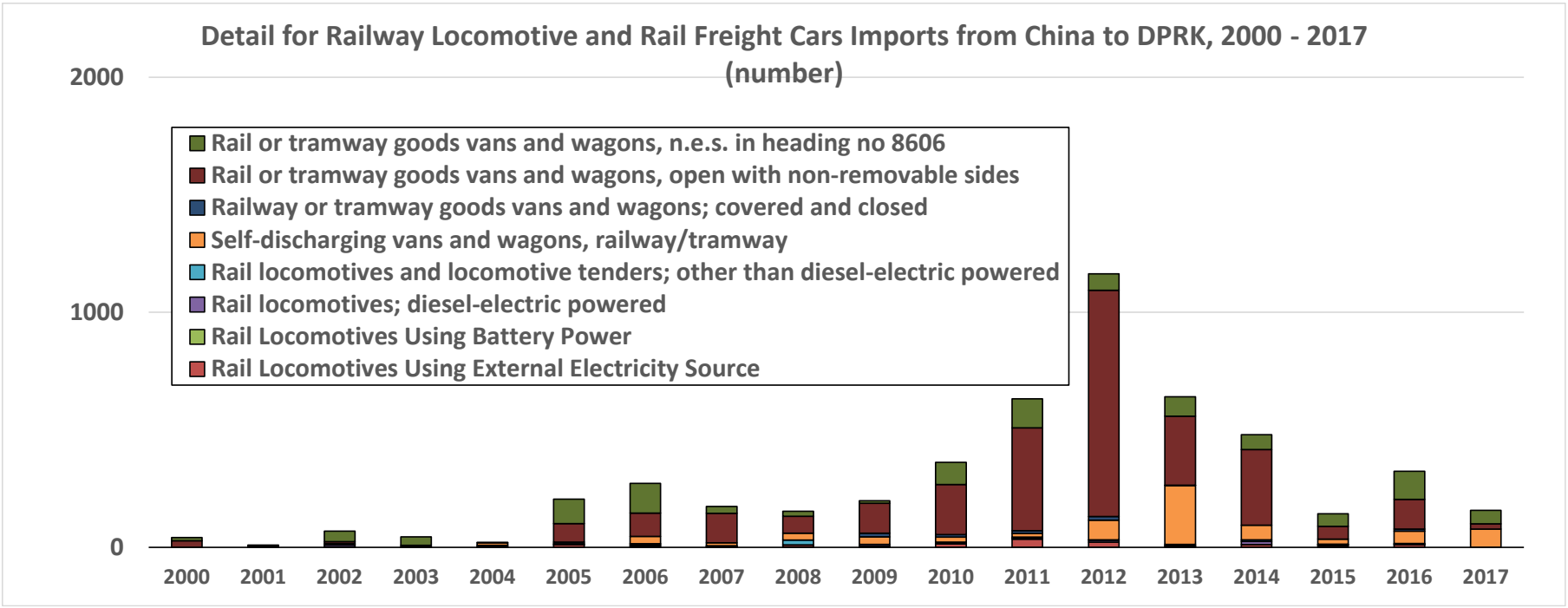

Railway Related Parts and Fixtures, Imports from China to DPRK, 2000 - 2017
(tonnes)
1,200
1,000
800
600
400
200
0
Locomotive and Rolling Stock Parts
Railway Fixtures and Mechanical Equipment
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

Additional Detail on Rail locomotives and cars (HS 8601, "Rail locomotives; powered from an external source of electricity or by electric accumulators", HS 8602, "Rail locomotives; (other than those of heading no. 8601), locomotive tenders", and HS 8606 "Railway or tramway goods vans and wagons; not self-propelled") (number of units)

Description	HS (code)	2000	2001	2002	2003	2004	2005	Value of Trades by Category 2000	2001	2002	2003	2004	2005
Rail locomotives; powered from an external source of electricity	860110	0	0	3	1	1	11	0	0	$81,982	$7,101	$6,410	$138,073
Rail locomotives; powered by electric accumulators	860120	0	0	0	0	2	1	0	0	0	0	$52,660	$15,000
Rail locomotives; diesel-electric powered	860210	0	5	8	2		4	0	$254,555	$1,676,400	$90,500		$44,800
Rail locomotives and locomotive tenders; other than diesel-electric powered	860290	0	5	5	6	6	6	0	$254,555	$104,387	$259,000	$226,100	$598,744
Self-discharging vans and wagons, railway/tramway	860630	0	0	0	0	10	0	0	0	0	0	$4,200	0
Rail or tramway goods vans and wagons, open with non-removable sides	860692	28	0	8	0	0	79	$68,750	0	$12,000	0	0	$872,793
Rail or tramway goods vans and wagons, n.e.s. in heading no 8606	860699	14	0	45	36	2	104	$47,250	0	$24,210	$13,850	$8,484	$366,320

Description	HS (code)	2006	2007	2008	2009	2010	2011	Value of Trades by Category 2006	2007	2008	2009	2010	2011
Rail locomotives; powered from an external source of electricity	860110	5	1	10	2	15	35	$93,391	$10,000	$132,711	$13,600	$236,557	$494,442
Rail locomotives; powered by electric accumulators	860120	4	3	0	3	4	3	$44,800	$35,326	0	$43,806	$81,656	$54,490
Rail locomotives; diesel-electric powered	860210	6	1	1	8	3	4	$226,100	$102,100	$160,000	$2,512,374	$697,000	$4,090,800
Rail locomotives and locomotive tenders; other than diesel-electric powered	860290	1	2	20	0	0	2	$70,000	$78,650	$2,337,120	0	0	$25,574
Self-discharging vans and wagons, railway/tramway	860630	31	12	29	32	22	15	$18,100	$4,500	$15,418	$25,660	$16,089	$12,308
Railway or tramway goods vans and wagons; covered and closed	860691	0	0	0	15	10	12	0	0	0	$68,934	$200,000	$261,000
Rail or tramway goods vans and wagons, open with non-removable sides	860692	99	126	72	128	213	437	$945,510	$450,089	$776,998	$1,473,105	$3,077,891	$7,050,519
Rail or tramway goods vans and wagons, n.e.s. in heading no 8606	860699	126	29	22	10	95	124	$107,669	$20,985	$36,990	$67,320	$86,031	$197,702

Description	HS (code)	2012	2013	2014	2015	2016	2017	Value of Trades by Category 2012	2013	2014	2015	2016	2017
Rail locomotives; powered from an external source of electricity	860110	22	6	12	8	11	0	$207,185	$79,607	$188,164	$97,789	$130,628	$114,067
Rail locomotives; powered by electric accumulators	860120	0	1	0	2	1	0	0	$16,000	0	$18,188	$11,177	$8,671
Rail locomotives; diesel-electric powered	860210	9	6	13	3	3	0	$3,873,384	$1,841,638	$4,086,309	$714,183	$437,139	$387,402
Rail locomotives and locomotive tenders; other than diesel-electric powered	860290	1	0	7	1	2	0	$118,500	0	$829,500	$118,500	$237,000	0
Self-discharging vans and wagons, railway/tramway	860630	84	250	62	21	52	78	$47,734	$161,788	$32,038	$9,683	$25,225	$37,691
Railway or tramway goods vans and wagons; covered and closed	860691	15	1	0	0	9	0	$419,772	$25,500	0	0	$146,500	0
Rail or tramway goods vans and wagons, open with non-removable sides	860692	963	294	322	54	126	22	$14,257,167	$4,531,757	$4,793,564	$428,271	$1,644,245	$478,037
Rail or tramway goods vans and wagons, n.e.s. in heading no 8606	860699	70	83	63	54	120	57	$51,525	$231,434	$178,647	$88,942	$95,504	$94,652


Detail for Railway Locomotive and Rail Freight Cars Imports from China to DPRK, 2000 - 2017
(number)
2000
1000
0
Rail or tramway goods vans and wagons, n.e.s. in heading no 8606
Rail or tramway goods vans and wagons, open with non-removable sides
Railway or tramway goods vans and wagons; covered and closed
Self-discharging vans and wagons, railway/tramway
Rail locomotives and locomotive tenders; other than diesel-electric powered
Rail locomotives; diesel-electric powered
Rail Locomotives Using Battery Power
Rail Locomotives Using External Electricity Source
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

SHIPS AND BOATS AND RELATED EQUIPMENT IMPORTS TO DPRK FROM CHINA

Units: Number of Vessels except as noted

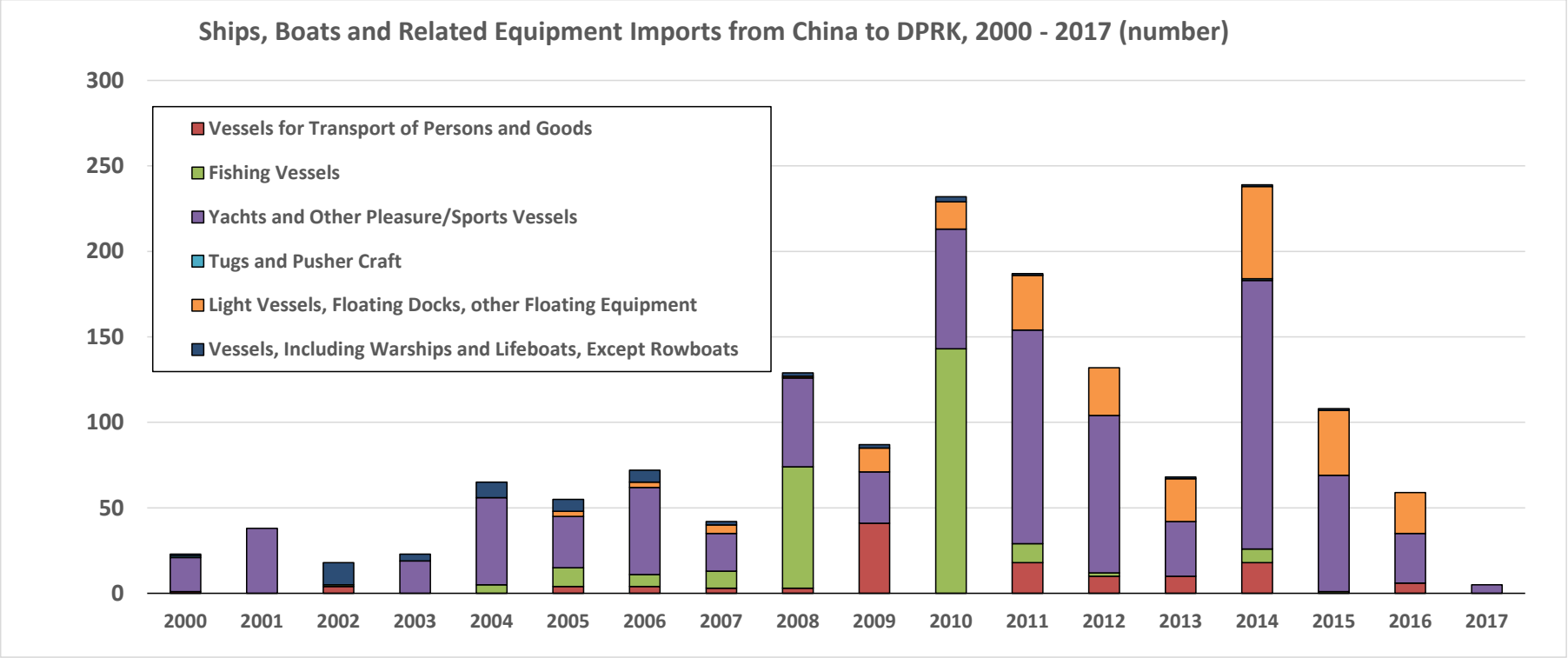
Description	HS (code)	2000	2001	2002	2003	2004	2005	Value of Trades 2000	2001	2002	2003	2004	2005
SHIPS AND BOATS (Number, through 8906)	89	23	38	18	23	65	55						
SHIPS AND BOATS (Value)	89	$493,435	$40,870	$602,175	$95,418	$163,470	$1,678,296	$ 493,435	$ 40,870	$ 602,175	$ 95,418	$ 163,470	$ 1,678,296
TRANSPORT PERSON/GOOD	8901	1	0	4	0	0	4	$390,000	0	$311,620	0	0	$1,449,000
FISH VESSEL;OTH SHIPS	8902	0	0	1	0	5	11	0	0	$28,600	0	$31,000	$6,535
YCHT & OT PLEAS VESSL	8903	20	38	0	19	51	30	$12,000	$40,870	0	$19,310	$47,581	$25,071
TUGS AND PUSHER CRAFT	8904	1	0	0	0	0	0	$87,700	0	0	0	0	0
LGT-VESS,FL DOCKS ETC	8905	0	0	0	0	0	3	0	0	0	0	0	$177,411
OT VESSEL,N ROW BOATS	8906	1	0	13	4	9	7	$3,735	0	$261,955	$50,230	$83,593	$10,600
OT FLT STRUCT,RFT,ETC	8907	0	0	0	160	1230	7	0	0	0	$25,878	$1,296	$9,679

Note: Based on their reported value of $1.45 million US, the four "transport person/goods" vessels imported by the DPRK in 2005 seem likely to be fairly large vessels.

Description	HS (code)	2006	2007	2008	2009	2010	2011	Value of Trades 2006	2007	2008	2009	2010	2011
SHIPS AND BOATS (Number, through 8906)	89	72	42	129	87	232	187						
SHIPS AND BOATS (Value)	89	$3,584,837	$5,124,227	$358,960	$832,829	$4,275,740	$16,338,482	$ 3,584,837	$ 5,124,227	$ 358,960	$ 832,829	$ 4,275,740	$ 16,338,482
TRANSPORT PERSON/GOOD	8901	4	3	3	41	0	18	$3,510,000	$4,915,042	$462,600	$48,101	0	$11,213,529
FISH VESSEL;OTH SHIPS	8902	7	10	71	0	143	11	$12,100	$9,600	$30,000	0	$2,749,000	$1,726,660
YCHT & OT PLEAS VESSL	8903	51	22	52	30	70	125	$23,020	$5,500	$21,945	$87,490	$220,983	$192,641
TUGS AND PUSHER CRAFT	8904	0	0	0	0	0	0	0	0	0	0	0	0
LGT-VESS,FL DOCKS ETC	8905	3	5	1	14	16	32	$20,500	$51,327	$11,450	$655,448	$1,187,330	$3,184,252
OT VESSEL,N ROW BOATS	8906	7	2	2	2	3	1	$5,390	$28,070	$41,828	$21,500	$78,434	$2,022
OT FLT STRUCT,RFT,ETC	8907	951	24	893	306	7523	85	$13,827	$9,393	$49,211	$20,290	$39,993	$19,378

Description	HS (code)	2012	2013	2014	2015	2016	2017	Value of Trades 2012	2013	2014	2015	2016	2017	Totals through 2017
SHIPS AND BOATS (Number, through 8906)	89	132	68	239	108	59	5							
SHIPS AND BOATS (Value)	89	$12,070,224	$3,631,864	$13,163,370	$2,877,938	$2,671,721	$1,980	$ 12,070,224	$ 3,631,864	$ 13,163,370	$ 2,877,938	$ 2,671,721	$ 1,980	$ 68,005,836
TRANSPORT PERSON/GOOD	8901	10	10	18	0	6	0	$10,283,010	$1,444,950	$3,971,449	0	$1,094,685	0	$ 39,093,986
FISH VESSEL;OTH SHIPS	8902	2	0	8	1	0	0	$52,000	0	$1,809,876	$239,516	0	0	$ 6,694,887
YCHT & OT PLEAS VESSL	8903	92	32	157	68	29	5	$168,529	$24,612	$411,631	$40,483	$11,537	$1,980	$ 1,355,183
TUGS AND PUSHER CRAFT	8904	0	0	1	0	0	0	0	0	$623,360	0	0	0	$ 711,060
LGT-VESS,FL DOCKS ETC	8905	28	25	54	38	24	0	$1,558,674	$2,103,268	$5,201,342	$2,550,229	$1,553,961	0	$ 18,255,192
OT VESSEL,N ROW BOATS	8906	0	1	1	1	0	0	0	$42,533	$50,000	$3,400	0	0	$ 683,290
OT FLT STRUCT,RFT,ETC	8907	80	167	676	156	820	0	$8,011	$16,501	$1,095,712	$44,310	$11,538	0	$ 1,365,017

Note that no trades from China were reported in the above categories in 2018, and only a handful of small volume trades exports involving other nations were reported.


Ships, Boats and Related Equipment Imports from China to DPRK, 2000 - 2017 (number)
300
250
200
150
100
50
0
Vessels for Transport of Persons and Goods
Fishing Vessels
Yachts and Other Pleasure/Sports Vessels
Tugs and Pusher Craft
Light Vessels, Floating Docks, other Floating Equipment
Vessels, Including Warships and Lifeboats, Except Rowboats
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

SHIPS AND BOATS AND RELATED EQUIPMENT IMPORTS TO DPRK FROM OTHER NATIONS (larger trades), AND EXPORTS FROM DPRK TO OTHER NATIONS

Description	Unit	2000	2001	2002	2003	2004	2005
IMPORTS FROM OTHER NATIONS, HS	NUMBER	0	0	0	586	4	1,207
8901 through 8907 (Larger trades only)	VALUE	0	0	0	$1,801,871	$1,634,592	$ 4,308,846
EXPORTS FROM THE DPRK IN HS 8908, SHIPS FOR SCRAP	NUMBER	1	0	0	6	3	5
	KG	2,702,209	0	0	17,704,547	15,624,969	15,134,145
	VALUE	$231,000	0	0	$2,334,699	$3,056,769	$2,690,047

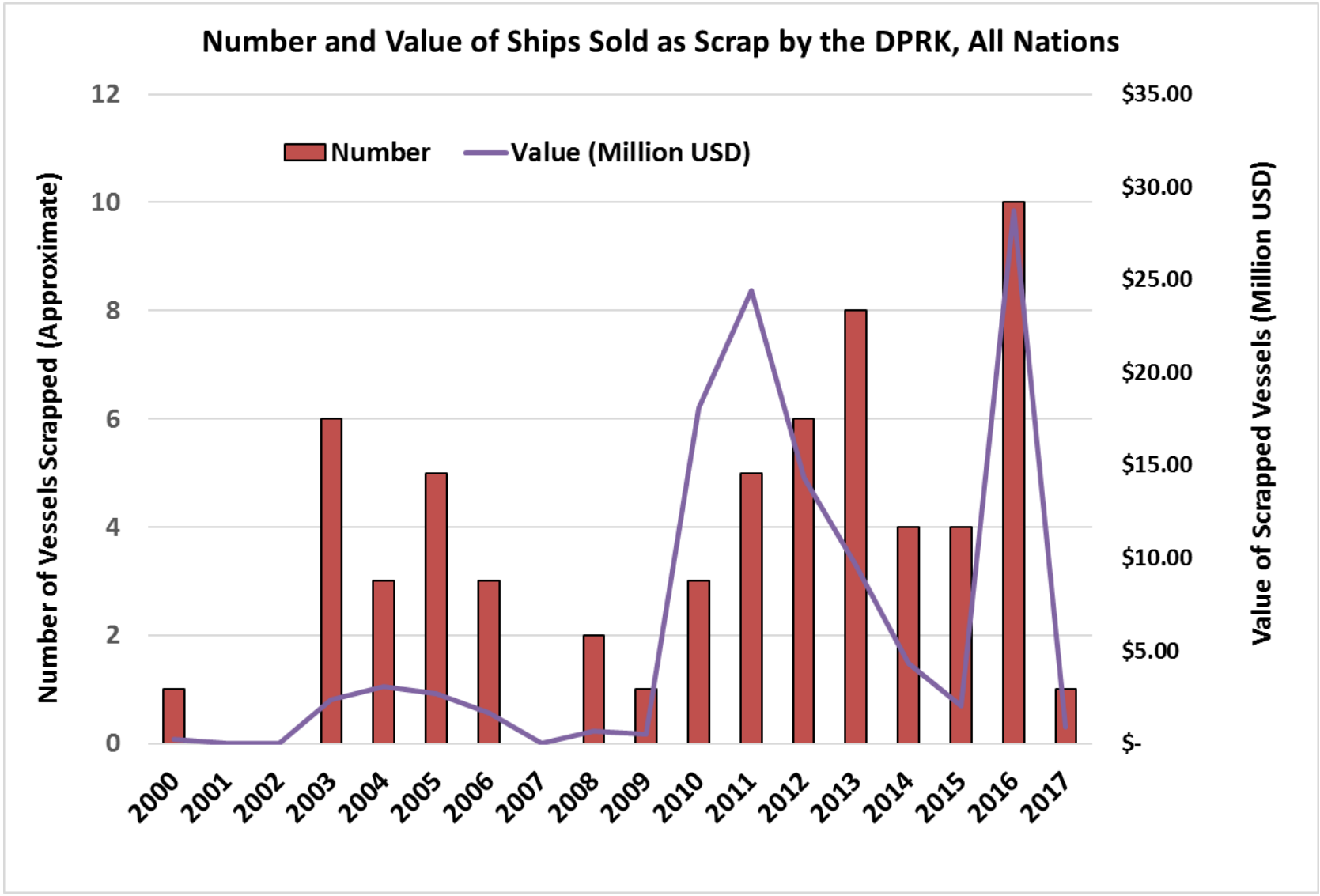
Description	Unit	2006	2007	2008	2009	2010	2011
IMPORTS FROM OTHER NATIONS, HS	NUMBER	821	639,933	7,527	0	0	1
8901 through 8907 (Larger trades only)	VALUE	$1,828,716	2,155,528	4,774,109	0	0	$860,000
EXPORTS FROM THE DPRK IN HS 8908, SHIPS FOR SCRAP	NUMBER	3	0	2	1	3	5
	KG	8,808,654	0	2,206,667	2083333.333	104,349,483	80,483,717
	VALUE	$1,643,284	0	$680,332	$500,000	$ 18,073,258	$24,392,412

Description	Unit	2012	2013	2014	2015	2016	2017	2018	Totals through 2017
IMPORTS FROM OTHER NATIONS, HS	NUMBER	0	0	4	0	0	0	0	650,083
8901 through 8907 (Larger trades only)	VALUE	0	0	$560,876	0	0	0	0	$ 17,924,538
EXPORTS FROM THE DPRK IN HS 8908, SHIPS FOR SCRAP	NUMBER*	6	8	4	4	10	1	0	62
	KG**	44,540,448	27,958,110	12,827,048	5,920,165	127,161,958	3,839,800	0	471,345,253
	VALUE	$14,305,589	$9,641,653	$4,344,036	$2,012,856	$28,706,866	$869,246	$ -	$ 113,482,047

*Note that this total is a minimum, as not all trades list number of ships scrapped.

**Includes some estimates of weight based on value per kg of recent trades.

Note that the above excludes some reported imports by countries other than China in categories other than 8908 (ships for scrap metal) because we are not sure if the trades were mis-reported or actual sales of vessels and related equipment by the DPRK to other nations. Some of the trades that seem most likely to have been mis-reported include a sale listed in HS 8901 with a value of $ 55,223,043 *to Spain in 2000, a sale of a vessel in HS 8901 with a value of* $94,051,208 *to Greece in 2008, and sale of a vessel, again in category 8901, to India in 2017 for* $8,860,024*. Possibilities explanations for these reports are that these are actually vessels that were built in the ROK, which is second internationally in shipbuilding of commercial vessels, and simply individual trades mis-reported as from the DPRK, or that they are ships that were destined for scrap but not reported in category 8908.*


Number and Value of Ships Sold as Scrap by the DPRK, All Nations
Number
Value (Million USD)
Number of Vessels Scrapped (Approximate)
Value of Scrapped Vessels (Million USD)
0
2
4
6
8
10
12
$-
$5.00
$10.00
$15.00
$20.00
$25.00
$30.00
$35.00
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

8 Anecdotal reports indicate that the use of biomass-fueled (gasifier-using) trucks remain very common in some areas of the DPRK, even in the years 2000 - 2005. We have assumed values of about 10 percent after 1996, with slight adjustments to balance fuel supply and demand.

9 Visitors to the DPRK, including the authors, have noted an increase in the number of imported, mostly diesel, trucks in use in the DPRK. Increasing imports of trucks from China from 2001 through 2005 reinforce these observations. Values shown are rough assumptions, adjusted slightly to balance fuel supply and demand.

10 Visitors to the DPRK, including the authors, have noted an increase in the number of imported automobiles in recent years. This observation is reinforced by the import statistics above. We assume that these vehicles are more efficient, on average, than the older vehicles (a declining percentage of them DPRK-made) in the DPRK automobile fleet, thus the improvement in energy intensity that is assumed over time. The increase in the number of imports of motorcycles noted above also supports this trend in efficiency improvement (gasoline use by private motorcycles is reported in the same row as gasoline use in private autos).

11 Another point of reference on the DPRK road vehicle sector is provided by the following from dprkguidebook.org (undated, but probably 2006 or 2007), in "III - MAIN INDUSTRIAL SECTORS & BUSINESS OPPORTUNITIES" available as http://dprkguidebook.org/contents_3.htm. Though this source claims that only 3000 passenger cars were on the roads of the DPRK as of 2005, that figure seems somewhat at odds with (too low relative to) the anecdotal reports and official import statistics described above. The text quoted below appears in the source under the headings "Automotive Industry" and "Passenger Cars".

"DPRK's automotive industry was born in November 1950 with the construction of the 600.000 m2 Tokchon Motor Plant in Tokchon City, South Pyongan Province, The factory name was changed to Sungri (Victory) Motor Plant in 1975 and produced a number of DPRK "classics" still to be seen on the country's roads. The "Sungri-58" truck debuted in November 1958 and was followed by the "Sungri 4.25" truck, the "Jaju" 5-seat passenger car, the "Konsol" (Construction) passenger car, the "Kumsusan" 40-ton truck, the "Paekdusan" (Mount Paekdu) passenger car and the "Kwangbok" jeep. The production of the "Mount Kumsusan" truck is said to have been discontinued because of excessive fuel consumption, among other reasons.like the WWII vintage "Jaju" (independence), "Sungri" trucks, the rickety " Kaengsaeng" Jeep as well as buses and trolleybuses assembled with imported parts.. Production facilities are concentrated at the foot of Mount Sungri in Tokchon City. Some of the facilities were built by the Chinese as a logistical base during the Korean War (1950-53). Car assembly and parts manufacturing are done on the ground, and most vehicle parts except glass and tires are produced there. The Sungri Motor Work s further received Czechoslovakian assistance to build improved trucks. The country's vehicle production capacity has grown to 33.000 u nits per annum as of 1997 through continuous expansion and diversification of the types of vehicle produced. When China and Russia, major su ppliers of parts and fuel, demanded cash instead of barter starting from 1993, the domestic vehicle industry was severely affected. The declin e went on until actual production bottomed to 1.300 vehicles in 1999. In 2004, domestic production climbed to 4.500 units and total number of vehicles on DPRK roads was estimated at around 250.000, 3.000 of them being passenger cars. Since all High-tech parts such as carburetors, filters and fuel injection pumps are imported in large quantities, the localization rate of the industry is estimated well below 60%. Th e low quality of locally produced parts has a direct impact on overall quality of domestically produced vehicle and breakdowns are very frequent."

"DPRK has never given any priority to the production of passenger cars given its ideological choice in favor of public transp ortation, the long ban on private ownership of a car and the absolute control exerted on the population's mobility. Passenger cars in DPRK repre sent nowadays around 3.000 units : they are either imported second-hand cars from Japan, Russian cars (VOLGA) or sometimes Romanian cars (DACIA) but the biggest fleet is still made by ageing MERCEDES-BENZ 190, 230 and others makes imported from Germany through the Trade Office of the DPRK Embassy in Vienna for the exclusive use of Party Central Committee members (mostly blue Mercedes 230 and newer types) as well as official foreign delegations (Bordeaux red 190 models). Since 2005 however, Pyongyang has decided for budgetary reasons to import hundreds of VOLKSWAGEN directly from Germany to gradually replace their fleet of MERCEDES which are costly to maintain."

"In 2002, South-Korea's Unification Church through its automobile business arm Pyeonghwa Motors invested U$ 55 millions together with DPRK's Korea Ryongbong Corporation to build the first ever foreign automotive Joint-Venture factory between Nampo and Pyongyang and started assembling FIAT SIENA (under the Korean name "Hwiparam") and a small SUV, the FIAT DOBLO (under the Korean name "Po kkugi") in association with a Chinese local maker, Dandong Shuguang Automobile. The venture targets the burgeoning middle-class in Pyongyang as well as the foreign community and elite. Cars typically sell around U$ 10.000 and the venture foresees to produce 20.000 units ann ually from 2006 and later even export its products to China, Russia and South-Korea. Pyeonghwa Motors also imports second-hand Japanese and foreign cars and is said to have secured the exclusivity to conduct all second-hand car business in DPRK. It was also Pyeonghwa Motors who paid for the first ever outdoor advertising in DPRK in 6 locations of Pyongyang for its Hwiparam car."

Pyeonghwa Motors Factory in Nampo (source as above)

12 In recent years, chronic electricity shortages have reportedly caused the DPRK to rely more on diesel-powered trains, including bringing old locomotives reserved for emergency use back into service (see, for example, Joon Ho Kim, Yunju Kim, and Roseanne Gerin (2015), "North Korea Resorts to Diesel Locomotives to Deal with Rail Power Shortage", Radio Free Asia, dated 2015-04-08 available as http://www.rfa.org/english/news/korea/authorities-use-diesel-locomotives-04082015165102.html). We assume that this caused a significant decrease in the fraction of passenger and freight traffic transported by electric rail.

13 We have not been able to obtain a definitive and complete listing of the number and tonnage of goods transport vessels in use by the DPRK, but the article "Busting North Korea's Sanctions-Evading Fleet", by Keith Johnson and Dan De Luce, FP (Foreign Policy), February 28, 2018, available as https://foreignpolicy.com/2018/02/28/busting-north-koreas-sanctions-evading-fleet-ofac-treasury-shipping/, suggests that the DPRK has "as many as 240 merchant ships in its fleet", and the Wikipedia article "List of North Korean merchant ships", which states that the list is incomplete, lists 122 ships with a gross tonnage of "420,000 grt" (Wikipedia article dated August, 2018, and available as https://en.wikipedia.org/wiki/List_of_North_Korean_merchant_ships). If the Wikipedia list is representative of the average weight per vessel in the overall DPRK fleet, and the Foreign Policy estimate of the number of vessels is correct, it suggests that there are on the order of 800,000 to one million gross registered tonnes of vessels in the DPRK fleet.

14 A Radio Free Asia article entitled "Charcoal-powered Vehicles Stage a Comeback in North Korea", dated 2016-12-09, reported by Jieun Kim for , translated by Soo Min Jo, *written in English by Roseanne Gerin, and available as https://www.rfa.org/english/news/korea/charcoal-powered-vehicles-make-a-comeback-in-north-korea-12092016160533.html, describes the resurgent use of "charcoal" fueled trucks in particularly rural parts of the DPRK, and in the Northeast city of Chongjin, for transport servirces of all kinds, including transport for hire. The article notes the use of these gasifier trucks (which we assume may be actually be using charcoal, wood, crop waste, and/or waste oil fuels in an on-truck gasifiers, has increased in recent years in some locales due to fuel restrictions, possibly due to sanctions. 1, 2.5, and 15, and 20-tonne truck models have been seen using the technology, but it appears that the 2.5-tonne, DPRK-made Seung-ri 58 (Victory 58) model is most frequently seen fueled by gasifiers. The article also notes that around 70 percent of gasifier-driven trucks (presumably in the specific area described) are from rural military units.*

15 *The DPRK is at the beginning of a transition to electricity use in personal transportation. Over 100,000 of what appear to be electric scooters (see note 7, under motorcycles) were imported in 2017 alone, as well as a few other electric vehicles. To estimate the electricity use of these vehicles, for scooters, we start with an estimate from an Indian case study that specify a battery pack of about* 2.4 kWh for a range of about 100 *km (Shashank Sripad, Tarun Mehta, Anil Srivastava, and Venkatasubramanian Viswanathan (2019), "The Future of Vehicle Electrification in IndiaMay Ride on Two Wheels", **ACS Energy Lett**.2019, 4, 2691−2694, available as https://pubs.acs.org/doi/pdf/10.1021/acsenergylett.9b02103), although this may apply mostly to a larger and more expensive scooter than has been on average purchased in the DPRK. The implied energy intensity for this example scooter is* 41.67 km/kWh. *A product available on Alibaba, https://www.alibaba.com/product-detail/2019-New-Foldable-8-inch-250w_62417306677.html?spm=a2700.7724857.normalList.129.7af41d3fZXerUK, described as "2019 New Foldable 8 inch 250w 500w Kick Scooter Folding Electric Scooters with Seat", suggests that it has a range of* 45 km for a *version with a battery capacity of* 10.4 Amp-hours at 36 volts, or 0.3744 kWh, an energy intensity of 120.19 km/kWh. *Another, even lighter example, the foldable stand-up scooter "2019 iEZway Alibaba portable lightweight m365 scooter elctrico electric kick scooter electric", at https://www.alibaba.com/product-detail/2019-iEZway-Alibaba-portable-lightweight-m365_62390620803.html?spm=a2700.7724857.normalList.57.7af41d3fZXerUK, is described at having a range of* 30 km, and also has a battery capacity of 10.4 Amp-hours a 36 volts, or 0.3744 kWh, an energy intensity o 80.13 km/kWh.

The Comtrade data on scooter exports to the DPRK from China in category HS 871160, and in common with exports in this category from China to other nations, tend to show, where both shipment weight and number of items are reported, a weight per scooter that is on the order of 5 kg or less, which is uniformly substantially less than the 9 or more kg that these scooters are listed on Alibaba. Why this difference exists is unclear, although it could be that the scooter and its battery are somehow accounted for separately in the customs statistics. For the moment we assume an energy intensity for and average DPRK electric scooter/motorcycle/bicycle of approximately 80 km/kWh. We assume that the average DPRK electric scooter (or other electric two-wheeler) is used *an average of approximately* 10 km per day (less than in Indian cities in the reference above, but both cities and scooters are smaller in the DPRK), *meaning a use of* 3650 km per year, and an average energy use of 45.63 kWh per scooter per year. By way of comparison this *would be about* 84% of the charge provided by a 60 watt solar panel located on a surface with fairly good solar access. *We assume charging at* 90% efficiency (see, for example, https://en.wikipedia.org/wiki/Lithium-ion_battery).

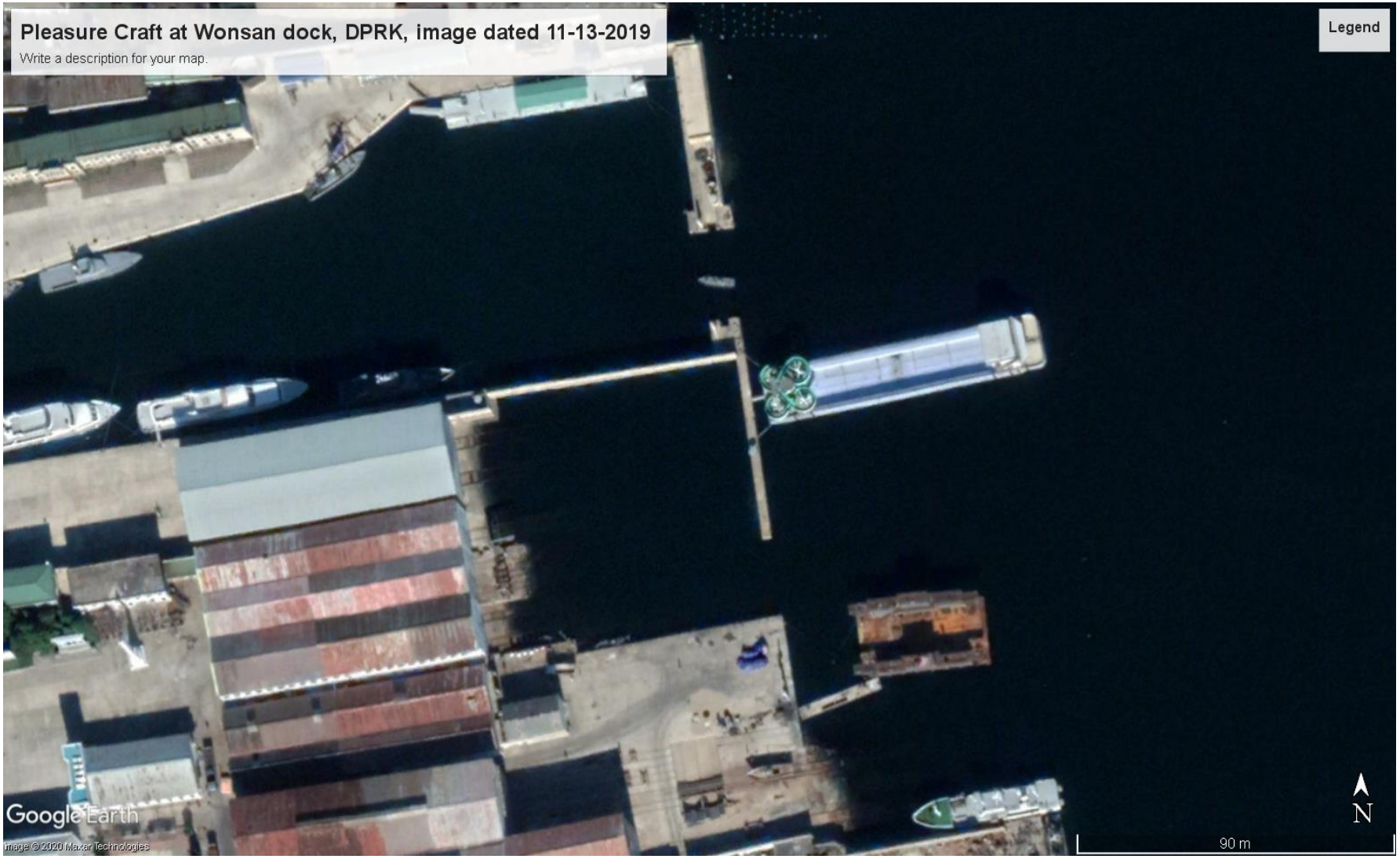
16 *The DPRK has also in recent years imported a very few larger electric vehicles. In the years before 2016 and 2018, these appear to have been smaller electric vehicles with costs of about $4000 to $7000 each and weights of several hundred kg each, suggesting that they are specialty vehicles. In 2016 and 2017 Comtrade statistics show a total of 30 vehicles imported, costing about $20,000 to $30,000 each, and weighing an average of about 1800 kg (for 2016, when weight was provided in the statistics), suggesting that these were on average full-sized cars. We assume the following, based on data for assumedly similar vehicles from Alibaba:*

Years	Annual km traveled/veh	km/kWh	Notes
All except 2016/2017	4000	25.43	Distance traveled is an assumption. Examples may include https://www.alibaba.com/product-detail/60V-4-0KW-2-seat-small_60663986851.html?spm=a2700.galleryofferlist.0.0.682d1bd6i9za4U, https://www.alibaba.com/product-detail/small-electric-car-with-long-driving_60839296446.html?spm=a2700.galleryofferlist.0.0.682d1bd6cQRluF, https://www.alibaba.com/product-detail/Chinese-factory-price-semi-automatic-adult_62138974081.html?spm=a2700.galleryofferlist.0.0.682d1bd6cQRluF, https://www.alibaba.com/product-detail/2019-New-Automatic-mini-electric-car_60830639059.html?spm=a2700.galleryofferlist.0.0.2c497ba1n0YiZY.
2016/2017	15000	8.95	Distance travelled is an assumption. Examples include https://www.alibaba.com/product-detail/electric-car-import-high-speed-electric_60869048896.html?spm=a2700.wholesale.deiletai6.9.525e7e14xe5WNo, https://www.alibaba.com/product-detail/Lithium-Battery-Cheap-Prices-Electric-Car_62018424249.html?spm=a2700.galleryofferlist.0.0.2c497ba1n0YiZY, and https://www.alibaba.com/product-detail/2019-4wheel-new-energy-China-electric_62102412059.html?spm=a2700.galleryofferlist.0.0.15c7200foFt5oM. These can be compared the the (similar weight but more powerful) Tesla Model 3 at a reported 6.25 km/kWh (https://en.wikipedia.org/wiki/Tesla_Model_3).

17 *There is no evidence to date that the DPRK has imported electric trucks, but it is possible that they could be used in the future. By way of comparison, a standard diesel semi-truck uses an average of* 6 *miles per gallon (see, for example, https://www.geotab.com/truck-mpg-benchmark/), while, for example, the Tesla semi-truck is advertized to achieve electricity use of less than* 2 *kWh per mile.(https://www.tesla.com/semi). Putting both values in the same units (MJ per km) yields the following:* 15.26 *for Diesel, and* 4.50 *for Electric, implying that the energy intensity of an electric truck would be about* 29.5% *that of a diesel truck. Adding a charging efficiency of* 86% *(see, for example, https://www.veic.org/documents/default-source/resources/reports/an-assessment-of-level-1-and-level-2-electric-vehicle-charging-efficiency.pdf), yields an overall fuel use ratio for electricity versus diesel of* 34.28%*. Of course this is only for large trucks, and a number of different comparisons can be made, but we use this as a figure of merit in estimating the relative fuel use of diesel and gasoline trucks on a per vehicle-km basis and, for trucks with similar-sized loads, on a per tonne-km basis. In practice truck fleets in the DPRK, as in other countries, will include vehicles ranging from semi-tractor-trailers used for long hauls and heavy loads (20-40 tonnes) to small trucks or three-wheelers carrying loads in the tens of hundreds of kilograms on short hauls in and around cities.*

18 *The most modern jet aircraft use* 3 *liters of fuel pe* 100 *passenger-km. At* 35.313 *MJ/liter, this is about* 1.06 *MJ per passenger-km, or about one third of average 1990 DPRK levels estimated here. (See, for example, https://en.wikipedia.org/wiki/Energy_efficiency_in_transport.) Smaller and private-sized aircraft can be more efficient.*

19 *Although certainly inconsequential to overall water transport energy demand, as a point of interest, an 80-meter ship dating from at least the year 1997 (its bow structure was revamped sometime between 2002 and 2009) that sports two figure-eight water slides, a 50-meter pool, and a two-story structure likely used for entertaining has been mostly docked at Wonsan over the last two decades. It is reportedly used by DPRK leadership when on holidays. See Colin Zwirko (2020), "Kim Jong Un's waterslide boat under repair in Wonsan ahead of annual outings"* ***NK News***, *dated, May 1, 2020, available as https://www.nknews.org/pro/kim-jong-uns-waterslide-boat-under-repair-in-wonsan-ahead-of-annual-outings/?t=1589307896448. A Google Earth Pro image of the ship, together with two additional ships with similar color schemes, one a houseboat and one possibly a yacht, is provided below. The additional ships are visible in images of the site for most of the last 20 years, suggesting they are under the same ownership. Other ships that look to be yachts are shown in the image as well, and a vessel similar to that at the top of the photo, but with a blue roof or canopy, also frequently appears in recent images of the same site. Image coordinates are approximately 39.161, 127.665.*


Pleasure Craft at Wonsan dock, DPRK, image dated 11-13-2019
Write a description for your map.
Legend
Google Earth
Image © 2020 Maxar Technologies
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90 m

*20 Additional evidence of the beginnings of electric vehicle use in the DPRK appears in another article by Colin Zwirko (2020), "Pyongyang to send tourist electric carts to delayed Wonsan-Kalma Resort", **NK News**, dated May 13, 2020, and available as https://www.nknews.org/2020/05/pyongyang-to-send-tourist-electric-carts-to-delayed-wonsan-kalma-resort/. Some of the carts shown in the images below (from the same article) are made in China, but others are reportedly made in the DPRK.*

*21 A 2016 article from **Reuters**, "Power to the people: electric bikes take off in North Korea", by James Pearson, dated May 7, 2016, and available as https://www.reuters.com/article/us-northkorea-congress-bicycles/power-to-the-people-electric-bikes-take-off-in-north-korea-idUSKCN0XY06I, provides additional anecdotal evidence of the rise of the use of personal electric vehicles in the DPRK. This article includes a reference to "A bike made by a Chinese company called Anqi was for sale this week in Pyongyang's Kwangbok Department Store for 2.62 million won - around $330 at the unofficial exchange rate of 8,000 won to the dollar." This price is roughly consistent with the cost per unit for exports from China to the DPRK as seen in Comtrade data for (probably) electric "motorcycles" in 2016 (see Note 7, above).*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
RESIDENTIAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

					Sources/Notes:
Estimate of Rural and Urban Households					
Total DPRK Population	2.20E+07				*1*
Military Personnel	1.20E+06				
Population in Households	2.08E+07				
Urban HH pop. fract	60%				*1*
Rural HH pop. fract	40%				*1*
Persons/HH, Urban	4.65				*4*
Persons/HH, Rural	4.65				*3*
Number of Urban HH	2,683,871				
Number of Rural HH	1,789,247				
Coal Use: Urban Households					
Fraction Using Coal:	91.2%				*5*
Average HH Dwelling Size	50	sq. meters			*19*
Te coal per HH/yr	2.20				*19*
GJ/Te Coal	24				
GJ Coal Use/HH	52.74				
Total Coal Use, Urban HH		1.29E+08	GJ/yr		
District Heat Use: Urban Households					
Fraction Using District Heat:	8.755%				*See "District_heat" worksheet*
Estimated delivered heat use per household		26.106	GJ/yr		*in this workbook*
Implied district heat use, Urban HH	7.01E+07	GJ/yr			
Coal Use: Rural Households					
Fraction Using Coal:	50%				*6*
Te coal per HH/yr	2.8				*2, 26*
GJ/Te Coal	24				*7*
GJ Coal Use/HH	67.2				
Total Coal Use, Rural HH		6.01E+07	GJ/yr		
Electricity Use: Urban Households					
Fraction Electrified HH:	100%				*8*
MWh per HH/yr	0.768				*9*
GJ/MWh	3.6				*10*
GJ Electricity Use/HH	2.7648				
Total Electricity Use, Urban HH		7.42E+06	GJ/yr		
Electricity Use: Rural Households					
Fraction Electrified HH:	100%				*8*
MWh per HH/yr	0.512				*9, 24*
GJ/MWh	3.6				*10*
GJ Electricity Use/HH	1.8432				
Total Electricity Use, Rural HH		3.30E+06	GJ/yr		
Oil Use: Urban Households					
Fraction using LPG/Kero:	25%	(for Cooking)			*11*
te per HH/yr	0.21				*12*
GJ/te	44.4				*13*
GJ LPG/Kero Use/HH	9.324				
Fraction of Kero/LPG use as Kero	66.0%				*Assumption to balance supply and demand*
Total LPG/Kero Use, Urban HH		6.26E+06	GJ/yr		
Oil Use: Rural Households					
Fraction using Kerosene/LPG:	2%	(for Cooking)			*30*
te per HH/yr	0.22				
GJ/te	44.4				
GJ Kerosene/LPG Use/HH	9.60				
Total Kerosene/LPG Use, Rural HH		3.44E+05	GJ/yr		
Charcoal Use: Urban Households					
Fraction Using Charcoal:	16%	(for Cooking--specialty foods)			*16*
Te Charcoal per HH/yr	0.15				*17, 27*
GJ/Te Charcoal	28.8				*18*
GJ Charcoal Use/HH	4.224				
Total Charcoal Use, Urban HH		1.81E+06	GJ/yr		
Charcoal Use: Rural Households					
Fraction Using Charcoal:	15%	(for Cooking--specialty foods)			*16*
Te Charcoal per HH/yr	0.15				*29*
GJ/Te Charcoal	28.8				*18*
GJ Charcoal Use/HH	4.32				
Total Charcoal Use, Rural HH		1.16E+06	GJ/yr		
Wood/Biomass Use: Rural Households					
Fraction Using Wood/Biomass:	48.00%	(all End Uses)			*6*
Te Wood/Biomass per HH/yr	6.6	(Dry basis)			*14, 28*
GJ/Te Wood/Biomass	15.25				*15*
GJ Wood/Biomass Use/HH	100.3				
Total Wood/Biomass Use, Rural HH		8.61E+07	GJ/yr		

Heating and Cooking Fuel Use Data from 2008 DPRK Census

The 2008 DPRK Census (D P R Korea 2008 Population Census National Report, Central Bureau of Statistics, Pyongyang, DPR Korea, 2009, available as http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/North_Korea/Final%20national%20census%20report.pdf), includes two tables (52 and 53) on heating and cooking energy use in the DPRK (respectively). This tables suggests that in 2008, the fractions of households that used various heating and cooking fuels were as follows:

	Type of Dwelling Unit				
Urban-Rural and Type of Heating System	Total	Single Detached House	Row House	Apartment Building	Others
All Areas--Number of Dwellings	5,887,471	1,988,415	2,584,435	1,261,709	52,912
Central or local heating system	263,809	1,315	1,894	258,942	1,658
Electronic heating system	40,624	3,018	7,415	29,495	696
Electronic heating system with others	55,712	1,841	4,575	49,115	181
Coal boiler or Briquette hole in the dwelling unit	2,773,238	600,671	1,399,295	757,398	15,874
Wood hole in the dwelling unit	2,656,866	1,328,122	1,142,644	157,912	28,188
Others	97,222	53,448	28,612	8,847	6,315
All Areas--Fraction of Total by Heating Type	100.00%	100.00%	100.00%	100.00%	100.00%
Central or local heating system	4.48%	0.07%	0.07%	20.52%	3.13%
Electronic heating system*	0.69%	0.15%	0.29%	2.34%	1.32%
Electronic heating system with others*	0.95%	0.09%	0.18%	3.89%	0.34%
Coal boiler or Briquette hole in the dwelling unit	47.10%	30.21%	54.14%	60.03%	30.00%
Wood hole in the dwelling unit	45.13%	66.79%	44.21%	12.52%	53.27%
Others	1.65%	2.69%	1.11%	0.70%	11.93%
Urban--Number of Dwellings	3,579,626	616,955	1,773,414	1,164,767	24,490
Central or local heating system	263,055	998	1,632	258,769	1,656
Electronic heating system*	35,630	1,860	5,354	27,823	593
Electronic heating system with others*	45,343	898	3,781	40,523	141
Coal boiler or Briquette hole in the dwelling unit	2,300,395	352,867	1,205,421	729,042	13,065
Wood hole in the dwelling unit	918,583	256,117	549,999	104,366	8,101
Others	16,620	4,215	7,227	4,244	934
Urban--Fraction of Total by Heating Type	100.00%	100.00%	100.00%	100.00%	100.00%
Central or local heating system	7.35%	0.16%	0.09%	22.22%	6.76%
Electronic heating system*	1.00%	0.30%	0.30%	2.39%	2.42%
Electronic heating system with others*	1.27%	0.15%	0.21%	3.48%	0.58%
Coal boiler or Briquette hole in the dwelling unit	64.26%	57.19%	67.97%	62.59%	53.35%
Wood hole in the dwelling unit	25.66%	41.51%	31.01%	8.96%	33.08%
Others	0.46%	0.68%	0.41%	0.36%	3.81%
Rural--Number of Dwellings	2,307,845	1,371,460	811,021	96,942	28,422
Central or local heating system	754	317	262	173	2
Electronic heating system*	4,994	1,158	2,061	1,672	103
Electronic heating system with others*	10,369	943	794	8,592	40
Coal boiler or Briquette hole in the dwelling unit	472,843	247,804	193,874	28,356	2,809
Wood hole in the dwelling unit	1,738,283	1,072,005	592,645	53,546	20,087
Others	80,602	49,233	21,385	4,603	5,381
Rural--Fraction of Total by Heating Type	100.00%	100.00%	100.00%	100.00%	100.00%
Central or local heating system	0.03%	0.02%	0.03%	0.18%	0.01%
Electronic heating system*	0.22%	0.08%	0.25%	1.72%	0.36%
Electronic heating system with others*	0.45%	0.07%	0.10%	8.86%	0.14%
Coal boiler or Briquette hole in the dwelling unit	20.49%	18.07%	23.90%	29.25%	9.88%
Wood hole in the dwelling unit	75.32%	78.17%	73.07%	55.24%	70.67%
Others	3.49%	3.59%	2.64%	4.75%	18.93%

*Note: "Electronic" probably means "Electrical", likely mostly portable or fixed resistance heating devices.

Type of Cooking Fuel	Total	Urban	Rural
Total (all of DPRK)	5,887,471	3,579,626	2,307,845
Electricity	79,057	65,814	13,243
Gas [likely almost all LPG]	167,462	157,228	10,234
Petroleum	103,091	90,927	12,164
Coal	2,714,511	2,271,128	443,383
Wood	2,758,400	984,407	1,773,993
Others	64,950	10,122	54,828
Fraction of Cooking Fuel by Types			
Total (all of DPRK)	100.00%	100.00%	100.00%
Electricity	1.34%	1.84%	0.57%
Gas [likely almost all LPG]	2.84%	4.39%	0.44%
Petroleum	1.75%	2.54%	0.53%
Coal	46.11%	63.45%	19.21%
Wood	46.85%	27.50%	76.87%
Others	1.10%	0.28%	2.38%
Type of Cooking Fuel			
Total for Pyongyang only	813,769	703,910	109,859
Electricity	52,470	46,592	5,878
Gas [likely almost all LPG]	160,873	153,605	7,268
Petroleum	99,646	88,832	10,814
Coal	458,212	397,766	60,446
Wood	38,312	16,936	21,376
Others	4,256	179	4,077
Fraction of DPRK Households using Cooking Fuel that are in Pyongyang			
Total for Pyongyang only	13.82%	19.66%	4.76%
Electricity	66.37%	70.79%	44.39%
Gas [likely almost all LPG]	96.07%	97.70%	71.02%
Petroleum	96.66%	97.70%	88.90%
Coal	16.88%	17.51%	13.63%
Wood	1.39%	1.72%	1.20%
Others	6.55%	1.77%	7.44%

1996, 2000, 2005, 2008 THROUGH 2010, AND 2014 THROUGH 2018 ENERGY USE IN RESIDENTIAL SECTOR

Growth in total number of households	0.079%	/yr (1990 to 2000 Estimate)						*20*
	1.021%	/yr 2000-2008 (average based on 2008 Census						*22*
	0.536%	/yr after 2008 through 2010						*22*
	0.500%	/yr after 2010 through 2014						*22*
	0.390%	/yr after 2014 through 2020						
		1996	**2000**	**2005**	**2008**	**2009**	**2010**	
Implied population (million)		2.210E+07	2.218E+07	2.333E+07	2.405E+07	2.418E+07	2.431E+07	
Estimated population not in households		1.106E+06	1.044E+06	9.655E+05	9.186E+05	9.030E+05	8.874E+05	
Estimated Persons per Household								
Urban		4.400	4.234	4.026	3.901	3.859	3.817	*21*
Rural		4.425	4.274	4.086	3.974	3.936	3.899	*21*
Fraction of Households as:								
Urban		60.27%	60.44%	60.67%	60.80%	60.85%	60.89%	*21*
Rural		39.73%	39.56%	39.33%	39.20%	39.15%	39.11%	*21*
Number of Households								
Urban		2,869,730	3,005,533	3,350,571	3,579,626	3,641,784	3,705,382	
Rural		1,891,971	1,966,822	2,172,292	2,307,845	2,343,540	2,380,017	
TOTAL		4,761,701	4,972,355	5,522,864	5,887,471	5,985,324	6,085,400	

	2014	2015	2016	2017	2018	2019	2020
Implied population (million)	2.480E+07	2.490E+07	2.499E+07	2.509E+07	2.519E+07	2.529E+07	2.539E+07
Estimated population not in households	8.248E+05	8.092E+05	7.936E+05	7.779E+05	7.779E+05	7.779E+05	7.779E+05
Estimated Persons per Household							
Urban	3.651	3.609	3.568	3.526	3.484	3.443	3.401
Rural	3.748	3.711	3.673	3.636	3.598	3.560	3.523
Fraction of Households as:							
Urban	61.07%	61.11%	61.16%	61.20%	61.25%	61.29%	61.33%
Rural	38.93%	38.89%	38.84%	38.80%	38.75%	38.71%	38.67%
Number of Households							
Urban	3,969,193	4,034,548	4,101,450	4,169,954	4,237,400	4,306,494	4,377,292
Rural	2,530,472	2,567,328	2,605,019	2,643,573	2,681,301	2,719,918	2,759,454
TOTAL	6,499,665	6,601,876	6,706,469	6,813,527	6,918,702	7,026,412	7,136,746

Fraction of Households using Coal Cooking/Heat		1996	2000	2005	2008	2009	2010	
Urban	***(See Note 37)***	81.7%	77.0%	72.4%	64.8%	64.9%	65.0%	
Rural	***(See Note 37)***	38.00%	33.00%	26.00%	18.76%	18.76%	18.76%	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	***(See Note 39)***	67.1%	68.2%	69.2%	72.3%	73.4%	73.5%	73.6%
Rural	***(See Note 39)***	22.00%	24.00%	26.00%	31.00%	32.00%	32.00%	32.00%

Coal Use per Household relative to 1990:		1996	2000	2005	2008	2009	2010	
Urban	***(See Note 38)***	75%	60%	53%	50%	50%	50%	
Rural	***(See Note 38)***	60%	50%	45%	45%	45%	45%	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	***(See Note 39)***	52%	54%	56%	60%	63%	63%	63%
Rural	***(See Note 39)***	47%	49%	51%	55%	58%	58%	58%

	1996	2000	2005	2008	2009	2010	
Fraction of Urban Households Using District Heating	8.29%	7.99%	7.60%	7.37%	7.29%	7.22%	
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	6.91%	6.83%	6.75%	6.68%	6.60%	6.52%	6.45%

	1996	2000	2005	2008	2009	2010	
Fraction of Urban Households Using District Heating	8.29%	7.99%	7.60%	7.37%	7.29%	7.22%	
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	6.91%	6.83%	6.75%	6.68%	6.60%	6.52%	6.45%

Electricity and Heat Use per HH relative to 1990:		1996	2000	2005	2008	2009	2010	
Urban	***(See Notes 23, 31, 32)***	59.05%	29.14%	36.73%	40.92%	35.00%	32.86%	
Rural	***(See Notes 24, 31)***	48.0%	12.0%	12.2%	14.7%	12.0%	11.0%	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	***(See Notes 23, 31, 32)***	25.87%	27.00%	27.97%	27.86%	29.71%	27.78%	47.89%
Rural	***(See Notes 24, 31)***	7.0%	7.0%	7.0%	7.0%	7.2%	7.0%	12.0%

Implied Electricity Use per Household (kWh)								
	1990	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	
Urban	***768***	453.50	223.76	282.09	314.27	268.80	252.36	
Rural	***512***	245.76	61.44	62.46	75.26	61.44	56.32	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban		198.68	207.36	214.81	213.96	228.17	213.35	367.80
Rural		35.84	35.84	35.84	35.84	36.86	35.84	61.44

Fraction of Households using Wood/Biomass Heat		1996	2000	2005	2008	2009	2010		
Urban	***(See Note 34)***	10%	15%	20%	27.78%	27.78%	27.78%		
Rural	***(See Note 34)***	60%	65%	72%	79.244%	79.24%	79.24%		
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Urban	***(See Note 39)***	26.00%	25.00%	24.00%	21.00%	20.00%	20.00%	20.00%	*See Note 39*
Rural	***(See Note 39)***	76.00%	74.00%	72.00%	67.00%	66.00%	66.00%	66.00%	*See Note 39*

Wood/Biomass Use per Household rel. to 1990:		1996	2000	2005	2008	2009	2010	
Urban	***(See Note 35)***	100%	80%	70%	65%	65%	65%	
Rural	***(See Note 36)***	90%	80%	70%	65%	65%	65%	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	***(See Note 39)***	63%	62%	61%	55%	52%	52%	52%
Rural	***(See Note 39)***	63%	62%	61%	55%	53%	53%	53%

Charcoal Use per Household rel. to 1990:		1996	2000	2005	2008	2009	2010	
Urban		75%	55%	50%	45%	45%	45%	
Rural		75%	55%	50%	45%	45%	45%	
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	***(See Note 40)***	46%	47%	48%	47%	47%	47%	47%
Rural	***(See Note 40)***	46%	47%	48%	47%	47%	47%	47%

	1996	2000	2005	2008	2009	2010		
Fraction of Households using Kero/LPG for cooking								
Urban	13.0%	12.0%	9.0%	6.93%	6.93%	7.02%		*33*
Rural	1.5%	1.5%	1.2%	0.971%	0.971%	1.020%		*33*
Kero/LPG Use per Household rel. to 1990:								
Urban	47.4%	57.2%	71.7%	82.8%	65.8%	78.1%		
---fraction of Urban use as Kero	26.1%	17.9%	40.0%	36.6%	36.6%	36.9%		*33*
Rural ***(See Note 25)***	50.0%	55%	61.0%	85.6%	64.9%	75.9%		
---fraction of Rural use as Kero	90.0%	54%	67.0%	54.3%	54.3%	53.0%		*33*
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Fraction of Households using Kero/LPG for cooking								
Urban	7.20%	8.60%	9.00%	8.90%	9.40%	9.50%	9.60%	*33*
Rural	1.00%	1.20%	1.40%	1.43%	1.56%	1.56%	1.56%	*33*
Kero/LPG Use per Household rel. to 1990:								
Urban	75.2%	78.2%	79.3%	79.4%	82.4%	78.6%	79.8%	
---fraction of Urban use as Kero	34.1%	33.8%	33.3%	21.2%	8.8%	7.0%	6.0%	*33*
Rural ***(See Note 25)***	75.2%	75.9%	75.9%	75.9%	77.4%	74.0%	75.0%	
---fraction of Rural use as Kero	53.0%	53.0%	56.2%	35.0%	18.0%	18.0%	18.0%	*33*

Sources/Notes:

1 from document in authors' files [HT1].

2 A document in authors' files [FC1] gives figures for coal use of 8 and 9.2 tonnes of coal per rural household in two areas of the DPRK. Based on other documents and the observations of visitor to the DPRK, these figures either represent very high-use areas, or are inaccurate, but do not seem to be consistent with average figures for rural coal consumption.

3 Value for Ongjin area (southern DPRK) from document in authors' files [FC1]. Value is similar to estimates given for rural areas in the central and northern regions of DPRK.

4 Assumed same as rural value.

5 Assumes all urban households, most in multi-unit concrete buildings, use coal for space heating, except for those that use district heat for space and water heating. See "District_heat" worksheet. Urban households also, except in Pyongyang, use coal for cooking. From document in authors' files [R1]. This assumes that wood and biomass use in urban households in 1990, with the exception of charcoal, was negligible, as coal supplies were generally sufficient in urban areas.

6 Fractions cited for three different areas of DPRK, from document in authors' files, vary from 8 to 50% coal use. Other observers of the DPRK situation suggest that the fraction of coal use in rural households as of 1990 or so was higher, perhaps 60%. We use 50% as an estimated national average.

7 From document in authors' files [FC1]. This value may be somewhat high.

8 Document in authors' files [HT1, p. 14], says "government reports that 100 percent of homes and industry are electrified".

9 Estimated based on 1.6X (rural) and 2.4X (urban) 1975 value for per household consumption of electricity in the Republic of Korea, as derived from pp. 121, 90, and 102 of "The Electric Future of Korea" East-West Center, September, 1983. At these levels, total sectoral energy use is approximately 10% of total national electricity consumption, as suggested in UNDP "Project of the Government of DPRK: Electric Power Management System".

10 Unit conversion (3600 kJ/kWh), no generation losses included.

11 From document in authors' files [FA1]. This source notes that cooking in (apparently Pyongyang) is by LPG or Kerosene stoves. Figure shown assumes that that petroleum-based fuels are rarely used outside Pyongyang, and that the 1990 population of Pyongyang is approximately 3.2 million (Microsoft Encarta lists a 1984 estimate of 2.64 million, Korea Foreign Trade Association lists 3.288 million for 1990)).

12 Estimated assuming petroleum product stoves have on average 50 percent of the energy intensity of wood stoves, and that wood use for cooking is approximately 19.2 GJ/HH-yr (estimate from Kumgang area, as given in from document in authors' files [FC1].

13 Rough ave. assuming fuel is 50% LPG (at approx. 45.5 GJ/te) and 50% Kerosene (at approx. 43.3 GJ/te)

14 Original value (earlier versions of analysis) based on est. (13.7 te/HH-yr) from Kumgang area, as given in document in authors' files [FC1].

15 Based on average of values for wood (16 MJ/dry kg) and crop residues (14.5 MJ/kg), source as in 14)

16 Rough estimates to yield 1990 charcoal consumtion approximately equal to wood charcoal produciton as described in UN FAO statistics (see Note 7 in "Biomass" worksheet in this workbook). Post-1990 UN FAO estimates of charcoal production were not used to estimate charcoal use after 1990 because the UN FAO estimates appear to just apply a constant growth rate every year, and thus may not reflect actual DPRK conditions.

17 Originally assumed heat energy requirements as for wood-fired rural cooking, but assumed fuel input per unit heat supplied to the cooking vessel was two-thirds that for wood stoves (original value 0.44 tonnes/HH-yr). Assumption has changed based on input from observers--see note 27.

18 Based on value used in LEAP (SEI-B) default data set (which is based on international sources)

19 Based on Chinese figure of 30 kgce/sq.m.-yr for centrally-heated residential buildings, and a rough average dwelling size of 50 sq. meters (from in-country observations by visitors to DPRK). An alternative "typical" dwelling size estimate of 120 sq. meters (from document in authors' files [FA1]. would seem to be large based on Chinese figures, which show less than 10 square meters/person ("Energy Use and Conservation in China's Residential and Commercial Sectors: Patterns, Problems, and Prospects", by Feng Liu, LBL, March, 1993.). Per-unit floor area figure from China increased by 20 percent to account for more severe weather, on average, in DPRK.

20 US Central Intelligence Agency, "Korea, North". CIA Factbook, 2001 (World Wide Web Version). USCIA, Washington, D.C., USA. 2001, http://www.odci.gov/cia/publications/factbook/geos/kn.html listed a 2001 estimated growth rate of 1.22 %/yr and a total population of just under 22 million. The USDOE Energy Information Administration lists a year 2000 population of 21.7 million in its North Korea Country Analysis Brief (www.eia.doe.gov/emeu/cabs/nkorea.html, visited 5/2002). A file of "DPRK Energy Data" provided to Nautilus by the Korea Energy Economics Institute (KEEI, 2002) suggested a year-2000 population of 22.175 million and a growth rate of 0.4 percent annually (with the growth rate decreasing substantially between 1990 and 2000), but uses a year-2000 base population of 20.221 million for the DPRK. While recognizing the extreme difficulty in estimating DPRK population, we continue to assume that year 1990 population was 22 million (as official estimates suggest) and adopt the figure provided by KEEI as the year 2000 population. This suggests a very modest increase in population over the decade, which is certainly consistent with food shortages and anecdotal but fairly widespread evidence of lack of proper food rations, as well as medical care, for the DPRK populace, offsetting the impacts of a national government program to increase the population.

21 Based on data in 2008 DPRK Census (see source in Note 22, Table 3), by 2008 there were 3,579,626 *urban households, and* 2,307,845 rural households in the DPRK. This implies an urban population fraction of 60.8%, *which is slightly higher than the 60 percent reported in 1990. We assume linear growth in the urban household fraction from 1990 through 2009. Based on figures for 2008 populations in households of* 13,962,973 *in urban households, and* 9,170,719 *in rural households, this implies average persons per household in 2008 of* 3.90 *in urban areas, and* 3.97 *in rural areas. In both urban and rural areas, about two-thirds of households are categorized as extended households (including relatives other than a nuclear family). Note that populations in households do not include individuals in institutions (that is, includes private households only), which are largely soldiers (mostly male) in the military. We assume linear trends in household size from 1990 through 2009. There have been reports of forced migration from the cities to the rural areas, but none have been confirmed. World Bank projections suggested continued rural-to-urban migration. The overall pattern of migration remains undocumented. There is anecdotal evidence that residents of cities in the North of the DPRK, for example, are leaving for the countryside where they can forage, rather than remain in cities where food distribution is sporadic at best. We assume that there has been at least a modest net migration from urban to rural areas in some places, but that this trend has been offset by a slow migration to the cities (which in any case has been much slower than in the Republic of Korea).*

22 This population growth assumption represents an attempt on our part to take into account the effects of the food shortages of the 1990s on future population growth in the DPRK, but also assumes that the results of the UN-directed 2008 DPRK Census are accurate, at a total population of 24,052,231 *(D P R Korea 2008 Population Census National Report, Central Bureau of Statistics Pyongyang, DPR Korea, 2009, available as http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/North_Korea/Final%20national%20census%20report.pdf). Historical (pre-1990) population growth rates had been near 2 percent annually. The 2008 Census document lists total births in the 12 months prior to the census as* 345,630 *(Table 16), and total deaths in the same period as* 216,616 *. These figures imply a rate of population increase as of 2008 of* 0.536% *annually. A compilation of DPRK statistics by the International Fund for Agricultural Development (IFAD), available as http://www.ruralpovertyportal.org/country/statistics/tags/dprkorea, estimates population growth at a slightly lower* 0.50% *annually as of 2014. We use this value as the estimated growth rate for population between 2010 and 2014.*

Population data from the United Nations (downloaded 1/28/2020 from https://population.un.org/wpp/Download/Standard/Population/ for the years 204 through 2020 are as follows:

2014	2015	2016	2017	2018	2019	2020
25 058	25 184	25 308	25 430	25 550	25 666	25 779

These data imply average population growth from 2014 through 2020 of 0.39% annually, which we take as the groth rate from 2014 through 2017.

23 Visitors to the DPRK in 2000 described electricity in Pyongyang as being generally available, but electricity in at least major portions of other cities being largely unavailable. Based on Korea Trade-Investment Promotion Agency (KOTRA) data (from http://www.kotra.or.kr/main/info/nk/eng/main.php3, visited 6/3/02) that lists the population of Pyongyang as 3.4 *million, assuming, based roughly on a record of of electrical outlet voltage collected in Pyongyang and covering most of 2000, that Pyongyang suffered from blackouts for about* 30% *of 2000, and further assuming that residents of cities other than Pyongyang had power only* 14% *of the time, we estimate that the average consumption of power per household was about* 29% *of that in 1990.*

24 Nautilus Institute's rural energy survey in the village of Unhari, (as reported on in "A RURAL ENERGY SURVEY IN UNHARI VILLAGE, THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK): METHODS, RESULTS, AND IMPLICATIONS", Asian Perspectives special issue, 2002.), suggested an annual average usage of 390 kWh per household per year, fairly close to the 1990 value estimated above. During our mission to Unhari in 2000, we determined that householders virtually never had electric power available in their homes during the day, especially in the winter months. As Unhari is relatively close to Pyongyang, it is our expectation that the situation there is likely, if anything, to be better than that in other rural areas. We therefore assume that the lack of availability of power limited rural residents to 10% *of 1990 levels of electricity consumption in the year 2000.*

25 Oil use in rural households increased for 2000 relative to 1996 to reflect more use of kerosene and diesel oil for lighting during the bulk of the year, when electricity for lighting is unavailable. On a national basis, the per-household rural oil consumption estimate shown here is approximately the same as that estimated for Unhari village (see reference in Note 24) based on a survey done in 1998. Other areas probably had less access to fuel supplies than Unhari, on average, but rural electricity availability in 2000 was worse than in 1998.

26 In earlier versions of this analysis, a much higher estimate of coal use per household (9 tonnes) was used. The results of the Nautilus Unhari survey, and input from recent DPRK visitors, have suggested that a substantial revision to this assumption is in order. Therefore, an average of 2.8 tonnes coal/HH year is assumed for households in rural areas in 1990 using coal (exclusively or nearly so) for cooking and heating. This is consistent with estimates from other documents in the authors files, and is consistent with the 2 tonnes/yr finding in (relatively temperate) Unhari, given that the Unhari survey was taken in 1998/2000, when supplies were not as adequate as in 1990 (by residents' estimation).

27 Initial assumption (in previous versions of analysis) for charcoal use in urban households reduced based on input from residents and recent visitors to the DPRK that charcoal use in urban households is not routine.

28 Initial assumption (in previous versions of analysis) for wood/biomass use in rural households reduced based on input from recent visitors and consideration of results of Unhari survey suggesting that coal use per household is lower than previously thought (see note 26 in this worksheet). The revised figure shown is calculated assuming that wood/biomass burns approximately 67% *as efficiently as coal, and takes into account the difference between the energy contents of coal and biomass fuels. By way of comparison, annual estimates of per-household woood/biomass fuel use in rural households vary from 9 to 13 or so tonnes per HH year, but in many cases the mass basis (wet or dry) of the biomass input was not specified (document in author's files).*

29 Assumed approximately the same as in urban households.

30 Assumed, based on input from observers, to be quite low, even in 1990.

31 Observers suggest that electricity supplies to residences and public/commercial buildings in the DPRK have improved somewhat by 2005, relative to 2000, though improvements, and the number of hours per day that residents can expect to have electricity services, varied substantially by region of the country, by proximity to power plants, and by time of year (allocation of electricity varies in seasons when agricultural uses have priority, and availability of *electricity varies seasonally as water flows affect hydroelectric output). Observers have reported levels of electricity availability ranging from an hour or two per day (intermittently) to nearly 24 hours per day.*

32 Availability of heat is assumed to be linked to availability of electricity for urban homes. Although some heat is generated in central district-heat-only boilers, we assume that those plants would be subject to most of the same fuel availability and maintenance issues affecting electricity generation (including combined heat and power) plants.

33 2008 and 2009 values based on data in 2008 DPRK Census (see tables from census above). We assume that households who had typically used liquid petroleum fuels (kerosene or diesel fuel) or LPG for cooking were forced to either cut back on their usage due to lowered oil products availability after 1990, or switch to other cooking fuels (coal or wood) altogether. This transition is modeled as a reduction to near 2008 fractions of households using these fuels by 2000. Over time, more of the total petroleum products used for cooking are assumed to be LPG, converging on 2008 Census figures by 2008.

34 2008 and 2009 values based on data in 2008 DPRK Census (see tables from census above). We assume that urban households used very little wood fuel as of 1990, but that as coal became more scarce, more household started using it, thus values shown for 1996 through 2005 are rough interpolations to the 2008 census value. For rural households, we assume based on literature sources that 48 percent of rural households used wood or other forms of biomass for cooking and heating as of 1990, and that value increased toward 2008 values over time as coal scarcity increased (and or coal became unaffordable). For 2008, we have used census-derived values for the fraction of wood and "other" (assumed to be crop waste or other biomass) used for cooking, but the fraction of heating reported by the 2008 Census as being done with wood and other fuels is within a few percent of the cooking fractions in both the urban and rural subsectors.

35 As we assume that there was little use of wood and biomass fuels for cooking and heating in urban households in 1990, the fractions of household usage shown here are the equivalent of the 1990 per-household use of coal per urban household, measured on an energy content basis, and roughly factoring in the lower efficiency of biomass fuel use relative to coal.

36 We assume that the usage of wood fuel per rural household has decresased somewhat over time due to a combination of scarcity of fuel, and possibly a reduction, on average, in the amount of food to be cooked.

37 Fraction of urban and rural households using coal for cooking and heating is adjusted downward over time to account for the increased in wood use, though in practice (though not directly reflected in Census statistics), many households probably used both fuels depending on availability and cost.

38 The amount of coal used for cooking and heating per household primarily using coal is assume to have trended downward over time due to lower availability.

39 The amount of coal used for cooking and heating per household primarily using coal afer 2014 is assumed to trend upward slightly over time due to higher availability and lower domestic prices, particularly in 2017 and 2018 following sanctions. Similarly, the fraction of households using biomass for heat, and the amount of biomass used for heat in those households, is assumed to have trended downward after 2010 due to an improved economy and better availability of coal.

40 Charcoal use (for specialty cooking) is assumed to rise slightly after 2010 with the improved economy before falling in 2017 due to the impact of sanctions on incomes, as well as reduced food production (with a presumed impact on livestock feed, and thus meat availability).

41 Population calculated from above (UN statistics, note 22) by year (million).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Index relative to 1990	1.0000	1.0008	1.0016	1.0024	1.0032	1.0040	1.0048	1.0056	1.0064	1.0072	1.0080
Population	22	22.02	22.03	22.05	22.07	22.09	22.10	22.12	22.14	22.16	22.18

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Index relative to 1990	1.0182	1.0286	1.0391	1.0498	1.0605	1.0713	1.0822	1.0933	1.0992	1.1050
Population	22.40	22.63	22.86	23.09	23.33	23.57	23.81	24.05	24.18	24.31

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Index relative to 1990	1.1106	1.1161	1.1217	1.1273	1.1317	1.1361	1.1406	1.1450	1.1495	1.1539
Population	24.43	24.55	24.68	24.80	24.90	24.99	25.09	25.19	25.29	25.39

42 Historical and projected fraction of population in the DPRK as Urban from United Nations World Urbanization Prospects are as follows. File WUP2018-F02-Proportion_Urban.xls, "Percentage of Population at Mid-Year Residing in Urban Areas by region, subegion and country, 1950-2050" downloaded 3-18-20 from https://population.un.org/wup/Download/.

	Percentage of Population at Mid-Year Residing in Urban Areas, 1950-2050								
	1950	**1955**	**1960**	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**
Urban	31.0	35.5	40.2	45.1	54.2	56.7	56.9	57.6	58.4	59.0
Rural (calculated)	*69.0*	*64.5*	*59.8*	*54.9*	*45.8*	*43.3*	*43.1*	*42.4*	*41.6*	*41.0*

	2000	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Urban	59.4	59.8	60.4	61.3	62.4	63.8	65.6	67.6	69.8	72.0	74.2
Rural (calculated)	*40.6*	*40.2*	*39.6*	*38.7*	*37.6*	*36.2*	*34.4*	*32.4*	*30.2*	*28.0*	*25.8*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
AGRICULTURAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: **6/26/2020**

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

				Sources/Notes:
Oil Use in Agricultural Sector				
Total Area of Field Crops:	1.70E+06	ha		*1*
Average Diesel use	41	l/ha-yr		*2*
Conversion Factor	1149	l/te		
Conversion Factor	43.17888	GJ/te		
Annual Oil Use: Agric. Machinery	2.62E+06	GJ		
Electricity Use in Agricultural Fields				
Total Area of All Crops:	2.00E+06	ha		*3,4*
Average electricity use	126	kWh/ha-yr		*2*
Conversion Factor	0.0036	GJ/kWh		
Annual Electricity Use: Agric./Fields	9.07E+05	GJ		
Coal Use: Processing/Other				
Area of Rice Cultivation	6.50E+05			*4*
Total Agr. Coal Use	1.50E+01	GJ/ha rice		*7*
Annual Processing/Other Coal Use	9.75E+06	GJ		
Oil Use: Processing/Other				
Total Agr. Oil Use	7.70E+00	GJ/ha rice-yr		*7*
Annual Oil Use in Agric. Machinery	2.62E+06	GJ		
Annual Net Oil Use, Processing/Other	2.39E+06	GJ		
Electricity Use: Processing/Other				
Total Agr. Electricity Use	4.44E+02	kgce/ha rice-yr		*7*
Conversion Factor	4.04E+02	kgce/MWhe		
Conversion Factor	3.60E+00	GJ/MWHe		
Annual Electricity Use: Agric./Fields	9.07E+05	GJ		
Annual Net Elect Use, Processing/Other	1.66E+06	GJ		*9*
Wood/Biomass Use: Processing/Other				
Grain straws used in Crop drying	3.00E+06	te/yr		*5*
Conversion Factor	14.5	GJ/te		*6*
Grain brans used in crop drying	1.00E+05	te/yr		*5*
Conversion Factor	14.5	GJ/te		*6*
Wood used in Agricultural Sector	0		*No data*	
Conversion Factor	16	GJ/te		*6*
Total Annual Wood/Biomass Use:	4.495E+07	GJ		

ESTIMATES OF CURRENT AND HISTORICAL ENERGY USE IN AGRICULTURAL SECTOR

(Notes 10, 15)

	1996	2000	2005	2008	2009	2010	***Sources/Notes:***
Area Harvested Relative to 1990:	87.86%	77.37%	86.17%	82.25%	82.39%	82.38%	*16*
Use of Tractors, etc. Relative to 1990:	30%	25%	27%	24%	24%	25.0%	*8*
Use of Electricity in Fields Relative to 1990:	90%	75%	65%	52.5%	48%	50%	*11*
Coal Use, Processing/Other, Rel. to 1990:	37.15%	37.48%	62.873%	63.52%	60.24%	61.09%	*8, 15*
Oil Use, Processing/Other, Rel. to 1990:	30.0%	25.0%	27.0%	25%	22%	25%	*8*
Elect. Use, Processing/Other, Rel. to 1990:	37.15%	35.13%	62.87%	63.52%	60.24%	61.09%	*8, 15*
Biomass Use, Processing/Other, Rel. to 1990:	37.15%	42.16%	66.57%	67.25%	63.79%	64.69%	*8, 15*

	2014	2015	2016	2017	2018	2019	2020	
Area Harvested Relative to 1990:	78.60%	77.14%	76.17%	70.92%	68.74%	68.74%	68.74%	*16*
Use of Tractors, etc. Relative to 1990:	25.0%	27.0%	29.0%	25.0%	22.0%	22.0%	22.0%	*8, 17, 18, 19, 20*
Use of Electricity in Fields Relative to 1990:	50%	51%	52%	53%	50%	50%	50%	*11, 18*
Coal Use, Processing/Other, Rel. to 1990:	70.60%	74.20%	67.38%	66.16%	65.20%	57.09%	54.14%	*8, 15, 21*
Oil Use, Processing/Other, Rel. to 1990:	25%	27%	29%	25%	22%	21.5%	21%	*8, 17, 18, 19, 20*
Elect. Use, Processing/Other, Rel. to 1990:	66.44%	69.84%	63.42%	62.27%	61.36%	53.73%	50.95%	*8, 15*
Biomass Use, Processing/Other, Rel. to 1990:	74.75%	78.57%	71.35%	70.05%	69.03%	60.45%	57.32%	*8, 15*

Sources/Notes:

1 Total reported cropped area less fruit orchards (300,000 ha), which are assumed to be relatively less energy intensive to operate. From document in authors' files [KJ1, p. 7].

2 P.81: F Liu et al, "An Overview of Energy Supply and Demand in China", LBL, May 1992.

3 Assumption is that most electricity use will be for irrigation.

4 Crop area. From document in authors' files [KJ1, p. 7].

5 From document in authors' files [HT1, p. 10].

6 From document in authors' files [FC1, p. 7]. Air dried wood.

7 Based on 1987 Chinese values. Agricultural coal use from J. Sinton, Ed, "China Energy Databook 1992" (Revised June 1993), LBL, page IV-56. Rice area in China from FAO.

8 Intensity of fuels use relative to 1990 values (for example, use of field machinery per hectare).

9 On a per hectare of rice basis, the sum of the "field" and "other" electricity consumption estimates shown here are very similar to the approximately 3.6 GJ per ha of rice estimated during Nautilus' 1998 and 2000 rural energy survey in Unhari village, the DPRK, as (as reported in "A RURAL ENERGY SURVEY IN UNHARI VILLAGE, THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK): METHODS, RESULTS, AND IMPLICATIONS", Asian Perspectives special issue, 2002.).

10 Estimates of fuel use in 2005 and 2000 relative to 1990 are subjective, and are based on observations by Nautilus and others who have visited farms in the DPRK. Typically, supplies of electricity and coal seem to be provided to farms at a priority to other sectors during the growing and harvest seasons, so supplies of those fuels are barely sufficient to accomplish the necessary threshing and milling, but motor fuel supplies are considerably less than in 1990, so that tractors are used only for essential purposes, and much more labor is done by hand. This is probably even more the case in more remote areas of the country. The lack of spare parts for tractors and trucks also diminishes demand for motor fuels. Electricity use for agriculture is assumed to be slightly higher in 2000 than in 1996 because, though availability of electricity for agricultural requirements are similar, intensity per unit of output is assumed to be higher due to a lack of access to spare parts and a lack of other fuels for support vehicles (thus decreasing overall efficiency). One observer of DPRK energy use has suggested that mechanized inputs to agriculture may have fallen by over 85 percent from 1990 to 2005. Other observers report increased use of manual and animal labor in the fields, including the transfer of office and factor workers, students, others from the cities in 2005 in larger numbers than in previous years to help bring in the harvest. We have loosely interpreted this anecdotal information to point to a continued decline in diesel fuel for tractors and other farm implements, with the result being that oil use in agriculture was 20 percent of 1990 levels by 2005. For related analysis, see also Hugh Bentley, "Trends in the DPRK Agricultural Sector & Implications for Energy Use", as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). This presentation is available as http://www.nautilus.org/DPRKEnergyMeeting/papers/Bentley.ppt.

11 An article in KCNA in English (Pyongyang), dated 14 March, 2005, and entitled "Kaechon-Lake Thaesong Waterway Pays Off", suggests that the waterway carried 100 million cubic meters of water over two years, and displaced more than 500 water pumps that "had to consume more than 60,000 kW of electricity a year to supply needed water to [the areas served]. Assuming that this note referred to the power input to the displaced pumps as 60 *MW, and assuming an annual average capacity factor for those pumps of about* 20% *this implies a displacement of* 105.12 GWhrs, or 3.78E+05 GJ of electricity, about 42% *of estimated field use of electricity in 1990. On this basis we decrease estimated use of electricity in 2005, but by somewhat less than this estimate, assuming that there may still be additional pumping from the new aqueduct into the fields, and assuming that the KCNA article may present a somewhat optimistic account of the impacts of the waterway.*

12 China Customs Statistics reported imports of meat to the DPRK from China (meat imports were 90% pork by 2005) had increased more than 20-fold (by weight), on average, between 1995-1997 and 2003-2005. This may be indicative of continued decline in DPRK agricultural production. Import data as compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf.

13 China Customs Statistics reported imports of fertilizers to the DPRK from China were

92,494	te in 2003	60,804	*te in 2004, and*	67,838	*te in 2005.*

95 percent or more of these imports were in the "nitrogeneous fertilizer" category (HS # 3102). DPRK fertilzer imports from China appear to vary considerably by year, but the average imports for 2003 - 2005 was about five times the average imports in 1995 - 1997. Source as in Note 12, above.

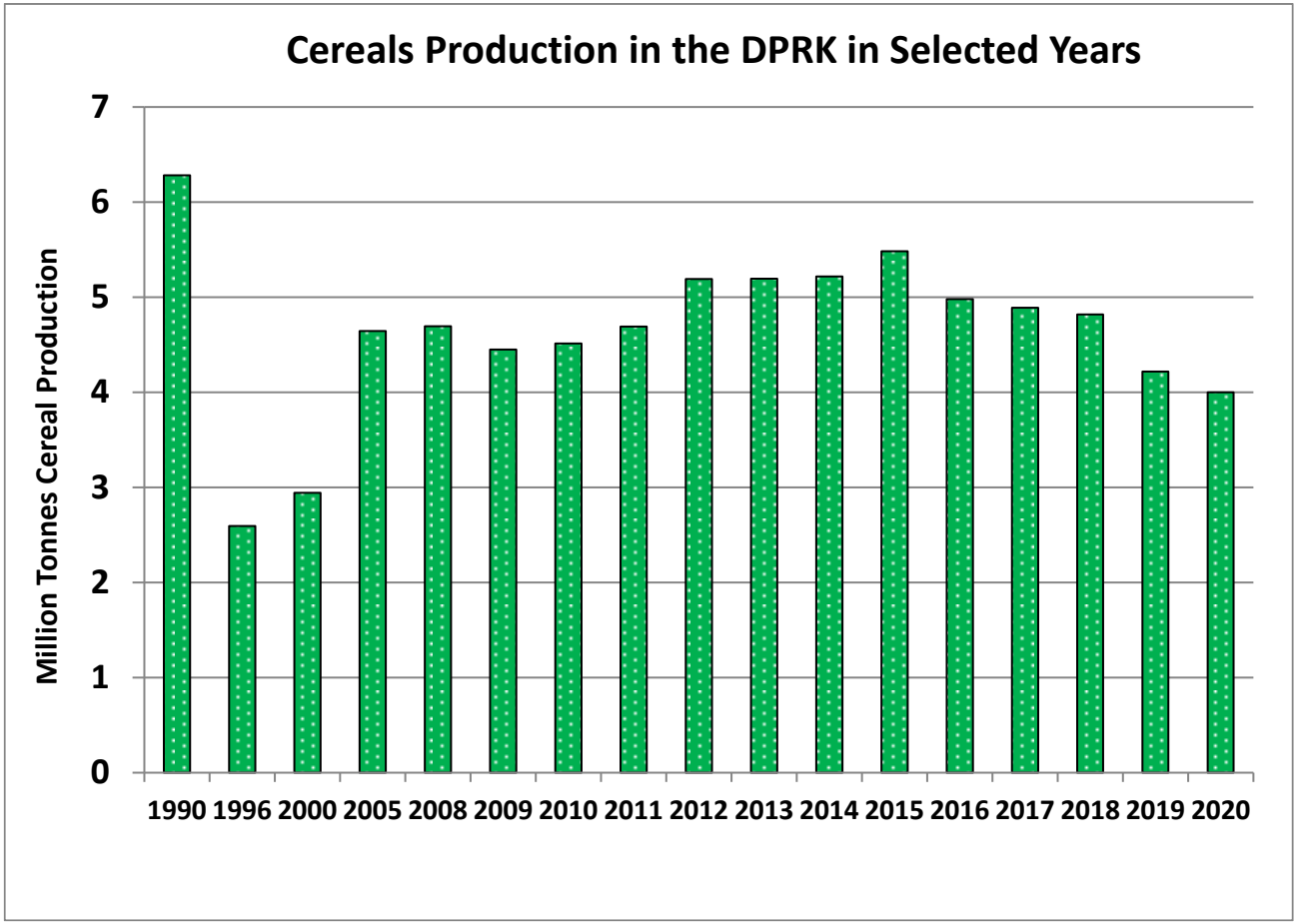
14 China Customs Statistics include reports of the following agricultural exports from the DPRK to China in 2005:

HS #	*Description*	*Tonnes*
12	MISC GRAIN,SEED,FRUIT	20,948
08	EDIBLE FRUIT AND NUTS	5,479
78	LEAD	4,666
14	OTHER VEGETABLE	3,903
07	VEGETABLES	1,912

The same compendium also notes exports from the DPRK to China of about 35 million live animals (types not specfied), up from about 21 million in 2004 and 7.8 million in 2003. Source as in Note 12, above.

*15 Coal and biomass use in crop drying, and electricity used in crop processing, are assumed to be roughly proportional to annual cereal-harvests, based on the following output statistics (**see Note 16, final table**):*

Year	Million tonnes cereal production
1990	6.280
1996	2.593
2000	2.942
2005	4.645
2008	4.693
2009	4.451
2010	4.514
2011	4.691
2012	5.190
2013	5.193
2014	5.216
2015	5.482
2016	4.979
2017	4.888
2018	4.817
2019	4.218
2020	4.000

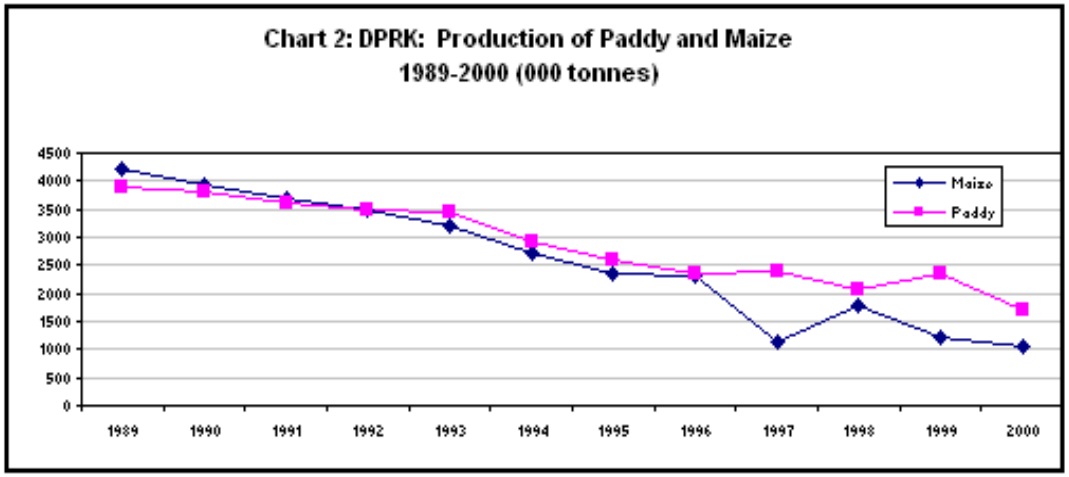

Cereals Production in the DPRK in Selected Years
Million Tonnes Cereal Production
0
1
2
3
4
5
6
7
1990 1996 2000 2005 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Additional data on DPRK grain output from various publications are provided below for reference.

Chart 2 (shown below) in FAO GLOBAL INFORMATION AND EARLY WARNING SYSTEM ON FOOD AND AGRICULTURE and WORLD FOOD PROGRAMME, SPECIAL REPORT FAO/WFP CROP AND FOOD SUPPLY ASSESSMENT MISSION TO THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA, dated 16 November 2000.

Page 17 of UN Food and Agriculture Organization and the World Food Programme, SPECIAL REPORT, FAO/WFP CROP AND FOOD SUPPLY ASSESSMENT MISSION TO THE DEMOCRATIC *PEOPLE'S REPUBLIC OF KOREA, dated 30 October 2003, and available as http://www.nautilus.org/DPRKBriefingBook/agriculture/fao-dprk-30oct.pdf*

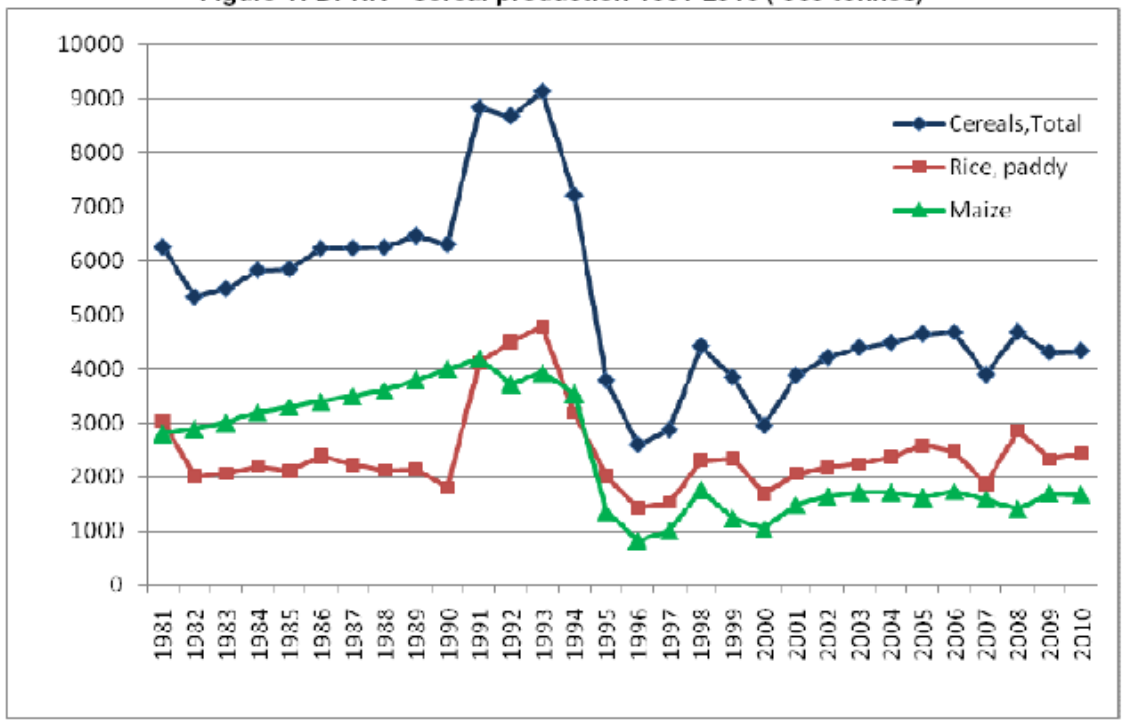
Randall Ireson, Food Security in North Korea: Designing Realistic Possibilities, dated February 2006, published by the Walter H. Shorenstein Asia-Pacific Research Center. Freeman Spogli Institute for International Studies, Stanford University, and available as http://iis-db.stanford.edu/pubs/21046/Ireson_FoodSecurity_2006.pdf. Table 2.



Figures for cereals production in 2008 are quoted in several sources, including S. Haggard and M. Nolan, "The North Korean Food Situation, Too Early to Break Out the Champagne", Asia Pacific Bulletin, Number 27, February 5, 2009, available as www.eastwestcenter.org/fileadmin/stored/pdfs/apb027.pdf.
Figure is roughly consistent with UN FAO statistics shown in Note 16, below, for DPRK agricultural production in 2008.

Figures for cereals production in over time are presented in UN Food and Agriculture Organization and World Food Program (2010), SPECIAL REPORT: FAO/WFP CROP AND FOOD SECURITY ASSESSMENT MISSION TO THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA , dated 16 November 2010, and available as URL http://www.fao.org/docrep/013/al968e/al968e00.pdf. Estimates are presented in Figure 1 (see below).

Figure 1: DPRK - Cereal production 1981-2010 ('000 tonnes)



In addition, coal, electricity, and biomass use in processing per unit crop harvested were assumed to have decreased somewhat relative to 1990, due to lack of availability of fuel and other factors, as follows:

	1996	2000	2005	2008	2009	2010
Coal Use, Processing/Other, Rel. to 1990:	90%	80%	85%	85%	85%	85%
Elect. Use, Processing/Other, Rel. to 1990:	90%	75%	85%	85%	85%	85%
Biomass Use, Processing/Other, Rel. to 1990:	90%	90%	90%	90%	90%	90%

	2014	2015	2016	2017	2018	2019	2020
Coal Use, Processing/Other, Rel. to 1990:	85%	85%	85%	85%	85%	85%	85%
Elect. Use, Processing/Other, Rel. to 1990:	80%	80%	80%	80%	80%	80%	80%
Biomass Use, Processing/Other, Rel. to 1990:	90%	90%	90%	90%	90%	90%	90%

16 Data from FAOSTAT on agricultural production in the DPRK for 2000, 2005, and 2008 (from http://faostat.fao.org/site/339/default.aspx) is as follows:

2000 Data

Rank	Commodity	Production (Int $1000)	Flag	Production (MT)	Flag
1	Vegetables fresh nes	450360	*	2400000	F
2	Rice, paddy	315459	*	1690000	
3	Potatoes	211506	*	1870000	
4	Apples	186693	*	650000	F
5	Indigenous Pigmeat	141771	*	140000	Fc
6	Tobacco, unmanufactured	114862	*	63000	F
7	Beans, dry	114142	*	290000	F
8	Maize	105894	*	1041000	
9	Hen eggs, in shell	93947	*	110000	F
10	Cabbages and other brassicas	87919	*	630000	F
11	Indigenous Rabbit Meat	82938	*	53690	Fc
12	Fruit Fresh Nes	73374	*	460000	F
13	Soybeans	71032	*	350000	*
14	Garlic	61745	*	80000	F
15	Indigenous Cattle Meat	41417	*	20025	Fc
16	Peaches and nectarines	39268	*	110000	F
17	Pears	37018	*	130000	F
18	Indigenous Chicken Meat	31306	*	26840	Fc
19	Sweet potatoes	25645	*	290000	*
20	Cow milk, whole, fresh	23934	*	90000	F
	Sum of Rice and Maize			2731000	

* : Unofficial figure
[ ]: Official data
F : FAO estimate
Fc: Calculated data

2005 Data

Rank	Commodity	Production (Int $1000)	Flag	Production (MT)	Flag
1	Rice, paddy	486562	*	2583400	
2	Vegetables fresh nes	459742	*	2450000	F
3	Potatoes	234117	*	2070000	F
4	Apples	191862	*	668000	F
5	Indigenous Pigmeat	170125	*	168000	Fc
6	Maize	151455	*	1630000	*
7	Indigenous Rabbit Meat	143385	*	92820	Fc
8	Hen eggs, in shell	119475	*	140000	F
9	Tobacco, unmanufactured	119238	*	65400	F
10	Beans, dry	118499	*	300000	F
11	Cabbages and other brassicas	96292	*	690000	F
12	Fruit Fresh Nes	78159	*	490000	F
13	Garlic	73322	*	95000	F
14	Soybeans	68853	*	340000	*
15	Indigenous Cattle Meat	44364	*	21450	Fc
16	Peaches and nectarines	44266	*	124000	F
17	Indigenous Chicken Meat	41699	*	35750	Fc
18	Pears	38442	*	135000	F
19	Sweet potatoes	31835	*	360000	F
20	Wheat	26166	*	193000	*
	Sum of Rice, Maize, and Wheat			4406400	

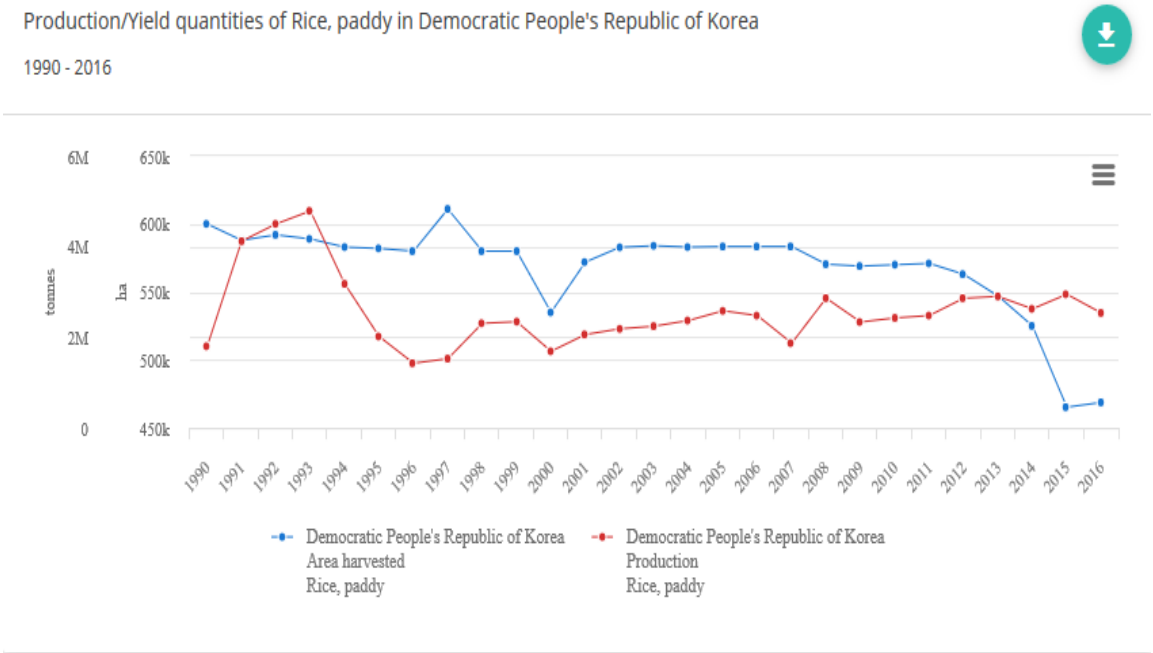
* : Unofficial figure
[ ]: Official data
F : FAO estimate
Fc: Calculated data

2008 Data

Rank	Commodity	Production (Int $1000)	Flag	Production (MT)	Flag
1	Rice, paddy	540166	*	2862000	*
2	Vegetables fresh nes	422212	*	2250000	F
3	Apples	182384	*	635000	F
4	Indigenous Pigmeat	182277	*	180000	Fc
5	Potatoes	171981	*	1520280	
6	Indigenous Rabbit Meat	140574	*	91000	Fc
7	Maize	137195	*	1411390	
8	Hen eggs, in shell	121125	*	142000	F
9	Beans, dry	118499	*	300000	F
10	Tobacco, unmanufactured	114862	*	63000	F
11	Cabbages and other brassicas	97688	*	700000	F
12	Fruit Fresh Nes	78159	*	490000	F
13	Garlic	73322	*	95000	F
14	Soybeans	69942	*	345000	*
15	Indigenous Cattle Meat	44985	*	21750	Fc
16	Peaches and nectarines	42838	*	120000	F
17	Indigenous Chicken Meat	37208	*	31900	Fc
18	Pears	35595	*	125000	F
19	Sweet potatoes	33610	*	380070	
20	Cow milk, whole, fresh	25530	*	96000	F
	Sum of Rice and Maize			4273390	

* : Unofficial figure
[ ]: Official data
F : FAO estimate
Fc: Calculated data

Following from http://www.fao.org/faostat/en/#data/QC/visualize, accessed 8/9/2018



Data for agricultural production in the DPRK for 2009 and 2010 below from UN FAO, http://faostat3.fao.org/home/index.html#VISUALIZE_TOP_20, accessed 8/30/2012.

Top 25 Commodities (2009)

Rank	Commodity	Production (tonnes)	Flag	Production (1000$ Int)	Flag
	Vegetables fresh nes	**2452000**	**F**	**462057**	*****
	Rice, paddy	**2336000**		**574736**	*****
	Maize	**1705000**		**230653**	*****
	Potatoes	1560000		205363	*
	Cabbages and other brassicas	751001	F	106762	*
	Apples	719682	F	304364	*
	Fruit Fresh Nes	522283	F	182295	*
	Sweet potatoes	390000		25921	*
	Soybeans	350000	*	89420	*
	Beans, dry	335000	F	189786	*
	Wheat	169000	*	22324	*
	Peaches and nectarines	147095	F	80081	*
	Pears	137901	F	56378	*
	Other melons (inc.cantaloupes)	120000	F	22091	*
	Onions (inc. shallots), green	116104	F	23693	*
	Watermelons	115000	F	13101	*
	Garlic	101347	F	53343	*
	Pumpkins, squash and gourds	77785	F	13639	*
	Tobacco, unmanufactured	73000	F	116272	*
	Cucumbers and gherkins	71620	F	14220	*
	Onions, dry	70209	F	14746	*
	Tomatoes	69466	F	25672	*
	Rye	68799	F	5364	*
	Barley	63000	*	6760	*
	Millet	62000	*	7875	*
	Sum of Rice and Maize	4041000			

Top 25 Commodities (2010)

Rank	Commodity	Production (tonnes)	Flag	Production (1000$ Int)	Flag
1	Rice, paddy	2426000		597308	*
2	Vegetables fresh nes	2038700	F	384175	*
3	Potatoes	1708000		224847	*
4	Maize	1683000		226010	*
5	Apples	752300	F	318158	*
6	Cabbages and other brassicas	616100	F	87585	*
7	Fruit Fresh Nes	548100	F	191306	*
8	Sweet potatoes	427000		28380	*
9	Soybeans	350000	*	89420	*
10	Beans, dry	224300	F	123211	*
11	Wheat	160000	*	21800	*
12	Pears	142800	F	58381	*
13	Peaches and nectarines	116000	F	63152	*
14	Other melons (inc.cantaloupes)	88100	F	16218	*
15	Onions (inc. shallots), green	87700	F	17896	*
16	Watermelons	86400	F	9843	*
17	Onions, dry	82700	F	17370	*
18	Barley	80000	*	6786	*
19	Tobacco, unmanufactured	78500	F	125032	*
20	Garlic	77000	F	40528	*
21	Pumpkins, squash and gourds	74800	F	13115	*
22	Millet	71200	F	9043	*
23	Rye	70000	F	5465	*
24	Cucumbers and gherkins	65800	F	13064	*
25	Tomatoes	64000	F	23652	*
	Sum of Rice and Maize	4109000			

Production of Crops in 2016 as Reported by FAO (http://www.fao.org/faostat/en/#data/QC)

Product	Unit	Production	FAO Note on Data Derivation
Rice, paddy	tonnes	2,536,400	Unofficial figure
Maize	tonnes	2,195,200	Unofficial figure
Vegetables, fresh nes	tonnes	2,188,440	FAO data based on imputation methodology
Potatoes	tonnes	1,698,511	FAO data based on imputation methodology
Apples	tonnes	779,490	FAO data based on imputation methodology
Cabbages and other brassi	tonnes	671,973	FAO data based on imputation methodology
Fruit, fresh nes	tonnes	551,047	FAO data based on imputation methodology
Sweet potatoes	tonnes	436,873	FAO data based on imputation methodology
Soybeans	tonnes	348,452	FAO data based on imputation methodology
Beans, dry	tonnes	320,399	FAO data based on imputation methodology
Pears	tonnes	146,601	FAO data based on imputation methodology
Peaches and nectarines	tonnes	120,473	FAO data based on imputation methodology
Watermelons	tonnes	94,796	FAO data based on imputation methodology
Onions, shallots, green	tonnes	90,909	FAO data based on imputation methodology
Melons, other (inc.cantalou	tonnes	85,640	FAO data based on imputation methodology
Onions, dry	tonnes	84,839	FAO data based on imputation methodology
Garlic	tonnes	83,083	FAO data based on imputation methodology
Tobacco, unmanufactured	tonnes	82,727	FAO data based on imputation methodology
Pumpkins, squash and gou	tonnes	77,687	FAO data based on imputation methodology
Millet	tonnes	73,482	FAO data based on imputation methodology
Tomatoes	tonnes	66,261	FAO data based on imputation methodology
Cucumbers and gherkins	tonnes	66,205	FAO data based on imputation methodology
Rye	tonnes	65,546	FAO data based on imputation methodology
Wheat	tonnes	56,702	FAO data based on imputation methodology
Chillies and peppers, green	tonnes	53,397	FAO data based on imputation methodology
Eggplants (aubergines)	tonnes	48,051	FAO data based on imputation methodology
Seed cotton	tonnes	38,669	FAO data based on imputation methodology
Sorghum	tonnes	28,838	FAO data based on imputation methodology
Hemp tow waste	tonnes	14,759	FAO data based on imputation methodology
Chestnut	tonnes	12,540	FAO data based on imputation methodology
Oats	tonnes	11,539	FAO data based on imputation methodology
Barley	tonnes	10,861	FAO data based on imputation methodology
Nuts, nes	tonnes	10,376	FAO data based on imputation methodology
Mushrooms and truffles	tonnes	5,868	FAO data based on imputation methodology
Hops	tonnes	2,005	FAO data based on imputation methodology

Following are summary data on DPRK cereals production from UN FAOStat,
http://faostat3.fao.org/home/index.html#DOWNLOAD, accessed 8/30/2012,
http://faostat3.fao.org/download/Q/QC/E, accessed 1/6/2016,
and http://www.fao.org/faostat/en/#data/QC, accessed 8/9/2018, and used
for the values for 2010 through 2016 for production and all values for area harvested in the table below.

Year	Item	Production	Unit	Area Harvested	Unit	Implied Average Yield (t/ha)
1990	Cereals,Total	6,280,305	tonnes	1,600,714	ha	3.92
1991	Cereals,Total	8,814,010	tonnes	1,574,272	ha	5.60
1992	Cereals,Total	8,681,000	tonnes	1,552,024	ha	5.59
1993	Cereals,Total	9,137,000	tonnes	1,491,739	ha	6.13
1994	Cereals,Total	7,215,000	tonnes	1,524,740	ha	4.73
1995	Cereals,Total	3,805,000	tonnes	1,517,102	ha	2.51
1996	Cereals,Total	2,592,699	tonnes	1,406,408	ha	1.84
1997	Cereals,Total	2,864,537	tonnes	1,446,929	ha	1.98
1998	Cereals,Total	4,420,150	tonnes	1,425,052	ha	3.10
1999	Cereals,Total	3,852,000	tonnes	1,348,472	ha	2.86
2000	Cereals,Total	2,942,000	tonnes	1,238,513	ha	2.38
2001	Cereals,Total	3,879,704	tonnes	1,286,500	ha	3.02
2002	Cereals,Total	4,211,000	tonnes	1,319,747	ha	3.19
2003	Cereals,Total	4,393,000	tonnes	1,351,540	ha	3.25
2004	Cereals,Total	4,485,000	tonnes	1,307,668	ha	3.43
2005	Cereals,Total	4,645,400	tonnes	1,379,280	ha	3.37
2006	Cereals,Total	4,675,500	tonnes	1,319,286	ha	3.54
2007	Cereals,Total	3,892,500	tonnes	1,332,294	ha	2.92
2008	Cereals,Total	4,693,060	tonnes	1,316,563	ha	3.56
2009	Cereals,Total	4,450,998	tonnes	1,318,854	ha	3.37
2010	Cereals,Total	4,514,037	tonnes	1,318,741	ha	3.42
2011	Cereals,Total	4,691,413	tonnes	1,309,000	ha	3.58
2012	Cereals,Total	5,190,105	tonnes	1,324,500	ha	3.92
2013	Cereals,Total	5,192,838	tonnes	1,306,500	ha	3.97
2014	Cereals,Total	5,216,047	tonnes	1,258,179	ha	4.15
2015	Cereals,Total	5,482,388	tonnes	1,234,809	ha	4.44
2016	Cereals,Total	4,978,568	tonnes	1,219,304	ha	4.08
2017	Cereals,Total	4,888,075	tonnes	1,135,200	ha	4.31
2018	Cereals,Total	4,817,000	tonnes	1,100,400	ha	4.38
2019	Cereals,Total	4,218,000	tonnes	1,093,000	ha	3.86
2020	Cereals,Total	4,000,000	tonnes	1,093,000	ha	3.66

2017 and 2018/2019 values are estimates derived from the tables below from the sources described in Notes 17 and 21.
2020 is a placeholder estimate. Area for 2019 based on table in source 21 plus an estimated 50,000 ha for early season cereals, as in 2018.

Table 3: Democratic People's Republic of Korea - Comparison between 2017/18 and 2016/17 national aggregate production of food crops in cereal equivalent

	2017/18			2016/17			Change 2017/18 from 2016/17		
	Area '000 ha	Yield t/ha	Prodn. '000 t	Area '000 ha	Yield t/ha	Prodn. '000 t	Area %	Yield %	Prodn. %
MAIN SEASON	**1 230.5**	**4.1**	**5 091.1**	**1 350.6**	**4.0**	**5 412.0**	**-8.9**	**3.3**	**-5.9**
Paddy	475.2	5.0	2 383.3	468.7	5.4	2 536.4	1.4	-7.3	-6.0
Maize	510.2	4.3	2 199.8	544.5	4.0	2 195.2	-6.3	6.9	0.2
Other cereals	65.0	2.1	136.5	72.1	2.2	156.4	-9.9	-3.2	-12.7
Potatoes[1]	30.3	4.9	148.3	40.0	5.6	222.0	-24.2	-11.9	-33.2
Soybeans	149.8	1.5	223.3	175.4	1.6	281.9	-14.6	-7.3	-20.8
Sloping land (mostly maize)[2]	0.0	0.0	0.0	50.0	0.4	20.0	-100.0	-100.0	-100.0
EARLY SEASON (winter and spring)	**180.0**	**2.2**	**395.5**	**172.3**	**1.9**	**332.0**	**4.5**	**14.0**	**19.1**
Wheat and barley	50.0	1.4	70.5	45.0	1.2	55.2	11.1	14.9	27.6
Potatoes	130.0	2.5	325.0	127.3	2.2	276.8	2.2	14.9	17.4
TOTAL - NATIONAL	**1 410.5**	**3.9**	**5 486.6**	**1 522.9**	**3.8**	**5 744.0**	**-7.4**	**3.1**	**-4.5**

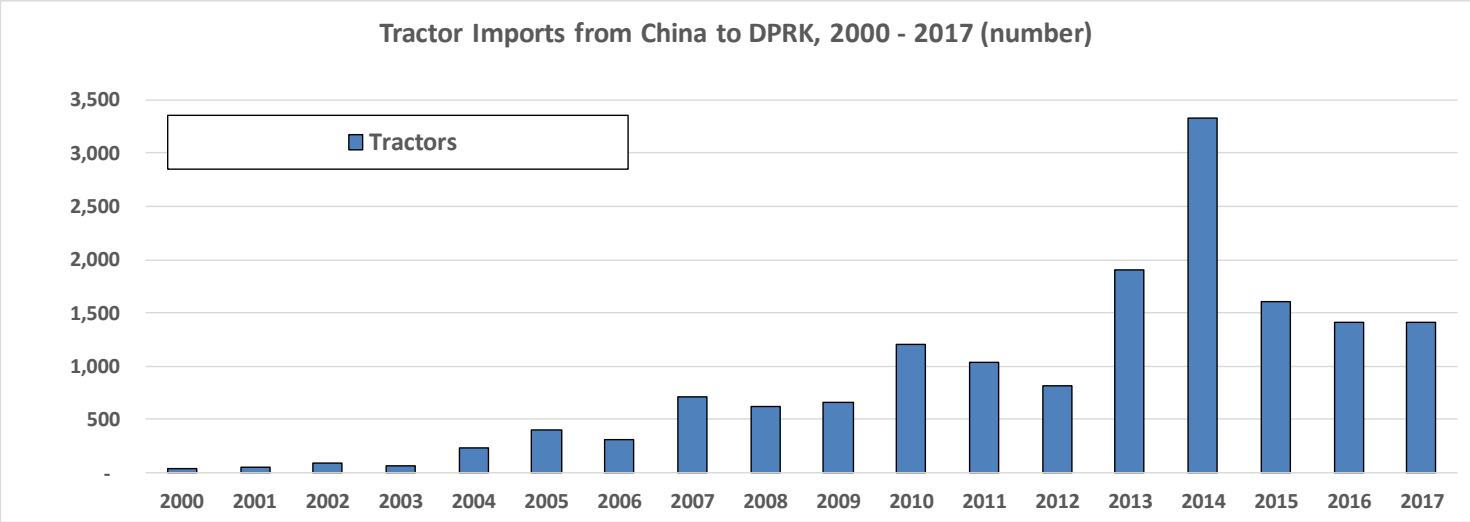
17 The UN FAO document ***GIEWS Update:The Democratic People's Republic of Korea, Food Supply and Demand Outlook in 2017/18 (November/October)****, dated 9 July 2018, and avaialble as http://www.fao.org/3/ca0363en/CA0363EN.pdf, citing DPRK government sources, includes the following table describing agricultural sector fuel demand:*

Table 2: Democratic People's Republic of Korea - Fuel Consumption in 2013-2017 *(tonnes)*

Fuel Type	2013	2014	2015	2016	2017	% change, 2017 over 2016
Diesel	64 425	55 171	53 700	60 990	54 350	-11
Petrol	7 000	5 500	7 000	7 000	6 000	-14
Total	71 425	60 671	60 700	67 990	60 350	-11

Source: Ministry of Agriculture (MoA).

18 The UN Comtrade compilation of trade statistics https://comtrade.un.org/data) shows a large increase in the imports of tractors from China in recent years, particularly after 2012. The graph below shows statistics for tractor imports from 2000 through 2017 (see notes to "Transport_96-on" worksheet for Comtrade data). The increased number of new tractors implies to us that agriculture in the DPRK was somewhat "re-mechanized"--more of the work done by machines--in 2014 through 2017, relative to previous years, both as a result of additional available tractors and additional available diesel fuel in those years. Our asssumptions as to changes in the use of diesel relateive to 1990 reflect those changes. We also assume somewhat better access to electricity in the farming sector in those years, perhaps partly due to better availability of generators. Our estimates for agricultural electricity use per unti of crop output are accordingly somewhat higher for 2014-2017 than in previous years.
See also, for example, Eric Talmadge (2014), "North Korean farmers under pressure to feed hungry nation", The Guardian, July 15, 2014, available as https://www.theguardian.com/world/2014/jul/15/north-korea-farmers-pressure-feed-nation-kim-jong-un.



19 Assumes reduction in agricultural sector oil use in 2017, and additional reductions in 2018, relative to previous years due to tightened supply as a result of UNSC sanctions.

20 *The UNFAO "GIEWS Country BriefDemocratic People's Republic of Korea", dated 13-May-2019, and available as http://www.fao.org/giews/countrybrief/country/PRK/pdf/PRK.pdf, includes the following table suggesting that crop yields production in the DPRK continued to fall during 2018 by about 12% overall relative to 2017.*

Democratic People's Republic of Korea

Food Crop Production

	2013-2017 average	2017	2018	change 2018/2017
	000 tonnes			percent
MAIN SEASON	5 178	5 105	4 546	-11.0
Paddy	2 479	2 383	2 088	-12.4
Maize	2 207	2 200	1 876	-14.7
Other cereals	117	151	197	30.5
Potatoes	166	148	249	68.2
Soybeans	210	223	135	-39.5
EARLY SEASON	345	404	307	-24.0
Wheat&barley	61	83	57	-31.3
Potatoes	284	321	250	-22.1
Total	5 523	5 509	4 853	-11.9

Note: percentage change calculated from unrounded data.
Source: CBS 2018/2019 early season crop mission forecast.

21 The ***DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK) FAO/WFP JOINT RAPID FOOD SECURITY ASSESSMENT***, *dated May 2019, and available as http://www.fao.org/3/ca4447EN/ca4447en.pdf, includes the following tables on fuel use and projected 2019 output in the DPRK agricultural sector.*

TABLE 6: DPRK - FUEL SUPPLY FOR 2017, 2018 AND 5-YR AVERAGE (IN MT)

Fuel Type	2018	2017	5 yr average	2017-2018 change	2018 change from 5 yr average
	mt			%	
Diesel	40,502	54,350	57,727	-25	-30
Petrol	4,000	6,000	6,500	-33	-38
TOTAL	44,502	60,350	64,227	-26	-31

TABLE 4: DPRK - NATIONAL HARVESTED AREA BY MAIN SEASON FOOD CROP BETWEEN 2018/19, 2017/18, AND 5-YR AVERAGE

Area	2018/2019	2017/2018	Average	Change 2018/19 from 2017/18	Change 2018/19 from Average
	('000 ha)			(%)	
Paddy	471	475	496	-0.8	-5.0
Maize	508	510	535	-0.4	-4.9
Other cereals	64	55	45	15.4	42.7
Potatoes	45	30	32	48.1	40.4
Soybeans	107	150	148	-28.6	-27.9
TOTAL	1196	1220	1256	-2.0	-4.8

Source: CBS.

TABLE 9: DPRK - 2018/19, 2017/18 AND 5-YR AVERAGE NATIONAL FOOD CROP PRODUCTION IN CEREAL EQUIVALENT

Production	2018/19	2017/18	5 yr average	2018/19-2017/18 change	2018/19 change from average
	('000 mt)			(%)	
MAIN SEASON	4,546	5,105	5,178	-11.0	-12.2
Paddy	2,088	2,383	2,479	-12.4	-15.8
Maize	1,876	2,200	2,207	-14.7	-15.0
Other cereals	197	151	117	30.6	68.9
Potatoes	249	148	166	68.3	50.0
Soybeans	135	223	210	-39.4	-35.5
EARLY SEASON (winter and spring)	307	404	345	-24.1	-10.8
Wheat and barley	57	83	61	-31.7	-6.8
Potatoes	250	321	284	-22.1	-11.7
TOTAL	4,853	5,510	5,523	-11.9	-12.1

Source: CBS. Note: 2018/19 early season crops Mission forecasts.

	2018/2019	2017/2018
Summary of Estimated Cereals Output (1000 te)	4218	4817

	2018/2019	2017/2018
Summary of Havest Area of Cereals (1000 ha)	1043	1040

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
FISHERIES SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 6/24/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

Sources/Notes:

Oil Use: Large Ships

Estimated Inventory of DPRK Larger Fishing Vessels (~1990s)

Average Displacement (tonnes)	Average Horsepower	Number	Description	*Composite estimate based on sources 1, 4, and 6*
10,000	2,250	8	Large Factory Ships	
485	400	554	"Multi-purpose"	
60	100	776	"Trap-fishing"	
200	200	215	Others (estimate)	
438,250	360,200	1,553	Total	

Total Engine horsepower of Larger Ships		360,200	*See above*
Average days at sea		200	*Estimate, consistent with data in 1 for collectives*
Operating hours/day		12	*Estimate*
Fraction of Ships in operation (as of 1990)		85%	*Estimate*
Average fraction of full power while operating		50%	*Estimate*
Total fishing fleet power use	3.674E+08	hp-hours	
Fuel consumption rate	0.18	kg/hp-hr	*7*
Conversion Factor	1.032	kg Diesel/kgoe	*From "Oil" Worksheet in this Workbook*
Conversion Factor	0.04184	GJ/kgce	
Total Oil Use, Larger Ships	2.68E+06	GJ	
Fraction of Oil Use as Diesel	95%		*Calculated*
Fraction of Oil Use as Heavy Fuel Oil	5%		*Assumes only large factory ships use Heavy Fuel Oil*
Diesel Oil Use in Large Ships	2.55E+06	GJ	
Heavy Fuel Oil Use in Large Ships	1.34E+05	GJ	

Oil Use: Fishing Collectives — *Placeholder estimate*

Number of fishing collectives	284			*5*
HP of motors on boats per collective	76			*8*
Average days at sea		200		*Estimate, consistent with data in 1 for collectives*
Operating hours/day		12		*Estimate*
Fraction of boats in operation (as of 1990)		75%		*Estimate*
Average fraction of full power while operating		25%		*Estimate*
Total collectives fishing fleet power use		9.71E+06	hp-hours	*Calculated*
Fuel consumption rate	0.2	kg/hp-hr		*Assumed somewhat higher than for larger boats*
Diesel Oil Use in Fishing Collectives	7.88E+04	GJ		

Oil Use: Processing/Other				*no data*
Fisheries product output, total	2.20E+06	tonnes		*1990 value from Table 2 from FAO source in note 6*
Fraction of product processed	60%			*Rough Estimate, assumes some not processed or minimally processsed*
Fuels consumption per unit output	1.14	GJ/tonne		*9*
Fraction of fuels consumption as heavy oil		15%		*Rough Estimate*
Fraction of fuels consumption as diesel oil		10%		*Rough Estimate*
Fraction of fuels consumption as coal		75%		*Rough Estimate*
Electricity Consumption per Unit output		110.32	kWh/tonne	*9*
	or	0.40	GJ/tonne	*9*
Heavy Oil Use, Processing/Other	2.264E+05	GJ		*Calculated*
Diesel Oil Use, Processing/Other	1.509E+05	GJ		*Calculated*
Total Oil Use, Fisheries Sector	3.14E+06	GJ		*Calculated*
Coal Use: Ships	0.00E+00	GJ		*no data*
Coal Use: Processing/Other	1.132E+06	GJ		*Calculated*
Total Coal Use, Fisheries Sector	1.132E+06	GJ		*Calculated*
Electricity Use: Processing/Other	5.243E+05	GJ		*Calculated*
Total Electricity Use, Fisheries Sector	5.243E+05	GJ		*Calculated*

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN FISHERIES SECTOR

(See Note 3)

	1996	2000	2005	2008	
Large Ships Fishing Effort Relative to 1990:	30.0%	24.9%	28.0%	27.0%	*Assumptions*
Fishing Collectives Fishing Effort Relative to 1990:	30.0%	24.9%	28.0%	26.0%	*Assumptions*
Oil/Coal Use, Processing/Other Relative to 1990:	45.0%	37.4%	40.0%	37.0%	*Assumptions*
Elect. Use, Processing/Other Relative to 1990:	45.0%	37.4%	40.0%	37.0%	*Assumptions*
	2009	**2010**	**2014**	**2015**	
Large Ships Fishing Effort Relative to 1990:	25.0%	27.0%	39.1%	26.75%	*Assumptions--scaling roughly with exports from 2010*
Fishing Collectives Fishing Effort Relative to 1990:	23.0%	27.0%	39.1%	26.75%	*Assumptions--scaling roughly with*
Oil/Coal Use, Processing/Other Relative to 1990:	35.0%	38.0%	38.0%	30.0%	*Assumptions*
Elect. Use, Processing/Other Relative to 1990:	34.0%	35.0%	33.0%	30.0%	*Assumptions*
	2016	**2017**	**2018**	**2019**	
Large Ships Fishing Effort Relative to 1990:	47.8%	46.0%	34.0%	34.0%	*Assumptions--scaling roughly with exports from 2010 except for 2018 and*
Fishing Collectives Fishing Effort Relative to 1990:	47.8%	46.0%	34.0%	34.0%	*2019 (see notes 12, 17)*
Oil/Coal Use, Processing/Other Relative to 1990:	38.0%	36.0%	25.2%	25.2%	*Assumptions (see Note 12)*
Elect. Use, Processing/Other Relative to 1990:	38.0%	40.0%	28.0%	28.0%	*Assumptions (see Note 12)*
	2020				
Large Ships Fishing Effort Relative to 1990:	30.6%				
Fishing Collectives Fishing Effort Relative to 1990:	30.6%				
Oil/Coal Use, Processing/Other Relative to 1990:	22.7%				
Elect. Use, Processing/Other Relative to 1990:	25.2%				

See ***Notes 12, 16*** *(for 2017 assumptions)* . ***17*** *(for 2018-2020 assumptions).*

Sources/Notes:

1 From document in authors' files [IF1].

2 Chinese data, c. 1990. From p. 23: "Energy of China, 1993" [provided by J. Sinton of LBL--Chinese language].

3 The Korea Trade-Investment Promotion Agency (KOTRA) suggests that DPRK marine products catch decreased substantially between 1996 and 1997, but increased somewhat between then and 2000. KOTRA data (from "Agriculture, Forestry, and Marine Products industries", available through http://www.kotra.or.kr/main/, visited 6/3/02) lists 1996 output of .876 million tonnes, and 1999 output of .664 million tonnes. A web page on "North Korea's Foreign Trade in 2000" from the same site listes the value of marine exports as having increased 9.4 % between 1999 and 2000. If all fisheries production tracked export earnings (which is not necessarily the case, but assumed for the sake of argument here), the implied ratio of fisheries output between 1996 and 2000 is 83%. We further assume that fisheries effort (as reflected in fuel use) is proportional to fisheries output. Alternatively, end of 1999 data based on the Economic and Social Comparison between the Two Koreas, published by the National Statistics Administration (December 2000) and provided on http://www.koreascope.org/english/sub/1/index3-h.htm, suggest that the DPRK fish catch in 1999 was 45.70% of the catch in 1990. This figure is very close to the 42 percent figure shown above. Further, data from source 6, below, shows 1996 total marine products production as 45% *of 1990 production, but also shows a marked shift in production, with 68 percent of output from "marine capture" in 1989, to only 32 percent in 1996 (with the remainder being from aquaculture, 99% of which was marine aquaculture. Since marine aquaculture seems likely to require significantly less energy for boats and ships than "marine capture", we estimate that 1996 energy use for fishing was 30% of 1990 energy use, and that 1996 energy use for processing and other fisheries sector energy use was reduced by the same amount as fisheries output was reported to decrease between 1990 and 1996. For 2000, the ratio shown above between 2000 and 1996 marine products output was used to scale energy use. The ROK Ministry of Unification site http://www.unikorea.go.kr/en/index.jsp includes a listing of fisheries output suggesting that total marine products production in the DPRK had increased to 1.16 million tonnes by 2004, a significant jump from 2002 and 2003 (0.81 and 0.84 million tonnes). 2009 information on DPRK fisheries from the UN FAO "Fishstat" database shows a very slight reduction in output between 2000 and 2002, but as the same values are used for the years from 2002 through 2009, our assumption is that no reliable data on total fisheries output in the DPRK have been made available to the UN. See, for example, page 9 of 2009 FAO Yearbook, Fishery and Aquaculture Statistics, available as http://www.fao.org/docrep/015/ba0058t/ba0058t.pdf, where DPRK fisheries output during 2002-2009 is listed at 205,000 tonnes.*

504

4 The document Seoul T'ongil Kyongje, dated January 2002, pages 38-50, is an article by Hong Mi-ri entitled "North Korean Industries (Part IX): Fisheries Industry". This article includes the following information about the DPRK fishing fleet: As of 1988, 30,600 boats, of which 21,000 were motorized. Of about 1540 primary fishing boats, 766 were 30 to 100-ton "trap-fishing boats", 554 were "multipurpose" vessels of 450-485 tons, and 8 large vessels in the 10,000-ton class (80 meters or more long, 2250 horsepower). The percentages of the fleet in various categories as given in the article (trap fishing boats 60.0 % of total) do not quite match the totals provided, but are close. The article states that "recent, unofficial information" suggests that only 400 of 1400 "relatively large motorized fishing boats" were operable due to "fuel shortages, faulty equipment, supply difficulties, engine problems, and such things."

5 The document cited in Note 4 describes DPRK fisheries production in 1984 as 1.65 million tons, and 1.78 million tons in 1993, but falling to 0.698 million tonnes by 2000.
The document describes 284 fisheries cooperatives of 70 - 100 households, owning 20 to 70 boats each.
The document also estimates that no more than 10 percent of the West Coast production potential is being used, and "the operation rate of fishing and processing facilities on the east coast is only at about 30 percent".
Cooperatives in 1998 are described as having 1500 motorized fishing boats, and 4000 non-motorized vessels, which is roughly consistent with information in Reference 1, above.

6 The document WORKING PAPER 6, DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA REPORT OF THE FISHERIES DEVELOPMENT PROGRAMMING MISSION, prepared for the Food and Agriculture Organization of the United Nations, dated November 1998, and available as http://www.fao.org/docrep/field/383547.htm#P108-15868 (and http://www.fao.org/docrep/field/383547.htm as of 3/2012), includes larger (as Table 1) a listing of the fishing boats in the DPRK fleet. This table is reproduced below. Some figures in this table correspond generally with the data from source 4, above, though there are some discrepencies (in particular, the 8 largest ships in the DPRK fleet are reported in various sources as 3750, 10,000, and 10,000 - 14,000 tonnes displacement) the reference in the table below to 1545 boats probably is meant to be a total number for all of the categories except the first.

Number of mechanized fishing boats classified by length and size of engine

Displacement Tonnage	Gross tons	Length (Metres)	HP of the Engine	Number
3 750	2 759	83	2 250	8
485	267	39	400	1 545
270	150	33	400	
140	77	23-25	200	
84	44	20-23	200	
30	18	16-18	30	

Original source for table cited:Ministry of Fisheries (DPRK)

7 Fuel consumption rate for diesels is assumed to average 0.18 kg/hp-hr, which is slightly higher than the (approximately) 1985 value for diesel-fueled boats in China cited on p. 18-6 in the chapter "Energy and Transport in China" in the document Energy Markets and the Future of Energy Demand, by Lawrence Berkeley National Laboratory (LBNL, USA), 1988. This figure is also similar to the fuel consumption estimate used for military ships elsewhere in this analysis.

8 Source 1 lists small collectives as having 150 member, and 2 boats with 28 hp engines plus 5 boats with 4 hp engines per collective. This is consistent with the lower end of the "20 - 70" boats per collective estimate provided in note 5, above, assuming that many boats counted in the total are not motorized.

9 In the document Improving Energy Use and Productivity in West Coast and Alaskan Seafood Processing Plants, by Greg Kelleher, Edward Kolbe, and Greg Wheeler (2001), the authors provide estimates of fuel consumption and output for five Alaskan seafood processing plants. The document is available as http://seagrant.oregonstate.edu/sgpubs/onlinepubs/t01004.pdf. Based on data in tables 1 and 2 of this document, per-unit output consumption of electricity and fuel oil can be calculated as follows:

Electricity Use	3.41	GWh (5 plants)	
Fuels Use (oil, LPG)	33502	Million Btu (5 plants)	
Output average	13.6	million lbs/yr per plant, or	
	0.031	Million Te total	
Implied electricity use per te output:		110.32	kWh.
Implied oil use per te output:		1,143,502	kJ.

The application of these intensities to the DPRK situation is admittedly inexact at best. Although Alaskan seafood processors certainly handle some of the same types of seafood as were and are handled in DPRK facilities, the compositions of the product lines will certainly be different (in fact, probably change year-to-year). Moreover, Alaskan seafood processing facilities are doubtless more efficient than DPRK facilities, but are also likely to be much more highly mechanized. As a result, these figures for electricity and thermal energy use, as applied to the DPRK situation, should be considered as initial estimates only, to be confirmed with better estimates when available.

10 China Customs Statistics report that the DPRK imported 5 fishing boats in 2004, and 11 in 2005. Based on the value of these shipments, however (and assuming that both the quantities and values reported in the China Customs Statistics are complete), these vessels, with average costs of $600 (2005) to $6000 (in 2004) US dollars each, would likely have been small in size (or, possibly, poor in quality and/or very old). Import/export data as compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf.

11 Anecdotal information about the status of North Korean Fisheries includes the following from North Korea Today, No. 298 (10/2009):

Wonsan Fishery Enterprise Reduced to a Fraction of Former Output

The Wonsan Fishery Enterprise has 2,500 laborers on its payroll and is not considered a large enterprise along the east coast. The Enterprise is one of three major companies in Wonsan. In the past the Enterprise was doing relatively well because of large catches of flounder. However, since the navy took over the fishery farm, the fishery enterprise has reached the point where it had to cease operations. The reason for the end of the Fishery Enterprise lies in the method of the naval headquarters' management. After enlarging operations to catch any and all fish without limitation, flounder numbers have been critically depleted. Additionally, the Daeheung Trade Company allowed Japan fishery rights in the area, causing severe competition with Japanese fishermen. Overseas Fishery was attempted, but failed because of difficulties in facilities investments. Currently, only the No. 9 work unit is in operation, which sends caught fish to Pyongyang. Virtually all the fishing activities of the Fishery Enterprise have come to an end.

The City of Wonsan currently has around 250 ships of different sizes in operation. Mostly of the ships belong to the military, trading companies earning foreign currency, and some wealthy people. Only those organizations or individuals capable of providing fuel can operate fisheries. Throughout Kangwon Province, small vessels with capacities of 8-HP (horse power) and 28-HP are concentrated in the Counties of Tongchun and Gosung. These small vessels are operated by individuals mainly because they require much less fuel to run.

12 Based on UN COMTRADE data, fisheries products exports from the DPRK (all nations and China) showed the following trends in value and weight:(China only).

	Value (USD)		Quantity (kg)			
Year	All Nations	China	China	Implied $/kg	Implied Fraction of Value as China	
2000	$ 94,095,193	$ 4,047,193	6,326,809	$ 0.64	4.3%	Most DPRK Exports went to Japan in 2000
2005	$ 129,815,406	$ 92,432,570	76,148,567	$ 1.21	71.2%	
2008	$ 40,454,018	$ 39,915,624	26,831,530	$ 1.49	98.7%	
2009	$ 57,848,371	$ 57,538,402	47,933,850	$ 1.20	99.5%	
2010	$ 64,715,567	$ 59,242,819	50,715,945	$ 1.17	91.5%	
2011	$ 84,453,497	$ 82,663,910	54,720,622	$ 1.51	97.9%	
2012	$ 102,770,056	$ 95,346,102	57,380,448	$ 1.66	92.8%	
2013	$ 118,231,968	$ 98,198,680	56,556,594	$ 1.74	83.1%	
2014	$ 143,496,127	$140,558,557	73,419,441	$ 1.91	98.0%	
2015	$ 114,078,384	108,017,339	40,854,316	$ 2.64	94.7%	
2016	$ 197,106,342	190,344,448	89,805,483	$ 2.12	96.6%	
2017	$ 164,545,685	163,029,081	95,910,651	$ 1.70	99.1%	
2018	$ 1,628,308	-	-	#DIV/0!	0.0%	
2019				#DIV/0!	#DIV/0!	No data export data available as yet (4/27/20)
2020				#DIV/0!	#DIV/0!	No data export data available as yet (4/27/20)

China imports the vast bulk of these products--well over 90 percent. Listing 03, "Fish and crustaceans, molluscs and other aquatic invertebrates" Most of China's imports from the DPRK are in the category "Molluscs", and specifically, "Fish and crustaceans, molluscs and other aquatic invertebrates // Molluscs, whether in shell or not, live, fresh, chilled, frozen, dried, whether in shell or not, whether or not cooked before or during the smoking process; flours, meals and pellets of molluscs, fit for human consumption. // - Cuttle fish (Sepia officinalis, Rossia macrosoma, Sepiola spp.) and squid (Ommastrephes spp., Loligo spp., Nototodarus spp., Sepioteuthis spp.) : // -- Other", that is, cuttlefish and squid. For the latter, quantities and values over the last several years for exports from the DPRK to China are as follows:

Year	Value (USD)	Quantity (kg)	Implied $/kg
2010	$45,566,076	42,928,981	$ 1.06
2011	$62,666,008	44,940,371	$ 1.39
2012	$86,738,468	52,649,548	$ 1.65
2013	$93,008,263	54,424,491	$ 1.71
2014	$111,760,185	67,872,432	$ 1.65
2015	$43,137,096	24,837,549	$ 1.74
2016	$78,277	40,501	$ 1.93
2017	$18,130,962	4,269,917	$ 4.25

For 2015 and especially 2016, most imports to China from the DPRK were in category 030799, "Molluscs, n.e.c., whether in shell or not, other than live, fresh, chilled, includes flours, meals and pellets of molluscs, fit for human consumption". statistics for these trades are as follows:

Year	Value (USD)	Quantity (kg)	Implied $/kg
2015	$26,982,649	9,784,411	$ 2.76
2016	$136,034,310	77,797,504	$ 1.75
2017	$147,544	46,070	$ 3.20

For 2017, the major fisheries products imported by China from the DPRK were in category 030743, frozen cuttlefish and squid (sales in this category were not reported in 2015 or 2016)

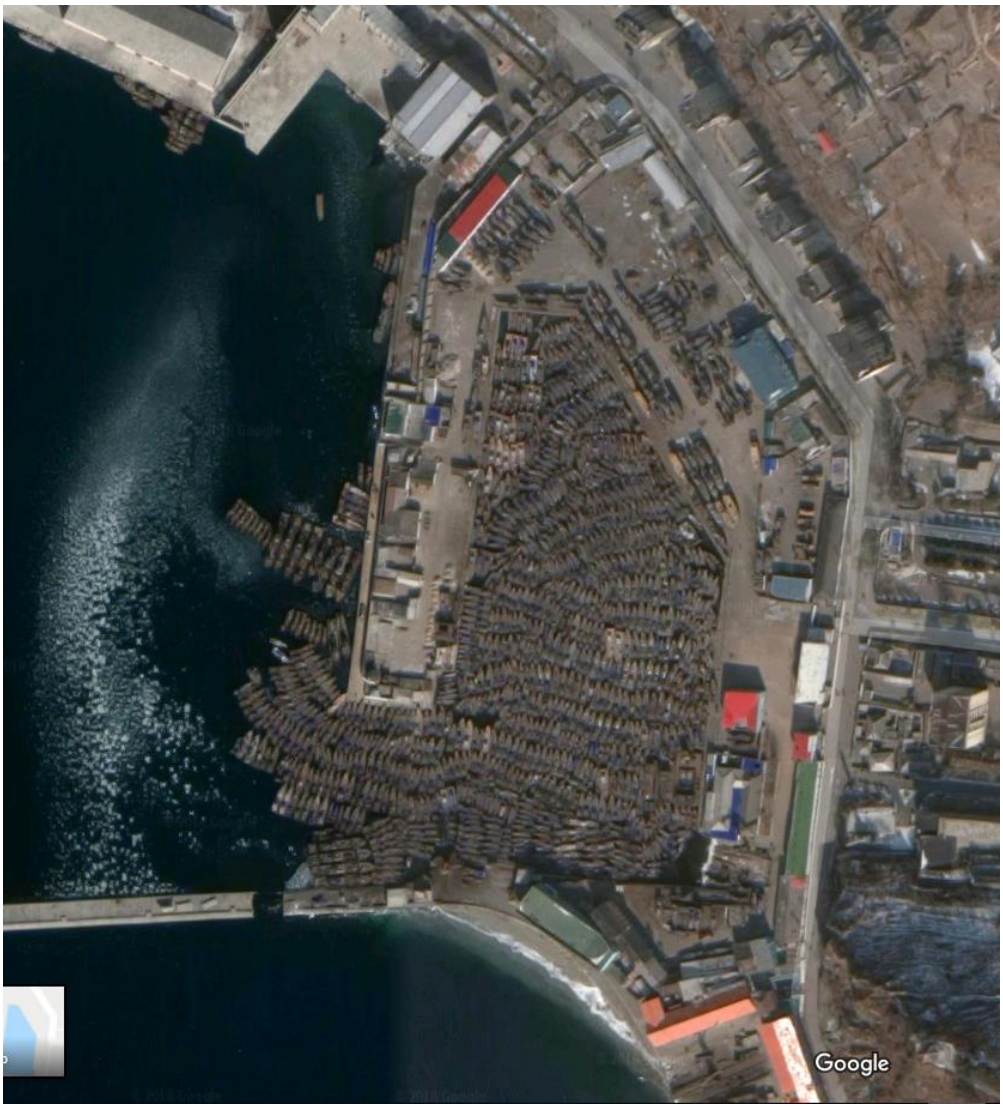
Year	Value (USD)	Quantity (kg)	Implied $/kg
2017	$110,989,172	81,152,778	$ 1.37

These statistics imply an increase in fishing effort, at least for this particular product, although it is unclear what fraction of fisheries effort squid fishing represents. Exports of custaceans to China from the DPRK have also increased markedly in recent years, though the volume of crustaceans caught (in kg) is much less than that of squid.
UN FAO data on DPRK fish "supplies" in recent years have not changed much, suggesting that no new data were availalble.
The increased harvest of squid is due, in part, to an abundance of squid as a result of the same conditions that have led to drought in the DPRK, as described in "North Koreans turn to squid to compensate for drought", prepared by Choi Song Min for Daily NK, dated July 15, 2015, and available as http://www.theguardian.com/world/2015/jul/15/north-korea-drought-squid-harvest.
See also "North Korea's military orders surge in squid poaching", Daily Telegraph, by Mike Firn, dated 28 Nov 2014, available as http://www.telegraph.co.uk/news/worldnews/asia/northkorea/11259846/North-Koreas-military-orders-surge-in-squid-poaching.html.
Similarly, "North Korean fishing industry increases output", NK News, February 10th, 2015, available as http://www.nknews.org/2015/02/north-korean-fishing-industry-increases-output/, also resports increased output after about 2011.
We assume that the sum total of these trends is an increase in fishing effort in smaller boats, mostly (fishing collectives), reflected in an increase in oil use in those boats between 2010 and 2014, and a smaller increase in the use of oil and electricity for processing of marine products, since the bulk of the processing of cuttlefish and squid, for example, seems to be being carried out by hand.
There was a major change in fisheries trade reports involving the DPRK as of 2018, as China reported no imports in the fisheries category from the DPRK at all. This lack of reporting is probably due to UNSC sanctions on the DPRK, although it seems improbable that fisheries exports from the DPRK to China really dropped to zero in 2018, when imports to the DPRK from China were at $ 71 *million, which was about* 69% *of 2017 imports to the DPRK from China, but hardly insignificant. With little else to go on with respect to available statistics (exports from the DPRK to other nations, mostly nations in Africa, continued at levels not very different than in 2017, although those levels were on the order of a percent of historical trade with China), we assume that fisheries effort probably did decline as a result of the combinations of sanctions on DPRK exports and on DPRK imports of diesel oil to fuel the fishing fleet, but that fishing effort did not fall to zero. We assume that 2017 fisheries effort and processing energy use was about* 70% *of that in 2017.*

13 The UN Food and Agriculture Organization, as of 2018, has published what appear to be new statistics for estimated DPRK fisheries production in the "Fishstat" database (see http://www.fao.org/fishery/statistics/global-commodities-production/en). Data for 2000 through 2017 for fisheries production are as shown below. All values are designated "F", for "FAO Estimate", described as "Data estimated from available source of information or calculation based on specific assumptions."
As such, the source and accuracy of these data are somewhat unclear. For example, fish catch varies very little over time, which is inconsistent with reports of changes in catch as ocean conditions have changed from year to year. In the table below, data before 2015 were downloaded from FAO in 2018 and 2019, while data for 2015 through 2017 were downloaded in February of 2020. 2017 was as of 2/2020 the most recent year for which statistics were available.

	Production (Tonnes)				
Year	Crustaceans	Fish	Molluscs, aquatic invertebrates	Total	Implied fraction of FAO-reported Production Imported by China
2000	5,402	70,297	781	76,480	8.3%
2001	8,562	66,330	500	75,392	
2002	19,994	67,378	5,629	93,001	
2003	20,531	66,331	3,936	90,798	
2004	18,892	67,699	21,405	107,996	
2005	7,366	66,599	36,937	110,902	68.7%
2006	3,341	66,115	22,758	92,214	
2007	2,660	61,880	10,215	74,755	
2008	2,300	59,439	19,080	80,819	33.2%
2009	2,250	57,950	40,037	100,237	47.8%
2010	2,100	56,975	43,550	102,625	49.4%
2011	2,600	58,290	45,325	106,215	51.5%
2012	2,010	58,205	53,170	113,385	50.6%
2013	1,670	58,935	54,900	115,505	49.0%
2014	2,235	63,805	68,360	134,400	54.6%
2015	2,168	65,810	39,820	107,798	37.9%
2016	9,855	62,150	40,540	112,545	79.8%
2017	8,280	62,400	81,460	152,140	63.0%

14 Image below is of a harbor in Chongjin filled with on the order of a thousand of what appear to be 10 to 15 meter fishing boats and about 15 larger boats (15 meters). Image from Google Earth, approximate coordinates 41.778022, 129.829610, probably winter, 2018. The image following is another basin about 4.5 km from the first, at coordinates 41.768142, 129.777686, and appears to also hold nearly 1000 10-15 meter boats. This would appear to be a significant portion of the DPRK's east coast fishing fleet. Whether they have been stored together in these basins for protection to wait out the winter and/or because they are idle for lack of fuel is an interesting question. In addition, at least one report suggests that some of these Chongjin-based vessels belong to Munitions factories that are tasked with fishing to generate foreign exchange income. See Radio Free Asia (2017), North Korean Munitions Reported by Jieun Kim for RFA's Korean Service, translated by Leejin Jun, and written in English by Roseanne Gerin. Available as https://www.rfa.org/english/news/korea/north-korean-munitions-factories-turn-to-fishing-to-generate-foreign-currency-08092017152812.html




O-hang
Google
Map
3D
Imagery ©2018 DigitalGlobe, Map data ©2018 Google
United States
Terms
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50 m

The following image of an individual DPRK fishing boat is taken from

https://www.google.com/imgres?imgurl=https%3A%2F%2Fi.dailymail.co.uk%2Fi%2Fpix%2F2017%2F11%2F28%2F14%2F46C42A4000000578-5125089-image-a-88_1511879839963.jpg&imgrefurl=https%3A%2F%2Fwww.dailymail.co.uk%2Fnews%2Farticle-5143573%2FAnother-North-Korean-ghost-ship-washes-ashore.html&docid=9-OFE5Y0MoDXRM&tbnid=YnnoidwAEWxGnM%3A&vet=10ahUKEwjD4ISEuqffAhUMIDQIHUWiD_0QMwg7KAAwAA..i&w=634&h=356&client=firefox-b-1&bih=916&biw=1920&q=DPRK%20squid%20boat%20photo&ved=0ahUKEwjD4ISEuqffAhUMIDQIHUWiD_0QMwg7KAAwAA&iact=mrc&uact=8

15 https://www.telegraph.co.uk/news/worldnews/asia/northkorea/11259846/North-Koreas-military-orders-surge-in-squid-poaching.html
http://www.asiapress.org/rimjin-gang/2017/12/news/why-boats-rush/
https://www.seafoodsource.com/news/supply-trade/north-korean-vessels-expand-illegal-squid-fishing

16 For 2017, assumes 10 percent reduction in effort per unit of exports relative to to previous years due to assumed impact of diesel supply restrictions due to UNSC sanctions.

17 The March 5, 2019 **Report of the Panel of Experts established pursuant to resolution 1874 (2009)**, *includes mention of the DPRK practice of "...prohibited transfer by the Democratic People's Republic of Korea of its fishing rights, as clarified inresolution 2397 (2017), continued throughout 2018, acting as a potential source of income for the country." (P. 28 of https://www.undocs.org/S/2019/171.) This practice apparently involved transferring DPRK fishing licenses to Chinese fishing boats and ships, which then operatated in the waters off the DPRK and elsewhere. It is unclear what impact this practice might have on DPRK fishing effort, and specifically, how it might affect DPRK fuel use for fishing. To the extent that DPRK fishing was effectively transferred to Chinese vessels, it seems likely that DPRK fishing effort would decrease, although it seems possible that some of the Chinese vessels fishing in DPRK waters (or in international waters near that DPRK) with DPRK licenses might be obtaining fuel in the DPRK. The same source includes a quote from a fisherman indicating "that there were around 200 Chinese fishing boats operating in the 'water of North Korea'". If these were larger fishing vessels (with engines of around 100 hp or more), this would be the equivalent of more than 10% of the DPRK fleet, but we do not really have information on the size of these vessels using DPRK licenses. We make the assumption that the practice of transferring licenses further reduced DPRK fishing effort by* 5% *in 2018, although this must be considered the roughest of estimates. We assume that this estimate also holds for 2019. For 2020, we assume that the impacts of the COVID-19 virus and the impacts of the measures taken to prevent it have had a relatively small impact on fishing effort, perhaps* 10% *relative to 2019, because fishing would likely be considered a crucial occupation, given the importance of fish and seafood protein to the DPRK population, as well as the importance of seafood exports to the economy. In addition, fishing itself involves gathering of relatively few people, though fish processing plants do typically require large numbers of people working close together.*

18 The UNSC "Panel of Experts" in UNSC (2020), ***Note by the President of the Security Council*** *, number S/2020/151, dated 2 March 2020, and including "Annex: Letter dated 26 February 2020 from the Panel of Experts established pursuant to resolution 1874 (2009) addressed to the President of the Security Council", available as https://undocs.org/S/2020/151, includes the following image of Chairman Kim Jong Un visiting a military fish processing factory. The robotic equipment shown is an ABB (a Swiss equipment maker) design, made in China, and possible exported second-hand to the DPRK. Photo from page 49 of UNSC document, dated November 19, 2019, and originally from the Korea Central News Agency (KCNA).*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
PUBLIC/COMMERCIAL SECTOR

Prepared By David Von Hippel
Date Last Modified: 6/23/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

				Sources/Notes:
Coal Use: Public/Commercial Sectors				
Urban Residential Floor Space:	1.34E+08	sq.m.		
Ratio of Res. Urban to Pub/Comml Space	29.60%			1
Commercial Floor Space	3.972E+07	sq.m.		4
Coal Use intensity	33	kgce/sq.m.-yr		2
Conversion Factor	0.0293	GJ/kgce		
Fraction of Buildings Heated with Coal	85%			
Total Coal Use, Public/Commercial Sectors	3.26E+07	GJ/yr		
District Heat Use: Public/Commercial Sectors				
Fraction of Public/Commercial Floorspace with District Heating			15.00%	*See "District_heat" worksheet*
District Heat Use	2.64E+06	GJ/yr		
Oil Use: Public/Commercial Sectors	9.79E+04	GJ/yr		*No Data*
Electricity Use: Public/Commercial Sectors				
Electricity Use intensity, Buildings	27.5	kWh/sq.m.		3
Conversion Factor	0.0036	GJ/kWh		
Electricity Use in Buildings	3.93E+06	GJ/yr		
Other Electricity Use, Public/Commercial	7.00E+06	GJ/yr		5
Total Elect. Use, Public/Commercial Sectors	1.09E+07	GJ/yr		
Wood/Biomass Use: Public/Commercial Sectors	1.63E+06	GJ/yr		10

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN PUBLIC/COMMERCIAL SECTORS
(See Note 8)

Parameter	1996	2000	2005	2008	2009	2010	Sources/Notes:
Public/Commercial Floor space per unit urban residential floor space relative to 1990:	100%	95.0%	90.0%	86%	85%	84%	7
Public/Commercial Floor space (sq.m.)	4.25E+07	4.226E+07	4.463E+07	4.556E+07	4.581E+07	4.6065E+07	
Implied floorspace relative to 1990	106.93%	106.39%	112.36%	114.70%	115.34%	115.97%	
Coal use per square meter relative to 1990:	75%	45%	45%	45.0%	45.0%	45.0%	12
Elect. and Heat use per square meter relative to 1990:	57%	29.14%	47.0%	46.0%	42.0%	39.9%	13
Other Public/Comm'l elect use rel to 1990.	57.0%	29.14%	43.9%	45.1%	40.0%	37.9%	13
Wood/Biomass Use as a fraction of coal use:	10%	20%	30%	30.0%	30.0%	30.0%	10
Oil use as a fraction of coal use:	0.5%	0.5%	1.0%	1.42%	1.95%	2.45%	11
Fraction of Oil Use as Kerosene (remainder assumed LPG	50.0%	50.0%	30.0%	25.0%	15.0%	15.00%	

Parameter	2014	2015	2016	2017	2018	2019	2020	
Public/Commercial Floor space per unit urban residential floor space relative to 1990:	87%	88%	89%	90%	90%	90%	88.7%	14
Public/Commercial Floor space (sq.m.)	5.111E+07	5.255E+07	5.402E+07	5.554E+07	5.644E+07	5.736E+07	5.746E+07	
Implied floorspace relative to 1990	128.66%	132.29%	136.01%	139.83%	142.10%	144.41%	144.67%	
Coal use per square meter relative to 1990:	46.0%	47.0%	48.0%	50.0%	52.0%	52.0%	37.4%	15
Elect. and Heat use per square meter relative to 1990:	32.9%	33.9%	34.9%	34.3%	34.6%	34.6%	24.9%	15
Other Public/Comm'l elect use rel to 1990.	33.0%	34.0%	34.8%	34.3%	34.6%	34.6%	24.9%	15
Wood/Biomass Use as a fraction of coal use:	26.0%	25.0%	24.0%	23.0%	22.0%	22.0%	22.0%	15
Oil use as a fraction of coal use:	2.54%	3.50%	3.50%	3.82%	4.00%	4.00%	4.00%	15
Fraction of Oil Use as Kerosene (remainder assumed LPG	13.00%	12.00%	11.00%	8.00%	6.00%	6.00%	5.00%	16

Sources/Notes:

1 Ratio of all commercial to urban resid. floor area, heating zone of China, 1989. From "Energy Use and Conservation in China's Residential and Commercial Sectors: Patterns, Problems, and Prospects", by Feng Liu, LBL, March, 1993, p.26.)

2 For centrally heated buildings. 10% higher than Chinese value from source as in 1, page 41.

3 Derived based on data in 1, pages 26 and 63.

4 Note that this is about twice current Chinese levels, but less than half of 1985 USSR levels.

5 Placeholder estimate to bring total Agric/Services/Military power demand up to 25% of electricity use as estimated in document in authors' files [EP1].

6 [Not Used]

7 Lower value in 2000 assumes the closure of some buildings no longer used. Trends after 2000 essentially assume that floorspace grows at more or less the same rate as population, and thus at a slower pace than the number of households, since the growth rate in the number of urban households is higher than the rate of population growth (due to trends in migration and smaller families).

8 Based on visits to the DPRK in 1998 and 2000, commercial/public space does not seem to be under construction at an unusual rate (when there is construction at all), so the ratio of residential to commercial/public space remains as in 1990. The reduction in electricity use relative to 1990 is a function of the same assumed average urban electricity outage rate used for the residential sector, namely that power outages in cities outside the Pyongyang area as of 2000 were by far the rule rather than the exception. The fraction of 1990 coal use per unit area assumed for 2000, 65%, reflects the assumption that coal availability is poor in many areas of the country.

9 China Customs Statistics reported imports of computers and computer components to the DPRK from China more than doubled, in both number and value, between 2004 and 2005. This increase in computer (HS #8471) imports may indicate or be a indicator of somewhat of an increase in public/commercial activity, including, possibly, in the information technology sector.
Import data as compiled by Nathanial Aden, 2006. For related analysis, see also N. Aden, North Korean Trade with China as Reported in Chinese Customs Statistics: Recent Energy Trends and Implications as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Dr. Aden's paper is available as http://www.nautilus.org/fora/security/0679Aden.pdf.

10 We have no direct data on use of wood and biomass as a heating and cooking fuel in the public/commercial sector in the DPRK as of 1990, but anecdotal evidence of widespread use of biomass fuels in at least some types of common public institutions in recent years suggests that at least some use of biomass fuels for heating and cooking occurred in at least rural areas as of 1990. Accordingly, we assume that public/commercial/institutional use of biomass was approximately 5% of coal use, in terms of energy content in 1990. *Given the lower heating efficiency of biomass relative to coal in most applications, this implies that biomass accounted for only a few percent of heating provided in 1990. Some observers note that the use of wood and other biomass fuels for heating (when used) and cooking in several types of public sector buildings has increased substantially since the mid-1990s, with wood often providing the bulk of fuel use.*

11 We have no direct data on oil use in the public/commercial sectors, but it seems clear that some oil (in the form of kerosene and LPG for cooking) was and is used in the sector. We make the nominal assumption that oil use in 1990 was 0.3 percent of coal use in the sector, rose to 0.5 percent in 1996, increased in 2000 to 1% of coal use, and to a level equal to 1.5 percent of coal use in 2005 and on as a result of the growth in the number of restaurants, primarily in Pyongyang, but also elsewhere in the country. Oil use is assumed to be 90.0% *kerosene and and* 10% *LPG in 1990 but ramping up to higher fractions of LPG in 1996, 2000, 2005, 2008, and 2009.*

12 Coal use is assume to decline substantially, particularly in 2000 and 2005, relative to 1990, based on observers reports that many public buildings, including most office buildings, have remained unheated in winter in recent years.

13 For 2000, public/commercial electricity use relative to 1990 is assumed similar to that for the residential sector. For 2005, some observers report a modest increase in the availability of electricity to public/commercial buildings, though the change in electricity availability varied substantially by area of the DPRK, including in relation to proximity to new or existing power plants, or to priority users of power. From 2005 on, electricity use in the sector is assumed to roughly follow estimated availability of electricity. Heat use in the sector is assumed to follow electricity use, as most of the distribution, fuel availability, and plant maintenance problems that pertain to the electricity sector are likely to be shared with the heat production sector, particularly as most heat production is from combined heat and power plants (or district heat boiler co-located with power plants).

14 Assumes, based on anecdotal reports, that the years from 2011-2017 saw an increase in the DPRK economy manifested, at least in some cities, in a modest increase in building of public/commercial buildings relative to residences. Due to the COVID-19 epidemic and DPRK measures to reduce its impact, we assume that commecial building space will not grow, on an annual basis, as fast in 2020 as it has in previous years. We also assume that restrictions on movemen due to COVID-19 will, by the end of 2020, have reduced overall commercial and public energy use per unit of floor area by 28% *relative to 2019.*

15 Assumes that the use of coal, electricity, and oil in the public commercial sector increased somewhat from 2011 through 2017 relative to previous years due to greater fuel availability and an improved economy, including, for example, greater market activity. For 2018, assumes somewhat greater coal use due to lower domestic prices/higher availability because less coal was exported due to UNSC sanctions. Conversely, biomass use in the sector is assumed to have declined somewhat with increasing availabity of other fuels.

16 Assumes more LPG use in the sector relative to kerosene use over time.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
ENERGY USED IN MILITARY BUILDINGS AND OTHER FACILITIES

Prepared By David Von Hippel
Date Last Modified: 6/24/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

				Sources/Notes:
Coal Use: Military Sector				
	Military Installation Floor Space:	2.00E+07	sq.m.	*1*
	Coal Use intensity	33	kgce/sq.m.-yr	*2*
	Conversion Factor	0.0293	GJ/kgce	
	Total Coal Use, Military Buildings	1.93E+07	GJ/yr	
	Coal Use, Military Manufacturing	8.90E+05	GJ/yr	*5, 8*
	Other Coal Use: Military Sector	9.60E+06	GJ/yr	*1*
	Total Coal Use, Buildings and Other	2.98E+07	GJ/yr	
Oil Use: Military Sector				
	Oil Use, Military Transport Vehicles	6.58E+06	GJ/yr	*5*
	Oil Use, Heavy Armaments	2.63E+05	GJ/yr	*5*
	Oil Use in Air Force	2.65E+06	GJ/yr	*5*
	Oil Use in Navy	6.94E+06	GJ/yr	*5*
	Oil Use, Buildings and Other	1.00E+05	GJ/yr	*1*
	Total Oil Use, Military Sector	1.65E+07	GJ/yr	
Electricity Use: Military Buildings and Other				
	Electricity Use intensity, Buildings	55	kWh/sq.m.-yr	*4*
	Conversion Factor	0.0036	GJ/kWh	
	Other Electricity Use	1.00E+07		*1*
	Total Electricity Use, Buildings and Other:	1.40E+07	GJ/yr	
	Electricity Use, Military Manufacturing	4.77E+04	GJ/yr	*5*
	Total Electricity Use, Military:	1.40E+07	GJ/yr	
Wood Use: Military Sector				
	Intensity of wood/biomass fuel use relative to coal use	200%		*10*

Energy Use in 1996, 2000, 2005, 2008 through 2010, and 2014-2018 Relative to 1990 for Subsectors/End-Uses Not Covered in Military Workbook		
1996 Coal/Wood Use, Buildings and Other, relative to 1990	95%	*Assumption*
2000 Coal/Wood Use, Buildings and Other, relative to 1990	85%	*Assumption*
2005 Coal/Wood Use, Buildings and Other, relative to 1990	80%	*Assumption*
2008 Coal/Wood Use, Buildings and Other, relative to 1990	75%	*Assumption; note 12*
2009 Coal/Wood Use, Buildings and Other, relative to 1990	75%	*Assumption; note 12*
2010 Coal/Wood Use, Buildings and Other, relative to 1990	75%	*Assumption; note 12*
2014 Coal/Wood Use, Buildings and Other, relative to 1990	77%	*Assumption; note 13*
2015 Coal/Wood Use, Buildings and Other, relative to 1990	78%	*Assumption; note 13*
2016 Coal/Wood Use, Buildings and Other, relative to 1990	79%	*Assumption; note 13*
2017 Coal/Wood Use, Buildings and Other, relative to 1990	80%	*Assumption; note 13*
2018 Coal/Wood Use, Buildings and Other, relative to 1990	82%	*Assumption; note 13*
2019 Coal/Wood Use, Buildings and Other, relative to 1990	82%	*Assumption; note 13*
2020 Coal/Wood Use, Buildings and Other, relative to 1990	71%	*Assumption; note 13*
1996 Oil Use, Buildings and Other, relative to 1990	95%	*Assumption*
2000 Oil Use, Buildings and Other, relative to 1990	85%	*Assumption*
2005 Oil Use, Buildings and Other, relative to 1990	85%	*Assumption*
2008 Oil Use, Buildings and Other, relative to 1990	82%	*Assumption*
2009 Oil Use, Buildings and Other, relative to 1990	78%	*Assumption*
2010 Oil Use, Buildings and Other, relative to 1990	76%	*Assumption*
2014 Oil Use, Buildings and Other, relative to 1990	78%	*Assumption; note 13*
2015 Oil Use, Buildings and Other, relative to 1990	79%	*Assumption; note 13*
2016 Oil Use, Buildings and Other, relative to 1990	80%	*Assumption; note 13*
2017 Oil Use, Buildings and Other, relative to 1990	80%	*Assumption; note 13*
2018 Oil Use, Buildings and Other, relative to 1990	76%	*Assumption; note 13*
2019 Oil Use, Buildings and Other, relative to 1990	76%	*Assumption; note 13*
2020 Oil Use, Buildings and Other, relative to 1990	65%	*Assumption; note 13*
1996 Fraction of Coal and Wood Use as Wood	10%	*9*
2000 Fraction of Coal and Wood Use as Wood	15%	*9*
2005 Fraction of Coal and Wood Use as Wood	17%	*9, 11*
2008 Fraction of Coal and Wood Use as Wood	17%	
2009 Fraction of Coal and Wood Use as Wood	17%	
2010 Fraction of Coal and Wood Use as Wood	17%	
2014 Fraction of Coal and Wood Use as Wood	16%	*13*
2015 Fraction of Coal and Wood Use as Wood	15%	*13*
2016 Fraction of Coal and Wood Use as Wood	14%	*13*
2017 Fraction of Coal and Wood Use as Wood	14%	*13*
2018 Fraction of Coal and Wood Use as Wood	14%	*13*
2019 Fraction of Coal and Wood Use as Wood	14%	*13*
2020 Fraction of Coal and Wood Use as Wood	14%	*13*
1996 Elect. Use, Buildings and Other, relative to 1990	55%	*Assumption*
2000 Elect. Use, Buildings and Other, relative to 1990 *(See Note 6)*	53%	*Assumption*
2005 Elect. Use, Buildings and Other, relative to 1990 *(See Note 7)*	62.5%	*Assumption*
2008 Elect. Use, Buildings and Other, relative to 1990	65.0%	*Assumption*
2009 Elect. Use, Buildings and Other, relative to 1990	58.2%	*Assumption*
2010 Elect. Use, Buildings and Other, relative to 1990	55.00%	*Assumption*
2014 Elect. Use, Buildings and Other, relative to 1990	58.00%	*Assumption; note 13*
2015 Elect. Use, Buildings and Other, relative to 1990	60.00%	*Assumption; note 13*
2016 Elect. Use, Buildings and Other, relative to 1990	61.50%	*Assumption; note 13*
2017 Elect. Use, Buildings and Other, relative to 1990	62.00%	*Assumption; note 13*
2018 Elect. Use, Buildings and Other, relative to 1990	63.00%	*Assumption; note 13*
2019 Elect. Use, Buildings and Other, relative to 1990	63.00%	*Assumption; note 13*
2020 Elect. Use, Buildings and Other, relative to 1990	54%	*Assumption; note 13*

Sources/Notes:

1 Placeholder Estimate, but electricity comparable to estimates by KERI ("Analysis of Present Status and Future Supply /Demand Prospects for the DPRK Power System", by J.Y. Yoon, presented at the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA) that military sector electricity demand in the DPRK would be about 4.9 TWh/yr if unconstrained. Since electricity demand in 1990 in the DPRK was already somewhat constrained by supply, we assume that total military electricity use in that year was about 80% of the KERI (Korea Electrotechnical Research Institute) figure. Dr. Yoon's presentation is avaialble as http://www.nautilus.org/DPRKEnergyMeeting/Papers/Yoon.ppt.

2 Assumed to be 10% higher than value for centrally heated Commercial/Public buildings from "Energy Use and Conservation in China's Residential and Commercial Sectors: Patterns, Problems, and Prospects", by Feng Liu, LBL, March, 1993, p.41.)

3 Derived based on data in 1, pages 26 and 63.

4 Assumed to be 100% higher than the level in (other) public and commercial buildings due to use of specialized electrical equipment.

5 As estimated in other Military Energy Consumption sections.

6 Rough assumption, but as the electricity situation in the country had continued to worsen, it.seems unlikely that electricity use in military buildings in the DPRK was larger in 2000 than in 1996, even considering the importance of the military sector in the DPRK

7 Rough assumption, taking into account that as the overall electricity situation in the country has improved slightly from 2000 to 2005, military sector electricity use should rise somewhat.

8 The journal Seoul T'ongil Kyongje, dated July 2002, contains an article (pages 28-36) by So Chu-sok entitled "North Korean Industries (Part X): Munitions Industry". Among the information in this article is the following: "...North Korean military power has not changed greatly since....the mid 1990s", apart from some missile development and "expanded forward deployment of long-range artillery". The article estimates the size of the military at 1.7 million people, consuming much more than 5% of food in the country, and more than 15 percent of fuel oil used in the DPRK. Military stockpiles of food and fuel are "100 to 120 days worth", but it is not stated whether. this refers to days under typical non-combat or combat conditions. The article states that there are about 180 munitions factories in the DPRK, including about 40 gun factories, 10 armored vehicle factories, 50 ammunitions factories, and 10 naval shipyards, producing a total of 25 percent of GNP. Exports of SCUD-C missiles in the early 1990s are estimated at 100 to 150 per year. Factories, largely based on Soviet/East Bloc technology, have become "technologically obsolete and their facilities are run down", resulting in "extremely low" efficiency and high rates of consumption of energy and materials that, coupled with fuel and materials shortages, have "caused production setbacks" in some factories. These trends are taken into account in the analysis of energy demand in the military manufacting sector (see military sector analysis workpapers).

9 The publication Seoul Wolgan Choson published an article by Kim Yon-kwang and Yi Sang-hun, dated 1 October, 2003 (pages 168-181), entitled "Kim Chong-il's Military is Hoarding All Rice Aid as Military Provision", which is based on an interview with a DPRK soldier named Chin Yon-kyu, who had defected to the ROK, but who was (or claimed to be) a driver for a high-ranking officer. This article contains one of a number of anecdotal reports, including reports by observers of and recent visitors to the DPRK, that suggest that soldiers, like many DPRK residents have in recent years, in many locales, been obliged to forage, in both the broad and specific senses of the word, for both food and fuel. Although no quantitative data are available to assist in estimating the impact of the need for military units to use wood fuel, we have assumed that the fraction of fuel for cooking and heating made up by wood has risen, starting at (near) zero, we assume, in 1990, rising substantially in 1996 and through 2000, and rising only slightly between 2000 and 2005 as the DPRK economy improved somewhat. After 2005, the fraction of of wood fuel use is assumed to be constant.

10 Rough assumption, but considering that much biomass is probably burned in open fireplaces, and much of the biomass/wood fuel used is probably green (wet and unseasoned), it seems reasonable to assume the the efficiency of biomass fuel use might be half that (twice the intensity) of coal use for cooking and heating end-uses.

11 By way of comparison, the assumptions above for 2005 suggests military wood/biomass fuel use of approximately 4.06E+06 *GJ is approximately the amount of wood fuel energy needed to cook* 1.27E+08 *kilograms of rice, assuming the use of* 2 *kg of (dry) wood fuel per kg of rice. (Note that this is a highly variable quantity, depending on cooking methods and the type of fireplace/stove and pots used, but the figure cited is within the range of values provided in, for example, http://www.fao.org/docrep/006/AB780E/AB780E03.htm http://www.worldenergy.org/wec-geis/publications/reports/rural/energy_use_in_rural_areas/2_3.asp, and http://www.fao.org/docrep/x5400e/x5400e04.htm.) At an average daily ration of* 0.5 *kg per soldier (various accounts put soldiers rations at about 500 grams per day, sometimes somewhat lower or higher, depending on the soldier's tasks, duty station, and food availability), this implies that wood equivalent to the amount needed to cook rice for about* 694,632 *soldiers is used. Given that some wood will in fact be used for heating, or for cooking other foods this figure--the equivalent of about 70 percent of the number of people the DPRK was estimated to in uniform as of about 2005, seems generally plausible.*

12 Anecdotal reports, both published and otherwise, suggest that military installations suffer from the same lack of heating fuels as other parts of the economy. See, for example, "Military-First, But Still No Heating on Bases", by Im Jeong Jin, Daily NK, dated 2011-01-24, and available as http://www.dailynk.com/english/read.php?cataId=nk01500&num=7290

13 Assumes slowly improving fuel availabiity for coal, oil, and electricity in military installations, consistent with both an emphasis on the military under Kim Jong Un and improving fuel availability in the country generally. Consistent with this trend, we assume that the use of wood fuel in the military slowly declined over 2010 through 2017. For 2018, assumes that reduced fuel availabilty due to UNSC sanctions results in lower use of oil than in 2017, with some additional coal use as less coal was exported and thus more coal might have been available for domestic use, but with little impact on electricity, and wood/biomass fuel use. Impacts of sanctions on military sector fuel use are assumed to be less than for other sectors, as military fuel use is typically prioritized in allocations. For 2019, assumes activity was similar to 2018. For 2020, due to the COVID-19 epidemic and the DPRK's measures to reduce its impact, we assume that the military lockdown reduced overall use of coal/wood, oil, and electricity use in military buildings by 14% *, which assumes that there was slightly lower building occupancy relative to previous years, but also less overall activity that required enegy use. Note that this fraction is less than (that is, assumes less of a reduction than) used for the commercial and public sector, largely because of the assumption that the occupants of military buildings will have been obliged to remain ath their posts or in their barracks during the COVID-19-related lockdown.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
OTHER/NON-SPECIFIED SECTOR

Prepared By David Von Hippel
Date Last Modified: 6/24/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Coal Use: Other/Non-Specified Sectors			
Diesel Oil Use: Other/Non-Specified Sectors	1.70E+06	GJ/yr	*1*
Kerosene/Jet Fuel Use: Other/Non-Specified Sect.	4.25E+06	GJ/yr	*1*
Electricity Use: Other/Non-Specified Sectors			
Wood/Biomass Use: Other/Non-Specified Sectors			
Heat from Yongbyon Nuclear Reactor used locally	4.73E+05	GJ/yr	*2*

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN NON-SPECIFIED SECTORS

Values Relative to 1990	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	
Oil used in unspecified/other sectors	0%	0%	0%	0%	0%	0%	*Assumption*
Heat from Yongbyon Nuclear Reactor	0%	0%	100%	0%	0%	0%	*3*

Values Relative to 1990	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Oil used in unspecified/other sectors	0%	0%	0%	0%	0%	0%
Heat from Yongbyon Nuclear Reactor	67%	67%	67%	67%	67%	0%

Values Relative to 1990	**2020**
Oil used in unspecified/other sectors	0%
Heat from Yongbyon Nuclear Reactor	33%

Sources/Notes:

1 Included to account for remainder of refined products production in balance sheet, 1990.

2 See Note 13 in "ELECTRICITY GENERATION IN 1990" worksheet.

3 Yongbyon reactor not operating in 1996 or 2000. Capacity factor in 2005 assumed to be similar to that in 1990 (about 60 percent). According to several sources (see, for example, Nuclear Threat Initiative, "Yongbyon 5 MWe Reactor", available at https://www.nti.org/learn/facilities/766/, and GlobalSecurity.org, "Weapons of Mass Destruction (WMD): Yongbyon (Nyongbyon)", available as as https://www.globalsecurity.org/wmd/world/dprk/yongbyon-5.htm), the Yongbyon plant operated at least "intermittently" from 2014 through 2018. We assume that the reactor operated somewhat less than in previous periods of activity, at an average capacity factor of about 40% *percent. In 2019, several sources suggest that the reactor did not operate at all, so we assume that heat output for 2019 was* 0% of full capacity. For 2020, some sources suggest that although *no activity had been detected to about March of 2020, the DPRK was possibly readying the reactor for a restart. We therefore assume that heat output in 2020 was about* 20% *of capacity. Relevant references include SHIM KYU-SEOK (2019), "Yongbyon reactor seems to be idle, says IAEA", Korea JoongAng Daily, dated September 18, 2019, and available as https://koreajoongangdaily.joins.com/news/article/article.aspx?aid=3068062; Joseph Bermudez and Victor Cha (2019) "Yongbyon Nuclear Complex: Normal Operations with Low Level Activity", Beyond Parallel, dated April 1, 2019, and available as https://beyondparallel.csis.org/yongbyon-nuclear-complex-normal-operations-with-low-level-activity/; 38 North (2019), "North Korea's Yongbyon Nuclear Center: Low Level Activity and Flood Management", dated August 30, 2019, and available as https://www.38north.org/2019/08/yongbyon083019/; and Peter Makowsky, Frank V. Pabian and Jack Liu (2020), "North Korea's Yongbyon Nuclear Center: Rail Activity at the Radioisotope Production and Uranium Enrichment Plants", dated February 14, 2020, and available as https://www.38north.org/2020/02/yongbyon021420/.*

The image below, from Google Earth Pro, shows the Yongbyon "5 Mwe" reactor as of October 13, 2019, apparently not operating, as indicated by the lack of steam from the smokestack.


"5 MWe" (Plutonium Production) Reactor at Yongbyon as of 10/13/2019
Write a description for your map.
Legend
Yongbyon Nuclear Science and Weapons Research Center
Yongbyon Nuclear Science and Weapons Research Center
Google Earth
Image © 2020 CNES / Airbus
N
100 m

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
NON-ENERGY RESOURCE USES

Prepared By David Von Hippel
Date Last Modified: 6/24/2020

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Coal and Oil Use as feedstock: Fertilizer (Ammonia) production	1.83E+07	GJ/yr	*1*
Total Coal Use: Non-Energy Applications:	1.37E+07	GJ/yr	
Oil Use: Non-Energy Products excluding:	5.771E+06	GJ/yr	*4*
-- heavy oil for fertilizer production	9.15E+05	GJ/yr	*5*
-- naptha for fertilizer production	3.66E+06	GJ/yr	*5*
Wood/Biomass Use: Roundwood for Wood Products:	1.20E+07	GJ/yr	*2*
Wood/Biomass Use: Non-Energy Applications	1.20E+07	GJ/yr	

Sources/Notes:

ESTIMATE OF CURRENT AND FUTURE NON-ENERGY USE OF FUELS

Values Relative to 1990	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	
Coal, Oil feedstock for ammonia production	24.7%	8%	11%	11%	7%	7%	*3*
Oil Use: Other Non-Energy Products	23.65%	38.00%	11.00%	10.40%	13.50%	15%	*6*
Wood/biomass used as roundwood:	60%	50%	50%	50%	50%	50%	*Assumption*

Values Relative to 1990	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
Coal, Oil feedstock for ammonia production	22.5%	21.0%	24.0%	16.3%	9.1%	9.1%	*3*
Oil Use: Other Non-Energy Products	10.20%	11.23%	9.30%	22.35%	18.72%	18.76%	*6*
Wood/biomass used as roundwood:	50%	50%	50%	50%	50%	50%	*Assumption*

Values Relative to 1990	**2020**	
Coal, Oil feedstock for ammonia production	4.6%	*3*
Oil Use: Other Non-Energy Products	15.00%	*6*
Wood/biomass used as roundwood:	50%	*Assumption*

Sources/Notes:

1 Imported from Industry sheet.

2 Imported from Biomass sheet.

3 Assumed same as production relative to 1990 for the fertilizer subsector; imported from "Industry--96-on" sheet.

4 Estimate based on estimated output of bitumen, petroleum coke, lubricants, and waxes in 1990. Some of these products were probably exported (to Russia and possibly China).

5 For Nitrogen fertilizer manufacture. See "Industry-96-on" worksheet in this workbook, note 3.

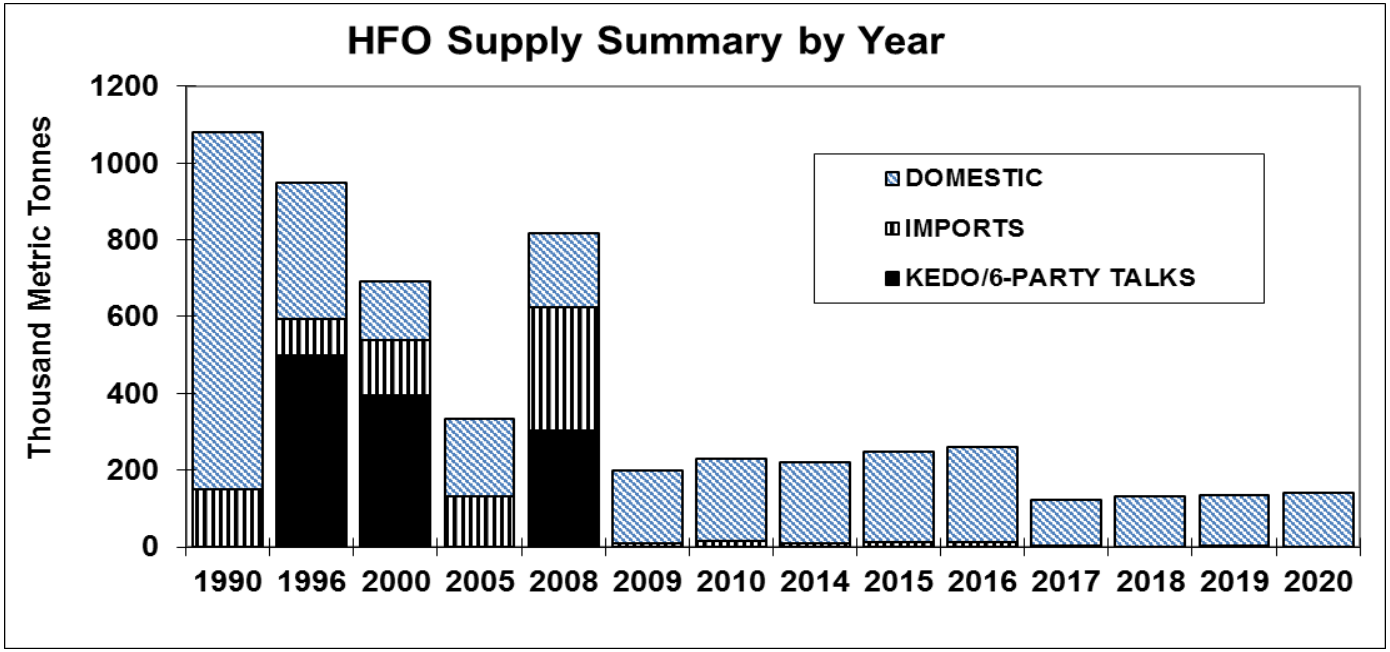
6 Adjusted in part to make production plus imports minus exports of "LPG/Refinery Fuel/Non-Energy Products" balance demand. Assumes lower consumption in 2018 and 2019 than in 2017 due to lower availability of these products due to UNSC sanctions. For 2020, assumes that use of non-energy products decreased due to restrictions on movement related to the COVID-19 epidemic response measures.

Additional Summary Figures and Tables

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ADDITIONAL GRAPHS AND FIGURES

HFO Supply Summary: Thousand tonnes

	YEAR													
SOURCE	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
KEDO/6-PARTY TALKS	0	500	395	-	304	-	-	-	-	-	-	-	-	-
IMPORTS	150	94	145	132	319	10	16	8	11	13	4	1	2	1
DOMESTIC	930.4	356	151	202	194	191	214	213	238	248	119	132	132	139
TOTAL	1,080	950	691	334	818	200	231	221	249	261	123	133	134	140
KEDO/6-PARTY TALKS	0%	53%	57%	0%	37%	0%	0%	0%	0%	0%	0%	0%	0%	0%
IMPORTS	14%	10%	21%	39%	39%	5%	7%	4%	4%	5%	3%	1%	1%	1%
DOMESTIC	86%	37%	22%	61%	24%	95%	93%	96%	96%	95%	97%	99%	99%	99%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

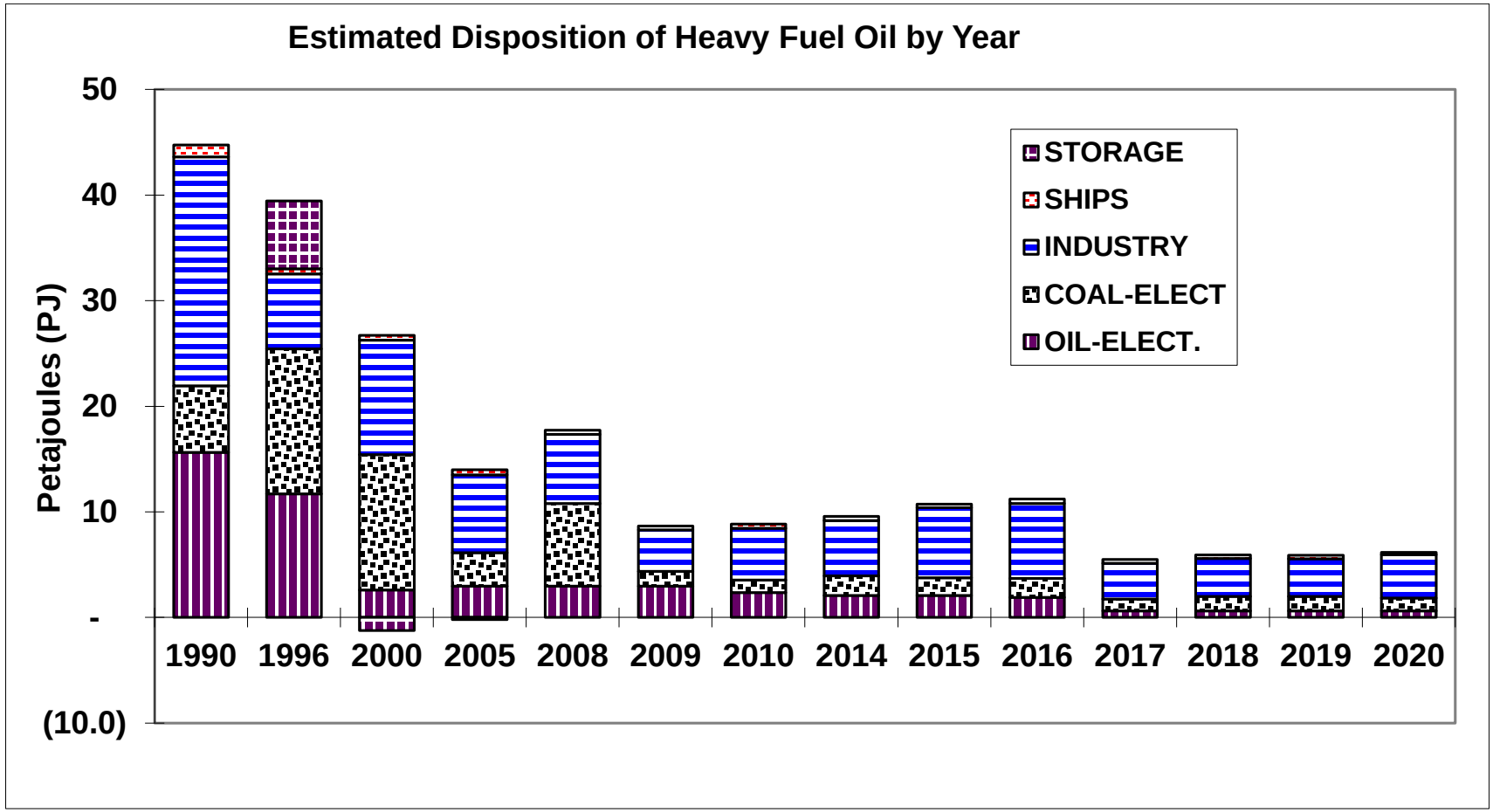


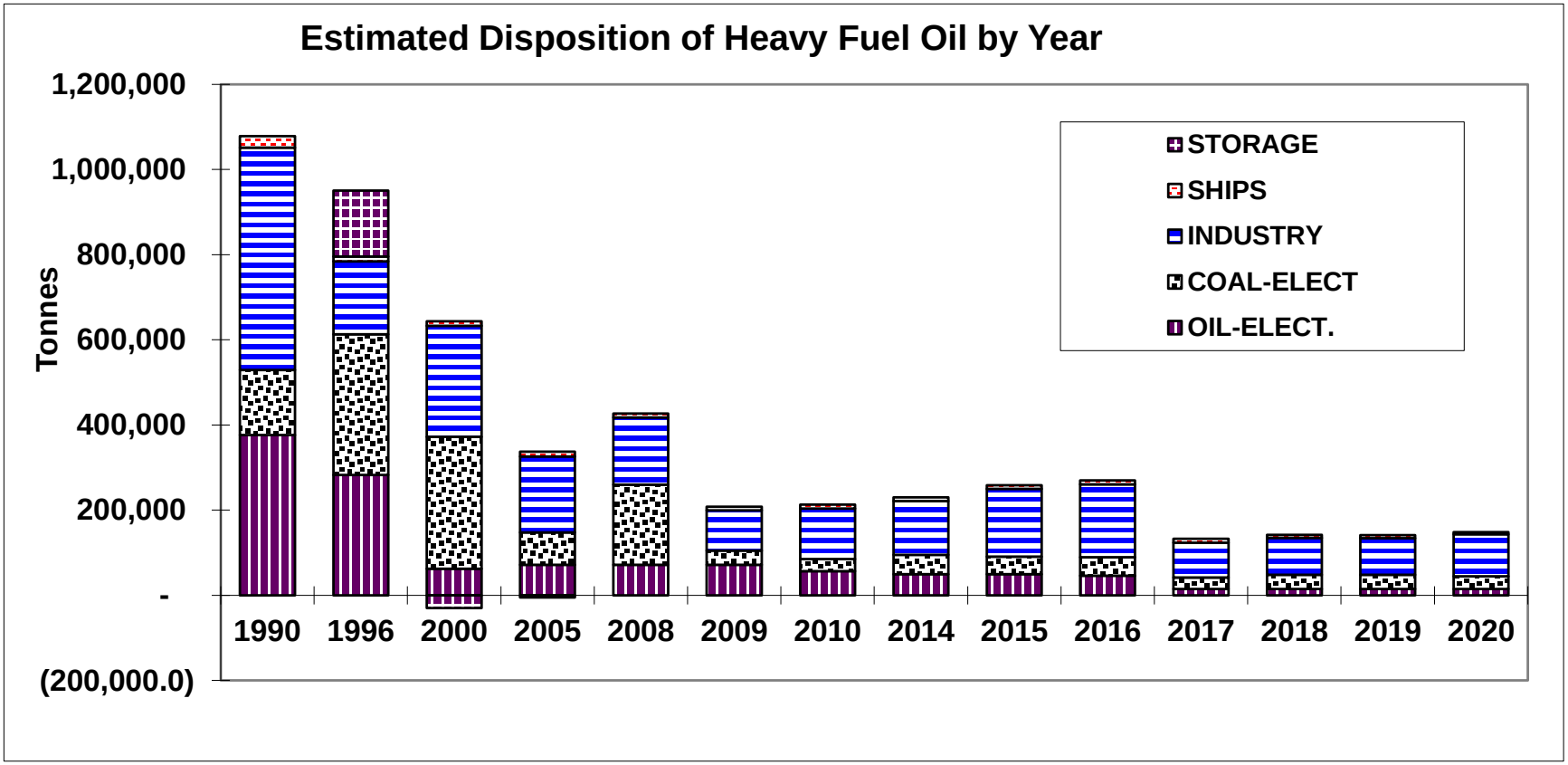
HFO Demand Summary: Petajoules (PJ)

	YEAR													
CONSUMER	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
OIL-ELECT.	15.6	11.7	2.6	3.0	3.0	3.0	2.4	2.1	2.1	1.9	0.6	0.6	0.6	0.6
COAL-ELECT	6.3	13.7	12.8	3.2	7.8	1.4	1.2	1.9	1.7	1.8	1.1	1.4	1.4	1.2
INDUSTRY	21.7	7.1	10.8	7.4	6.5	3.9	4.9	5.2	6.6	7.1	3.4	3.6	3.6	4.1
SHIPS	1.1	0.5	0.5	0.5	0.40	0.36	0.39	0.38	0.35	0.40	0.36	0.31	0.31	0.22
STORAGE	-	6.4	(1.24)	(0.21)	-	-	-	-	-	-	-	-	-	-
TOTAL	**44.8**	**39.4**	**25.5**	**13.8**	**17.7**	**8.6**	**8.8**	**9.6**	**10.7**	**11.2**	**5.5**	**5.9**	**5.9**	**6.2**
OIL-ELECT.	35%	30%	10%	21%	17%	34%	27%	22%	19%	17%	11%	10%	10%	10%
COAL-ELECT	14%	35%	50%	23%	44%	16%	13%	20%	16%	16%	20%	24%	23%	20%
INDUSTRY	48%	18%	42%	54%	37%	45%	56%	55%	62%	63%	62%	61%	61%	66%
SHIPS	3%	1%	2%	4%	2%	4%	4%	4%	3%	4%	7%	5%	5%	4%
STORAGE	0%	16%	-5%	-2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
HFO Supply Summary														
KEDO/Six Party Talks	-	20.7	16.4	-	12.6	-	-	-	-	-	-	-	-	-
Net Non-KEDO Imports	6.2	4.1	3.2	5.5	(3.2)	0.4	(0.4)	0.3	0.5	0.5	0.2	0.0	0.0	0.0
Domestic Refining	38.6	14.8	6.3	8.4	8.5	8.3	9.3	9.2	10.3	10.7	5.4	5.9	5.9	6.2
TOTAL	**44.8**	**39.6**	**25.9**	**13.9**	**17.9**	**8.7**	**8.9**	**9.6**	**10.8**	**11.2**	**5.5**	**5.9**	**5.9**	**6.2**

HFO Demand Summary: Tonnes

	YEAR													
CONSUMER	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
OIL-ELECT.	376,474	282,433	62,524	71,343	71,343	71,343	57,074	49,940	49,940	46,143	14,766	14,766	14,766	14,766
COAL-ELECT	152,473	330,940	309,475	76,341	188,492	33,882	28,399	45,241	40,719	43,017	27,049	33,536	33,177	29,819
INDUSTRY	522,652	170,671	260,751	178,032	157,819	94,621	118,455	126,233	159,700	171,295	81,927	86,595	86,274	98,747
SHIPS	27,024	11,771	10,867	11,756	9,614	8,564	9,337	9,072	8,388	9,696	8,740	7,455	7,455	5,248
STORAGE	-	154,538	(30,000)	(5,000)	-	-	-	-	-	-	-	-	-	-
TOTAL	**1,078,623**	**950,353**	**613,616**	**332,471**	**427,268**	**208,410**	**213,264**	**230,486**	**258,748**	**270,151**	**132,482**	**142,352**	**141,673**	**148,579**
OIL-ELECT.	35%	30%	10%	21%	17%	34%	27%	22%	19%	17%	11%	10%	10%	10%
COAL-ELECT	14%	35%	50%	23%	44%	16%	13%	20%	16%	16%	20%	24%	23%	20%
INDUSTRY	48%	18%	42%	54%	37%	45%	56%	55%	62%	63%	62%	61%	61%	66%
SHIPS	3%	1%	2%	4%	2%	4%	4%	4%	3%	4%	7%	5%	5%	4%
STORAGE	0%	16%	-5%	-2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
HFO Supply Summary														
KEDO/Six Party Talks	-	500,000	394,722	-	304,000	-	-	-	-	-	-	-	-	-
Net Non-KEDO Imports	150,000	98,541	76,795	131,847	(77,422)	8,511	(10,263)	8,415	11,188	12,706	3,774	721	46	721
Domestic Refining	930,400	355,745	151,552	202,323	204,501	200,753	224,384	222,864	248,412	258,285	129,278	142,515	142,515	149,165
TOTAL	**1,080,400**	**954,285**	**623,069**	**334,169**	**431,079**	**209,264**	**214,120**	**231,280**	**259,599**	**270,991**	**133,052**	**143,235**	**142,561**	**149,885**


Estimated Disposition of Heavy Fuel Oil by Year
Petajoules (PJ)
50
40
30
20
10
-
(10.0)
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020
STORAGE
SHIPS
INDUSTRY
COAL-ELECT
OIL-ELECT.


Estimated Disposition of Heavy Fuel Oil by Year
Tonnes
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
(200,000.0)
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020
STORAGE
SHIPS
INDUSTRY
COAL-ELECT
OIL-ELECT.

Demand Summary for Other Refined Products: Terajoules

	DIESEL OIL				GASOLINE				KERO/JET FUEL/LPG			
SECTOR	**1990**	**1996**	**2000**	**2005**	**1990**	**1996**	**2000**	**2005**	**1990**	**1996**	**2000**	**2005**
INDUSTRIAL	3,050	671	633	844	-	-	-	-	-	-	-	-
TRANSPORT	12,926	5,180	4,020	7,761	23,220	10,378	3,350	2,395	399	320	354	611
RESIDENTIAL	-	-	-	-	-	-	-	-	6,600	1,785	2,079	909
AGRICULTURAL	5,005	1,319	968	1,164	-	-	-	-	-	-	-	-
FISHERIES	2,777	856	710	796	-	-	-	-	-	-	-	-
MILITARY	6,859	5,248	5,320	5,372	7,386	6,352	4,634	4,128	1,798	1,199	824	1,386
NON-SPECIFIED/OTHER	1,700	-	-	-	-	-	-	-	4,250	-	-	-
TOTAL	32,317	13,274	11,651	15,937	30,606	16,729	7,984	6,524	13,047	3,303	3,257	2,906
INDUSTRIAL	9%	5%	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%
TRANSPORT	40%	39%	35%	49%	76%	62%	42%	37%	3%	10%	11%	21%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	51%	54%	64%	31%
AGRICULTURAL	15%	10%	8%	7%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	9%	6%	6%	5%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	21%	40%	46%	34%	24%	38%	58%	63%	14%	36%	25%	48%
NON-SPECIFIED/OTHER	5%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Demand Summary for Other Refined Products: Terajoules

	DIESEL OIL													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION	-	-	-	1,390	1,889	2,380	3,428	7,279	10,060	13,221	6,768	6,740	7,681	7,002
INDUSTRIAL	3,050	671	633	844	403	463	503	336	419	470	235	235	235	235
TRANSPORT	12,926	5,180	4,020	7,761	5,172	4,004	4,360	4,362	4,424	4,761	4,028	3,894	4,129	2,907
RESIDENTIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURAL	5,005	1,319	968	1,164	1,008	950	1,031	983	1,042	1,106	887	757	749	741
FISHERIES	2,777	856	710	796	764	708	766	1,084	748	1,313	1,261	930	930	837
MILITARY	6,859	5,248	5,320	5,372	4,147	3,836	4,447	3,852	3,884	3,991	3,066	2,872	2,872	1,587
NON-SPECIFIED/OTHER	1,700	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	32,317	13,274	11,651	17,327	13,383	12,341	14,535	17,895	20,578	24,862	16,246	15,427	16,595	13,308
ELECTRICITY GENERATION	0%	0%	0%	8%	14%	19%	24%	41%	49%	53%	42%	44%	46%	53%
INDUSTRIAL	9%	5%	5%	5%	3%	4%	3%	2%	2%	2%	1%	2%	1%	2%
TRANSPORT	40%	39%	35%	45%	39%	32%	30%	24%	21%	19%	25%	25%	25%	22%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
AGRICULTURAL	15%	10%	8%	7%	8%	8%	7%	5%	5%	4%	5%	5%	5%	6%
FISHERIES	9%	6%	6%	5%	6%	6%	5%	6%	4%	5%	8%	6%	6%	6%
MILITARY	21%	40%	46%	31%	31%	31%	31%	22%	19%	16%	19%	19%	17%	12%
NON-SPECIFIED/OTHER	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

	GASOLINE													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION	**-**	**-**	**-**	-	32	87	135	957	2,844	2,667	2,982	3,041	3,029	3,900
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	23,220	10,378	3,350	2,395	6,022	4,491	5,074	4,942	5,041	5,090	4,973	4,741	4,515	3,679
RESIDENTIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MILITARY	7,386	6,352	4,634	4,128	3,747	3,531	3,775	4,192	4,555	4,702	4,733	4,709	4,722	3,030
TOTAL	30,606	16,729	7,984	6,524	9,801	8,108	8,984	10,092	12,439	12,459	12,688	12,490	12,266	10,609
ELECTRICITY GENERATION	0%	0%	0%	0%	0%	1%	1%	9%	23%	21%	23%	24%	25%	37%
INDUSTRIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TRANSPORT	76%	62%	42%	37%	61%	55%	56%	49%	41%	41%	39%	38%	37%	35%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
AGRICULTURAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	24%	38%	58%	63%	38%	44%	42%	42%	37%	38%	37%	38%	38%	29%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

	GASOLINE													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION	-	-	-	-	717	1,973	3,061	21,769	64,683	60,676	67,824	69,166	68,901	88,720
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	528,192	236,062	76,208	54,485	136,988	102,148	115,425	112,427	114,677	115,775	113,130	107,836	102,703	83,693
RESIDENTIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MILITARY	168,018	144,484	105,404	93,912	85,242	80,320	85,871	95,363	103,602	106,955	107,667	107,108	107,418	68,915
TOTAL	696,210	380,546	181,613	148,397	222,947	184,440	204,357	229,559	282,963	283,406	288,621	284,110	279,022	241,328
ELECTRICITY GENERATION	0%	0%	0%	0%	0%	1%	1%	9%	23%	21%	23%	24%	25%	37%
INDUSTRIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TRANSPORT	76%	62%	42%	37%	61%	55%	56%	49%	41%	41%	39%	38%	37%	35%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
AGRICULTURAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	24%	38%	58%	63%	38%	44%	42%	42%	37%	38%	37%	38%	38%	29%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

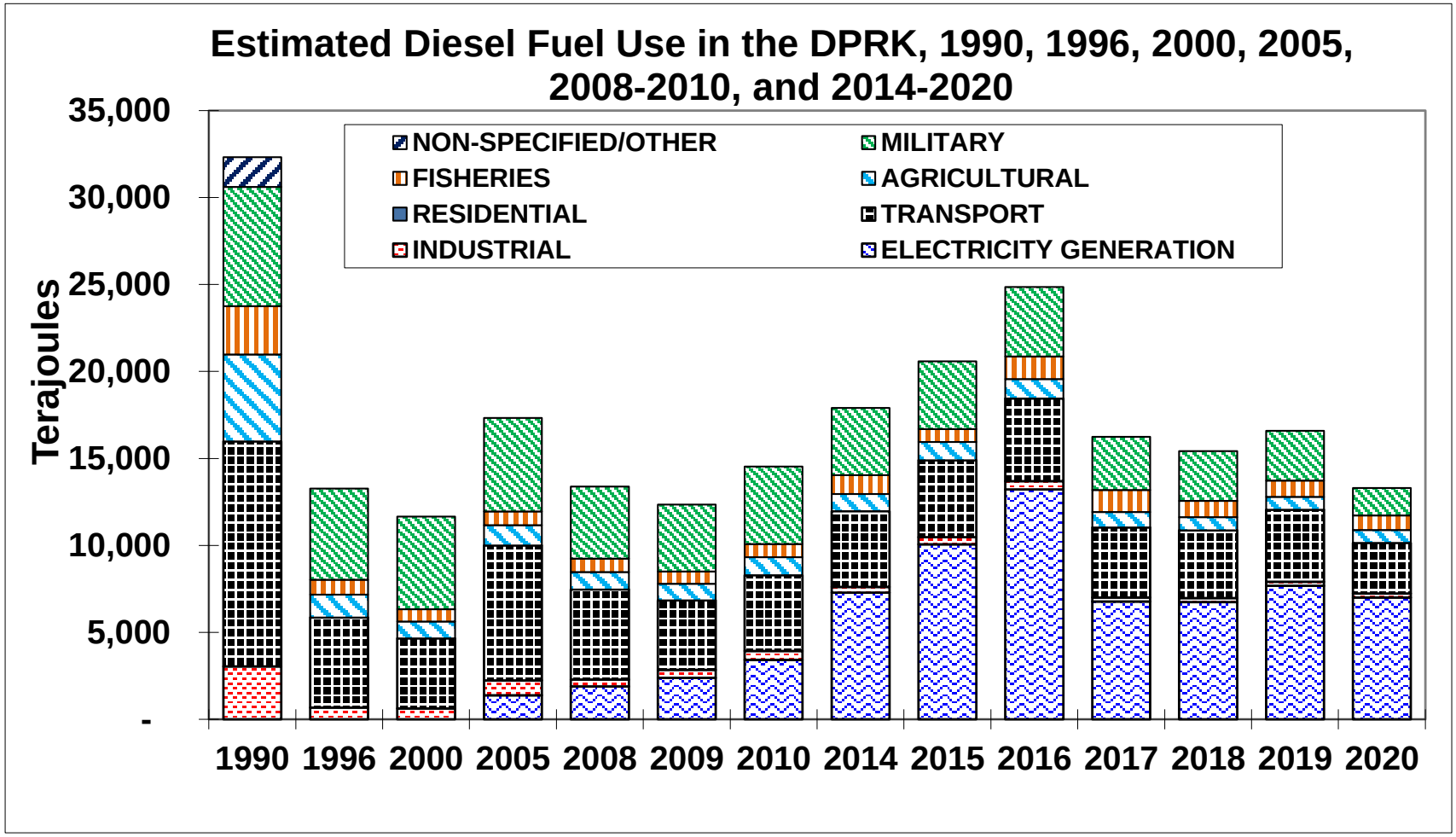
	KEROSENE/JET FUEL													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	9,243	7,395	8,191	14,145	15,835	14,379	16,600	16,268	18,253	19,514	17,255	17,255	17,099	10,900
RESIDENTIAL	103,513	12,797	9,916	21,030	18,560	14,916	18,346	18,055	22,531	24,478	15,712	7,527	6,113	5,633
AGRICULTURAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MILITARY	41,612	27,741	19,072	32,076	36,410	26,007	32,076	24,672	32,504	38,148	27,073	25,381	28,765	18,612
TOTAL	154,368	47,933	37,178	67,251	70,805	55,303	67,022	58,995	73,289	82,140	60,040	50,163	51,977	35,145
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	6%	15%	22%	21%	22%	26%	25%	28%	25%	24%	29%	34%	33%	31%
RESIDENTIAL	67%	27%	27%	31%	26%	27%	27%	31%	31%	30%	26%	15%	12%	16%
AGRICULTURAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	27%	58%	51%	48%	51%	47%	48%	42%	44%	46%	45%	51%	55%	53%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

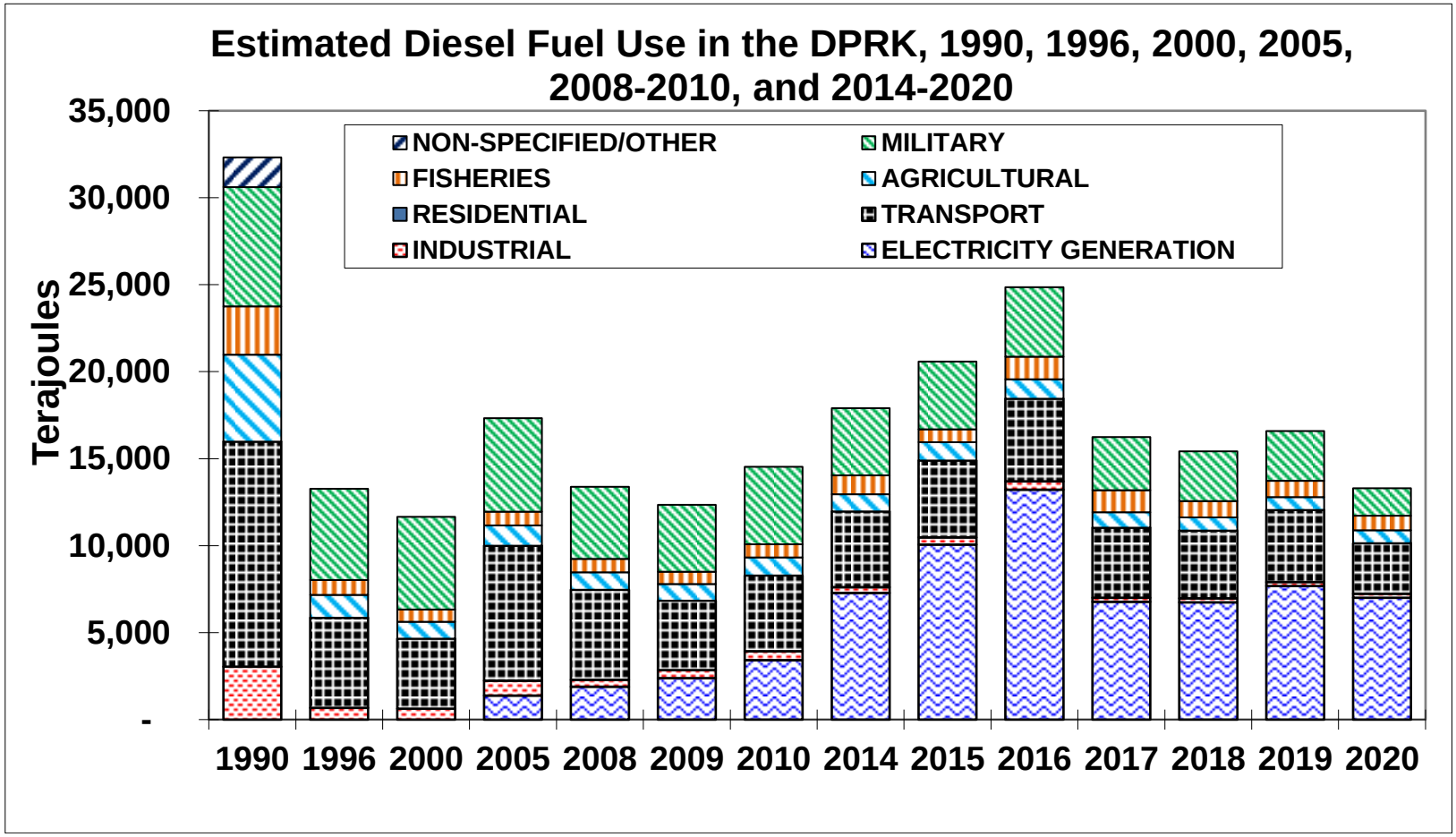
Demand Summary for Other Refined Products: Tonnes

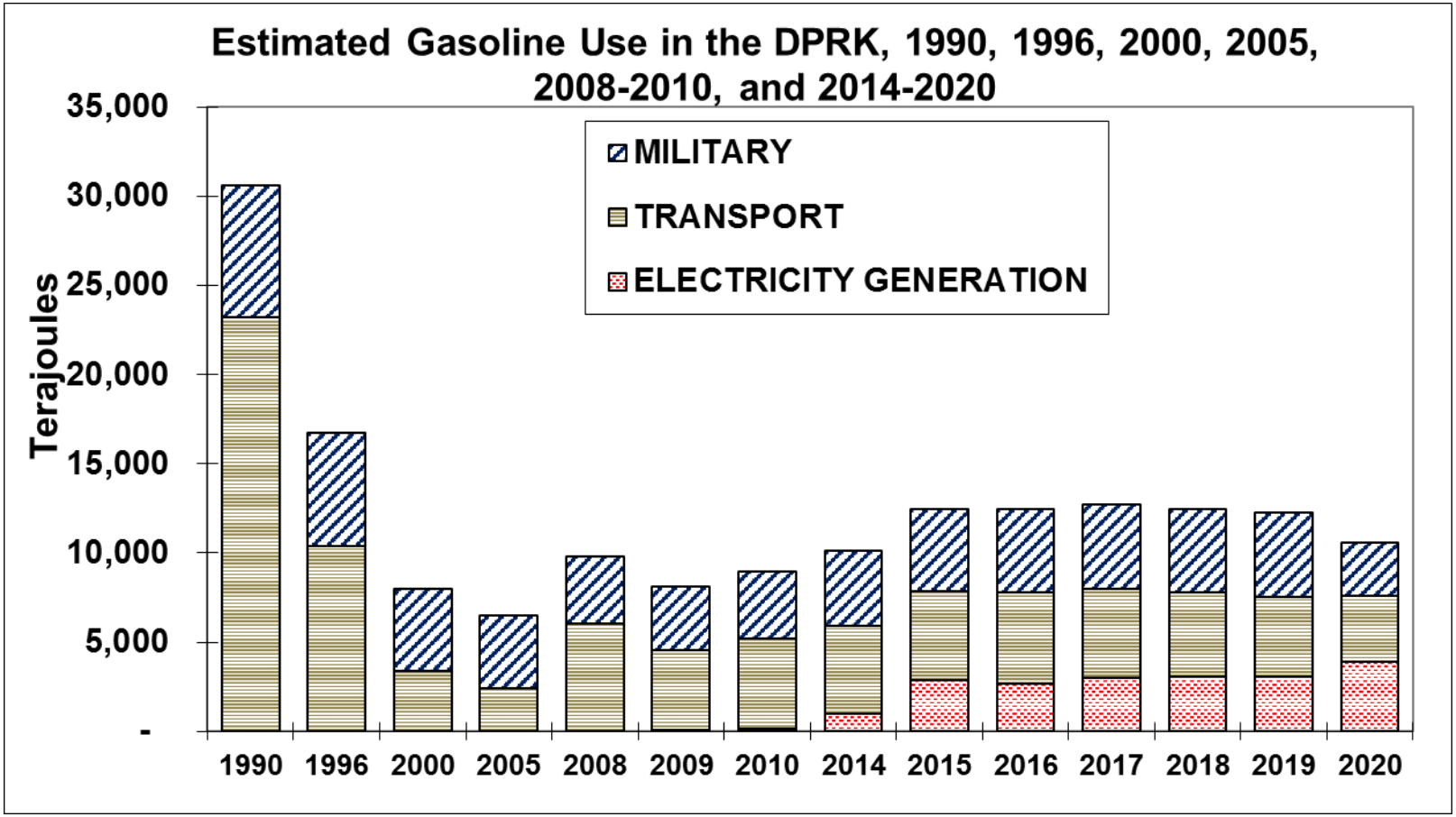
	DIESEL OIL													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION	-	-	-	32,181	43,709	55,072	79,334	168,454	232,829	305,991	156,639	155,985	177,758	162,061
INDUSTRIAL	70,589	15,530	14,653	19,528	9,318	10,715	11,647	7,765	9,706	10,871	5,435	5,435	5,435	5,435
TRANSPORT	299,164	119,885	93,043	179,620	119,709	92,673	100,896	100,956	102,393	110,184	93,223	90,125	95,572	67,272
RESIDENTIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURAL	115,836	30,532	22,406	26,949	23,320	21,995	23,858	22,762	24,126	25,588	20,537	17,519	17,329	17,139
FISHERIES	64,269	19,805	16,438	18,414	17,684	16,380	17,737	25,083	17,305	30,384	29,187	21,517	21,517	19,365
MILITARY	158,739	121,469	123,116	124,334	95,986	88,787	102,915	89,154	89,897	92,378	70,965	66,461	66,461	36,721
NON-SPECIFIED/OTHER	39,345	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	747,942	307,221	269,655	401,026	309,725	285,623	336,387	414,173	476,257	575,397	375,986	357,042	384,071	307,994
ELECTRICITY GENERATION	0%	0%	0%	8%	14%	19%	24%	41%	49%	53%	42%	44%	46%	53%
INDUSTRIAL	9%	5%	5%	5%	3%	4%	3%	2%	2%	2%	1%	2%	1%	2%
TRANSPORT	40%	39%	35%	45%	39%	32%	30%	24%	21%	19%	25%	25%	25%	22%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
AGRICULTURAL	15%	10%	8%	7%	8%	8%	7%	5%	5%	4%	5%	5%	5%	6%
FISHERIES	9%	6%	6%	5%	6%	6%	5%	6%	4%	5%	8%	6%	6%	6%
MILITARY	21%	40%	46%	31%	31%	31%	31%	22%	19%	16%	19%	19%	17%	12%
NON-SPECIFIED/OTHER	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

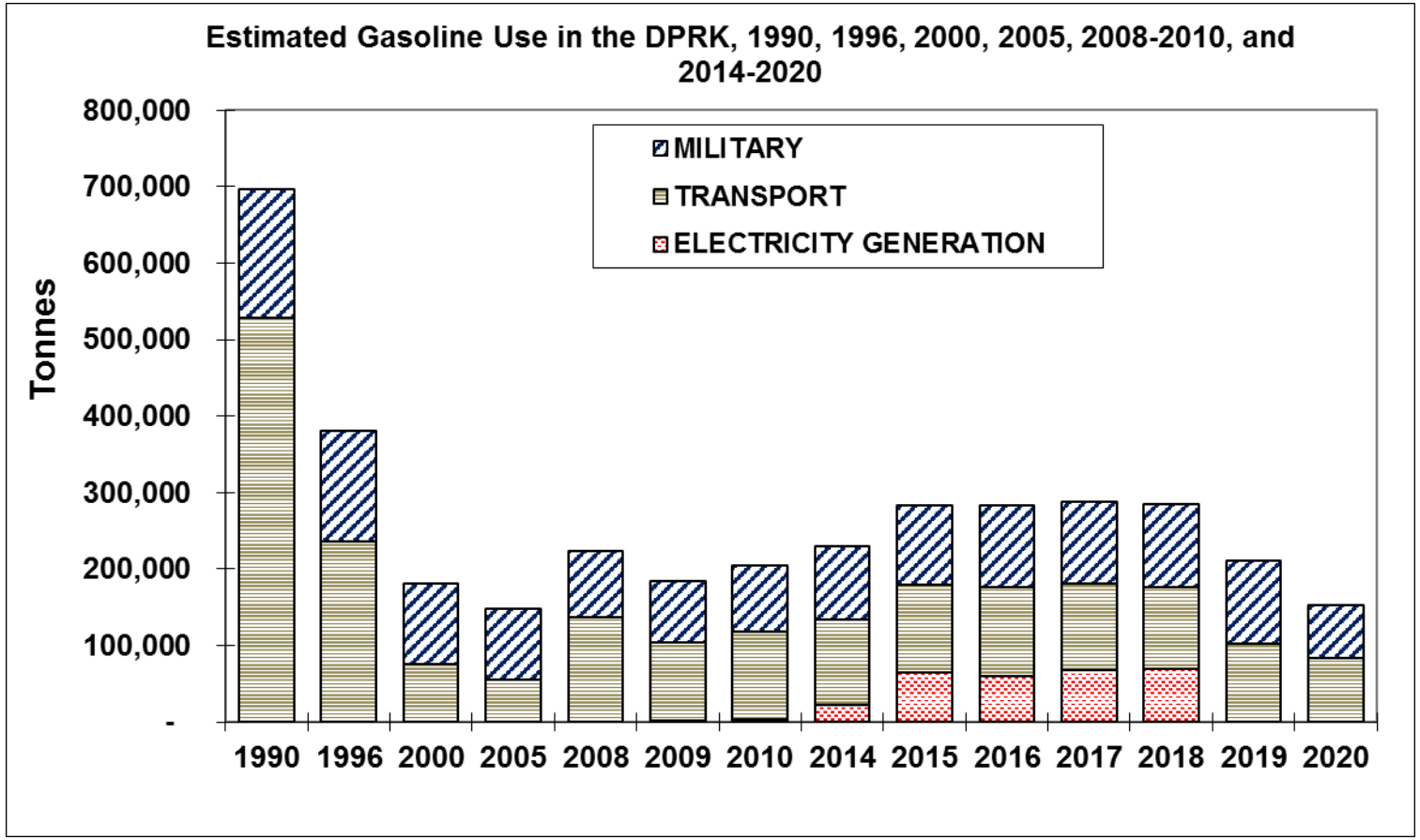
	GASOLINE													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION	-	-	-	-	717	1,973	3,061	21,769	64,683	60,676	67,824	69,166	68,901	88,720
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	528,192	236,062	76,208	54,485	136,988	102,148	115,425	112,427	114,677	115,775	113,130	107,836	102,703	83,693
RESIDENTIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AGRICULTURAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MILITARY	168,018	144,484	105,404	93,912	85,242	80,320	85,871	95,363	103,602	106,955	107,667	107,108	107,418	68,915
TOTAL	696,210	380,546	181,613	148,397	222,947	184,440	204,357	229,559	282,963	283,406	288,621	284,110	279,022	241,328
ELECTRICITY GENERATION	0%	0%	0%	0%	0%	1%	1%	9%	23%	21%	23%	24%	25%	37%
INDUSTRIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TRANSPORT	76%	62%	42%	37%	61%	55%	56%	49%	41%	41%	39%	38%	37%	35%
RESIDENTIAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
AGRICULTURAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	24%	38%	58%	63%	38%	44%	42%	42%	37%	38%	37%	38%	38%	29%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

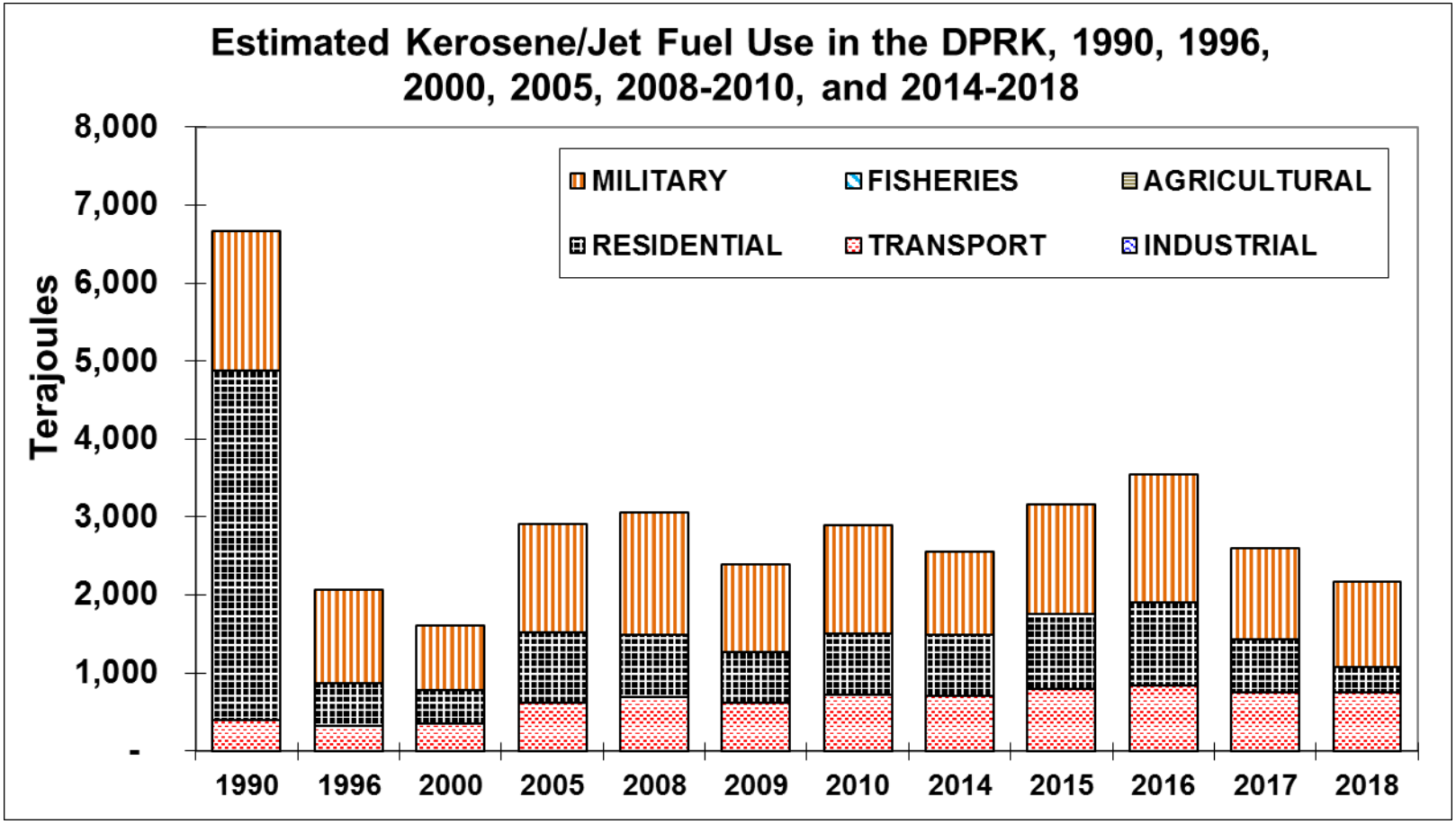
	KEROSENE/JET FUEL													
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	9,243	7,395	8,191	14,145	15,835	14,379	16,600	16,268	18,253	19,514	17,255	17,255	17,099	10,900
RESIDENTIAL	103,513	12,797	9,916	21,030	18,560	14,916	18,346	18,055	22,531	24,478	15,712	7,527	6,113	5,633
AGRICULTURAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MILITARY	41,612	27,741	19,072	32,076	36,410	26,007	32,076	24,672	32,504	38,148	27,073	25,381	28,765	18,612
TOTAL	154,368	47,933	37,178	67,251	70,805	55,303	67,022	58,995	73,289	82,140	60,040	50,163	51,977	35,145
INDUSTRIAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANSPORT	6%	15%	22%	21%	22%	26%	25%	28%	25%	24%	29%	34%	33%	31%
RESIDENTIAL	67%	27%	27%	31%	26%	27%	27%	31%	31%	30%	26%	15%	12%	16%
AGRICULTURAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	27%	58%	51%	48%	51%	47%	48%	42%	44%	46%	45%	51%	55%	53%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

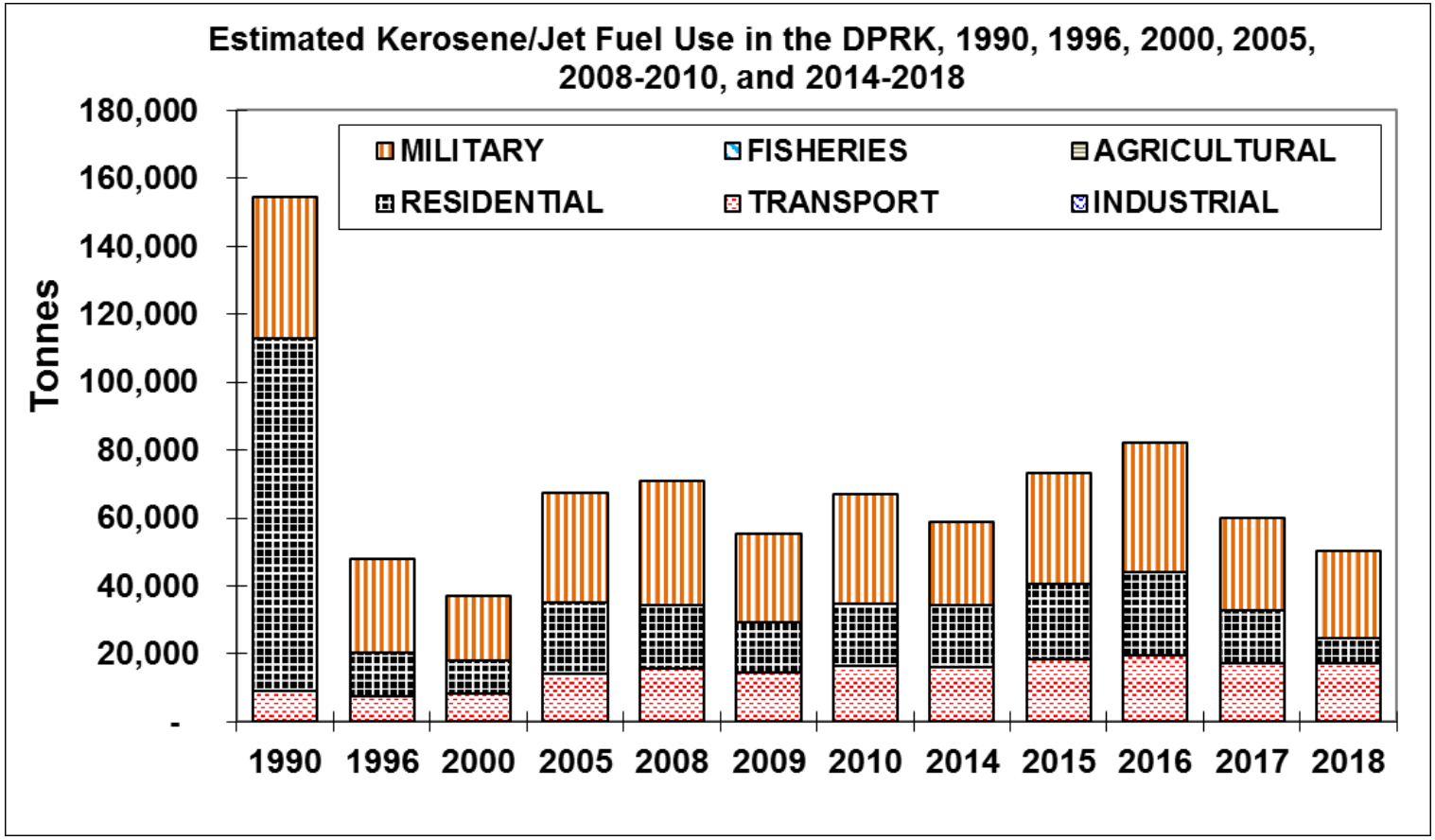

Estimated Diesel Fuel Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
NON-SPECIFIED/OTHER
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL
ELECTRICITY GENERATION
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020


Estimated Diesel Fuel Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
NON-SPECIFIED/OTHER
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL
ELECTRICITY GENERATION
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020


Estimated Gasoline Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
MILITARY
TRANSPORT
ELECTRICITY GENERATION
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

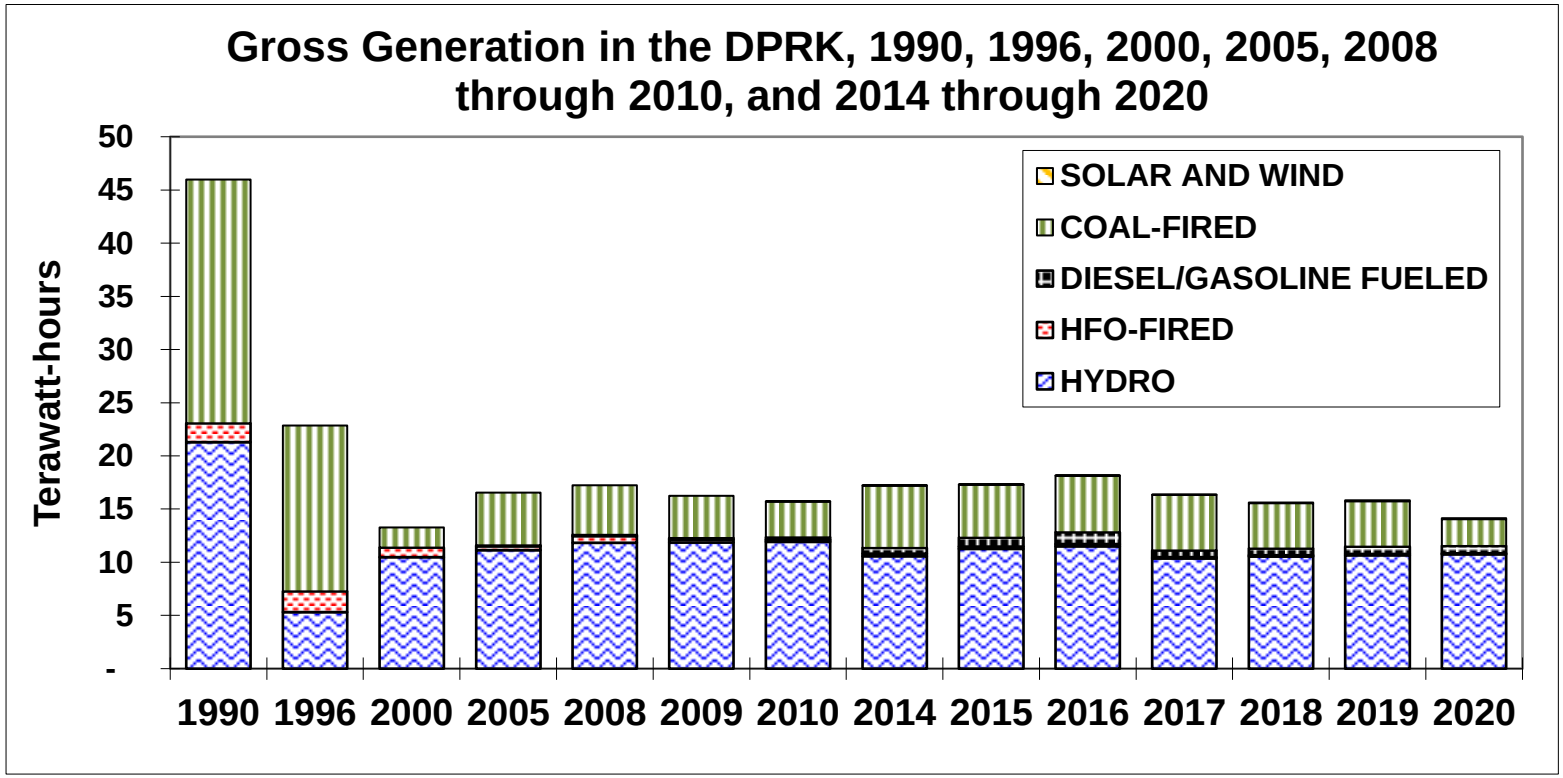

Estimated Gasoline Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Tonnes
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
MILITARY
TRANSPORT
ELECTRICITY GENERATION
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020


Estimated Kerosene/Jet Fuel Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2018
Terajoules
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018


Estimated Kerosene/Jet Fuel Use in the DPRK, 1990, 1996, 2000, 2005, 2008-2010, and 2014-2018
Tonnes
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018

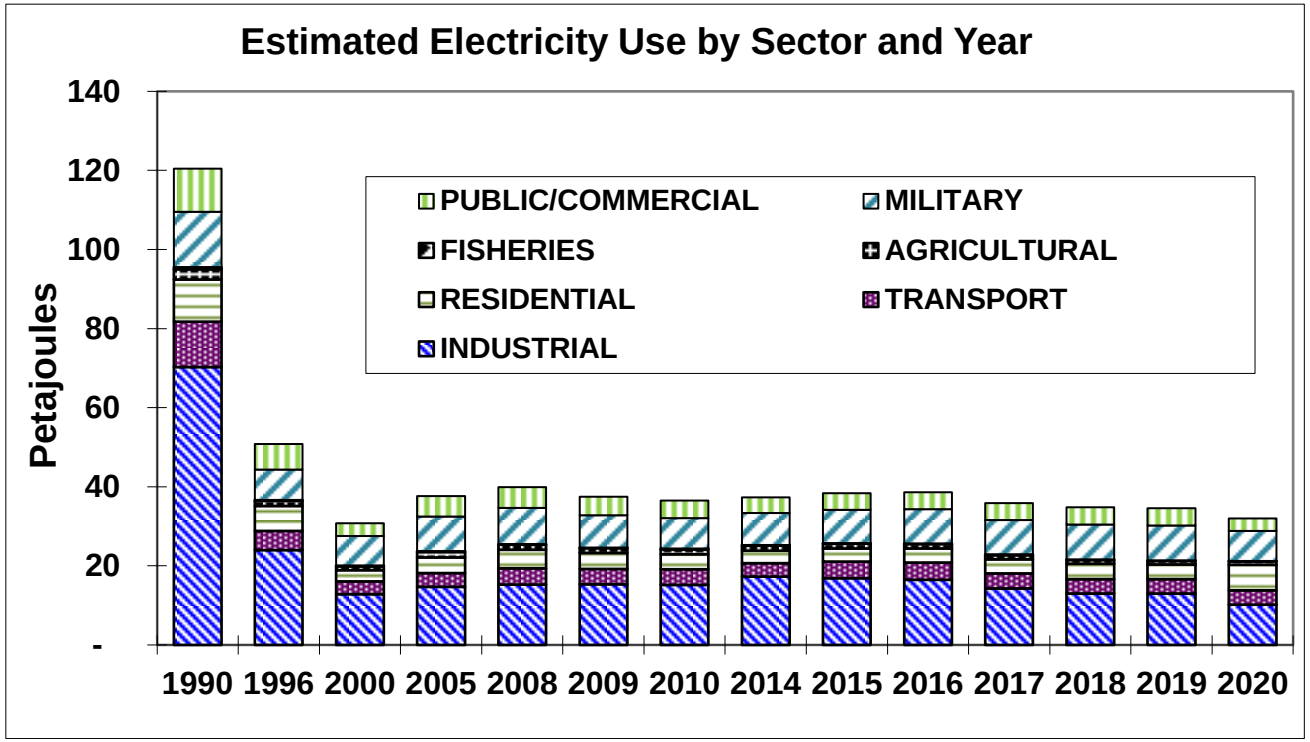
Supply Summary for Electricity: Terawatt-hours of Gross Generation

	YEAR													
GENERATION	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
HYDRO	21.29	5.32	10.47	11.15	11.83	11.87	11.91	10.57	11.25	11.50	10.37	10.55	10.66	10.74
HFO-FIRED	1.77	1.94	0.90	0.36	0.63	0.25	0.21	0.23	0.22	0.22	0.10	0.12	0.12	0.11
DIESEL/GASOLINE FUELED	-	-	-	0.08	0.12	0.15	0.22	0.54	0.84	1.10	0.63	0.63	0.70	0.69
COAL-FIRED	22.94	15.58	1.89	4.97	4.66	3.97	3.37	5.86	4.98	5.33	5.23	4.26	4.26	2.51
SOLAR AND WIND							0.00	0.01	0.02	0.03	0.05	0.06	0.08	0.09
NUCLEAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	46.00	22.84	13.26	16.55	17.23	16.24	15.71	17.21	17.31	18.18	16.38	15.62	15.82	14.13
HYDRO	46.3%	23.3%	79.0%	67.3%	68.6%	73.1%	75.8%	61.4%	65.0%	63.2%	63.3%	67.5%	67.4%	76.0%
HFO-FIRED	3.9%	8.5%	6.8%	2.2%	3.6%	1.6%	1.3%	1.3%	1.3%	1.2%	0.6%	0.7%	0.7%	0.8%
DIESEL/GASOLINE FUELED	0.0%	0.0%	0.0%	0.5%	0.7%	0.9%	1.4%							
COAL-FIRED	49.9%	68.2%	14.3%	30.0%	27.0%	24.4%	21.4%	34.0%	28.8%	29.3%	31.9%	27.3%	26.9%	17.7%
SOLAR AND WIND	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.5%	0.6%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%



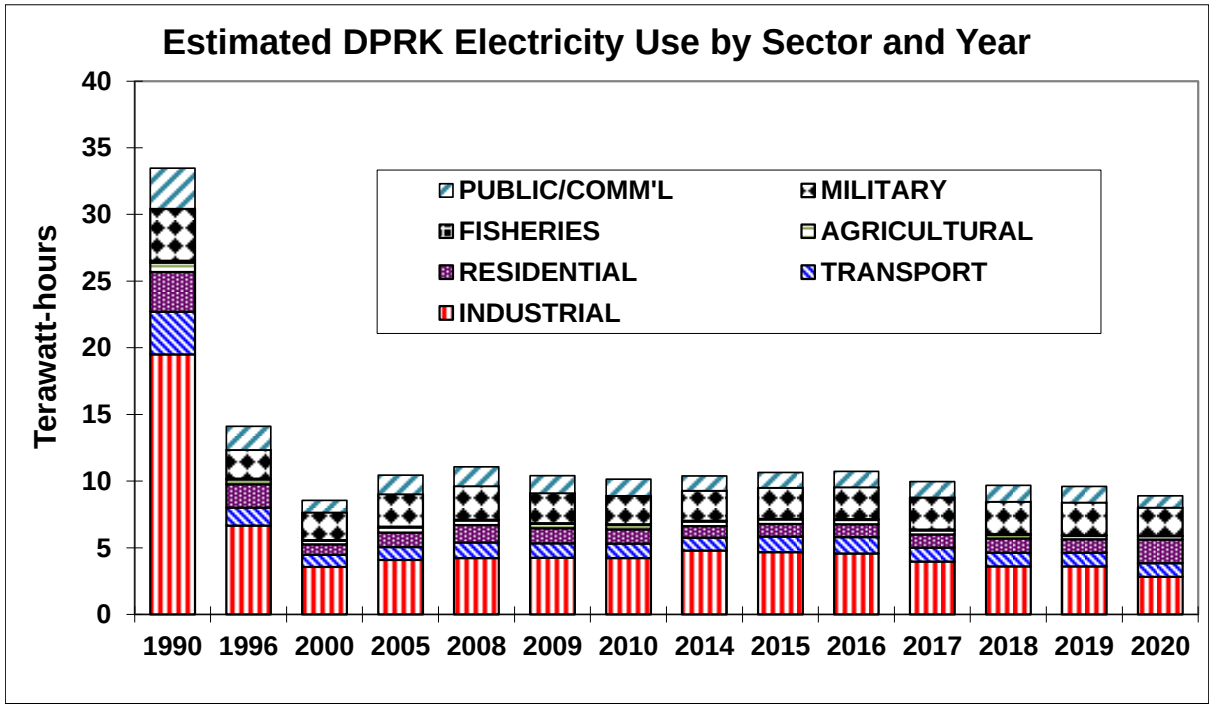
Demand Summary for Electricity: Petajoules

	ELECTRICITY													
SECTOR	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
INDUSTRIAL	70	24	13	15	15	15	15	17	17	16	14	13	13	10
TRANSPORT	11	5	3	4	4	4	4	3	4	4	4	4	4	4
RESIDENTIAL	11	6	3	4	5	4	4	3	3	4	4	4	4	6
AGRICULTURAL	3	1	1	1	1	1	1	1	1	1	1	1	1	1
FISHERIES	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MILITARY	14	8	7	9	9	8	8	8	8	9	9	9	9	8
PUBLIC/COMMERCIAL	11	6	3	5	5	5	4	4	4	4	4	4	4	3
TOTAL	120	51	31	38	40	37	37	37	38	39	36	35	35	32
INDUSTRIAL	58%	47%	42%	39%	38%	41%	42%	46%	44%	43%	40%	37%	38%	32%
TRANSPORT	10%	9%	11%	9%	10%	10%	11%	9%	11%	11%	11%	11%	11%	11%
RESIDENTIAL	9%	13%	9%	10%	12%	11%	11%	8%	9%	9%	10%	11%	11%	20%
AGRICULTURAL	2%	2%	3%	4%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
FISHERIES	0%	0%	1%	1%	0%	0%	1%	0%	0%	1%	1%	0%	0%	0%
MILITARY	12%	15%	24%	23%	23%	22%	21%	22%	22%	22%	24%	25%	25%	24%
PUBLIC/COMMERCIAL	9%	13%	11%	14%	13%	13%	12%	11%	11%	11%	12%	13%	13%	10%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%



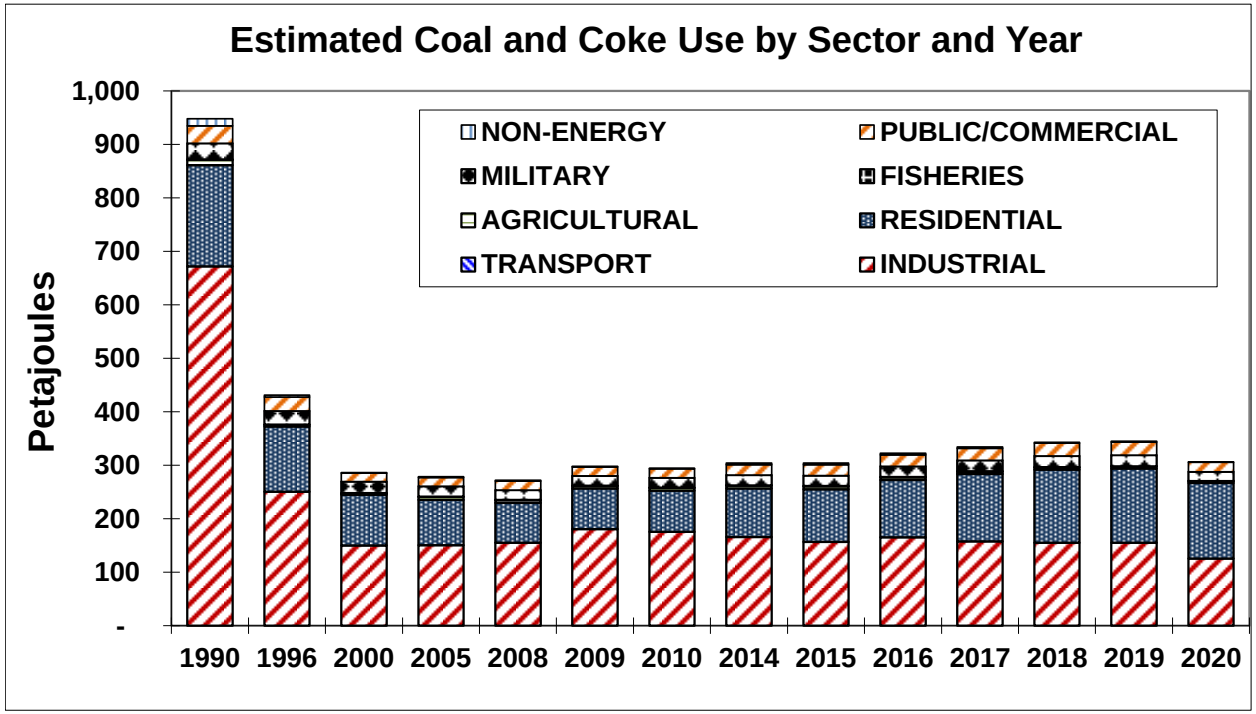
SUMMARY TABLE OF ELECTRICTY SUPPLY AND DEMAND
Units: TWh

	YEAR													
GENERATION	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
HYDRO	21.3	5.3	10.5	11.1	11.8	11.9	11.9	10.6	11.3	11.5	10.4	10.5	10.7	10.7
HFO-FIRED	1.8	1.9	0.9	0.4	0.6	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
COAL-FIRED	22.9	15.6	1.9	5.0	4.7	4.0	3.4	5.9	5.0	5.3	5.2	4.3	4.3	2.5
NUCLEAR	-	-	-		-	-	-	-	-	-	-	-	-	-
TOTAL	46.0	22.8	17.2	16.2	16.6	16.2	15.7	17.2	17.3	18.2	16.4	15.6	15.8	14.1
EXPORTS	-	-	(0.0)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.1)	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)
COAL PROD.	(2.4)	(1.2)	(0.6)	(0.8)	(0.8)	(0.9)	(0.9)	(1.5)	(1.7)	(1.8)	(1.0)	(1.0)	(1.1)	(0.8)
OWN USE	(3.4)	(2.8)	(0.5)	(1.0)	(1.0)	(0.8)	(0.7)	(1.1)	(1.0)	(1.0)	(1.0)	(0.8)	(0.8)	(0.5)
LOSSES	(6.6)	(4.6)	(3.5)	(4.3)	(4.5)	(4.2)	(4.1)	(4.3)	(4.3)	(4.4)	(4.1)	(3.9)	(3.9)	(3.5)
TOTAL DEMAND	33.5	14.1	8.5	10.4	11.1	10.4	10.1	10.4	10.7	10.7	10.0	9.7	9.6	8.9
INDUSTRIAL	19.5	6.7	3.6	4.1	4.2	4.3	4.2	4.8	4.7	4.6	4.0	3.6	3.6	2.8
TRANSPORT	3.2	1.3	0.9	1.0	1.2	1.1	1.1	1.0	1.2	1.2	1.1	1.0	1.0	1.0
RESIDENTIAL	3.0	1.8	0.8	1.1	1.3	1.1	1.1	0.9	0.9	1.0	1.0	1.1	1.0	1.8
AGRICULTURAL	0.7	0.4	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
FISHERIES	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
MILITARY	3.9	2.1	2.1	2.4	2.5	2.3	2.1	2.3	2.3	2.4	2.4	2.4	2.4	2.1
PUBLIC/COMM'L	3.0	1.8	0.9	1.4	1.5	1.3	1.2	1.1	1.2	1.2	1.2	1.2	1.2	0.9



Demand Summary for Coal and Coke: Petajoules

	COAL AND COKE													
SECTOR	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
INDUSTRIAL	672	251	150	150	155	181	176	166	157	165	158	155	155	125
TRANSPORT	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RESIDENTIAL	189	122	95	85	74	76	77	91	99	107	126	137	139	141
AGRICULTURAL	10	3	3	5	5	5	5	5	6	5	5	4	4	4
FISHERIES	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MILITARY	30	25	21	20	18	18	18	19	20	20	20	21	21	17
PUBLIC/COMMERCIAL	33	26	16	17	17	17	17	19	20	21	23	24	25	18
NON-ENERGY	14	3	1	2	1	1	1	3	3	3	2	1	1	1
TOTAL	948	431	286	279	272	298	294	304	304	322	334	343	345	306
INDUSTRIAL	71%	58%	52%	54%	57%	61%	60%	55%	52%	51%	47%	45%	45%	41%
TRANSPORT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RESIDENTIAL	20%	28%	33%	30%	27%	25%	26%	30%	32%	33%	38%	40%	40%	46%
AGRICULTURAL	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%	1%
FISHERIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MILITARY	3%	6%	7%	7%	7%	6%	6%	6%	6%	6%	6%	6%	6%	6%
PUBLIC/COMMERCIAL	3%	6%	5%	6%	6%	6%	6%	6%	7%	7%	7%	7%	7%	6%
NON-ENERGY	1%	1%	0%	1%	1%	0%	0%	1%	1%	1%	1%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%



Supply Summary for Electricity Nominal (Operable and Previously Operable) Capacity (MW), Estimated Capacity Factors, and Generation in Gigawatt-hours of Gross Generation

	YEAR													
CAPACITY (MW)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
HYDRO	4,500	1,250	3,100	4,116	4,245	4,283	4,321	4,716	4,781	4,846	4,921	4,961	4,991	5,011
HFO-FIRED	200	200	270	270	270	270	270	270	270	70	70	70	70	70
DIESEL/GASOLINE FUELED*	-	-	-	100	161	222	282	805	1,105	1,272	1,370	1,383	1,393	1,395
COAL-FIRED	3,200	3,250	3,350	3,350	3,350	3,350	3,350	3,350	3,350	3,350	3,350	3,350	3,350	3,350
SOLAR, WIND, AND TIDAL*							1	12	21	33	48	64	80	88
NUCLEAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**7,900**	**4,700**	**6,720**	**7,836**	**8,025**	**8,125**	**8,224**	**9,152**	**9,527**	**9,570**	**9,758**	**9,828**	**9,884**	**9,914**
ESTIMATED CAPACITY FACTORS (%)														
HYDRO	54.0%	48.6%	38.6%	30.9%	31.8%	31.6%	31.5%	25.6%	26.8%	27.0%	23.9%	24.1%	24.2%	24.3%
HFO-FIRED	73.1%	52.0%	6.3%	7.3%	7.3%	7.3%	5.8%	5.1%	5.1%	18.3%	5.8%	5.8%	5.8%	5.8%
DIESEL/GASOLINE FUELED*				9.7%	8.3%	7.6%	9.0%	7.7%	8.6%	9.9%	5.3%	5.2%	5.8%	5.6%
COAL-FIRED	83.6%	58.3%	9.0%	17.6%	17.4%	13.8%	11.7%	20.3%	17.3%	18.5%	18.0%	14.8%	14.8%	8.8%
SOLAR, WIND, AND TIDAL*							6.2%	11.5%	11.3%	11.3%	11.2%	11.2%	11.2%	11.2%
NUCLEAR														
GENERATION (GWH)														
HYDRO	21,289	5,322	10,474	11,146	11,826	11,866	11,907	10,568	11,250	11,499	10,370	10,548	10,664	10,744
HFO-FIRED**	1,772	1,941	897	357	629	255	207	230	219	216	101	117	116	108
DIESEL/GASOLINE FUELED*	-	-	-	85	116	148	223	540	837	1,103	632	632	702	688
COAL-FIRED**	22,939	15,580	1,892	4,966	4,661	3,968	3,368	5,858	4,982	5,333	5,227	4,259	4,260	2,505
SOLAR, WIND, AND TIDAL*	-	-	-	-	-	-	1	12	20	32	47	63	79	86
NUCLEAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL **	**46,000**	**22,844**	**13,263**	**16,555**	**17,232**	**16,237**	**15,705**	**17,207**	**17,309**	**18,182**	**16,377**	**15,619**	**15,821**	**14,131**

* Some generation probably occurred in these categries prior to the first years in which they are reported, but capacity and output for previous years have not been estimated.

** HFO-fired generation includes, and coal-fired generation excludes, generation in coal-fired units fueled with HFO, usually (but not exclusively) as a starter fuel.

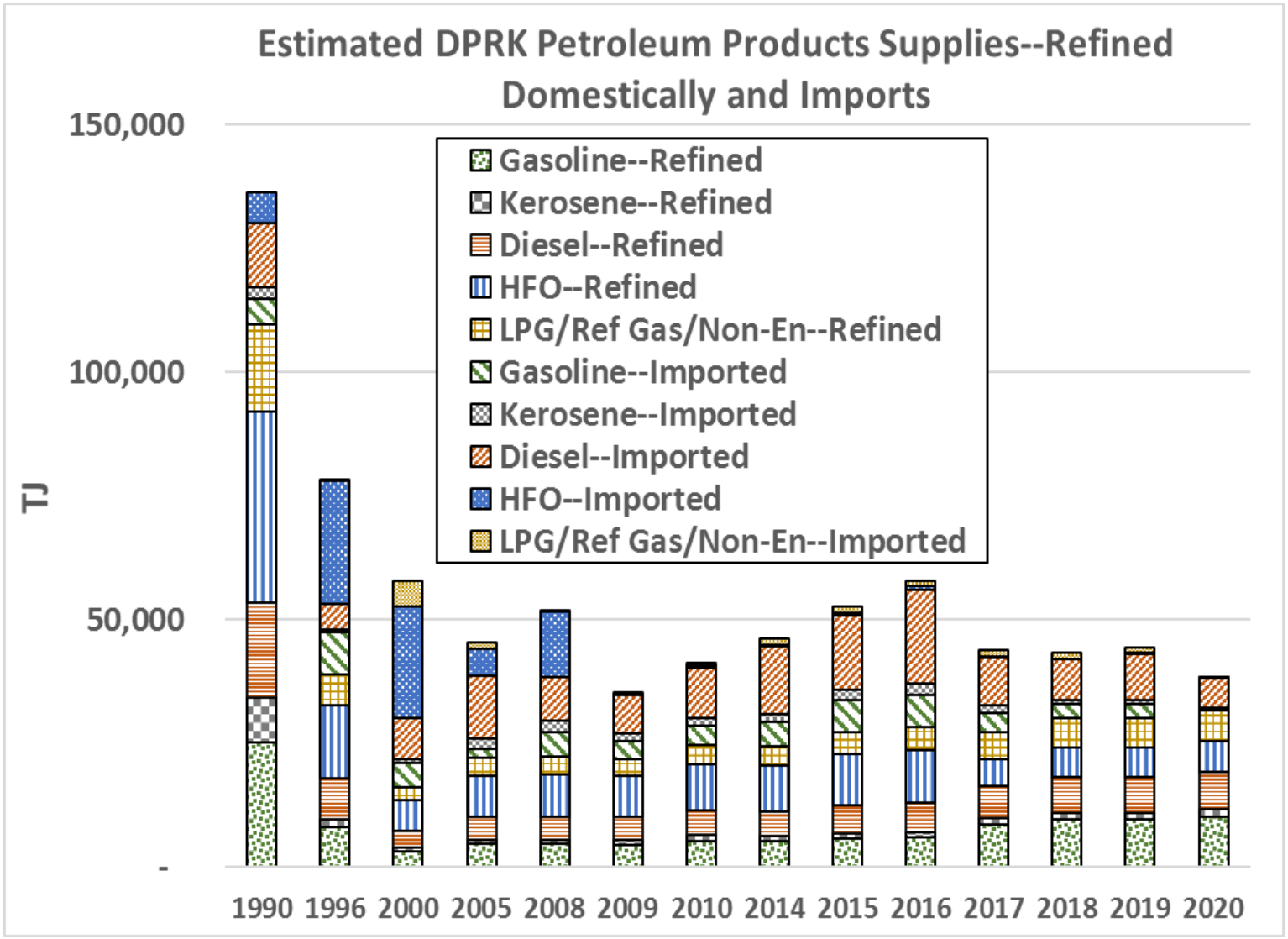
Refined Products Production and Imports

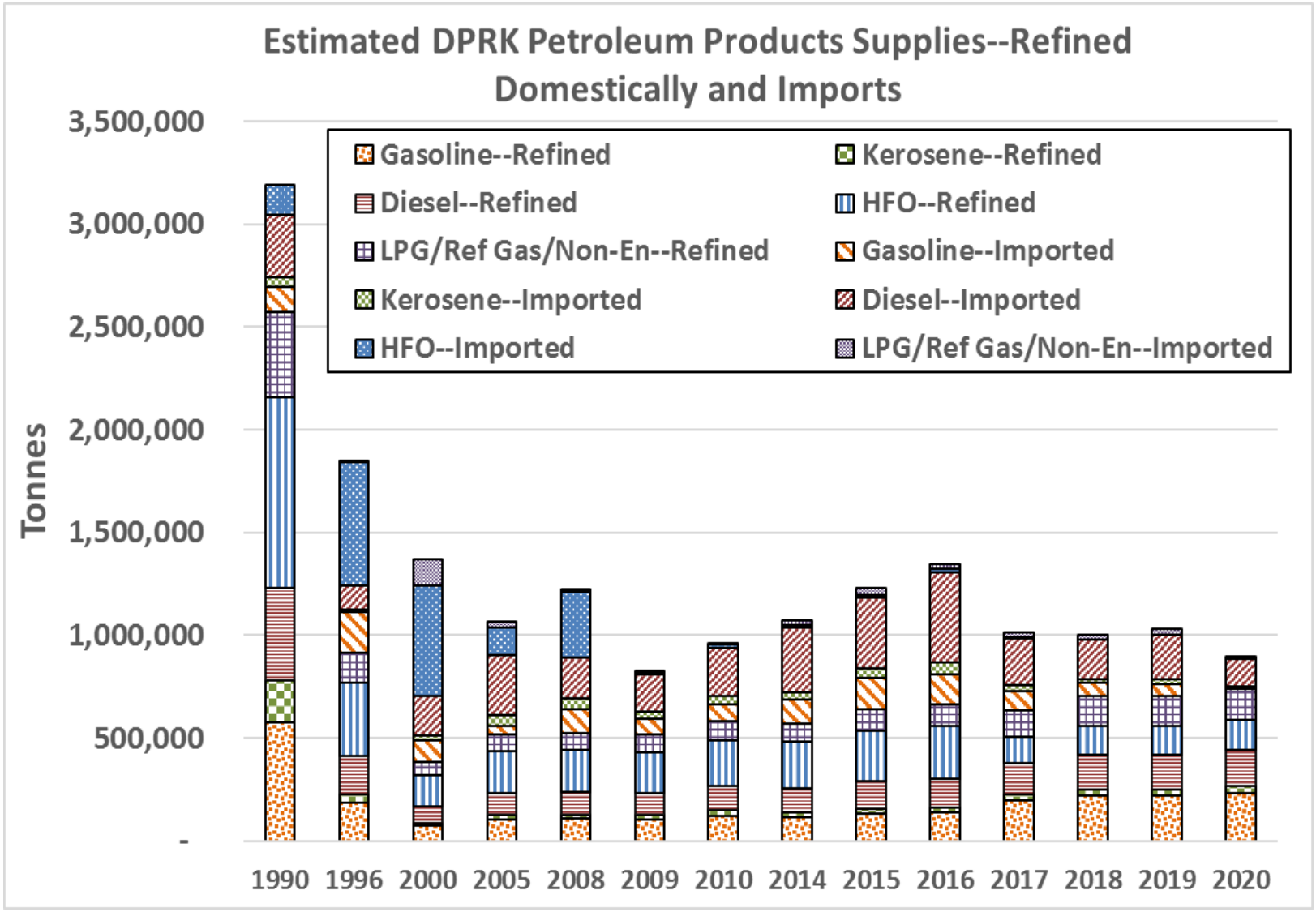
Production (TJ)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline--Refined	25,332	8,183	3,191	4,682	4,714	4,629	5,333	5,175	5,769	6,025	8,610	9,612	9,586	10,228
Kerosene--Refined	8,849	1,618	694	925	935	918	1,218	1,019	1,135	1,180	1,302	1,441	1,441	1,511
Diesel--Refined	19,357	8,090	3,431	4,586	4,635	4,550	5,013	5,053	5,634	5,859	6,468	7,163	7,163	7,512
HFO--Refined	38,603	14,760	6,288	8,395	8,485	8,329	9,310	9,247	10,307	10,717	5,364	5,913	5,913	6,189
LPG/Ref Gas/Non-En--Refined	17,521	6,352	2,618	3,524	3,563	3,496	3,956	3,891	4,347	4,523	5,495	6,095	6,095	6,396
Imports (TJ)														
Gasoline--Imported	5,275	8,545	4,791	1,840	5,089	3,479	3,649	4,916	6,670	6,434	4,077	2,879	2,679	381
Kerosene--Imported	2,160	518	951	2,031	2,184	1,522	1,741	1,593	2,118	2,452	1,363	785	864	43
Diesel--Imported	12,962	5,185	8,221	12,741	8,745	7,790	9,955	13,695	14,943	19,004	9,778	8,263	9,432	5,797
HFO--Imported	6,224	24,834	22,391	5,470	13,253	395	684	349	464	537	157	30	80	30
LPG/Ref Gas/Non-En--Imported	-	17	5,424	1,301	388	320	430	1,155	1,287	1,207	1,169	1,071	1,071	379
Total Gross Supply (TJ)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline	30,607	16,728	7,983	6,522	9,802	8,107	8,983	10,091	12,440	12,459	12,688	12,491	12,266	10,609
Kerosene	11,009	2,136	1,645	2,956	3,119	2,440	2,959	2,612	3,253	3,632	2,664	2,225	2,305	1,554
Diesel	32,319	13,275	11,652	17,327	13,381	12,340	14,967	18,748	20,577	24,862	16,246	15,426	16,595	13,308
HFO	44,827	39,594	28,679	13,865	21,738	8,725	9,994	9,596	10,771	11,254	5,520	5,943	5,994	6,219
LPG/Refinery Gas/Non-Energy	17,521	6,369	8,042	4,825	3,951	3,816	4,386	5,046	5,634	5,731	6,664	7,165	7,165	6,775

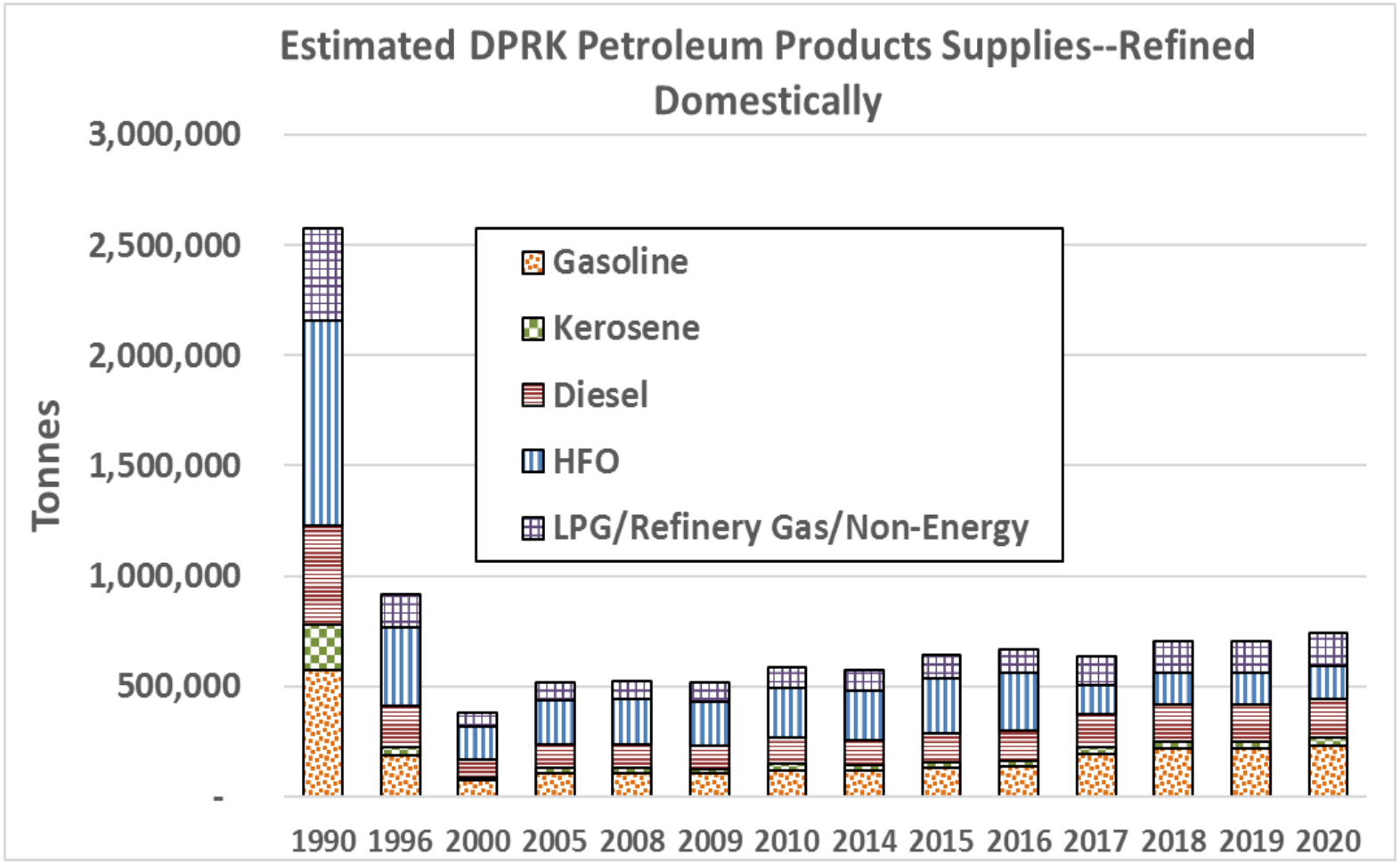
Production (Tonnes)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline--Refined	576,229	186,141	72,591	106,512	107,223	105,289	121,320	117,717	131,235	137,046	195,858	218,648	218,059	232,652
Kerosene--Refined	204,800	37,447	16,072	21,417	21,646	21,252	28,192	23,579	26,268	27,308	30,129	33,344	33,344	34,960
Diesel--Refined	448,000	187,234	79,416	106,137	107,284	105,311	116,011	116,949	130,395	135,591	149,699	165,775	165,775	173,852
HFO--Refined	930,400	355,745	151,552	202,323	204,501	200,753	224,384	222,864	248,412	258,285	129,278	142,515	142,515	149,165
LPG/Ref Gas/Non-En--Refined	413,380	149,868	61,760	83,149	84,066	82,487	93,335	91,803	102,565	106,724	129,641	143,801	143,801	150,914
Imports (Tonnes)														
Gasoline--Imported	120,000	194,378	108,991	41,846	115,755	79,130	83,011	111,827	151,735	146,354	92,751	65,478	60,947	8,665
Kerosene--Imported	50,000	12,000	22,000	46,994	50,542	35,230	40,295	36,869	49,014	56,751	31,537	18,157	20,000	1,000
Diesel--Imported	300,000	120,000	190,258	294,885	202,405	180,292	230,392	316,961	345,832	439,817	226,299	191,244	218,293	134,157
HFO--Imported	150,000	598,541	539,652	131,847	319,409	9,527	16,483	8,415	11,188	12,953	3,774	721	1,940	721
LPG/Ref Gas/Non-En--Imported	-	399	127,984	30,699	9,145	7,552	10,146	27,249	30,370	28,481	27,578	25,260	25,260	8,932
Total Gross Supply (Tonnes)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline	696,229	380,519	181,583	148,358	222,979	184,419	204,331	229,544	282,970	283,399	288,609	284,126	279,006	241,318
Kerosene	254,800	49,447	38,072	68,411	72,188	56,481	68,486	60,448	75,283	84,059	61,666	51,501	53,344	35,960
Diesel	748,000	307,234	269,674	401,022	309,688	285,603	346,403	433,910	476,227	575,408	375,998	357,020	384,068	308,008
HFO	1,080,400	954,285	691,203	334,169	523,910	210,280	240,867	231,280	259,599	271,238	133,052	143,235	144,454	149,885
LPG/Refinery Gas/Non-Energy	413,380	150,268	189,743	113,848	93,212	90,039	103,481	119,051	132,935	135,205	157,219	169,061	169,061	159,845

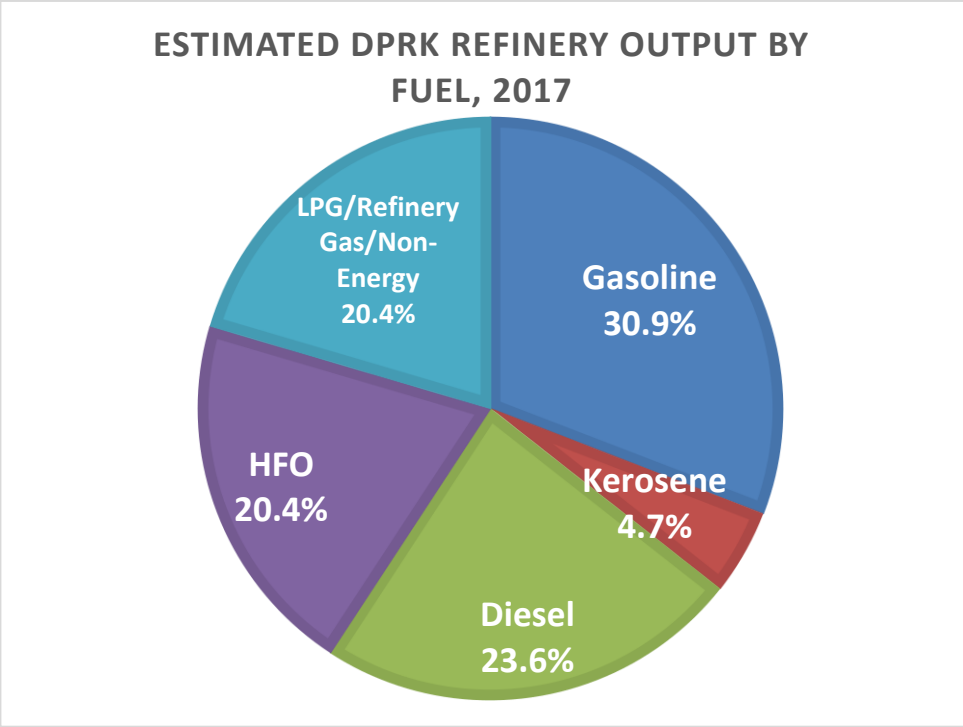
Production (Tonnes)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline	576,229	186,141	72,591	106,512	107,223	105,289	121,320	117,717	131,235	137,046	195,858	218,648	218,059	232,652
Kerosene	204,800	37,447	16,072	21,417	21,646	21,252	28,192	23,579	26,268	27,308	30,129	33,344	33,344	34,960
Diesel	448,000	187,234	79,416	106,137	107,284	105,311	116,011	116,949	130,395	135,591	149,699	165,775	165,775	173,852
HFO	930,400	355,745	151,552	202,323	204,501	200,753	224,384	222,864	248,412	258,285	129,278	142,515	142,515	149,165
LPG/Refinery Gas/Non-Energy	413,380	149,868	61,760	83,149	84,066	82,487	93,335	91,803	102,565	106,724	129,641	143,801	143,801	150,914

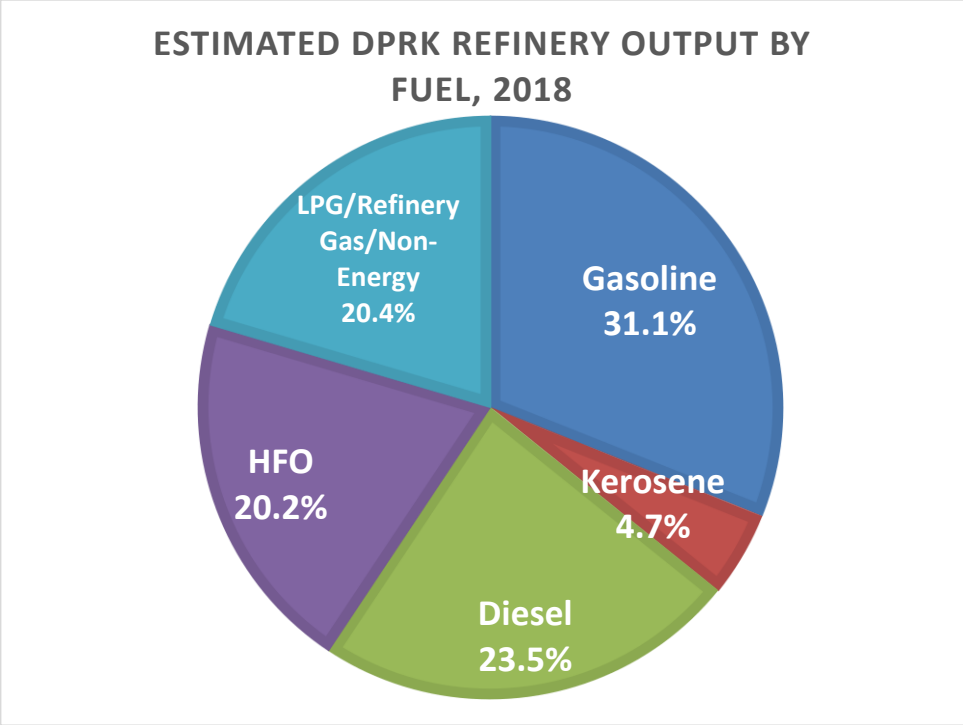
Imports (Tonnes)	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gasoline	120,000	194,378	108,991	41,846	115,755	79,130	83,011	111,827	151,735	146,354	92,751	65,478	60,947	8,665
Kerosene	50,000	12,000	22,000	46,994	50,542	35,230	40,295	36,869	49,014	56,751	31,537	18,157	20,000	1,000
Diesel	300,000	120,000	190,258	294,885	202,405	180,292	230,392	316,961	345,832	439,817	226,299	191,244	218,293	134,157
HFO	150,000	598,541	539,652	131,847	319,409	9,527	16,483	8,415	11,188	12,953	3,774	721	1,940	721
LPG/Refinery Gas/Non-Energy	-	399	127,984	30,699	9,145	7,552	10,146	27,249	30,370	28,481	27,578	25,260	25,260	8,932

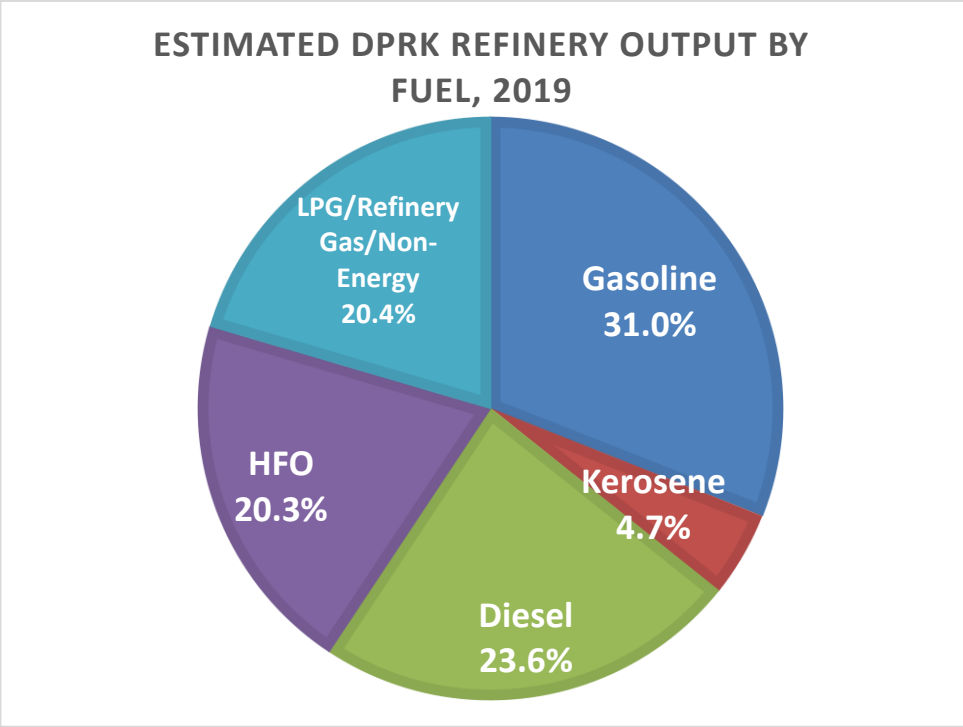

Estimated DPRK Petroleum Products Supplies--Refined Domestically and Imports
150,000
100,000
50,000
-
TJ
Gasoline--Refined
Kerosene--Refined
Diesel--Refined
HFO--Refined
LPG/Ref Gas/Non-En--Refined
Gasoline--Imported
Kerosene--Imported
Diesel--Imported
HFO--Imported
LPG/Ref Gas/Non-En--Imported
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

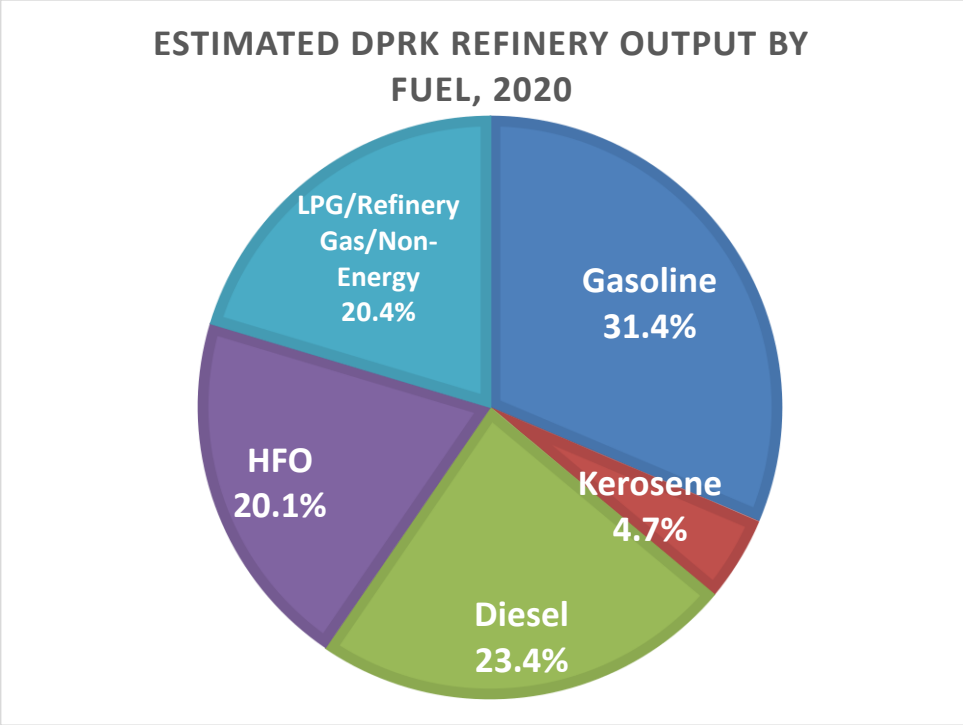

Estimated DPRK Petroleum Products Supplies--Refined Domestically and Imports
Tonnes
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
Gasoline--Refined
Kerosene--Refined
Diesel--Refined
HFO--Refined
LPG/Ref Gas/Non-En--Refined
Gasoline--Imported
Kerosene--Imported
Diesel--Imported
HFO--Imported
LPG/Ref Gas/Non-En--Imported
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

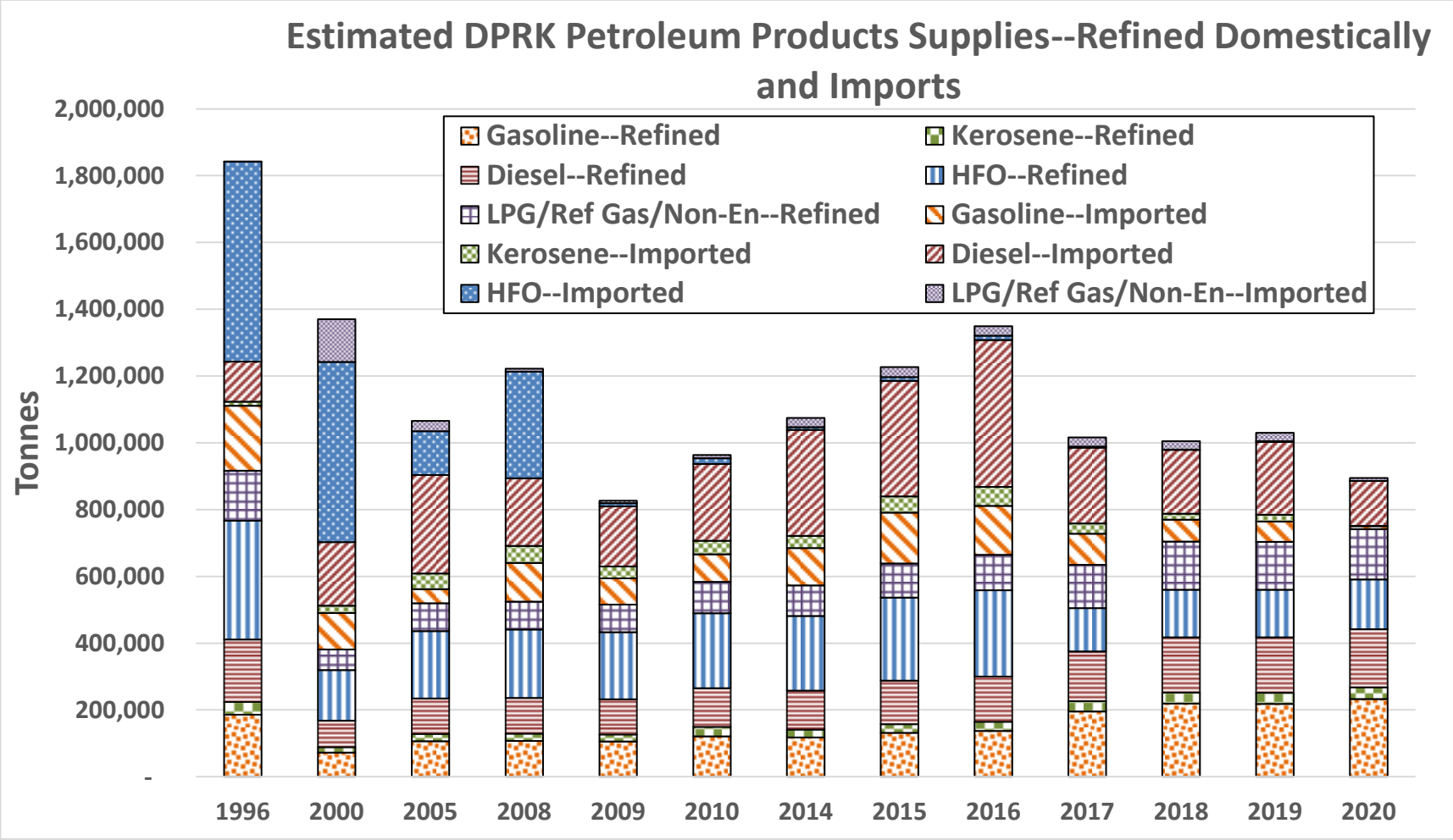

Estimated DPRK Petroleum Products Supplies--Refined Domestically
Tonnes
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
Gasoline
Kerosene
Diesel
HFO
LPG/Refinery Gas/Non-Energy
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

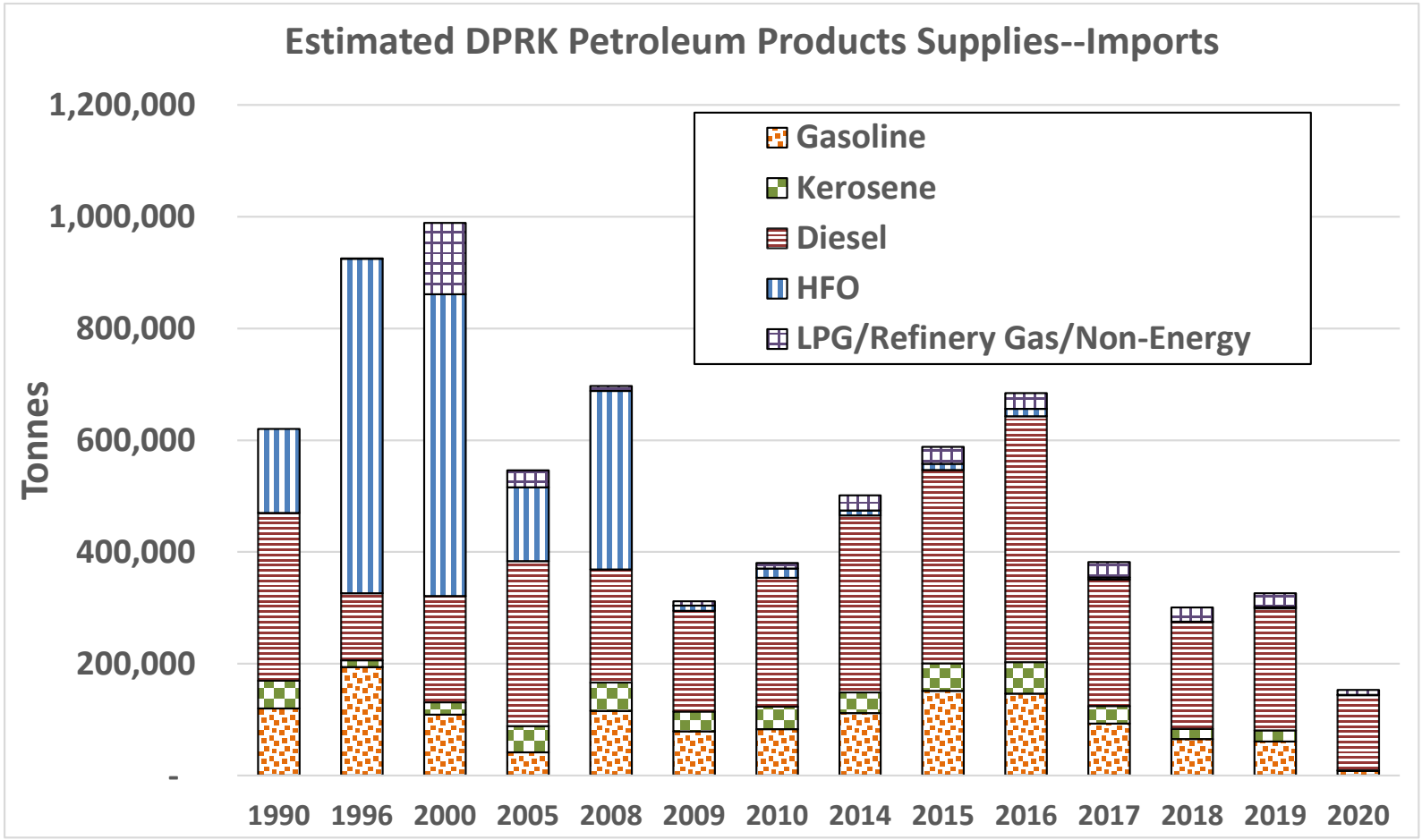

ESTIMATED DPRK REFINERY OUTPUT BY FUEL, 2017
LPG/Refinery Gas/Non-Energy 20.4%
Gasoline 30.9%
HFO 20.4%
Kerosene 4.7%
Diesel 23.6%


ESTIMATED DPRK REFINERY OUTPUT BY FUEL, 2018
LPG/Refinery Gas/Non-Energy 20.4%
Gasoline 31.1%
HFO 20.2%
Kerosene 4.7%
Diesel 23.5%


ESTIMATED DPRK REFINERY OUTPUT BY FUEL, 2019
LPG/Refinery Gas/Non-Energy 20.4%
Gasoline 31.0%
HFO 20.3%
Kerosene 4.7%
Diesel 23.6%


ESTIMATED DPRK REFINERY OUTPUT BY FUEL, 2020
LPG/Refinery Gas/Non-Energy 20.4%
Gasoline 31.4%
HFO 20.1%
Kerosene 4.7%
Diesel 23.4%


Estimated DPRK Petroleum Products Supplies--Refined Domestically and Imports
Tonnes
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Gasoline--Refined
Kerosene--Refined
Diesel--Refined
HFO--Refined
LPG/Ref Gas/Non-En--Refined
Gasoline--Imported
Kerosene--Imported
Diesel--Imported
HFO--Imported
LPG/Ref Gas/Non-En--Imported
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020


Estimated DPRK Petroleum Products Supplies--Imports
Tonnes
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Gasoline
Kerosene
Diesel
HFO
LPG/Refinery Gas/Non-Energy
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

Estimates of Cost and Savings of Selected Energy Efficiency Measures

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: END-USES

Prepared By David Von Hippel
Date Last Modified: 7/7/2020

BASED ON YEAR 2018 CONSUMPTION

Sources/Notes:

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.755		*Note 3*
Fraction of total investment represented by annualized CCE:	15%		*Note 4*
Inflator to convert 1990 costs to 2019 costs:	197%		*Note 18*
Energy Conversion Factor:	29.3	GJ/tce	
Energy Conversion Factor:	0.0036	GJ/kWh	

Sources/Notes:

Efficiency Improvements in Coal Fired Boilers: Industrial

Coal Use (Fuel) by Industrial Subsector

Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	Total TJ/yr Boilers & Furnaces	
		Note 5		
Iron and Steel	55,184	60%	33,111	
Cement	42,164	100%	42,164	
Fertilizers	2,359	100%	2,359	*1*
Other Chemicals	1,356	100%	1,356	
Pulp and Paper	443	100%	443	
Other Metals	12,785	100%	12,785	
Other Minerals	4,899	100%	4,899	
Textiles	3,556	100%	3,556	
Non-specified Industry	16,447	100%	16,447	
Agricultural Processing	4,370	100%	4,370	
Military Manufacturing	445	100%	445	

TOTAL EST COAL USE IN BOILERS AND FURNACES	121,933	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	37.5%		*6, 19*
ESTIMATED POTENTIAL COAL SAVINGS	45,725	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	537	Yuan/(tce/yr)	*7*
Per Unit Upgrade Costs, Boilers and Furnaces	$ 7.60	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 347,412,503	($2019)	

Coal Use in Small/Medium Boilers and Furnaces:

(Assumes that essentially all coal use is in boilers and furnaces)

Sector/Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	TJ/yr in Boilers & Furnaces	
	Note 5			
Residential/Urban	103,341	90%	93,007	*2*
Public/Commercial	20,407	100%	20,407	
Military Buildings	24,122	100%	24,122	

TOTAL EST COAL USE IN BOILERS AND FURNACES	137,536	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	23.0%		*8, 19*
ESTIMATED POTENTIAL COAL SAVINGS	31,633	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	300	Yuan/(tce/yr)	*8*
Per Unit Upgrade Costs, Boilers and Furnaces	$ 4.24	/(GJ/yr) ($2010)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 134,187,972	($2019)	
Fract. Savings Potential, Building Envelope Improvements:	21%		*12*
ESTIMATED POTENTIAL COAL SAVINGS	22,572	TJ/yr	
Per Unit Upgrade Costs, Building Envelope Improvements:	213	$/(tce/yr) ($2014)	*12*
Per Unit Upgrade Costs, Building Envelope Improvements:	$ 7.77	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 175,411,541	($2019)	

Coal Savings through Solar Water Heat

(Assumes that essentially all coal use is in boilers, furnaces, and rural heating stoves)

Sector/Subsector	Total TJ/yr	Fraction in Boilers, Stoves, and Furnaces	TJ/yr in Boilers, Stoves, and Furnaces
	Note 5		
Residential/Urban	103,341	90%	93,007
Residential/Rural	33,442	90%	30,098
Public/Commercial	20,407	100%	20,407
Military Buildings	24,122	100%	24,122

Estimated fraction of residential energy used for water heeating			
Water heat use per urban household, 1990, (delivered electricity equivalent)	1500	kWh	*Assumption*
Water heat use per rural household, 1990, (delivered electricity equivalent)	2000	kWh	*Assumption*
Average efficiency of coal use for water heating, all households	55%		*Assumption*
Implied GJ/yr coal use for water heat, urban households	9.82	per household	
Implied GJ/yr coal use for water heat, rural households	13.09	per household	
Implied fraction of coal use for water heating, urban households	18.6%		
Implied fraction of coal use for water heating, urban households	19.5%		
Fraction of coal use for water heating in non-residential buildings	10%		*Assumption*
Ultimate potential fraction of urban residential units using solar HW	35%		*Assumption*
Ultimate potential fraction of rural residential units using solar HW	50%		*Assumption*
Ultimate potential fraction of non-residential buildings using solar HW	50%		*Assumption*
Fraction of water heating coal use displaced in households and non-residential buildings using solar water heaters	80%		*Assumption*
Potential coal savings from solar water heat, residential/urban	4,848	TJ/yr	
Potential coal savings from solar water heat, residential/rural	2,345	TJ/yr	
Potential coal savings from solar water heat, public/commercial	816	TJ/yr	
Potential coal savings from solar water heat, military buildings	3,377	TJ/yr	
TOTAL of above	11,387	TJ/yr	
Estimated cost per household of solar water heater	$350	per unit	
(Based roughly on 2020 costs of solar water heaters in China from Alibaba.com)			
Implied capital cost per unit energy savings, residential units (urban)	$45	per GJ/yr ($2019)	
Assume capital costs for non-residential installations are	75%		
of residential costs per unit output, based on generally larger system size and associated economies of scale.			
Then capital cost per unit energy savings for non-residential units implied is	$33.42	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 140,461,810	($2019)	

Coal Use in Household cooking and heating stoves:

Residential/Rural Coal Use (TJ)	33,442	TJ/yr	
Residential/Urban Cooking Coal Use	10,334	TJ/yr	
TOTAL EST COAL USE IN DOMESTIC STOVES	43,776	TJ/yr	
Fractional Savings Potential, Domestic Stoves:	25.0%		*9*
ESTIMATED POTENTIAL COAL SAVINGS	10,944	TJ/yr	
Per Unit Upgrade Costs, Domestic Stoves	100	Yuan/(tce/yr)	*9*
Per Unit Upgrade Costs, Domestic Stoves	$ 1.41	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 15,474,836	($2019)	

Electricity Use by Industrial Subsector: Motors and Drives

Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Iron and Steel	2,956	50%	1,478
Cement	2,552	95%	2,424
Fertilizers	1,857	50%	928
Other Chemicals	801	50%	400
Pulp and Paper	103	95%	97
Other Metals	2,224	20%	445
Other Minerals	192	95%	183
Textiles	302	95%	287
Building Materials	48	95%	46
Non-specified Industry	1,960	80%	1,568
Transportation	3,656	95%	3,474
Agricultural Processing	702	95%	562
Military Manufacturing	24	80%	23

TOTAL EST ELECT USE, IND. MOTORS & DRIVES	11,915	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11, 19*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,787	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 137,117,550	($2019)	

Electricity Use in Other Sectors: Motors and Drives

Sector/Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Residential/Urban	3,481	10%	348
Public/Commercial	8,795	30%	2,638
Military Buildings	4,355	30%	1,307

TOTAL EST ELECT USE, NON-IND. MOTORS & DRIVES	4,293	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	644	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 49,406,749	($2019)	

Electricity Use: Lighting

Sector/Subsector	Total TJ/yr	Fraction in Lighting	Total TJ/yr Lighting
	Note 13		
Industrial (All)	12,995	5%	650
Transportation (All)	3,656	2.5%	91
Residential/Rural	356	50%	178
Residential/Urban	3,481	50%	1,740
Public/Commercial	8,795	50%	4,397
Military Buildings	4,355	50%	2,178

TOTAL EST ELECT USE, RESIDENTIAL LIGHTING	1,918	TJ/yr	
Fractional Savings Potential, Lighting Improvements (LED replacing incandescent)	85.0%		*14*
Fractional Savings Potential, Lighting Improvements (LED replacing fluorescent)	50.0%		
Fraction of households lamps already LEDs	40.0%	*Assumption*	
Fraction of remaining lamps that are incandescents	50.0%	*Assumption*	
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	777	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent	0.011	$/kWh	*14*
Per Unit Upgrade Costs, Residential Lighting	$ 20.32	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 15,782,823	($2019)	

TOTAL EST ELECT USE, NON-RESIDENTIAL LIGHTING	7,225	TJ/yr	
Fractional Savings Potential, Lighting Improvements	50.0%		*15*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	3,612	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent, controls, and other lighting efficiency upgrades.	0.025	$/kWh ($2019)	*15*
Per Unit Upgrade Costs, Non-Residential Lighting	$ 46.30	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 167,241,002	($2019)	

Petroleum Fuel Use: Medium-Sized Trucks

Fuel Use: Civilian Transport/Freight (gasoline trucks only)	1,747	TJ/yr	
Freight transported by gasoline trucks	2.58E+08	te-km	
Average tonne-km per vehicle/yr	15,000	te-km	*Rough Est.*
Implied number of 2.5 tonne trucks in use (civilian):	17,168		
Fuel Use: Military Trucks (2 1/2 tonne only)	4,544	TJ/yr	
Total number 2 1/2 tonne military trucks in active service	42,407		
Total number of 2.5 tonne trucks in service:	59,575		
Fraction of trucks to be replaced	45%		*22*
Fraction of energy use represented by trucks replaced	70%		*22*
Fractional energy savings by replacing trucks	43%		*16*
TOTAL ENERGY SAVED	1,911	TJ/yr	
Cost per truck to replace	$ 14,000		*17*
TOTAL COST OF NEW TRUCKS	$ 375,322,310	($2019)	

Estimate of Residential Electricity End-Uses (Fraction of Residential Electricity Used in Each Subsector)

End Use	Urban	Rural	
Lighting	50.0%	50.0%	As assumed above
Space and Water Heating	5.4%	1.3%	Assumption based roughly on 2008 Census results (***Note 21***)
Motors and Drives	10.0%	0.0%	Urban as assumed above
Air Conditioning	1.1%	0.0%	Rough assumption--urban elites only (***Note 20***)
Other End-uses	33.5%	48.7%	Remainder; rural roughly consistent with Unhari survey results.

Estimate of Agricultural Electricity End-Uses (Fraction of Agricultural Electricity Used in Each Subsector)

End Use	Field Operations	Processing/ Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of FIsheries Electricity End-Uses (Fraction of Fisheries Electricity Used in Each Subsector)

End Use	Large Ships	Collectives/Proce ssing/Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of Military Electricity End-Uses (Fraction of Military Electricity Used in Each Subsector)

End Use	Military Manu- facturing	Military Buildings and Other	
Lighting	5.0%	50.0%	As assumed above
Other End Uses	15.0%	20.0%	Calculated by difference
Motors and Drives	80.0%	30.0%	As assumed above

Estimate of Public/Commercial Electricity End-Uses (Fraction of Electricity Used in Sector)

End Use	Fraction			
Lighting	50.0%	As assumed above		
Other End Uses	10.0%	Calculated by difference		
Motors and Drives	20.0%	As assumed above, less	10%	assumed used in air conditioning/fans
Space and Water Heating	10.0%			
Air Conditioning	10.0%			

Sources/Notes:

1 *Total coal use shown here does not include coal used as a non-energy feedstock in carbide production.*

2 *Assumes 10 percent or less of urban coal use is burned in individual cooking stoves*

3 *1990 Value from Microsoft Encarta, 1994.*

4 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments.*
J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).

5 *End-use fractions are rough assumptions*

6 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers & furnaces (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 50% to 65 or 70%, plus additional savings from other measures. 50% initial (existing boiler) efficiency estimate from document in authors' files [R1].*
Savings fractions and costs for measures taken from China studies:
M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211;
D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China";
and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435.
Note that the savings potential assumed here, 37.5%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").

7 *Assumes (based on sources in 6) 8% increase in efficiency from microprocessor controls at investment of 1200 Y/tce-yr, 10% increase for insulation of piping (and similar furnace improvements) at 412 Y/tce-yr, and 12% increase for boiler and furnace rennovation at 200 Y/tce-yr.*
Although the values above come from a reference that is relatively old, a more recent reference by authors in China suggests that the costs of saved energy for energy efficiency measures applied to boilers in China based on more recent data may be similar. The article "Cost-effectiveness Analysis to Improve China's Coal-fired Industrial Boiler", by Manzhi Liu, Bo Shen, Yafeng Han, Lynn Price, and Mingchao Xu, Energy Procedia, 5 (2015), pp 1549 – 1554, available as doi: 10.1016/j.egypro.2015.07.330 , although it incorporates coal price as a factor in the calculation of the levelized cost of energy savings, lists measures (excluding fuel swicthing measures) that together can save on the order of 40 percent of initial coal use (Nautilus estimate) at an average weighted cost that appears to be a small fraction of the cost of coal in China, though it is difficult to determine an exact comparison of costs because the authors do not provide all of the underlying data for their calculations.

8 *Assumes (based roughly on sources in 6) that a 15% efficiency increase with general boiler rennovations, starting from an average efficiency of 50%, is available for an investment of 250 Y/(tce/yr) (20 percent higher than value estimated for industrial boilers in Levine et al).*

9 *Various estimates place the efficiency of chinese coal stoves/heaters at anywhere from 20 to 50 percent.*
We have assumed that efficiency measures can increase the thermal efficiency of individual rural stove/heaters and urban stoves from ave. of 30% to 40%, for a 25% reduction in coal use. Doc. in authors' files [R1] cites an estimated DPRK residential coal-fired heating stove efficiency of 30%, and cooking stove efficiency of 20%.
Efficiency investment of 100 Y/tce for domestic coal burning improvements from Levine et al (1992--see note 6).
It is not clear exactly which measures these improvements include; likely candidates include coal briquetting and stove technology improvements.

10 *Values are rough estimates. By way of comparison, 65 percent of the electricity used in the entire Chinese economy has been estimated to be consumed in electric motors (Sathaye, 1992).*

11 *Assumes (based on Chinese experience) that motors can be upgraded from an average efficiency of 75% to an efficiency of 88% (the latter is close to standard US motors) at a (per unit) cost of 0.1 Y/kWh. Costs and efficiency improvements from Sathaye, 1992. Note that other improvements such as variable speed electronic drives, improved valving and gearing, piping retrofits represent substantial additional savings potential. The 2011 UNIDO document* ***Energy efficiency in electric motor systems:Technology, saving potentials and policy options for developing countries*** *includes a number of examples of motor and drive effiiciency improvements in China, India, the EU, the US, and elsewhere that show payback periods on the order of two years or less, which would be consistent with (possibly less than) the costs shown in the older Sathaye document. The UNIDO document, (United Nations Industrial Development Organization) was authored by Tobias Fleiter and Wolfgang Eichhammer, and is available as https://open.unido.org/api/documents/4818324/download/Energy%20efficiency%20in%20electric%20motor%20systems%20-%20Technology,%20saving%20potentials%20and%20policy%20options%20for%20developing%20countries.*

12 *In our initial estimate, based on Chinese studies, assumes a 20% increase in thermal performance through two measures:* a 30mm perlite cement mortar coat on inside of walls plus double glazing. Costs based on estimated *Payback of 2-3 years and market coal price of 110Y/tce. Source: S. Lang et al, "Energy Conservation Standards for Spare Heating in Chinese Residential Buildings", 1992, LBL. Note that these two simple measures do not begin to exhaust the cost effective measures available for building shell improvements. Other estimates based on the Chinese situation show that 30 percent improvements in building energy efficiency are possible for a modest 5% increase in building costs. (Source: "An Overview of Energy Demand and Supply in China", F. Liu et al, 1992 (LBL).)*

A more recent (2014) study, "Marginal abatement cost and carbon reduction potential outlook of key energy efficiency technologies in China's building sector to 2030", by He Xiao, Qingpeng Wei, and Hailin Wang, ***Energy Policy*** *Volume 69, June 2014, Pages 92-105, available as https://doi.org/10.1016/j.enpol.2014.02.021, includes an analysis of 34 building energy improvement technologies that provide an aggregate* 17% savings in *primary energy use, a total of* 229 Mtce in 2030, and CO2e savings of 499.8 million tonnes by the same *year, at an average cost of* $ 19.50 per tonne CO2e. This implies a cost of saved energy of $ 42.56 *per tce. We expect that the cost per unit of saved energy for DPRK buildings will likely be lower, and savings higher, due to the likely better energy efficiency performance of average Chinese buildings versus average DPRK buildings, and lower labor rates in the DPRK. We assume that savings are* 25% higher than in this *example, and unit costs are* 25% lower. It is probable that an aggressive building energy efficiency program could *reduce DPRK building energy use much further over time (the same is likely true in China).*

13 *Rough estimates. For comparison, lighting comprises about 28% of household electricity use in Thailand, and 33% in the FSU, but in both cases use of household appliances, including cooling, refrigeration, and electric water and space heating, probably account for a larger fraction of energy use than in DPRK homes. Nautilus' 1998 rural energy survey suggested that lighting comprised over 50 percent of total electricity use in the households in one rural village.*

14 *Assumes that 50% of residential lighting energy is currently used in incandescent bulbs, that light-emitting diode (LED) bulbs save 85% of the energy of incandescent bulbs (and 50% of the energy of compact fluorescent bulbs (CFLs) or fluorescent tube lighting, and that LEDs can be used to replace incandescent or fluorescent bulbs for all existing residential incandescent or fluorescent bulb lighting use. An earlier version of this analysis used costs based on Sathaye, 1992, and based on setting up CFL factory in China at an investment cost of $5M to produces 3 million CFLs per year at roughly 6.9Y/unit. Extensive use of LEDs may require that DPRK the power grid be upgraded to reduce voltage fluctuations and improve power factors (or replaced by a series of mini-grids). An addendum to this earlier estimate is that the DPRK apparently has placed CFLs, reportedly made in the DPRK, in virtually all DPRK households during approximately 2005 - 2006. The DPRK reportedly deployed both imported bulbs, including bulbs made by Phillips, but over time have developed DPRK-based manufacturing. News of this program is based on a report provided by the DPRK delegation attending the 2006 "Asian Energy Security" workshop organized by Nautilus with EETC of Tsinghua University, Beijing (November, 2006). To estimate costs of saved energy for the current analysis, we assume two simple replacements: The first replaces a 40 W DPRK incandescent bulb with a 5 W LED bulb, with annual usage of* 1000 *hours (about 3 hours daily). We assume a bulb cost of* $1, *and a bulb lifetime of* 20000 *hours. Wholesale costs for similar bulbs made in China are shown on Alibaba.com at $0.15 to $0.40 each, so we assume a retail cost of $1 per bulb is quite possible. Listed lifetimes for some bulbs are longer. With a (consumer) discount rate of* 12% *annually, the annualized capital cost of the bulb, ignoring saved O&M costs and the cost of the bulb being replaced, would be* $0.13 *per year to save* 35 *kWh, for a levelized cost of saved energy (CSE) of* $ 0.0038 *per kWh. Similarly, a 13 W LED tube lamp fixture (90 cm) replacing a 30 W fluorescent fixture is available on Alibaba for a cost of around $1.6 per fixture (which includes both the fixture and the lamp). Again assuming no credit for avoided O&M or existing bulbs/fixtures, and assuming a retail fixture cost in the DPRK of* $ 3.00 *each, a lifetime of* 20000 *hours, and annual usage of* 1500 *hours per year, and a discount rate of* 12% *annually, the annualized capital cost of the fixture would be* $0.46 *per year to save* 25.5 *kWh, or* $ 0.0181 *per kWh. Averaging these two cases yields a CSE of* $ 0.011 *per kWh, which we use as a rough estimate for residential lighting improvements. In practice, factoring in net savings in O&M costs and the value of avoided (base case) light bulb purchases, these costs are likely much lower, and probably negative.*

15 *In a 2015 American Council for an Energy-Efficient Economy (ACEEE) document,* ***New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030*** *, commercial lighting energy efficiency options are provided with costs on the order of 5 to 10 cents per kWh in the United States. It is highly likely that opportunities in the DPRK will be even more cost-effective, because buildings on average will start from a much lower base of efficiency, and because of the lower labor costs in the DPRK, although it is likely that lighting efficiency improvements will be accompanied by upgrades in the lumens provided as well. We assume an average of* $0.025 *per kWh as an average cost of saved energy for lighting improvements in the public/commercial, military, and industrial sectors in the DPRK. This is likely a substantial over-estimate, given the long lifetime of typical LED lighting bulbs and systems. ACEEE document prepared by Dan York, Steven Nadel, Ethan Rogers, Rachel Cluett, Sameer Kwatra, Harvey Sachs, Jennifer Amann, and Meegan Kelly, dated September 2015, Report Number U1507, and available as https://www.aceee.org/sites/default/files/publications/researchreports/u1507.pdf. This document includes an example with savings of 65 percent covering 68 percent of lighting end-uses. We assume average lighting energy savings of 50 percent.*

16 *Estimated based on our estimates for the fuel economy of 2 1/2 tonne trucks in the DPRK military and quoted estimate from US Isuzu truck vendor for average fuel economy of new 2 1/2 tonne Isuzu (diesel) truck (11 miles per gallon). Adjustment has been made for higher fuel energy content of diesel (vs. gasoline).*

17 *Approximate cost of new truck from China, including roughly estimated taxes and shipping costs. See, for example, the diesel "Dongfeng" trucks described on Alibaba here* https://www.alibaba.com/product-detail/4X2-wheel-drive-3-5-tons_60714507616.html?spm=a2700.7724838.2017115.93.28d138f2PRkKGF *and gasoline-fueled "FOTON" brand units here* https://www.alibaba.com/product-detail/New-China-5-ton-mini-truck_60642742600.html?spm=a2700.7724838.2017115.84.287b43a48AOfyp *But note that trucks come in many configurations, sizes, and thus costs.*

18 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

19 *The savings figures shown here may well be conservative (low) for DPRK conditions. In his presentation "Energy Efficiency Activities in the DPRK and Opportunities for Rationalization of Energy Use", prepared as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Prof. Jan Jasiewicz notes the results of energy audits in industrial installations in the DPRK where potential savings were found to be between 15 and 60 percent, with payback times (presumably under market prices for energy commodities) of less than three years. Although a number of years have passed since then, we assume that many of the DPRK's boilers and furnaces have not been significantly updated, and thus the difference between the efficiencies of existing and modern units remain, on average, at about this level.*

20 *As a rough calculation, assume* 10000 elite households using a room air conditioner rated at *1.5* kW an average of 700 full-time hours per year. This would imply usage of *10500* MWh/yr or about 37800 GJ per year, or about 1.1% of estimated *DPRK urban electricity use in 2018.*

21 *The DPRK's 2008 Census lists the following data for fraction of households with electric space heating by type*

	Urban	Rural
Electronic heating system*	1.00%	0.22%
Electronic heating system with others*	1.27%	0.45%
Total Households	3,579,626	2,307,845

*Note: "Electronic" probably means "Electrical", likely mostly portable or fixed resistance heating devices.

If we assume the following about electric heating in each sector (average of both types of "electronic" heating)

	Urban	Rural	
Average Hours full-time equivalent use/yr	500	100	Rural especially limited by electricity supplies.
Average capacity (kW)	1.50	1.50	
Implied MWh/yr electricity use	60,730	2,304	
Fraction of estimated subsectoral MWh	5.40%	1.33%	

22 *Very rough estimate incorporating the observation that many trucks have been imported into the DPRK in recent years, but that many of the older 2.5 tonne trucks are doubtless still on the road. The assumption that these trucks to be replaced account for 70 percent of fuel use takes into account A) that many of the older trucks in the estimated truck fleet may be inoperable much of the time, and B) that new trucks have been increasingly used in recent years.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: END-USES

Prepared By David Von Hippel
Date Last Modified: 7/8/2020

BASED ON YEAR 2019 CONSUMPTION

Sources/Notes:

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.755		*Note 3*
Fraction of total investment represented by annualized CCE:	15%		*Note 4*
Inflator to convert 1990 costs to 2019 costs:	197%		*Note 18*
Energy Conversion Factor:	29.3	GJ/tce	
Energy Conversion Factor:	0.0036	GJ/kWh	

Sources/Notes:

Efficiency Improvements in Coal Fired Boilers: Industrial

Coal Use (Fuel) by Industrial Subsector

Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	Total TJ/yr Boilers & Furnaces	
	Note 5			
Iron and Steel	55,184	60%	33,111	
Cement	42,177	100%	42,177	
Fertilizers	2,359	100%	2,359	*1*
Other Chemicals	1,356	100%	1,356	
Pulp and Paper	443	100%	443	
Other Metals	12,785	100%	12,785	
Other Minerals	4,899	100%	4,899	
Textiles	3,556	100%	3,556	
Non-specified Industry	16,447	100%	16,447	
Agricultural Processing	3,826	100%	3,826	
Military Manufacturing	445	100%	445	

TOTAL EST COAL USE IN BOILERS AND FURNACES	121,403	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	37.5%		*6, 19*
ESTIMATED POTENTIAL COAL SAVINGS	45,526	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	537	Yuan/(tce/yr)	7
Per Unit Upgrade Costs, Boilers and Furnaces	$ 7.60	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 345,902,203	($2019)	

Coal Use in Small/Medium Boilers and Furnaces:

(Assumes that essentially all coal use is in boilers and furnaces)

Sector/Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	TJ/yr in Boilers & Furnaces	
		Note 5		
Residential/Urban	105,137	90%	94,623	*2*
Public/Commercial	20,407	100%	20,407	
Military Buildings	24,515	100%	24,515	

TOTAL EST COAL USE IN BOILERS AND FURNACES	139,545	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	23.0%		*8, 19*
ESTIMATED POTENTIAL COAL SAVINGS	32,095	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	300	Yuan/(tce/yr)	*8*
Per Unit Upgrade Costs, Boilers and Furnaces	$ 4.24	/(GJ/yr) ($2010)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 136,148,013	($2019)	
Fract. Savings Potential, Building Envelope Improvements:	21%		*12*
ESTIMATED POTENTIAL COAL SAVINGS	22,902	TJ/yr	
Per Unit Upgrade Costs, Building Envelope Improvements:	213	$/(tce/yr) ($2014)	*12*
Per Unit Upgrade Costs, Building Envelope Improvements:	$ 7.77	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 177,973,722	($2019)	

Coal Savings through Solar Water Heat

(Assumes that essentially all coal use is in boilers, furnaces, and rural heating stoves)

Sector/Subsector	Total TJ/yr	Fraction in Boilers, Stoves, and Furnaces	TJ/yr in Boilers, Stoves, and Furnaces
		Note 5	
Residential/Urban	105,137	90%	94,623
Residential/Rural	33,924	90%	30,531
Public/Commercial	20,407	100%	20,407
Military Buildings	24,515	100%	24,515

Estimated fraction of residential energy used for water heeating			
Water heat use per urban household, 1990, (delivered electricity equivalent)	1500	kWh	*Assumption*
Water heat use per rural household, 1990, (delivered electricity equivalent)	2000	kWh	*Assumption*
Average efficiency of coal use for water heating, all households	55%		*Assumption*
Implied GJ/yr coal use for water heat, urban households	9.82	per household	
Implied GJ/yr coal use for water heat, rural households	13.09	per household	
Implied fraction of coal use for water heating, urban households	18.6%		
Implied fraction of coal use for water heating, urban households	19.5%		
Fraction of coal use for water heating in non-residential buildings	10%		*Assumption*
Ultimate potential fraction of urban residential units using solar HW	35%		*Assumption*
Ultimate potential fraction of rural residential units using solar HW	50%		*Assumption*
Ultimate potential fraction of non-residential buildings using solar HW	50%		*Assumption*
Fraction of water heating coal use displaced in households and non-residential buildings using solar water heaters			
	80%		*Assumption*
Potential coal savings from solar water heat, residential/urban	4,932	TJ/yr	
Potential coal savings from solar water heat, residential/rural	2,379	TJ/yr	
Potential coal savings from solar water heat, public/commercial	816	TJ/yr	
Potential coal savings from solar water heat, military buildings	3,432	TJ/yr	
TOTAL of above	11,560	TJ/yr	
Estimated cost per household of solar water heater	$350	per unit	
(Based roughly on 2020 costs of solar water heaters in China from Alibaba.com)			
Implied capital cost per unit energy savings, residential units (urban)	$45	per GJ/yr ($2019)	
Assume capital costs for non-residential installations are	75%		
of residential costs per unit output, based on generally larger system size and associated economies of scale.			
Then capital cost per unit energy savings for non-residential units implied is	$33.42	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 142,307,337	($2019)	

Coal Use in Household cooking and heating stoves:

Residential/Rural Coal Use (TJ)	33,924	TJ/yr	
Residential/Urban Cooking Coal Use	10,514	TJ/yr	
TOTAL EST COAL USE IN DOMESTIC STOVES	44,437	TJ/yr	
Fractional Savings Potential, Domestic Stoves:	25.0%		*9*
ESTIMATED POTENTIAL COAL SAVINGS	11,109	TJ/yr	
Per Unit Upgrade Costs, Domestic Stoves	100	Yuan/(tce/yr)	*9*
Per Unit Upgrade Costs, Domestic Stoves	$ 1.41	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 15,708,553	($2019)	

Electricity Use by Industrial Subsector: Motors and Drives

Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Iron and Steel	2,956	50%	1,478
Cement	2,552	95%	2,424
Fertilizers	1,857	50%	928
Other Chemicals	801	50%	400
Pulp and Paper	103	95%	97
Other Metals	2,224	20%	445
Other Minerals	192	95%	183
Textiles	302	95%	287
Building Materials	48	95%	46
Non-specified Industry	1,960	80%	1,568
Transportation	3,661	95%	3,478
Agricultural Processing	615	95%	492
Military Manufacturing	24	80%	23

TOTAL EST ELECT USE, IND. MOTORS & DRIVES	11,849	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11, 19*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,777	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 136,366,995	($2019)	

Electricity Use in Other Sectors: Motors and Drives

Sector/Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Residential/Urban	3,308	10%	331
Public/Commercial	8,795	30%	2,638
Military Buildings	4,387	30%	1,316

TOTAL EST ELECT USE, NON-IND. MOTORS & DRIVES	4,285	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	643	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 49,316,445	($2019)	

Electricity Use: Lighting

Sector/Subsector	Total TJ/yr	Fraction in Lighting	Total TJ/yr Lighting
	Note 13		
Industrial (All)	12,995	5%	650
Transportation (All)	3,661	2.5%	92
Residential/Rural	351	50%	175
Residential/Urban	3,308	50%	1,654
Public/Commercial	8,795	50%	4,397
Military Buildings	4,387	50%	2,193

TOTAL EST ELECT USE, RESIDENTIAL LIGHTING	1,829	TJ/yr	
Fractional Savings Potential, Lighting Improvements (LED replacing incandescent)	85.0%		*14*
Fractional Savings Potential, Lighting Improvements (LED replacing fluorescent)	50.0%		
Fraction of households lamps already LEDs	40.0%	*Assumption*	
Fraction of remaining lamps that are incandescents	50.0%	*Assumption*	
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	741	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent	0.011	$/kWh	*14*
Per Unit Upgrade Costs, Residential Lighting	$ 20.32	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 15,050,791	($2019)	

TOTAL EST ELECT USE, NON-RESIDENTIAL LIGHTING	7,241	TJ/yr	
Fractional Savings Potential, Lighting Improvements	50.0%		*15*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	3,620	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent, controls, and other lighting efficiency upgrades.	0.025	$/kWh ($2019)	*15*
Per Unit Upgrade Costs, Non-Residential Lighting	$ 46.30	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 167,605,873	($2019)	

Petroleum Fuel Use: Medium-Sized Trucks

Fuel Use: Civilian Transport/Freight (gasoline trucks only)	1,662	TJ/yr	
Freight transported by gasoline trucks	2.45E+08	te-km	
Average tonne-km per vehicle/yr	15,000	te-km	*Rough Est.*
Implied number of 2.5 tonne trucks in use (civilian):	16,330		
Fuel Use: Military Trucks (2 1/2 tonne only)	4,558	TJ/yr	
Total number 2 1/2 tonne military trucks in active service	42,534		
Total number of 2.5 tonne trucks in service:	58,864		
Fraction of trucks to be replaced	45%		*22*
Fraction of energy use represented by trucks replaced	70%		*22*
Fractional energy savings by replacing trucks	43%		*16*
TOTAL ENERGY SAVED	1,889	TJ/yr	
Cost per truck to replace	$ 14,000		*17*
TOTAL COST OF NEW TRUCKS	$ 370,842,501	($2019)	

Estimate of Residential Electricity End-Uses (Fraction of Residential Electricity Used in Each Subsector)

End Use	Urban	Rural	
Lighting	50.0%	50.0%	As assumed above
Space and Water Heating	5.4%	1.3%	Assumption based roughly on 2008 Census results (***Note 21***)
Motors and Drives	10.0%	0.0%	Urban as assumed above
Air Conditioning	1.1%	0.0%	Rough assumption--urban elites only (***Note 20***)
Other End-uses	33.5%	48.7%	Remainder; rural roughly consistent with Unhari survey results.

Estimate of Agricultural Electricity End-Uses (Fraction of Agricultural Electricity Used in Each Subsector)

End Use	Field Operations	Processing/ Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of FIsheries Electricity End-Uses (Fraction of Fisheries Electricity Used in Each Subsector)

End Use	Large Ships	Collectives/Proce ssing/Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of Military Electricity End-Uses (Fraction of Military Electricity Used in Each Subsector)

End Use	Military Manu- facturing	Military Buildings and Other	
Lighting	5.0%	50.0%	As assumed above
Other End Uses	15.0%	20.0%	Calculated by difference
Motors and Drives	80.0%	30.0%	As assumed above

Estimate of Public/Commercial Electricity End-Uses (Fraction of Electricity Used in Sector)

End Use	Fraction			
Lighting	50.0%	As assumed above		
Other End Uses	10.0%	Calculated by difference		
Motors and Drives	20.0%	As assumed above, less	10%	assumed used in air conditioning/fans
Space and Water Heating	10.0%			
Air Conditioning	10.0%			

Sources/Notes:

1 *Total coal use shown here does not include coal used as a non-energy feedstock in carbide production.*

2 *Assumes 10 percent or less of urban coal use is burned in individual cooking stoves*

3 *1990 Value from Microsoft Encarta, 1994.*

4 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments. J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).*

5 *End-use fractions are rough assumptions*

6 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers & furnaces (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 50% to 65 or 70%, plus additional savings from other measures. 50% initial (existing boiler) efficiency estimate from document in authors' files [R1]. Savings fractions and costs for measures taken from China studies: M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211; D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China"; and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435. Note that the savings potential assumed here, 37.5%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").*

7 *Assumes (based on sources in 6) 8% increase in efficiency from microprocessor controls at investment of 1200 Y/tce-yr, 10% increase for insulation of piping (and similar furnace improvements) at 412 Y/tce-yr, and 12% increase for boiler and furnace rennovation at 200 Y/tce-yr. Although the values above come from a reference that is relatively old, a more recent reference by authors in China suggests that the costs of saved energy for energy efficiency measures applied to boilers in China based on more recent data may be similar. The article "Cost-effectiveness Analysis to Improve China's Coal-fired Industrial Boiler", by Manzhi Liu, Bo Shen, Yafeng Han, Lynn Price, and Mingchao Xu, Energy Procedia, 5 (2015), pp 1549 – 1554, available as doi: 10.1016/j.egypro.2015.07.330 , although it incorporates coal price as a factor in the calculation of the levelized cost of energy savings, lists measures (excluding fuel swicthing measures) that together can save on the order of 40 percent of initial coal use (Nautilus estimate) at an average weighted cost that appears to be a small fraction of the cost of coal in China, though it is difficult to determine an exact comparison of costs because the authors do not provide all of the underlying data for their calculations.*

8 *Assumes (based roughly on sources in 6) that a 15% efficiency increase with general boiler rennovations, starting from an average efficiency of 50%, is available for an investment of 250 Y/(tce/yr) (20 percent higher than value estimated for industrial boilers in Levine et al).*

9 *Various estimates place the efficiency of chinese coal stoves/heaters at anywhere from 20 to 50 percent. We have assumed that efficiency measures can increase the thermal efficiency of individual rural stove/heaters and urban stoves from ave. of 30% to 40%, for a 25% reduction in coal use. Doc. in authors' files [R1] cites an estimated DPRK residential coal-fired heating stove efficiency of 30%, and cooking stove efficiency of 20%. Efficiency investment of 100 Y/tce for domestic coal burning improvements from Levine et al (1992--see note 6). It is not clear exactly which measures these improvements include; likely candidates include coal briquetting and stove technology improvements.*

10 *Values are rough estimates. By way of comparison, 65 percent of the electricity used in the entire Chinese economy has been estimated to be consumed in electric motors (Sathaye, 1992).*

11 *Assumes (based on Chinese experience) that motors can be upgraded from an average efficiency of 75% to an efficiency of 88% (the latter is close to standard US motors) at a (per unit) cost of 0.1 Y/kWh. Costs and efficiency improvements from Sathaye, 1992. Note that other improvements such as variable speed electronic drives, improved valving and gearing, piping retrofits represent substantial additional savings potential. The 2011 UNIDO document* ***Energy efficiency in electric motor systems:Technology, saving potentials and policy options for developing countries*** *includes a number of examples of motor and drive effiiciency improvements in China, India, the EU, the US, and elsewhere that show payback periods on the order of two years or less, which would be consistent with (possibly less than) the costs shown in the older Sathaye document. The UNIDO document, (United Nations Industrial Development Organization) was authored by Tobias Fleiter and Wolfgang Eichhammer, and is available as https://open.unido.org/api/documents/4818324/download/Energy%20efficiency%20in%20electric%20motor%20systems%20-%20Technology,%20saving%20potentials%20and%20policy%20options%20for%20developing%20countries.*

12 *In our initial estimate, based on Chinese studies, assumes a 20% increase in thermal performance through two measures:* a 30mm perlite cement mortar coat on inside of walls plus double glazing. Costs based on estimated *Payback of 2-3 years and market coal price of 110Y/tce. Source: S. Lang et al, "Energy Conservation Standards for Spare Heating in Chinese Residential Buildings", 1992, LBL. Note that these two simple measures do not begin to exhaust the cost effective measures available for building shell improvements. Other estimates based on the Chinese situation show that 30 percent improvements in building energy efficiency are possible for a modest 5% increase in building costs. (Source: "An Overview of Energy Demand and Supply in China", F. Liu et al, 1992 (LBL).)*
A more recent (2014) study, "Marginal abatement cost and carbon reduction potential outlook of key energy efficiency technologies in China's building sector to 2030", by He Xiao, Qingpeng Wei, and Hailin Wang, ***Energy Policy*** *Volume 69, June 2014, Pages 92-105, available as https://doi.org/10.1016/j.enpol.2014.02.021, includes an analysis of 34 building energy improvement technologies that provide an aggregate* 17% savings in *primary energy use, a total of* 229 Mtce in 2030, and CO2e savings of 499.8 million tonnes by the same *year, at an average cost of* $ 19.50 per tonne CO2e. This implies a cost of saved energy of $ 42.56 *per tce. We expect that the cost per unit of saved energy for DPRK buildings will likely be lower, and savings higher, due to the likely better energy efficiency performance of average Chinese buildings versus average DPRK buildings, and lower labor rates in the DPRK. We assume that savings are* 25% higher than in this *example, and unit costs are* 25% lower. It is probable that an aggressive building energy efficiency program could *reduce DPRK building energy use much further over time (the same is likely true in China).*

13 *Rough estimates. For comparison, lighting comprises about 28% of household electricity use in Thailand, and 33% in the FSU, but in both cases use of household appliances, including cooling, refrigeration, and electric water and space heating, probably account for a larger fraction of energy use than in DPRK homes. Nautilus' 1998 rural energy survey suggested that lighting comprised over 50 percent of total electricity use in the households in one rural village.*

14 *Assumes that 50% of residential lighting energy is currently used in incandescent bulbs, that light-emitting diode (LED) bulbs save 85% of the energy of incandescent bulbs (and 50% of the energy of compact fluorescent bulbs (CFLs) or fluorescent tube lighting, and that LEDs can be used to replace incandescent or fluorescent bulbs for all existing residential incandescent or fluorescent bulb lighting use. An earlier version of this analysis used costs based on Sathaye, 1992, and based on setting up CFL factory in China at an investment cost of $5M to produces 3 million CFLs per year at roughly 6.9Y/unit. Extensive use of LEDs may require that DPRK the power grid be upgraded to reduce voltage fluctuations and improve power factors (or replaced by a series of mini-grids). An addendum to this earlier estimate is that the DPRK apparently has placed CFLs, reportedly made in the DPRK, in virtually all DPRK households during approximately 2005 - 2006. The DPRK reportedly deployed both imported bulbs, including bulbs made by Phillips, but over time have developed DPRK-based manufacturing. News of this program is based on a report provided by the DPRK delegation attending the 2006 "Asian Energy Security" workshop organized by Nautilus with EETC of Tsinghua University, Beijing (November, 2006).*
To estimate costs of saved energy for the current analysis, we assume two simple replacements: The first replaces a 40 W DPRK incandescent bulb with a 5 W LED bulb, with annual usage of 1000 *hours (about 3 hours daily). We assume a bulb cost of* $1, and a bulb lifetime of *20000* hours. Wholesale costs for similar bulbs made in China are shown on Alibaba.com at *$0.15 to $0.40 each, so we assume a retail cost of $1 per bulb is quite possible. Listed lifetimes for some bulbs are longer. With a (consumer) discount rate of* 12% annually, the annualized capital cost of the bulb, ignoring saved *O&M costs and the cost of the bulb being replaced, would be* $0.13 per year to save *35* kWh, for a levelized cost of saved energy (CSE) of $ 0.0038 per kWh. Similarly, *a 13 W LED tube lamp fixture (90 cm) replacing a 30 W fluorescent fixture is available on Alibaba for a cost of around $1.6 per fixture (which includes both the fixture and the lamp). Again assuming no credit for avoided O&M or existing bulbs/fixtures, and assuming a retail fixture cost in the DPRK of* $ 3.00 each, a lifetime of 20000 *hours, and annual usage of* 1500 hours per year, and a discount rate of 12% annually, the annualized capital cost of the fixture would be $0.46 per year to save 25.5 *kWh, or* $ 0.0181 per kWh. Averaging these two cases yields a CSE of $ 0.011 *per kWh, which we use as a rough estimate for residential lighting improvements. In practice, factoring in net savings in O&M costs and the value of avoided (base case) light bulb purchases, these costs are likely much lower, and probably negative.*

15 *In a 2015 American Council for an Energy-Efficient Economy (ACEEE) document,* ***New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030****, commercial lighting energy efficiency options are provided with costs on the order of 5 to 10 cents per kWh in the United States. It is highly likely that opportunities in the DPRK will be even more cost-effective, because buildings on average will start from a much lower base of efficiency, and because of the lower labor costs in the DPRK, although it is likely that lighting efficiency improvements will be accompanied by upgrades in the lumens provided as well. We assume an average of* $0.025 per kWh as an average cost of saved energy for lighting improvements *in the public/commercial, military, and industrial sectors in the DPRK. This is likely a substantial over-estimate, given the long lifetime of typical LED lighting bulbs and systems. ACEEE document prepared by Dan York, Steven Nadel, Ethan Rogers, Rachel Cluett, Sameer Kwatra, Harvey Sachs, Jennifer Amann, and Meegan Kelly, dated September 2015, Report Number U1507, and available as https://www.aceee.org/sites/default/files/publications/researchreports/u1507.pdf. This document includes an example with savings of 65 percent covering 68 percent of lighting end-uses. We assume average lighting energy savings of 50 percent.*

16 *Estimated based on our estimates for the fuel economy of 2 1/2 tonne trucks in the DPRK military and quoted estimate from US Isuzu truck vendor for average fuel economy of new 2 1/2 tonne Isuzu (diesel) truck (11 miles per gallon). Adjustment has been made for higher fuel energy content of diesel (vs. gasoline).*

17 *Approximate cost of new truck from China, including roughly estimated taxes and shipping costs. See, for example, the diesel "Dongfeng" trucks described on Alibaba here* https://www.alibaba.com/product-detail/4X2-wheel-drive-3-5-tons_60714507616.html?spm=a2700.7724838.2017115.93.28d138f2PRkKGF *and gasoline-fueled "FOTON" brand units here* https://www.alibaba.com/product-detail/New-China-5-ton-mini-truck_60642742600.html?spm=a2700.7724838.2017115.84.287b43a48AOfyp *But note that trucks come in many configurations, sizes, and thus costs.*

18 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

19 *The savings figures shown here may well be conservative (low) for DPRK conditions. In his presentation "Energy Efficiency Activities in the DPRK and Opportunities for Rationalization of Energy Use", prepared as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Prof. Jan Jasiewicz notes the results of energy audits in industrial installations in the DPRK where potential savings were found to be between 15 and 60 percent, with payback times (presumably under market prices for energy commodities) of less than three years. Although a number of years have passed since then, we assume that many of the DPRK's boilers and furnaces have not been significantly updated, and thus the difference between the efficiencies of existing and modern units remain, on average, at about this level.*

20 *As a rough calculation, assume* 10000 elite households using a room air conditioner rated at *1.5* kW an average of 700 full-time hours per year. This would imply usage of *10500* MWh/yr or about 37800 GJ per year, or about 1.1% of estimated *DPRK urban electricity use in 2018.*

21 *The DPRK's 2008 Census lists the following data for fraction of households with electric space heating by type*

	Urban	Rural
Electronic heating system*	1.00%	0.22%
Electronic heating system with others*	1.27%	0.45%
Total Households	3,579,626	2,307,845

*Note: "Electronic" probably means "Electrical", likely mostly portable or fixed resistance heating devices.

If we assume the following about electric heating in each sector (average of both types of "electronic" heating)

	Urban	Rural	
Average Hours full-time equivalent use/yr	500	100	Rural especially limited by electricity supplies.
Average capacity (kW)	1.50	1.50	
Implied MWh/yr electricity use	60,730	2,304	
Fraction of estimated subsectoral MWh	5.40%	1.33%	

22 *Very rough estimate incorporating the observation that many trucks have been imported into the DPRK in recent years, but that many of the older 2.5 tonne trucks are doubtless still on the road. The assumption that these trucks to be replaced account for 70 percent of fuel use takes into account A) that many of the older trucks in the estimated truck fleet may be inoperable much of the time, and B) that new trucks have been increasingly used in recent years.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: END-USES

Prepared By David Von Hippel
Date Last Modified: 7/8/2020

BASED ON YEAR 2020 CONSUMPTION

Sources/Notes:

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.755		*Note 3*
Fraction of total investment represented by annualized CCE:	15%		*Note 4*
Inflator to convert 1990 costs to 2019 costs:	197%		*Note 18*
Energy Conversion Factor:	29.3	GJ/tce	
Energy Conversion Factor:	0.0036	GJ/kWh	

Sources/Notes:

Efficiency Improvements in Coal Fired Boilers: Industrial

Coal Use (Fuel) by Industrial Subsector

Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	Total TJ/yr Boilers & Furnaces	
	Note 5			
Iron and Steel	47,069	60%	28,241	
Cement	32,188	100%	32,188	
Fertilizers	1,179	100%	1,179	*1*
Other Chemicals	986	100%	986	
Pulp and Paper	354	100%	354	
Other Metals	9,654	100%	9,654	
Other Minerals	3,810	100%	3,810	
Textiles	2,586	100%	2,586	
Non-specified Industry	16,447	100%	16,447	
Agricultural Processing	3,629	100%	3,629	
Military Manufacturing	223	100%	223	

TOTAL EST COAL USE IN BOILERS AND FURNACES	99,298	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	37.5%		*6, 19*
ESTIMATED POTENTIAL COAL SAVINGS	37,237	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	537	Yuan/(tce/yr)	7
Per Unit Upgrade Costs, Boilers and Furnaces	$ 7.60	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 282,918,981	($2019)	

Coal Use in Small/Medium Boilers and Furnaces:

(Assumes that essentially all coal use is in boilers and furnaces)

Sector/Subsector	Total TJ/yr	Fraction in Boilers & Furnaces	TJ/yr in Boilers & Furnaces	
	Note 5			
Residential/Urban	106,977	90%	96,279	*2*
Public/Commercial	17,085	100%	17,085	
Military Buildings	17,682	100%	17,682	

TOTAL EST COAL USE IN BOILERS AND FURNACES	131,046	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	23.0%		*8, 19*
ESTIMATED POTENTIAL COAL SAVINGS	30,141	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	300	Yuan/(tce/yr)	*8*
Per Unit Upgrade Costs, Boilers and Furnaces	$ 4.24	/(GJ/yr) ($2010)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 127,855,969	($2019)	
Fract. Savings Potential, Building Envelope Improvements:	21%		*12*
ESTIMATED POTENTIAL COAL SAVINGS	21,507	TJ/yr	
Per Unit Upgrade Costs, Building Envelope Improvements:	213	$/(tce/yr) ($2014)	*12*
Per Unit Upgrade Costs, Building Envelope Improvements:	$ 7.77	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 167,134,299	($2019)	

Coal Savings through Solar Water Heat

(Assumes that essentially all coal use is in boilers, furnaces, and rural heating stoves)

Sector/Subsector	Total TJ/yr	Fraction in Boilers, Stoves, and Furnaces	TJ/yr in Boilers, Stoves, and Furnaces
	Note 5		
Residential/Urban	106,977	90%	96,279
Residential/Rural	34,417	90%	30,975
Public/Commercial	17,085	100%	17,085
Military Buildings	17,682	100%	17,682

Estimated fraction of residential energy used for water heeating			
Water heat use per urban household, 1990, (delivered electricity equivalent)	1500	kWh	*Assumption*
Water heat use per rural household, 1990, (delivered electricity equivalent)	2000	kWh	*Assumption*
Average efficiency of coal use for water heating, all households	55%		*Assumption*
Implied GJ/yr coal use for water heat, urban households	9.82	per household	
Implied GJ/yr coal use for water heat, rural households	13.09	per household	
Implied fraction of coal use for water heating, urban households	18.6%		
Implied fraction of coal use for water heating, urban households	19.5%		
Fraction of coal use for water heating in non-residential buildings	10%		*Assumption*
Ultimate potential fraction of urban residential units using solar HW	35%		*Assumption*
Ultimate potential fraction of rural residential units using solar HW	50%		*Assumption*
Ultimate potential fraction of non-residential buildings using solar HW	50%		*Assumption*
Fraction of water heating coal use displaced in households and non-residential buildings using solar water heaters			
	80%		*Assumption*
Potential coal savings from solar water heat, residential/urban	5,019	TJ/yr	
Potential coal savings from solar water heat, residential/rural	2,414	TJ/yr	
Potential coal savings from solar water heat, public/commercial	683	TJ/yr	
Potential coal savings from solar water heat, military buildings	2,475	TJ/yr	
TOTAL of above	10,591	TJ/yr	
Estimated cost per household of solar water heater	$350	per unit	
(Based roughly on 2020 costs of solar water heaters in China from Alibaba.com)			
Implied capital cost per unit energy savings, residential units (urban)	$45	per GJ/yr ($2019)	
Assume capital costs for non-residential installations are	75%		
of residential costs per unit output, based on generally larger system size and associated economies of scale.			
Then capital cost per unit energy savings for non-residential units implied is	$33.42	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 105,900,591	($2019)	

Coal Use in Household cooking and heating stoves:

Residential/Rural Coal Use (TJ)	34,417	TJ/yr	
Residential/Urban Cooking Coal Use	10,698	TJ/yr	

TOTAL EST COAL USE IN DOMESTIC STOVES	45,114	TJ/yr	
Fractional Savings Potential, Domestic Stoves:	25.0%		*9*
ESTIMATED POTENTIAL COAL SAVINGS	11,279	TJ/yr	
Per Unit Upgrade Costs, Domestic Stoves	100	Yuan/(tce/yr)	*9*
Per Unit Upgrade Costs, Domestic Stoves	$ 1.41	per GJ/yr ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 15,947,919	($2019)	

Electricity Use by Industrial Subsector: Motors and Drives

Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Iron and Steel	2,956	50%	1,478
Cement	2,552	95%	2,424
Fertilizers	1,857	50%	928
Other Chemicals	801	50%	400
Pulp and Paper	103	95%	97
Other Metals	2,224	20%	445
Other Minerals	192	95%	183
Textiles	302	95%	287
Building Materials	48	95%	46
Non-specified Industry	1,960	80%	1,568
Transportation	3,661	95%	3,478
Agricultural Processing	615	95%	492
Military Manufacturing	24	80%	23

TOTAL EST ELECT USE, IND. MOTORS & DRIVES	11,849	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11, 19*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,777	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 136,366,995	($2019)	

Electricity Use in Other Sectors: Motors and Drives

Sector/Subsector	Total TJ/yr	Fraction in Motors & Drives	Total TJ/yr Motors & Drives
		Note 10	
Residential/Urban	5,796	10%	580
Public/Commercial	7,564	30%	2,269
Military Buildings	3,161	30%	948

TOTAL EST ELECT USE, NON-IND. MOTORS & DRIVES	3,797	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	570	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 76.72	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 43,696,700	($2019)	

Electricity Use: Lighting

Sector/Subsector	Total TJ/yr	Fraction in Lighting	Total TJ/yr Lighting
	Note 13		
Industrial (All)	10,180	5%	509
Transportation (All)	3,663	2.5%	92
Residential/Rural	610	50%	305
Residential/Urban	5,796	50%	2,898
Public/Commercial	7,564	50%	3,782
Military Buildings	3,161	50%	1,581

TOTAL EST ELECT USE, RESIDENTIAL LIGHTING	3,203	TJ/yr	
Fractional Savings Potential, Lighting Improvements (LED replacing incandescent)	85.0%		*14*
Fractional Savings Potential, Lighting Improvements (LED replacing fluorescent)	50.0%		
Fraction of households lamps already LEDs	40.0%	*Assumption*	
Fraction of remaining lamps that are incandescents	50.0%	*Assumption*	
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,297	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent	0.011	$/kWh	*14*
Per Unit Upgrade Costs, Residential Lighting	$ 20.32	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 26,353,820	($2019)	
TOTAL EST ELECT USE, NON-RESIDENTIAL LIGHTING	5,871	TJ/yr	
Fractional Savings Potential, Lighting Improvements	50.0%		*15*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	2,936	TJ/yr	
Per Unit Costs: LED Replacement of Incandescent and Fluorescent, controls, and other lighting efficiency upgrades.	0.025	$/kWh ($2019)	*15*
Per Unit Upgrade Costs, Non-Residential Lighting	$ 46.30	/(GJ/yr) ($2019)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 135,909,676	($2019)	

Petroleum Fuel Use: Medium-Sized Trucks

Fuel Use: Civilian Transport/Freight (gasoline trucks only)	1,334	TJ/yr	
Freight transported by gasoline trucks	1.97E+08	te-km	
Average tonne-km per vehicle/yr	15,000	te-km	*Rough Est.*
Implied number of 2.5 tonne trucks in use (civilian):	13,104		
Fuel Use: Military Trucks (2 1/2 tonne only)	2,796	TJ/yr	
Total number 2 1/2 tonne military trucks in active service	26,093		
Total number of 2.5 tonne trucks in service:	39,197		
Fraction of trucks to be replaced	45%		*22*
Fraction of energy use represented by trucks replaced	70%		*22*
Fractional energy savings by replacing trucks	43%		*16*
TOTAL ENERGY SAVED	1,254	TJ/yr	
Cost per truck to replace	$ 14,000		*17*
TOTAL COST OF NEW TRUCKS	$ 246,940,382	($2019)	

Estimate of Residential Electricity End-Uses (Fraction of Residential Electricity Used in Each Subsector)

End Use	Urban	Rural	
Lighting	50.0%	50.0%	As assumed above
Space and Water Heating	5.4%	1.3%	Assumption based roughly on 2008 Census results (***Note 21***)
Motors and Drives	10.0%	0.0%	Urban as assumed above
Air Conditioning	1.1%	0.0%	Rough assumption--urban elites only (***Note 20***)
Other End-uses	33.5%	48.7%	Remainder; rural roughly consistent with Unhari survey results.

Estimate of Agricultural Electricity End-Uses (Fraction of Agricultural Electricity Used in Each Subsector)

End Use	Field Operations	Processing/ Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of FIsheries Electricity End-Uses (Fraction of Fisheries Electricity Used in Each Subsector)

End Use	Large Ships	Collectives/Proce ssing/Other	
Lighting	0.0%	3.0%	Rough assumption
Other End Uses	0.0%	2.0%	Calculated by difference
Motors and Drives	100.0%	95.0%	Processing as assumed above

Estimate of Military Electricity End-Uses (Fraction of Military Electricity Used in Each Subsector)

End Use	Military Manu- facturing	Military Buildings and Other	
Lighting	5.0%	50.0%	As assumed above
Other End Uses	15.0%	20.0%	Calculated by difference
Motors and Drives	80.0%	30.0%	As assumed above

Estimate of Public/Commercial Electricity End-Uses (Fraction of Electricity Used in Sector)

End Use	Fraction			
Lighting	50.0%	As assumed above		
Other End Uses	10.0%	Calculated by difference		
Motors and Drives	20.0%	As assumed above, less	10%	assumed used in air conditioning/fans
Space and Water Heating	10.0%			
Air Conditioning	10.0%			

Sources/Notes:

1 *Total coal use shown here does not include coal used as a non-energy feedstock in carbide production.*

2 *Assumes 10 percent or less of urban coal use is burned in individual cooking stoves*

3 *1990 Value from Microsoft Encarta, 1994.*

4 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments. J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).*

5 *End-use fractions are rough assumptions*

6 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers & furnaces (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 50% to 65 or 70%, plus additional savings from other measures. 50% initial (existing boiler) efficiency estimate from document in authors' files [R1]. Savings fractions and costs for measures taken from China studies: M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211; D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China"; and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435. Note that the savings potential assumed here, 37.5%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").*

7 *Assumes (based on sources in 6) 8% increase in efficiency from microprocessor controls at investment of 1200 Y/tce-yr, 10% increase for insulation of piping (and similar furnace improvements) at 412 Y/tce-yr, and 12% increase for boiler and furnace rennovation at 200 Y/tce-yr. Although the values above come from a reference that is relatively old, a more recent reference by authors in China suggests that the costs of saved energy for energy efficiency measures applied to boilers in China based on more recent data may be similar. The article "Cost-effectiveness Analysis to Improve China's Coal-fired Industrial Boiler", by Manzhi Liu, Bo Shen, Yafeng Han, Lynn Price, and Mingchao Xu, Energy Procedia, 5 (2015), pp 1549 – 1554, available as doi: 10.1016/j.egypro.2015.07.330 , although it incorporates coal price as a factor in the calculation of the levelized cost of energy savings, lists measures (excluding fuel swicthing measures) that together can save on the order of 40 percent of initial coal use (Nautilus estimate) at an average weighted cost that appears to be a small fraction of the cost of coal in China, though it is difficult to determine an exact comparison of costs because the authors do not provide all of the underlying data for their calculations.*

8 *Assumes (based roughly on sources in 6) that a 15% efficiency increase with general boiler rennovations, starting from an average efficiency of 50%, is available for an investment of 250 Y/(tce/yr) (20 percent higher than value estimated for industrial boilers in Levine et al).*

9 *Various estimates place the efficiency of chinese coal stoves/heaters at anywhere from 20 to 50 percent. We have assumed that efficiency measures can increase the thermal efficiency of individual rural stove/heaters and urban stoves from ave. of 30% to 40%, for a 25% reduction in coal use. Doc. in authors' files [R1] cites an estimated DPRK residential coal-fired heating stove efficiency of 30%, and cooking stove efficiency of 20%. Efficiency investment of 100 Y/tce for domestic coal burning improvements from Levine et al (1992--see note 6). It is not clear exactly which measures these improvements include; likely candidates include coal briquetting and stove technology improvements.*

10 *Values are rough estimates. By way of comparison, 65 percent of the electricity used in the entire Chinese economy has been estimated to be consumed in electric motors (Sathaye, 1992).*

11 *Assumes (based on Chinese experience) that motors can be upgraded from an average efficiency of 75% to an efficiency of 88% (the latter is close to standard US motors) at a (per unit) cost of 0.1 Y/kWh. Costs and efficiency improvements from Sathaye, 1992. Note that other improvements such as variable speed electronic drives, improved valving and gearing, piping retrofits represent substantial additional savings potential. The 2011 UNIDO document* ***Energy efficiency in electric motor systems:Technology, saving potentials and policy options for developing countries*** *includes a number of examples of motor and drive effiiciency improvements in China, India, the EU, the US, and elsewhere that show payback periods on the order of two years or less, which would be consistent with (possibly less than) the costs shown in the older Sathaye document. The UNIDO document, (United Nations Industrial Development Organization) was authored by Tobias Fleiter and Wolfgang Eichhammer, and is available as https://open.unido.org/api/documents/4818324/download/Energy%20efficiency%20in%20electric%20motor%20systems%20-%20Technology,%20saving%20potentials%20and%20policy%20options%20for%20developing%20countries.*

12 *In our initial estimate, based on Chinese studies, assumes a 20% increase in thermal performance through two measures:* a 30mm perlite cement mortar coat on inside of walls plus double glazing. Costs based on estimated *Payback of 2-3 years and market coal price of 110Y/tce. Source: S. Lang et al, "Energy Conservation Standards for Spare Heating in Chinese Residential Buildings", 1992, LBL. Note that these two simple measures do not begin to exhaust the cost effective measures available for building shell improvements. Other estimates based on the Chinese situation show that 30 percent improvements in building energy efficiency are possible for a modest 5% increase in building costs. (Source: "An Overview of Energy Demand and Supply in China", F. Liu et al, 1992 (LBL).)*
A more recent (2014) study, "Marginal abatement cost and carbon reduction potential outlook of key energy efficiency technologies in China's building sector to 2030", by He Xiao, Qingpeng Wei, and Hailin Wang, ***Energy Policy*** *Volume 69, June 2014, Pages 92-105, available as https://doi.org/10.1016/j.enpol.2014.02.021, includes an analysis of 34 building energy improvement technologies that provide an aggregate* 17% savings in *primary energy use, a total of* 229 Mtce in 2030, and CO2e savings of 499.8 million tonnes by the same *year, at an average cost of* $ 19.50 per tonne CO2e. This implies a cost of saved energy of $ 42.56 *per tce. We expect that the cost per unit of saved energy for DPRK buildings will likely be lower, and savings higher, due to the likely better energy efficiency performance of average Chinese buildings versus average DPRK buildings, and lower labor rates in the DPRK. We assume that savings are* 25% higher than in this *example, and unit costs are* 25% lower. It is probable that an aggressive building energy efficiency program could *reduce DPRK building energy use much further over time (the same is likely true in China).*

13 *Rough estimates. For comparison, lighting comprises about 28% of household electricity use in Thailand, and 33% in the FSU, but in both cases use of household appliances, including cooling, refrigeration, and electric water and space heating, probably account for a larger fraction of energy use than in DPRK homes. Nautilus' 1998 rural energy survey suggested that lighting comprised over 50 percent of total electricity use in the households in one rural village.*

14 *Assumes that 50% of residential lighting energy is currently used in incandescent bulbs, that light-emitting diode (LED) bulbs save 85% of the energy of incandescent bulbs (and 50% of the energy of compact fluorescent bulbs (CFLs) or fluorescent tube lighting, and that LEDs can be used to replace incandescent or fluorescent bulbs for all existing residential incandescent or fluorescent bulb lighting use. An earlier version of this analysis used costs based on Sathaye, 1992, and based on setting up CFL factory in China at an investment cost of $5M to produces 3 million CFLs per year at roughly 6.9Y/unit. Extensive use of LEDs may require that DPRK the power grid be upgraded to reduce voltage fluctuations and improve power factors (or replaced by a series of mini-grids). An addendum to this earlier estimate is that the DPRK apparently has placed CFLs, reportedly made in the DPRK, in virtually all DPRK households during approximately 2005 - 2006. The DPRK reportedly deployed both imported bulbs, including bulbs made by Phillips, but over time have developed DPRK-based manufacturing. News of this program is based on a report provided by the DPRK delegation attending the 2006 "Asian Energy Security" workshop organized by Nautilus with EETC of Tsinghua University, Beijing (November, 2006).*
To estimate costs of saved energy for the current analysis, we assume two simple replacements: The first replaces a 40 W DPRK incandescent bulb with a 5 W LED bulb, with annual usage of 1000 *hours (about 3 hours daily). We assume a bulb cost of* $1, and a bulb lifetime of *20000* hours. Wholesale costs for similar bulbs made in China are shown on Alibaba.com at *$0.15 to $0.40 each, so we assume a retail cost of $1 per bulb is quite possible. Listed lifetimes for some bulbs are longer. With a (consumer) discount rate of* 12% annually, the annualized capital cost of the bulb, ignoring saved *O&M costs and the cost of the bulb being replaced, would be* $0.13 per year to save *35* kWh, for a levelized cost of saved energy (CSE) of $ 0.0038 per kWh. Similarly, *a 13 W LED tube lamp fixture (90 cm) replacing a 30 W fluorescent fixture is available on Alibaba for a cost of around $1.6 per fixture (which includes both the fixture and the lamp). Again assuming no credit for avoided O&M or existing bulbs/fixtures, and assuming a retail fixture cost in the DPRK of* $ 3.00 each, a lifetime of 20000 *hours, and annual usage of* 1500 hours per year, and a discount rate of 12% annually, the annualized capital cost of the fixture would be $0.46 per year to save 25.5 *kWh, or* $ 0.0181 per kWh. Averaging these two cases yields a CSE of $ 0.011 *per kWh, which we use as a rough estimate for residential lighting improvements. In practice, factoring in net savings in O&M costs and the value of avoided (base case) light bulb purchases, these costs are likely much lower, and probably negative.*

15 *In a 2015 American Council for an Energy-Efficient Economy (ACEEE) document,* ***New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030*** *, commercial lighting energy efficiency options are provided with costs on the order of 5 to 10 cents per kWh in the United States. It is highly likely that opportunities in the DPRK will be even more cost-effective, because buildings on average will start from a much lower base of efficiency, and because of the lower labor costs in the DPRK, although it is likely that lighting efficiency improvements will be accompanied by upgrades in the lumens provided as well. We assume an average of* $0.025 per kWh as an average cost of saved energy for lighting improvements *in the public/commercial, military, and industrial sectors in the DPRK. This is likely a substantial over-estimate, given the long lifetime of typical LED lighting bulbs and systems. ACEEE document prepared by Dan York, Steven Nadel, Ethan Rogers, Rachel Cluett, Sameer Kwatra, Harvey Sachs, Jennifer Amann, and Meegan Kelly, dated September 2015, Report Number U1507, and available as https://www.aceee.org/sites/default/files/publications/researchreports/u1507.pdf. This document includes an example with savings of 65 percent covering 68 percent of lighting end-uses. We assume average lighting energy savings of 50 percent.*

16 *Estimated based on our estimates for the fuel economy of 2 1/2 tonne trucks in the DPRK military and quoted estimate from US Isuzu truck vendor for average fuel economy of new 2 1/2 tonne Isuzu (diesel) truck (11 miles per gallon). Adjustment has been made for higher fuel energy content of diesel (vs. gasoline).*

17 *Approximate cost of new truck from China, including roughly estimated taxes and shipping costs. See, for example, the diesel "Dongfeng" trucks described on Alibaba here* https://www.alibaba.com/product-detail/4X2-wheel-drive-3-5-tons_60714507616.html?spm=a2700.7724838.2017115.93.28d138f2PRkKGF *and gasoline-fueled "FOTON" brand units here* https://www.alibaba.com/product-detail/New-China-5-ton-mini-truck_60642742600.html?spm=a2700.7724838.2017115.84.287b43a48AOfyp *But note that trucks come in many configurations, sizes, and thus costs.*

18 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

19 *The savings figures shown here may well be conservative (low) for DPRK conditions. In his presentation "Energy Efficiency Activities in the DPRK and Opportunities for Rationalization of Energy Use", prepared as prepared for the DPRK Energy Experts Working Group Meeting, June 26th and 27th, 2006, Palo Alto, CA, USA). Prof. Jan Jasiewicz notes the results of energy audits in industrial installations in the DPRK where potential savings were found to be between 15 and 60 percent, with payback times (presumably under market prices for energy commodities) of less than three years. Although a number of years have passed since then, we assume that many of the DPRK's boilers and furnaces have not been significantly updated, and thus the difference between the efficiencies of existing and modern units remain, on average, at about this level.*

20 *As a rough calculation, assume* 10000 elite households using a room air conditioner rated at *1.5* kW an average of 700 full-time hours per year. This would imply usage of *10500* MWh/yr or about 37800 GJ per year, or about 1.1% of estimated *DPRK urban electricity use in 2018.*

21 *The DPRK's 2008 Census lists the following data for fraction of households with electric space heating by type*

	Urban	Rural
Electronic heating system*	1.00%	0.22%
Electronic heating system with others*	1.27%	0.45%
Total Households	3,579,626	2,307,845

*Note: "Electronic" probably means "Electrical", likely mostly portable or fixed resistance heating devices.

If we assume the following about electric heating in each sector (average of both types of "electronic" heating)

	Urban	Rural	
Average Hours full-time equivalent use/yr	500	100	Rural especially limited by electricity supplies.
Average capacity (kW)	1.50	1.50	
Implied MWh/yr electricity use	60,730	2,304	
Fraction of estimated subsectoral MWh	5.40%	1.33%	

22 *Very rough estimate incorporating the observation that many trucks have been imported into the DPRK in recent years, but that many of the older 2.5 tonne trucks are doubtless still on the road. The assumption that these trucks to be replaced account for 70 percent of fuel use takes into account A) that many of the older trucks in the estimated truck fleet may be inoperable much of the time, and B) that new trucks have been increasingly used in recent years.*

Estimates of Cost and Savings of Selected Electricity Supply Measures

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: ELECTRICITY SUPPLY

Prepared By David Von Hippel
Date Last Modified: 7/3/2020

BASED ON YEAR 2018 ACTIVITIES

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.73		*Note 1*
Fraction of total investment represented by annualized CCE:	15%		*Note 2*
Inflator to convert 1990 costs to 2019 costs:	197%		*Note 10*
Energy Conversion Factor:	29.3	GJ/tce	
Energy Conversion Factor:	0.0036	GJ/kWh	

Sources/Notes:

Electricity Supply Improvements:

Coal and HFO Consumption in Electricity Generation Boilers	84,802	TJ/yr	
Fractional Savings Potential, Boilers:	30.0%		*3*
ESTIMATED POTENTIAL COAL/HFO SAVINGS	25,441	TJ/yr	
Per Unit Upgrade Costs, Boilers	537	Yuan/(tce/yr)	*3*
Per Unit Upgrade Costs, Boilers	$ 7.64	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Boilers	$ 194,316,248		

Own Use of electricity in Coal and HFO-Fired Power Plants	1,417	TJ/yr	
Potential reduction in "Own Use" in Coal/HFO-Fired Plants:	50.0%		*4*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	708	TJ/yr	
Per Unit Upgrade Costs, Plant Self-Use	0.12	Yuan/kWh	
Per Unit Upgrade Costs, Plant Self-Use	$ 92.55	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Self Use	$ 129,146,699		

Emergency Losses of electricity in Coal/HFO-Fired Power Plant	1,406	TJ/yr	
Potential red. in Emergency Losses in Coal-Fired Plants:	90%		*6*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,266	TJ/yr	
Per Unit Upgrade Costs, Reduction in Emergency Losses	0.075	Yuan/kWh	*6*
Per Unit Upgrade Costs, Reduction in Emergency Losses	$ 57.85	/(GJ/yr) ($2019)	
EST. ENERGY EFFICIENCY INVESTMENT: Emer. Losses	$ 73,215,450		

Transmission and Distribution Losses of Electricity	14,017	TJ/yr	*7*
Potential reduction in Transmission and Distribution Losses:	37.5%		*5*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	5,256	TJ/yr	
Per Unit Upgrade Costs, Electricity T&D	0.075	Yuan/kWh	*5*
Per Unit Upgrade Costs, Electricity T&D	$ 57.85	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: T&D	$ 304,050,030		

DPRK Wind Power Resource	???	MW	
Total Wind Power Generation Implemented, 2020 to 2030	500	MW	
Capacity factor of Wind generators	30%		*7*
Energy Produced by Wind Generators (year 10)	1,314	GWhe/yr	
Energy Produced by Wind Generators (year 10)	4,730	TJ/yr	
Installed Capital Cost of Wind Generators (per unit capacity)	$ 1,500	per kW ($2019)	*8*
Variable Operations and Maintenance Costs	$ 0.013	per KWhe	*9*
Total Capital Costs of installed Wind Generators	$ 750,000,000		
Capital Costs, Wind Power, per unit output	$ 159	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 17,082,000	per yr ($2019)	

DPRK Average Solar Power Resource	1,300	kWh/yr per kWp	*11*
Total Solar Power Generation Implemented, 2020 to 2030	500	MW	
Capacity factor of Wind generators	14.8%		
Energy Produced by Solar Generators (year 10)	650	GWhe/yr	
Energy Produced by Solar Generators (year 10)	2,340	TJ/yr	
Installed Capital Cost of Solar PV Systems (per unit capacity)	$ 1,000	per kW ($2019)	*12*
Operations and Maintenance Costs	$10	per KW/yr	*13*
Total Capital Costs of installed Solar PV Generators	$ 500,000,000		
Capital Costs, Solar Power, per unit output	$ 214	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 5,000,000	per yr ($2019)	

Sources/Notes:

1 *1990 Value from https://www.macrotrends.net/2575/us-dollar-yuan-exchange-rate-historical-chart.*

2 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments. J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).*

3 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 55-60% to 75-80%. Savings fractions and costs for measures taken from China studies on industrial boilers; we assume similar savings will be available for DPRK utility boilers (probably at a lower price, due to economies of scale). Sources: M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211; D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China"; and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435.*
Note that the savings potential assumed here, 30%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").

4 *Assumes Own use can be reduced from current (estimated) 9.0% to 4.5% of gross generation. Savings fraction range and cost range from Sathaye, 1992.*

5 *Assumes Transmission and Distribution losses can be reduced from current (reported) 16% to 10% of net generation. Savings fraction range and cost range from Sathaye, 1992.*
A chapter in the document ***Implementing EPA's Clean Power Plan: A Menu of Options****, by 4CleanAir.org, lists, in Chapter 10. "Reduce Losses in the Transmission and Distribution System", a payback time of as little as 2.4 years for transformer investments, even in the United States, to reduce T&D losses. This represents a cost of on the order of a few US cents or less per kWh on a levelized cost basis, and thus similar to the older costs quoted by Sathaye. Full document available as www.4cleanair.org/sites/default/files/Documents/NACAA_Menu_of_Options_HR.pdf. Dated May 2015, and authored by NACAA, the National Association of Clean Air Agencies (US).*

6 *Assumes that emergency losses can be nearly eliminated by plant and T&D improvements, and that measures to reduce emergency losses will be available at a cost per kWh saved similar to that for transmission and distribution improvements. In fact, reduction in emergency losses may occur as a result of boiler and T&D improvements even without any additional outlay.*

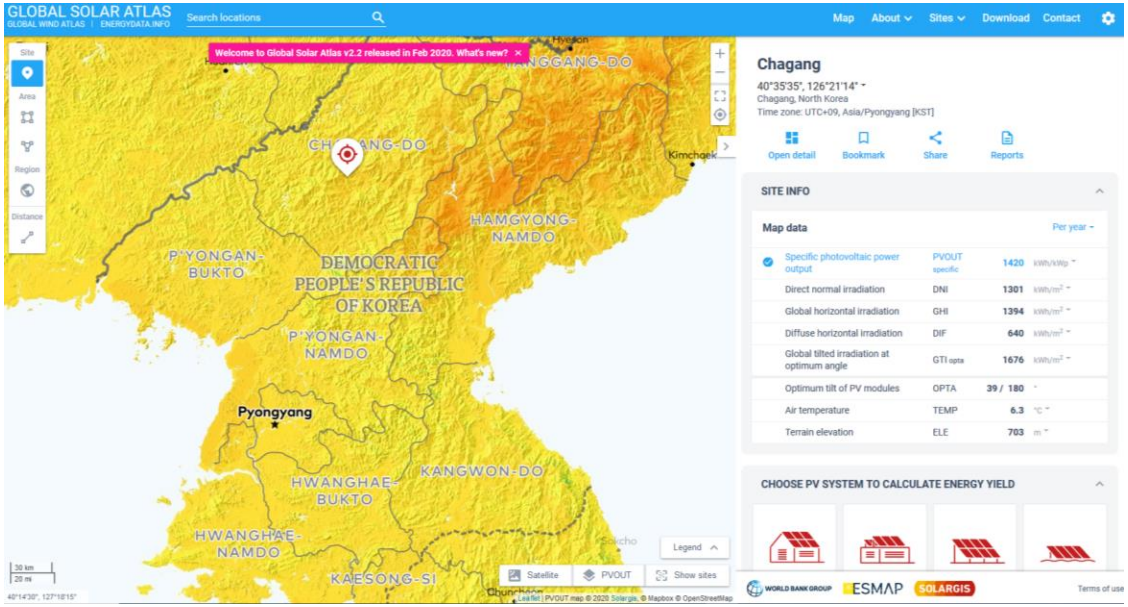
7 *Rough estimate. By way of comparison, Cavallo, Hock and Smith ("Wind Energy: Technology and Economics", in Renewable Energy, Sources for Fuels and Electricity, T.B. Johansson et al, 1993. Island Press, Washington, DC) cite capacity figures of 25 and 26.7 percent for California and Denmark, respectively. Wiser and Bolinger (2019--see reference in* ***Note 8****), indicate that capacity factors for wind turbines have been climbing in recent years, and have been in the range of 40 percent for recent installations. We assume a lower average value for DPRK installations based on the assumption that the number of high-quality resource areas for wind in the DPRK are relatively limited.*

8 *Assumes that wind machines can be produced in DPRK under license to an existing manufacturer, and/or can be imported from manufacturers in China (for example), at least as the program matures. For comparison, US installed wind power capacity costs in the 2009-2011 time frame was about $2000 per kW, with price quotes for equipment (uninstalled capacity) ranging from $900 to $1600 per kW. As most US wind power purchases were probably larger-capacity machines in recent years, and North Korean wind machines, for various reasons (including logistics of installation and grid-compatibility issues, among others) migth be smaller, this estimate could be either a bit high or low for the wind devices actually deployed in the DPRK. For figures on the US wind market, see, for example, 2010 Wind Technologies Market Report, primary authors Ryan Wiser and Mark Bolinger, Lawrence Berkeley National Laboratory, LBNL Report Number 4820e, dated June, 2011, and available* as http://www1.eere.energy.gov/wind/pdfs/51783.pdf. The 2018 version of this same report, dated August 2019 ***2018 Wind Technologies Market Report,*** *Report Number DOE/GO-102019-5191, is available as https://emp.lbl.gov/sites/default/files/wtmr_final_for_posting_8-9-19.pdf, lists US average installed costs at about $1500 per kW. In addition, as of 2020, a number of vendors listed in Alibaba.com offer wind turbines on the scale of about 500 kW to several MW at a costs on the order of $600 to $1000 per kW, which would also be* consistent with an installed cost of about $1500 per kW, although installation costs in the DPRK could be lower, *given likely lower labor costs, or higher, due to more difficult transportation and installation, depending on the location within the DPRK.*

9 *Rough estimate. Source above shows recent O&M costs in the US of about $9/MWhe, but for larger wind turbines than would likely be installed in the DPRK. Still, as O&M costs are labor-intensive as opposed to material-intensive, these costs may well be less in the DPRK.*

10 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

11 *A review of data for sites from around the DPRK from the Global Solar Atlas for "Specific photovoltaic power output" shows sites ranging from 1300 to 1600 annual kWh output per peak kW of photovoltaic panel capacity. We assume a value on the low end of this range to factor in sub-optimal siting in some instances or conversion or inverter losses, for example. The Global Solar Atlas is made available by the World Bank Group. See,*
for example, https://globalsolaratlas.info/map?c=39.690281,126.529541,8&s=40.672306,126.721802&m=site for a map and *date for a site in Chagang Province in the Northern part of the DPRK (also shown below)..*



12 *The International Renewable Energy Agency (IRENA) document RENEWABLE POWER GENERATION COSTS IN 2018, dated 2019 and available as https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf, provides show total installed cost for utility scale solar photovoltaic power of less than $1000 USD per kW in 2018, with recent trends showing costs falling rapidly. Alibaba.com, as of July, 2020, showed numerous vendors offering solar PV modules for as low as USD $200 per kW, so the estimate used here, $1000 per kW, may be high for even 2020..*

13 *The (US) National Renewable Energy Laboratory publication U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018, by Ran Fu, David Feldman, and Robert Margolis, Technical ReportNREL/TP-6A20-72399. dated November 2018, and available as https://www.nrel.gov/docs/fy19osti/72399.pdf, lists 2018 O&M costs for utility-scale solar PV systems at an average of $13 per kW/yr. These costs have been falling steadily; for example, 2010 costs were more than twice 2018 costs. DPRK labor costs will be lower than in the US, though some other costs may be higher. We assume* $10 *per kW-yr as an average O&M cost over 2020-2030.*

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Inflator to convert 1990 costs to 2019 costs:	197%		*Note 10*
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Energy Conversion Factor:	0.0036	GJ/kWh	

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Fractional Savings Potential, Boilers:	30.0%		*3*
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Per Unit Upgrade Costs, Boilers	537	Yuan/(tce/yr)	*3*
Per Unit Upgrade Costs, Boilers	$ 7.64	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Boilers	$ 194,350,348		

Own Use of electricity in Coal and HFO-Fired Power Plants	1,417	TJ/yr	
Potential reduction in "Own Use" in Coal/HFO-Fired Plants:	50.0%		*4*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	708	TJ/yr	
Per Unit Upgrade Costs, Plant Self-Use	0.12	Yuan/kWh	
Per Unit Upgrade Costs, Plant Self-Use	$ 92.55	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Self Use	$ 129,146,699		

Emergency Losses of electricity in Coal/HFO-Fired Power Plant	1,406	TJ/yr	
Potential red. in Emergency Losses in Coal-Fired Plants:	90%		*6*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,266	TJ/yr	
Per Unit Upgrade Costs, Reduction in Emergency Losses	0.075	Yuan/kWh	*6*
Per Unit Upgrade Costs, Reduction in Emergency Losses	$ 57.85	/(GJ/yr) ($2019)	
EST. ENERGY EFFICIENCY INVESTMENT: Emer. Losses	$ 73,215,450		

Transmission and Distribution Losses of Electricity	14,117	TJ/yr	*7*
Potential reduction in Transmission and Distribution Losses:	37.5%		*5*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	5,294	TJ/yr	
Per Unit Upgrade Costs, Electricity T&D	0.075	Yuan/kWh	*5*
Per Unit Upgrade Costs, Electricity T&D	$ 57.85	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: T&D	$ 306,223,829		

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Energy Produced by Wind Generators (year 10)	4,730	TJ/yr	
Installed Capital Cost of Wind Generators (per unit capacity)	$ 1,500	per kW ($2019)	*8*
Variable Operations and Maintenance Costs	$ 0.013	per KWhe	*9*
Total Capital Costs of installed Wind Generators	$ 750,000,000		
Capital Costs, Wind Power, per unit output	$ 159	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 17,082,000	per yr ($2019)	

DPRK Average Solar Power Resource	1,300	kWh/yr per kWp	*11*
Total Solar Power Generation Implemented, 2020 to 2030	500	MW	
Capacity factor of Wind generators	14.8%		
Energy Produced by Solar Generators (year 10)	650	GWhe/yr	
Energy Produced by Solar Generators (year 10)	2,340	TJ/yr	
Installed Capital Cost of Solar PV Systems (per unit capacity)	$ 1,000	per kW ($2019)	*12*
Operations and Maintenance Costs	$10	per KW/yr	*13*
Total Capital Costs of installed Solar PV Generators	$ 500,000,000		
Capital Costs, Solar Power, per unit output	$ 214	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 5,000,000	per yr ($2019)	

Sources/Notes:

1 *1990 Value from https://www.macrotrends.net/2575/us-dollar-yuan-exchange-rate-historical-chart.*

2 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments. J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).*

3 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 55-60% to 75-80%. Savings fractions and costs for measures taken from China studies on industrial boilers; we assume similar savings will be available for DPRK utility boilers (probably at a lower price, due to economies of scale). Sources: M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211; D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China"; and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435.*
Note that the savings potential assumed here, 30%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").

4 *Assumes Own use can be reduced from current (estimated) 9.0% to 4.5% of gross generation. Savings fraction range and cost range from Sathaye, 1992.*

5 *Assumes Transmission and Distribution losses can be reduced from current (reported) 16% to 10% of net generation. Savings fraction range and cost range from Sathaye, 1992.*
A chapter in the document ***Implementing EPA's Clean Power Plan: A Menu of Options****, by 4CleanAir.org, lists, in Chapter 10. "Reduce Losses in the Transmission and Distribution System", a payback time of as little as 2.4 years for transformer investments, even in the United States, to reduce T&D losses. This represents a cost of on the order of a few US cents or less per kWh on a levelized cost basis, and thus similar to the older costs quoted by Sathaye. Full document available as www.4cleanair.org/sites/default/files/Documents/NACAA_Menu_of_Options_HR.pdf. Dated May 2015, and authored by NACAA, the National Association of Clean Air Agencies (US).*

6 *Assumes that emergency losses can be nearly eliminated by plant and T&D improvements, and that measures to reduce emergency losses will be available at a cost per kWh saved similar to that for transmission and distribution improvements. In fact, reduction in emergency losses may occur as a result of boiler and T&D improvements even without any additional outlay.*

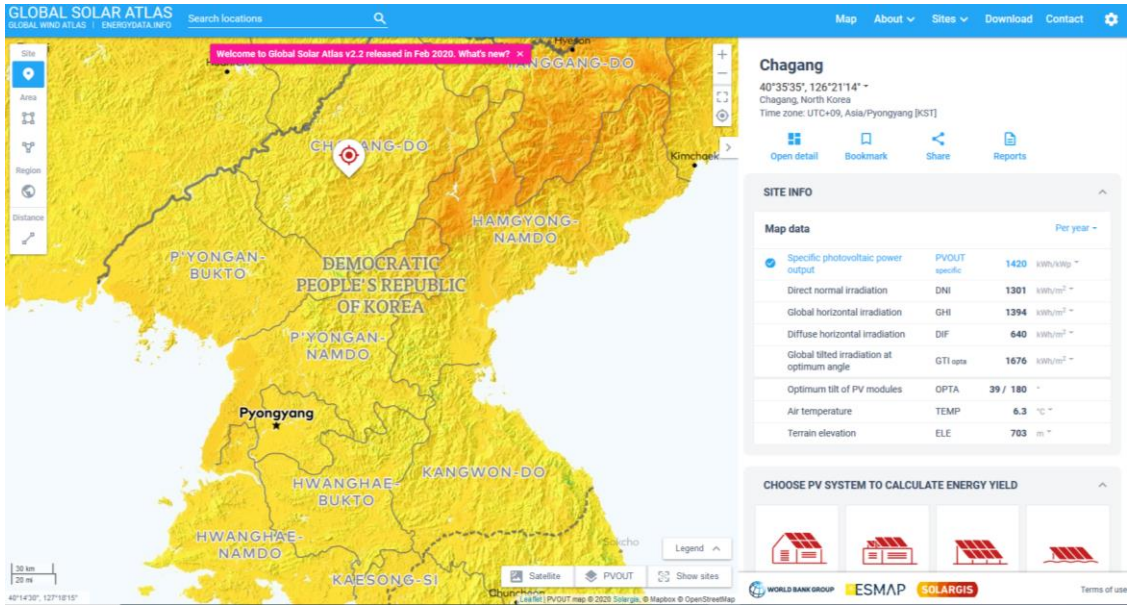
7 *Rough estimate. By way of comparison, Cavallo, Hock and Smith ("Wind Energy: Technology and Economics", in Renewable Energy, Sources for Fuels and Electricity, T.B. Johansson et al, 1993. Island Press, Washington, DC) cite capacity figures of 25 and 26.7 percent for California and Denmark, respectively. Wiser and Bolinger (2019--see reference in* ***Note 8****), indicate that capacity factors for wind turbines have been climbing in recent years, and have been in the range of 40 percent for recent installations. We assume a lower average value for DPRK installations based on the assumption that the number of high-quality resource areas for wind in the DPRK are relatively limited.*

8 *Assumes that wind machines can be produced in DPRK under license to an existing manufacturer, and/or can be imported from manufacturers in China (for example), at least as the program matures. For comparison, US installed wind power capacity costs in the 2009-2011 time frame was about $2000 per kW, with price quotes for equipment (uninstalled capacity) ranging from $900 to $1600 per kW. As most US wind power purchases were probably larger-capacity machines in recent years, and North Korean wind machines, for various reasons (including logistics of installation and grid-compatibility issues, among others) migth be smaller, this estimate could be either a bit high or low for the wind devices actually deployed in the DPRK. For figures on the US wind market, see, for example, 2010 Wind Technologies Market Report, primary authors Ryan Wiser and Mark Bolinger, Lawrence Berkeley National Laboratory, LBNL Report Number 4820e, dated June, 2011, and available* as http://www1.eere.energy.gov/wind/pdfs/51783.pdf. The 2018 version of this same report, dated August 2019 ***2018 Wind Technologies Market Report,*** *Report Number DOE/GO-102019-5191, is available as https://emp.lbl.gov/sites/default/files/wtmr_final_for_posting_8-9-19.pdf, lists US average installed costs at about $1500 per kW. In addition, as of 2020, a number of vendors listed in Alibaba.com offer wind turbines on the scale of about 500 kW to several MW at a costs on the order of $600 to $1000 per kW, which would also be* consistent with an installed cost of about $1500 per kW, although installation costs in the DPRK could be lower, *given likely lower labor costs, or higher, due to more difficult transportation and installation, depending on the location within the DPRK.*

9 *Rough estimate. Source above shows recent O&M costs in the US of about $9/MWhe, but for larger wind turbines than would likely be installed in the DPRK. Still, as O&M costs are labor-intensive as opposed to material-intensive, these costs may well be less in the DPRK.*

10 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

11 *A review of data for sites from around the DPRK from the Global Solar Atlas for "Specific photovoltaic power output" shows sites ranging from 1300 to 1600 annual kWh output per peak kW of photovoltaic panel capacity. We assume a value on the low end of this range to factor in sub-optimal siting in some instances or conversion or inverter losses, for example. The Global Solar Atlas is made available by the World Bank Group. See,*
for example, https://globalsolaratlas.info/map?c=39.690281,126.529541,8&s=40.672306,126.721802&m=site for a map and *date for a site in Chagang Province in the Northern part of the DPRK (also shown below)..*



12 *The International Renewable Energy Agency (IRENA) document RENEWABLE POWER GENERATION COSTS IN 2018, dated 2019 and available as https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf, provides show total installed cost for utility scale solar photovoltaic power of less than $1000 USD per kW in 2018, with recent trends showing costs falling rapidly. Alibaba.com, as of July, 2020, showed numerous vendors offering solar PV modules for as low as USD $200 per kW, so the estimate used here, $1000 per kW, may be high for even 2020..*

13 *The (US) National Renewable Energy Laboratory publication U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018, by Ran Fu, David Feldman, and Robert Margolis, Technical ReportNREL/TP-6A20-72399. dated November 2018, and available as https://www.nrel.gov/docs/fy19osti/72399.pdf, lists 2018 O&M costs for utility-scale solar PV systems at an average of $13 per kW/yr. These costs have been falling steadily; for example, 2010 costs were more than twice 2018 costs. DPRK labor costs will be lower than in the US, though some other costs may be higher. We assume* $10 *per kW-yr as an average O&M cost over 2020-2030.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: ELECTRICITY SUPPLY

Prepared By David Von Hippel
Date Last Modified: 7/3/2020

BASED ON YEAR 2020 ACTIVITIES

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.73		*Note 1*
Fraction of total investment represented by annualized CCE:	15%		*Note 2*
Inflator to convert 1990 costs to 2019 costs:	197%		*Note 10*
Energy Conversion Factor:	29.3	GJ/tce	
Energy Conversion Factor:	0.0036	GJ/kWh	

Sources/Notes:

Electricity Supply Improvements:

Coal and HFO Consumption in Electricity Generation Boilers	54,739	TJ/yr	
Fractional Savings Potential, Boilers:	30.0%		*3*
ESTIMATED POTENTIAL COAL/HFO SAVINGS	16,422	TJ/yr	
Per Unit Upgrade Costs, Boilers	537	Yuan/(tce/yr)	*3*
Per Unit Upgrade Costs, Boilers	$ 7.64	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Boilers	$ 125,429,619		

Own Use of electricity in Coal and HFO-Fired Power Plants	845	TJ/yr	
Potential reduction in "Own Use" in Coal/HFO-Fired Plants:	50.0%		*4*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	423	TJ/yr	
Per Unit Upgrade Costs, Plant Self-Use	0.12	Yuan/kWh	
Per Unit Upgrade Costs, Plant Self-Use	$ 92.55	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Self Use	$ 77,071,558		

Emergency Losses of electricity in Coal/HFO-Fired Power Plant	835	TJ/yr	
Potential red. in Emergency Losses in Coal-Fired Plants:	90%		*6*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	752	TJ/yr	
Per Unit Upgrade Costs, Reduction in Emergency Losses	0.075	Yuan/kWh	*6*
Per Unit Upgrade Costs, Reduction in Emergency Losses	$ 57.85	/(GJ/yr) ($2019)	
EST. ENERGY EFFICIENCY INVESTMENT: Emer. Losses	$ 43,477,108		

Transmission and Distribution Losses of Electricity	12,745	TJ/yr	*7*
Potential reduction in Transmission and Distribution Losses:	37.5%		*5*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	4,779	TJ/yr	
Per Unit Upgrade Costs, Electricity T&D	0.075	Yuan/kWh	*5*
Per Unit Upgrade Costs, Electricity T&D	$ 57.85	/(GJ/yr) ($2019)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: T&D	$ 276,469,554		

DPRK Wind Power Resource	???	MW	
Total Wind Power Generation Implemented, 2020 to 2030	500	MW	
Capacity factor of Wind generators	30%		*7*
Energy Produced by Wind Generators (year 10)	1,314	GWhe/yr	
Energy Produced by Wind Generators (year 10)	4,730	TJ/yr	
Installed Capital Cost of Wind Generators (per unit capacity)	$ 1,500	per kW ($2019)	*8*
Variable Operations and Maintenance Costs	$ 0.013	per KWhe	*9*
Total Capital Costs of installed Wind Generators	$ 750,000,000		
Capital Costs, Wind Power, per unit output	$ 159	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 17,082,000	per yr ($2019)	

DPRK Average Solar Power Resource	1,300	kWh/yr per kWp	*11*
Total Solar Power Generation Implemented, 2020 to 2030	500	MW	
Capacity factor of Wind generators	14.8%		
Energy Produced by Solar Generators (year 10)	650	GWhe/yr	
Energy Produced by Solar Generators (year 10)	2,340	TJ/yr	
Installed Capital Cost of Solar PV Systems (per unit capacity)	$ 1,000	per kW ($2019)	*12*
Operations and Maintenance Costs	$10	per KW/yr	*13*
Total Capital Costs of installed Solar PV Generators	$ 500,000,000		
Capital Costs, Solar Power, per unit output	$ 214	/(GJ/yr) ($2019)	
Total of Other Generation Costs (year 10)	$ 5,000,000	per yr ($2019)	

Sources/Notes:

1 *1990 Value from https://www.macrotrends.net/2575/us-dollar-yuan-exchange-rate-historical-chart.*

2 *Assumes 12 percent discount rate and average 15 year lifetime for energy efficiency investments. J. Sathaye (1992), "Economics of Improving Efficiency of China's Electricity Supply and Use: Are Efficiency Investments Cost-effective?" (LBL--In draft form as of May 1992).*

3 *Assumes the following measures: Microcomputer control (8% increase in efficiency), insulation of piping (responsible for heat loss equal to 10% of energy use), and rennovation of boilers (10 -15% increase in efficiency). Overall, assumes increase in average boiler energy efficiency from 55-60% to 75-80%. Savings fractions and costs for measures taken from China studies on industrial boilers; we assume similar savings will be available for DPRK utility boilers (probably at a lower price, due to economies of scale). Sources: M.Levine, L.Xueyi, "Energy Conservation Programs in the PRC", Aug, 1990, LBL-29211; D. Yande, "An Analysis of the Potential in Investment-Cum-Energy Conservation in Chemical Industry in China"; and Levine et al, "China's Energy System: Historical Evolution, Current Issues, and Prospects", Ann. Rev Energy Environ., 1992, 17:405-435.*
Note that the savings potential assumed here, 30%, comports with the estimate (UN document) that the conservation potential in DPRK is 30 to 50% (and further, up to 20% can be saved at "little or no cost").

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7 *Rough estimate. By way of comparison, Cavallo, Hock and Smith ("Wind Energy: Technology and Economics", in Renewable Energy, Sources for Fuels and Electricity, T.B. Johansson et al, 1993. Island Press, Washington, DC) cite capacity figures of 25 and 26.7 percent for California and Denmark, respectively. Wiser and Bolinger (2019--see reference in* ***Note 8****), indicate that capacity factors for wind turbines have been climbing in recent years, and have been in the range of 40 percent for recent installations. We assume a lower average value for DPRK installations based on the assumption that the number of high-quality resource areas for wind in the DPRK are relatively limited.*

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10 *See, for example, "Inflation Calculator" on http://data.bls.gov/cgi-bin/cpicalc.pl.*

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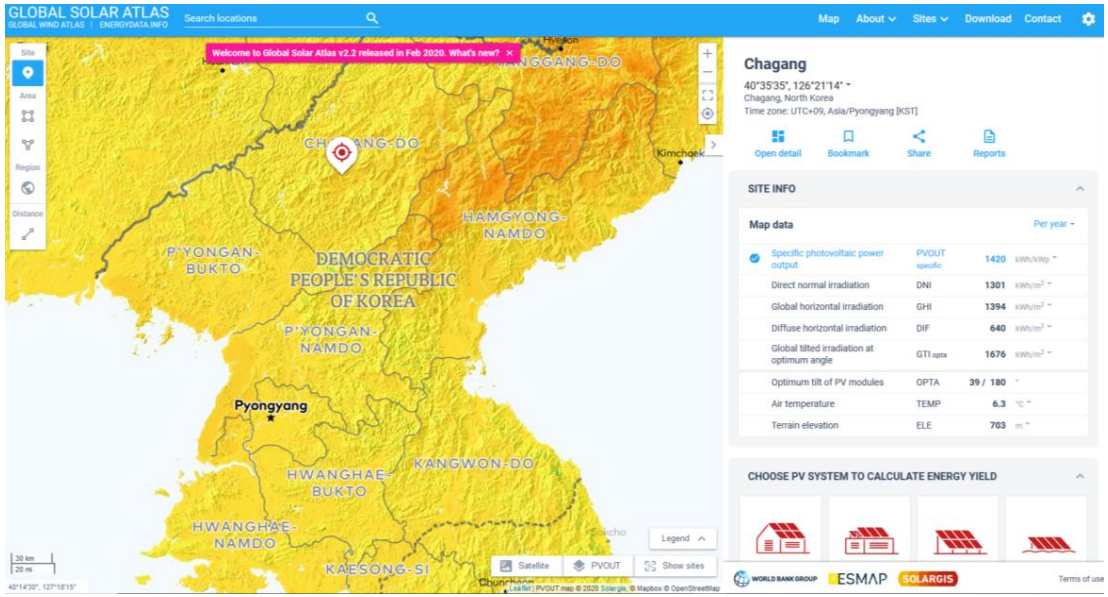

12 *The International Renewable Energy Agency (IRENA) document RENEWABLE POWER GENERATION COSTS IN 2018, dated 2019 and available as https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf, provides show total installed cost for utility scale solar photovoltaic power of less than $1000 USD per kW in 2018, with recent trends showing costs falling rapidly. Alibaba.com, as of July, 2020, showed numerous vendors offering solar PV modules for as low as USD $200 per kW, so the estimate used here, $1000 per kW, may be high for even 2020..*

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$10

Summary of Energy Efficiency and Electricity Supply Measure Results

2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: SUMMARY

Prepared By David Von Hippel
Date Last Modified: 7/8/2020

BASED ON YEAR 2018 ACTIVITIES

Inflator for 2010 to 2019 (*Note 1*):	1.180

MEASURES TO SAVE COAL:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Boiler and Furnace Improvements	45,725		$ 409,946,754
Residential and Public/Commercial/Military Boiler Impr.	31,633		$ 158,341,807
Building Envelope Improvements	22,572		$ 206,985,618
Solar Water Heating	11,387		$ 140,461,810
Domestic Stove/Heater Improvements	10,944		$ 18,260,306
Electric Utility Boiler Improvements	25,441		$ 229,293,173
TOTALS	147,702	TJ/yr	$ 1,163,289,468
Avoided Losses of Coal During Transport:	1,477.02	TJ/yr	
TOTAL COAL SUPPLY SAVINGS	149,179	TJ/yr	
Fraction of 2010 Total Coal Supply	38.9%		
Investment required, $ per GJ/yr of Coal Supply Savings			**$ 7.80**
Investment required, $ per tce/yr of Coal Supply Savings			**$ 228**

MEASURES TO SAVE/GENERATE ELECTRICITY:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Motors and Drives	1,787		$ 161,798,709
Motors and Drives in other Sectors	644		$ 58,299,963
Residential Lighting	777		$ 18,623,731
Non-residential Lighting	3,612		$ 197,344,383
Own Use reduction in Power Plants	708		$ 152,393,105
Reduction of Emergency Use in Power Plants	1,266		$ 86,394,231
Transmission and Distribution Improvements	5,256		$ 358,779,035
Wind-powered Electricity Generation	4,730		$ 750,000,000
Solar-powered Electricity Generation	2,340		$ 500,000,000
TOTALS	21,121	TJ/yr	$ 2,283,633,156
Additional Avoided T&D Losses (based on 2010 Rates)	1,891	TJ/yr	
TOTAL ELECTRICITY SUPPLY SAVINGS/GENERATION	23,012	TJ/yr	
Fraction of 2018 Total Electricity Generation	41.1%		
Investment required, $ per GJ/yr of Electricity Supply Savings/Generation			**$ 99.24**
Investment required, $ per MWh/yr of Electricity Supply Savings/Generation			**$ 357**

MEASURE TO SAVE PETROLEUM PRODUCTS:

Measure	Estimated Energy Energy Savings Potential, TJ/yr	Total Estimated Investment Cost, $US 2010
Improvements in 2 1/2 tonne truck fleet	1,911	442,880,326
Fraction of 2018 Total Refined Products Use	6.3%	
Fract. of 2018 Total Refined Prod. Use in Road Transport	23.9%	
Investment required, $ per GJ/yr of refined products Savings		**$ 231.80**
Investment required, $ per toe/yr of petroleum products Savings		**$ 9,699**

ESTIMATED EMISSIONS REDUCTION (Rough Calculations)

	Sulfur Oxides (tonnes)	Nitrogen Oxides (tonnes)	Carbon Dioxide (tonnes)
MEASURES TO SAVE COAL	81,518	50,782	12,751,951
MEASURES TO SAVE ELECTRICITY	19,291	12,573	3,206,623

Sources/Notes:

1 *From https://www.bls.gov/data/inflation_calculator.htm but not used--costs already updated to 2019 USD in efficiency estimates worksheets.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

BACK-UP CALCULATIONS AND DATA: POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: SUMMARY

Prepared By David Von Hippel

Date Last Modified: 7/8/2020

BASED ON YEAR 2019 ACTIVITIES

Inflator for 2010 to 2019 (*Note 1*):	1.180

MEASURES TO SAVE COAL:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Boiler and Furnace Improvements	45,526		$ 408,164,600
Residential and Public/Commercial/Military Boiler Impr.	32,095		$ 160,654,656
Building Envelope Improvements	22,902		$ 210,008,992
Solar Water Heating	11,560		$ 142,307,337
Domestic Stove/Heater Improvements	11,109		$ 18,536,092
Electric Utility Boiler Improvements	25,445		$ 229,333,411
TOTALS	148,638	TJ/yr	$ 1,169,005,088
Avoided Losses of Coal During Transport:	1,486.38	TJ/yr	
TOTAL COAL SUPPLY SAVINGS	150,124	TJ/yr	
Fraction of 2010 Total Coal Supply	39.1%		
Investment required, $ per GJ/yr of Coal Supply Savings			**$ 7.79**
Investment required, $ per tce/yr of Coal Supply Savings			**$ 228**

MEASURES TO SAVE/GENERATE ELECTRICITY:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Motors and Drives	1,777		$ 160,913,054
Motors and Drives in other Sectors	643		$ 58,193,405
Residential Lighting	741		$ 17,759,933
Non-residential Lighting	3,620		$ 197,774,930
Own Use reduction in Power Plants	708		$ 152,393,105
Reduction of Emergency Use in Power Plants	1,266		$ 86,394,231
Transmission and Distribution Improvements	5,294		$ 361,344,118
Wind-powered Electricity Generation	4,730		$ 750,000,000
Solar-powered Electricity Generation	2,340		$ 500,000,000
TOTALS	21,120	TJ/yr	$ 2,284,772,776
Additional Avoided T&D Losses (based on 2010 Rates)	1,880	TJ/yr	
TOTAL ELECTRICITY SUPPLY SAVINGS/GENERATION	22,999	TJ/yr	
Fraction of 2018 Total Electricity Generation	41.1%		
Investment required, $ per GJ/yr of Electricity Supply Savings/Generation			**$ 99.34**
Investment required, $ per MWh/yr of Electricity Supply Savings/Generation			**$ 358**

MEASURE TO SAVE PETROLEUM PRODUCTS:

Measure	Estimated Energy Energy Savings Potential, TJ/yr	Total Estimated Investment Cost, $US 2019
Improvements in 2 1/2 tonne truck fleet	1,889	437,594,151
Fraction of 2018 Total Refined Products Use	6.2%	
Fract. of 2018 Total Refined Prod. Use in Road Transport	23.6%	
Investment required, $ per GJ/yr of refined products Savings		**$ 231.67**
Investment required, $ per toe/yr of petroleum products Savings		**$ 9,693**

ESTIMATED EMISSIONS REDUCTION (Rough Calculations)

	Sulfur Oxides (tonnes)	Nitrogen Oxides (tonnes)	Carbon Dioxide (tonnes)
MEASURES TO SAVE COAL	82,545	51,422	12,912,234
MEASURES TO SAVE ELECTRICITY	19,338	12,658	3,232,461

Sources/Notes:

1 *From https://www.bls.gov/data/inflation_calculator.htm but not used--costs already updated to 2019 USD in efficiency estimates worksheets.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
BACK-UP CALCULATIONS AND DATA:
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Prepared By David Von Hippel
Date Last Modified: 7/8/2020

BASED ON YEAR 2020 ACTIVITIES

Inflator for 2010 to 2019 (*Note 1*):	1.180

MEASURES TO SAVE COAL:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Boiler and Furnace Improvements	37,237		$ 333,844,398
Residential and Public/Commercial/Military Boiler Impr.	30,141		$ 150,870,044
Building Envelope Improvements	21,507		$ 197,218,473
Solar Water Heating	10,591		$ 105,900,591
Domestic Stove/Heater Improvements	11,279		$ 18,818,545
Electric Utility Boiler Improvements	16,422		$ 148,006,950
TOTALS	127,176	TJ/yr	$ 954,659,001
Avoided Losses of Coal During Transport:	1,271.76	TJ/yr	
TOTAL COAL SUPPLY SAVINGS	128,448	TJ/yr	
Fraction of 2010 Total Coal Supply	33.5%		
Investment required, $ per GJ/yr of Coal Supply Savings			**$ 7.43**
Investment required, $ per tce/yr of Coal Supply Savings			**$ 218**

MEASURES TO SAVE/GENERATE ELECTRICITY:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2019
Industrial Motors and Drives	1,777		$ 160,913,054
Motors and Drives in other Sectors	570		$ 51,562,106
Residential Lighting	1,297		$ 31,097,507
Non-residential Lighting	2,936		$ 160,373,417
Own Use reduction in Power Plants	423		$ 90,944,438
Reduction of Emergency Use in Power Plants	752		$ 51,302,988
Transmission and Distribution Improvements	4,779		$ 326,234,074
Wind-powered Electricity Generation	4,730		$ 750,000,000
Solar-powered Electricity Generation	2,340		$ 500,000,000
TOTALS	19,604	TJ/yr	$ 2,122,427,584
Additional Avoided T&D Losses (based on 2010 Rates)	1,824	TJ/yr	
TOTAL ELECTRICITY SUPPLY SAVINGS/GENERATION	21,428	TJ/yr	
Fraction of 2018 Total Electricity Generation	38.3%		
Investment required, $ per GJ/yr of Electricity Supply Savings/Generation			**$ 99.05**
Investment required, $ per MWh/yr of Electricity Supply Savings/Generation			**$ 357**

MEASURE TO SAVE PETROLEUM PRODUCTS:

Measure	Estimated Energy Energy Savings Potential, TJ/yr	Total Estimated Investment Cost, $US 2019
Improvements in 2 1/2 tonne truck fleet	1,254	291,389,650
Fraction of 2020 Total Refined Products Use	5.2%	
Fract. of 2020 Total Refined Prod. Use in Road Transport	20.5%	
Investment required, $ per GJ/yr of refined products Savings		**$ 232.35**
Investment required, $ per toe/yr of petroleum products Savings		**$ 9,721**

ESTIMATED EMISSIONS REDUCTION (Rough Calculations)

	Sulfur Oxides (tonnes)	Nitrogen Oxides (tonnes)	Carbon Dioxide (tonnes)
MEASURES TO SAVE COAL	62,839	39,146	9,834,094
MEASURES TO SAVE ELECTRICITY	11,142	7,419	1,916,890

Sources/Notes:

1 *From https://www.bls.gov/data/inflation_calculator.htm but not used--costs already updated to 2019 USD in efficiency estimates worksheets.*

Estimates of Acid Gas and Greenhouse Gas Emissions

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 1990

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.08	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.001867	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.299	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	1990				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**1.25E+08**	**1.00E+07**	**0.00E+00**	**0.00E+00**	**1.35E+08**
Methane from Combustion	**2.20E+03**	**1.32E+03**	**2.18E+03**	**5.55E+00**	**5.70E+03**
Methane from Production	**7.18E+05**	**0.00E+00**	**0.00E+00**	**2.50E+02**	**7.18E+05**
Nitrous Oxide from Combustion	**5.83E+03**	**4.61E+02**	**9.52E+02**	**6.94E+01**	**7.31E+03**
Sulfur Oxides from Combustion	**7.91E+05**	**3.94E+04**	**0.00E+00**	**0.00E+00**	**8.31E+05**
Nitrogen Oxides from Combustion	**4.93E+05**	**3.15E+04**	**1.65E+04**	**1.20E+03**	**5.42E+05**

Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**1.35E+08**	**7.24E+05**	**7.31E+03**	**8.31E+05**	**5.42E+05**
ENERGY SUPPLY	0.00E+00	7.18E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	6.95E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	2.35E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	3.65E+07	1.14E+03	1.77E+03	2.29E+05	1.45E+05
Electricity Generation	2.97E+07	7.21E+02	1.40E+03	1.87E+05	1.17E+05
Coal Prod./Prep.	6.01E+06	1.07E+02	2.84E+02	3.85E+04	2.40E+04
Charcoal Production	0.00E+00	2.50E+02	4.86E+01	0.00E+00	8.40E+02
District Heat Production	3.31E+05	6.54E+00	1.56E+01	2.11E+03	1.32E+03
Own Use	4.36E+05	5.96E+01	2.09E+01	1.78E+03	1.42E+03
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	9.84E+07	4.81E+03	5.54E+03	6.02E+05	3.97E+05
INDUSTRIAL	6.61E+07	1.45E+03	3.13E+03	4.19E+05	2.63E+05
TRANSPORT	2.77E+06	4.06E+02	1.44E+02	1.13E+04	9.26E+03
RESIDENTIAL	1.85E+07	1.77E+03	1.50E+03	1.18E+05	8.44E+04
AGRICULTURAL	1.30E+06	7.86E+02	3.76E+02	7.45E+03	1.03E+04
FISHERIES	3.37E+05	3.33E+01	1.61E+01	1.63E+03	1.18E+03
MILITARY	4.05E+06	2.16E+02	1.92E+02	2.32E+04	1.53E+04
PUBLIC/COMML	3.12E+06	8.26E+01	1.59E+02	2.00E+04	1.26E+04
NON-SPECIFIED	4.35E+05	5.95E+01	2.08E+01	1.78E+03	1.42E+03
NON-ENERGY	1.73E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SO_x, CO_2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SO_x emission factor for petroleum products estimated as shown below. SO_x emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SO_x. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (SO_x, NO_x, and CO_2) in Asia. NISTEP Report No. 21, page 37.*

6 *NO_x emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NO_x factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NO_x factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NO_x emission factors for petroleum products were assumed to be 10 kg/te. NO_x emission factors vary considerably by fuel type and usage (NO_x from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF AGGREGATE SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	731	1.07	782	0.12
Diesel	772	1.035	799	0.4
Heavy Oil	1,069	0.96	1026	1.5
Kerosene/Jet Fuel	263	1.045	275	0.032
LPG	276	1.13	312	0.00016
Aviation Gasoline	26	1.07	28	0.04
Weighted Average: Sulfur content in kg/GJ				**0.150**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.299**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	1,325,571	26,622	162,092	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.18E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	1,301,288		149,909						6.95E+05			
Imports	68,392	26,622	12,183									
Exports	44,108								2.35E+04			
Inputs to International Marine Bunkers												
Stock Changes												
ENERGY TRANSFORMATION	(377,571)	82,762	(9,920)	2,976	3.45E+07	2.04E+06	0.00E+00	0.00E+00	6.14E+02	2.80E+02	0.00E+00	2.50E+02
Electricity Generation	(294,926)	(21,947)			2.81E+07	1.60E+06	0.00E+00	0.00E+00	5.01E+02	2.19E+02	0.00E+00	0.00E+00
Petroleum Refining	-	110,742				-2.13E-09				-2.91E-13		
Coal Production/Preparation	(63,092)				6.01E+06				1.07E+02			
Charcoal Production			(9,920)	2,976								2.50E+02
Coke Production												
District Heat Production	(3,417)	(73)			3.26E+05	5.36E+03	0.00E+00	0.00E+00	5.81E+00	7.33E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(5,960)			0.00E+00	4.36E+05	0.00E+00	0.00E+00	0.00E+00	5.96E+01	0.00E+00	0.00E+00
Losses	(16,136)											
FUELS FOR FINAL CONSUMPTION	948,000	109,384	152,172	2,976								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	948,009	109,384	147,995	2,973	9.04E+07	7.99E+06	0.00E+00	0.00E+00	1.59E+03	1.04E+03	2.18E+03	5.55E+00
INDUSTRIAL SECTOR	671,661	28,393	1,600	-	6.40E+07	2.08E+06	0.00E+00	0.00E+00	1.14E+03	2.84E+02	2.56E+01	0.00E+00
Iron and Steel	324,615	-			3.09E+07	0.00E+00	0.00E+00	0.00E+00	5.52E+02	0.00E+00	0.00E+00	0.00E+00
Cement	68,139	7,571			6.50E+06	5.53E+05	0.00E+00	0.00E+00	1.16E+02	7.57E+01	0.00E+00	0.00E+00
Fertilizers	23,994	4,573			2.29E+06	3.34E+05	0.00E+00	0.00E+00	4.08E+01	4.57E+01	0.00E+00	0.00E+00
Other Chemicals	11,203	-			1.07E+06	0.00E+00	0.00E+00	0.00E+00	1.90E+01	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	4,026	-			3.84E+05	0.00E+00	0.00E+00	0.00E+00	6.84E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	23,720	-			2.26E+06	0.00E+00	0.00E+00	0.00E+00	4.03E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	-	12,600			0.00E+00	9.21E+05	0.00E+00	0.00E+00	0.00E+00	1.26E+02	0.00E+00	0.00E+00
Textiles	29,385	-			2.80E+06	0.00E+00	0.00E+00	0.00E+00	5.00E+01	0.00E+00	0.00E+00	0.00E+00
Building Materials	61,980	-			5.91E+06	0.00E+00	0.00E+00	0.00E+00	1.05E+02	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	124,600	3,650	1,600		1.19E+07	2.67E+05	0.00E+00	0.00E+00	2.12E+02	3.65E+01	2.56E+01	0.00E+00
TRANSPORT SECTOR	-	37,896	1,672	-	0.00E+00	2.77E+06	0.00E+00	0.00E+00	0.00E+00	3.79E+02	2.68E+01	0.00E+00
Road		32,571	1,672		0.00E+00	2.38E+06	0.00E+00	0.00E+00	0.00E+00	3.26E+02	2.68E+01	0.00E+00
Rail	-	1,949			0.00E+00	1.42E+05	0.00E+00	0.00E+00	0.00E+00	1.95E+01	0.00E+00	0.00E+00
Water	-	1,253			0.00E+00	9.16E+04	0.00E+00	0.00E+00	0.00E+00	1.25E+01	0.00E+00	0.00E+00
Air		1,123			0.00E+00	8.21E+04	0.00E+00	0.00E+00	0.00E+00	1.12E+01	0.00E+00	0.00E+00
Non-Specified		1,000			0.00E+00	7.31E+04	0.00E+00	0.00E+00	0.00E+00	1.00E+01	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	189,274	6,600	86,140	2,973	1.80E+07	4.82E+05	0.00E+00	0.00E+00	3.22E+02	6.60E+01	1.38E+03	5.55E+00
Urban	129,155	6,256	-	1,814	1.23E+07	4.57E+05	0.00E+00	0.00E+00	2.20E+02	6.26E+01	0.00E+00	3.39E+00
Rural	60,119	344	86,140	1,159	5.73E+06	2.51E+04	0.00E+00	0.00E+00	1.02E+02	3.44E+00	1.38E+03	2.16E+00
AGRICULTURAL SECTOR	9,750	5,005	44,950	-	9.30E+05	3.66E+05	0.00E+00	0.00E+00	1.66E+01	5.01E+01	7.19E+02	0.00E+00
Field Operations		2,619	-		0.00E+00	1.91E+05	0.00E+00	0.00E+00	0.00E+00	2.62E+01	0.00E+00	0.00E+00
Processing/Other	9,750	2,386	44,950		9.30E+05	1.74E+05	0.00E+00	0.00E+00	1.66E+01	2.39E+01	7.19E+02	0.00E+00
FISHERIES SECTOR	1,132	3,137	-	-	1.08E+05	2.29E+05	0.00E+00	0.00E+00	1.92E+00	3.14E+01	0.00E+00	0.00E+00
Large Ships	-	2,681	-		0.00E+00	1.96E+05	0.00E+00	0.00E+00	0.00E+00	2.68E+01	0.00E+00	0.00E+00
Processing/Other	1,132	456	-		1.08E+05	3.33E+04	0.00E+00	0.00E+00	1.92E+00	4.56E+00	0.00E+00	0.00E+00
MILITARY SECTOR	29,828	16,533	-	-	2.84E+06	1.21E+06	0.00E+00	0.00E+00	5.07E+01	1.65E+02	0.00E+00	0.00E+00
Trucks and other Transport		6,585	-		0.00E+00	4.81E+05	0.00E+00	0.00E+00	0.00E+00	6.58E+01	0.00E+00	0.00E+00
Armaments		263	-		0.00E+00	1.92E+04	0.00E+00	0.00E+00	0.00E+00	2.63E+00	0.00E+00	0.00E+00
Air Force		2,648	-		0.00E+00	1.94E+05	0.00E+00	0.00E+00	0.00E+00	2.65E+01	0.00E+00	0.00E+00
Naval Forces		6,937	-		0.00E+00	5.07E+05	0.00E+00	0.00E+00	0.00E+00	6.94E+01	0.00E+00	0.00E+00
Military Manufacturing	890	-	-		8.49E+04	0.00E+00	0.00E+00	0.00E+00	1.51E+00	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	28,938	100	-		2.76E+06	7.31E+03	0.00E+00	0.00E+00	4.92E+01	1.00E+00	0.00E+00	0.00E+00
PUBLIC/COMMERCIAL SECTORS	32,646	98	1,632	-	3.11E+06	7.16E+03	0.00E+00	0.00E+00	5.55E+01	9.79E-01	2.61E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		5,950			0.00E+00	4.35E+05	0.00E+00	0.00E+00	0.00E+00	5.95E+01	0.00E+00	0.00E+00
NON-ENERGY USE	13,718	5,771	12,000		1.31E+06	4.19E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	1,325,571	26,622	162,092	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	1,301,288		149,909													
Imports	68,392	26,622	12,183													
Exports	44,108															
Inputs to International Marine Bunkers																
Stock Changes																
ENERGY TRANSFORMATION	(377,571)	82,762	(9,920)	2,976	1.63E+03	9.79E+01	0.00E+00	4.86E+01	2.21E+05	8.37E+03	0.00E+00	0.00E+00	1.38E+05	6.69E+03	0.00E+00	8.40E+02
Electricity Generation	(294,926)	(21,947)			1.33E+03	7.68E+01	0.00E+00	0.00E+00	1.80E+05	6.56E+03	0.00E+00	0.00E+00	1.12E+05	5.25E+03	0.00E+00	0.00E+00
Petroleum Refining	-	110,742				-1.02E-13				-8.70E-12				-6.96E-12		
Coal Production/Preparation	(63,092)				2.84E+02				3.85E+04				2.40E+04			
Charcoal Production			(9,920)	2,976				4.86E+01				0.00E+00				8.40E+02
Coke Production																
District Heat Production	(3,417)	(73)			1.54E+01	2.57E-01	0.00E+00	0.00E+00	2.09E+03	2.19E+01	0.00E+00	0.00E+00	1.30E+03	1.75E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(5,960)			0.00E+00	2.09E+01	0.00E+00	0.00E+00	0.00E+00	1.78E+03	0.00E+00	0.00E+00	0.00E+00	1.42E+03	0.00E+00	0.00E+00
Losses	(16,136)															
FUELS FOR FINAL CONSUMPTION	948,000	109,384	152,172	2,976												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	948,009	109,384	147,995	2,973	4.20E+03	3.63E+02	9.52E+02	2.08E+01	5.71E+05	3.10E+04	0.00E+00	0.00E+00	3.55E+05	2.48E+04	1.65E+04	3.60E+02
INDUSTRIAL SECTOR	671,661	28,393	1,600	-	3.02E+03	9.94E+01	1.12E+01	0.00E+00	4.10E+05	8.49E+03	0.00E+00	0.00E+00	2.56E+05	6.79E+03	1.94E+02	0.00E+00
Iron and Steel	324,615	-			1.46E+03	0.00E+00	0.00E+00	0.00E+00	1.98E+05	0.00E+00	0.00E+00	0.00E+00	1.24E+05	0.00E+00	0.00E+00	0.00E+00
Cement	68,139	7,571			3.07E+02	2.65E+01	0.00E+00	0.00E+00	4.16E+04	2.26E+03	0.00E+00	0.00E+00	2.59E+04	1.81E+03	0.00E+00	0.00E+00
Fertilizers	23,994	4,573			1.08E+02	1.60E+01	0.00E+00	0.00E+00	1.47E+04	1.37E+03	0.00E+00	0.00E+00	9.13E+03	1.09E+03	0.00E+00	0.00E+00
Other Chemicals	11,203	-			5.04E+01	0.00E+00	0.00E+00	0.00E+00	6.84E+03	0.00E+00	0.00E+00	0.00E+00	4.26E+03	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	4,026	-			1.81E+01	0.00E+00	0.00E+00	0.00E+00	2.46E+03	0.00E+00	0.00E+00	0.00E+00	1.53E+03	0.00E+00	0.00E+00	0.00E+00
Other Metals	23,720	-			1.07E+02	0.00E+00	0.00E+00	0.00E+00	1.45E+04	0.00E+00	0.00E+00	0.00E+00	9.03E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	-	12,600			0.00E+00	4.41E+01	0.00E+00	0.00E+00	0.00E+00	3.77E+03	0.00E+00	0.00E+00	0.00E+00	3.01E+03	0.00E+00	0.00E+00
Textiles	29,385	-			1.32E+02	0.00E+00	0.00E+00	0.00E+00	1.79E+04	0.00E+00	0.00E+00	0.00E+00	1.12E+04	0.00E+00	0.00E+00	0.00E+00
Building Materials	61,980	-			2.79E+02	0.00E+00	0.00E+00	0.00E+00	3.79E+04	0.00E+00	0.00E+00	0.00E+00	2.36E+04	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	124,600	3,650	1,600		5.61E+02	1.28E+01	1.12E+01	0.00E+00	7.61E+04	1.09E+03	0.00E+00	0.00E+00	4.74E+04	8.72E+02	1.94E+02	0.00E+00
TRANSPORT SECTOR	-	37,896	1,672	-	0.00E+00	1.33E+02	1.17E+01	0.00E+00	0.00E+00	1.13E+04	0.00E+00	0.00E+00	0.00E+00	9.06E+03	2.02E+02	0.00E+00
Road		32,571	1,672		0.00E+00	1.14E+02	1.17E+01	0.00E+00	0.00E+00	9.74E+03	0.00E+00	0.00E+00	0.00E+00	7.78E+03	2.02E+02	0.00E+00
Rail	-	1,949			0.00E+00	6.82E+00	0.00E+00	0.00E+00	0.00E+00	5.83E+02	0.00E+00	0.00E+00	0.00E+00	4.66E+02	0.00E+00	0.00E+00
Water	-	1,253			0.00E+00	4.39E+00	0.00E+00	0.00E+00	0.00E+00	3.75E+02	0.00E+00	0.00E+00	0.00E+00	2.99E+02	0.00E+00	0.00E+00
Air		1,123			0.00E+00	3.93E+00	0.00E+00	0.00E+00	0.00E+00	3.36E+02	0.00E+00	0.00E+00	0.00E+00	2.69E+02	0.00E+00	0.00E+00
Non-Specified		1,000			0.00E+00	3.50E+00	0.00E+00	0.00E+00	0.00E+00	2.99E+02	0.00E+00	0.00E+00	0.00E+00	2.39E+02	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	189,274	6,600	86,140	2,973	8.52E+02	2.31E+01	6.03E+02	2.08E+01	1.16E+05	1.97E+03	0.00E+00	0.00E+00	7.20E+04	1.58E+03	1.04E+04	3.60E+02
Urban	129,155	6,256	-	1,814	5.81E+02	2.19E+01	0.00E+00	1.27E+01	7.89E+04	1.87E+03	0.00E+00	0.00E+00	4.91E+04	1.50E+03	0.00E+00	2.19E+02
Rural	60,119	344	86,140	1,159	2.71E+02	1.20E+00	6.03E+02	8.12E+00	3.67E+04	1.03E+02	0.00E+00	0.00E+00	2.29E+04	8.21E+01	1.04E+04	1.40E+02
AGRICULTURAL SECTOR	9,750	5,005	44,950	-	4.39E+01	1.75E+01	3.15E+02	0.00E+00	5.96E+03	1.50E+03	0.00E+00	0.00E+00	3.71E+03	1.20E+03	5.44E+03	0.00E+00
Field Operations		2,619	-		0.00E+00	9.17E+00	0.00E+00	0.00E+00	0.00E+00	7.83E+02	0.00E+00	0.00E+00	0.00E+00	6.26E+02	0.00E+00	0.00E+00
Processing/Other	9,750	2,386	44,950		4.39E+01	8.35E+00	3.15E+02	0.00E+00	5.96E+03	7.14E+02	0.00E+00	0.00E+00	3.71E+03	5.70E+02	5.44E+03	0.00E+00
FISHERIES SECTOR	1,132	3,137	-	-	5.09E+00	1.10E+01	0.00E+00	0.00E+00	6.91E+02	9.38E+02	0.00E+00	0.00E+00	4.31E+02	7.50E+02	0.00E+00	0.00E+00
Large Ships	-	2,681	-		0.00E+00	9.38E+00	0.00E+00	0.00E+00	0.00E+00	8.02E+02	0.00E+00	0.00E+00	0.00E+00	6.41E+02	0.00E+00	0.00E+00
Processing/Other	1,132	456	-		5.09E+00	1.60E+00	0.00E+00	0.00E+00	6.91E+02	1.36E+02	0.00E+00	0.00E+00	4.31E+02	1.09E+02	0.00E+00	0.00E+00
MILITARY SECTOR	29,828	16,533	-	-	1.34E+02	5.79E+01	0.00E+00	0.00E+00	1.82E+04	4.94E+03	0.00E+00	0.00E+00	1.13E+04	3.95E+03	0.00E+00	0.00E+00
Trucks and other Transport		6,585	-		0.00E+00	2.30E+01	0.00E+00	0.00E+00	0.00E+00	1.97E+03	0.00E+00	0.00E+00	0.00E+00	1.57E+03	0.00E+00	0.00E+00
Armaments		263	-		0.00E+00	9.21E-01	0.00E+00	0.00E+00	0.00E+00	7.87E+01	0.00E+00	0.00E+00	0.00E+00	6.29E+01	0.00E+00	0.00E+00
Air Force		2,648	-		0.00E+00	9.27E+00	0.00E+00	0.00E+00	0.00E+00	7.92E+02	0.00E+00	0.00E+00	0.00E+00	6.33E+02	0.00E+00	0.00E+00
Naval Forces		6,937	-		0.00E+00	2.43E+01	0.00E+00	0.00E+00	0.00E+00	2.07E+03	0.00E+00	0.00E+00	0.00E+00	1.66E+03	0.00E+00	0.00E+00
Military Manufacturing	890	-	-		4.01E+00	0.00E+00	0.00E+00	0.00E+00	5.44E+02	0.00E+00	0.00E+00	0.00E+00	3.39E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	28,938	100	-		1.30E+02	3.50E-01	0.00E+00	0.00E+00	1.77E+04	2.99E+01	0.00E+00	0.00E+00	1.10E+04	2.39E+01	0.00E+00	0.00E+00
PUBLIC/COMMERCIAL SECTORS	32,646	98	1,632	-	1.47E+02	3.43E-01	1.14E+01	0.00E+00	1.99E+04	2.93E+01	0.00E+00	0.00E+00	1.24E+04	2.34E+01	1.98E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		5,950			0.00E+00	2.08E+01	0.00E+00	0.00E+00	0.00E+00	1.78E+03	0.00E+00	0.00E+00	0.00E+00	1.42E+03	0.00E+00	0.00E+00
NON-ENERGY USE	13,718	5,771	12,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 1996

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.91	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.001867	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.380	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	1996				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**6.42E+07**	**5.29E+06**	**0.00E+00**	**0.00E+00**	**6.95E+07**
Methane from Combustion	**1.14E+03**	**7.07E+02**	**2.27E+03**	**4.43E+00**	**4.12E+03**
Methane from Production	**3.71E+05**	**0.00E+00**	**0.00E+00**	**1.99E+02**	**3.71E+05**
Nitrous Oxide from Combustion	**3.02E+03**	**2.47E+02**	**9.93E+02**	**5.54E+01**	**4.31E+03**
Sulfur Oxides from Combustion	**4.09E+05**	**2.32E+04**	**0.00E+00**	**0.00E+00**	**4.33E+05**
Nitrogen Oxides from Combustion	**2.55E+05**	**1.69E+04**	**1.72E+04**	**9.58E+02**	**2.90E+05**

Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**6.95E+07**	**3.75E+05**	**4.31E+03**	**4.33E+05**	**2.90E+05**
ENERGY SUPPLY	0.00E+00	3.71E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	3.64E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	6.47E+03	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	2.52E+07	8.91E+02	1.23E+03	1.59E+05	9.97E+04
Electricity Generation	2.17E+07	6.08E+02	1.02E+03	1.37E+05	8.51E+04
Coal Prod./Prep.	3.12E+06	5.56E+01	1.47E+02	2.00E+04	1.24E+04
Charcoal Production	0.00E+00	1.99E+02	3.88E+01	0.00E+00	6.70E+02
District Heat Production	2.47E+05	5.83E+00	1.17E+01	1.57E+03	9.78E+02
Own Use	1.66E+05	2.27E+01	7.93E+00	6.78E+02	5.41E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	4.43E+07	3.43E+03	3.08E+03	2.74E+05	1.90E+05
INDUSTRIAL	2.45E+07	5.22E+02	1.16E+03	1.56E+05	9.75E+04
TRANSPORT	1.22E+06	1.81E+02	6.47E+01	5.00E+03	4.10E+03
RESIDENTIAL	1.17E+07	2.11E+03	1.39E+03	7.49E+04	6.13E+04
AGRICULTURAL	4.00E+05	2.53E+02	1.22E+02	2.34E+03	3.30E+03
FISHERIES	1.21E+05	1.08E+01	5.78E+00	6.10E+02	4.32E+02
MILITARY	3.38E+06	2.63E+02	1.99E+02	1.94E+04	1.35E+04
PUBLIC/COMML	2.51E+06	8.77E+01	1.37E+02	1.60E+04	1.03E+04
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	4.26E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	400	1.07	428	0.12
Diesel	317	1.035	328	0.4
Heavy Oil	789	0.96	757	1.5
Kerosene/Jet Fuel	51	1.045	53	0.032
LPG	85	1.13	96	0.00016
Aviation Gasoline	21	1.07	22	0.04
Weighted Average: Sulfur content in kg/GJ				**0.190**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.380**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	682,118	38,578	161,880	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.71E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	682,630		148,292						3.64E+05			
Imports	11,614	39,100	13,588									
Exports	12,125	521							6.47E+03			
Inputs to International Marine Bunkers												
Stock Changes		6,412										
ENERGY TRANSFORMATION	(251,225)	11,979	(7,916)	2,375	2.32E+07	2.06E+06	0.00E+00	0.00E+00	4.13E+02	2.79E+02	0.00E+00	1.99E+02
Electricity Generation	(207,721)	(25,467)			1.98E+07	1.88E+06	0.00E+00	0.00E+00	3.53E+02	2.55E+02	0.00E+00	0.00E+00
Petroleum Refining	-	39,874				0.00E+00				0.00E+00		
Coal Production/Preparation	(32,678)				3.12E+06				5.56E+01			
Charcoal Production			(7,916)	2,375								1.99E+02
Coke Production												
District Heat Production	(2,468)	(163)			2.35E+05	1.21E+04	0.00E+00	0.00E+00	4.20E+00	1.63E+00	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(2,266)			0.00E+00	1.66E+05	0.00E+00	0.00E+00	0.00E+00	2.27E+01	0.00E+00	0.00E+00
Losses	(8,358)											
FUELS FOR FINAL CONSUMPTION	430,893	50,558	153,964	2,375								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	430,897	44,146	149,061	2,374	4.11E+07	3.23E+06	0.00E+00	0.00E+00	7.27E+02	4.28E+02	2.27E+03	4.43E+00
INDUSTRIAL SECTOR	250,538	8,655	581	-	2.39E+07	6.33E+05	0.00E+00	0.00E+00	4.26E+02	8.66E+01	9.29E+00	0.00E+00
Iron and Steel	124,977	-			1.19E+07	0.00E+00	0.00E+00	0.00E+00	2.12E+02	0.00E+00	0.00E+00	0.00E+00
Cement	29,981	3,331			2.86E+06	2.43E+05	0.00E+00	0.00E+00	5.10E+01	3.33E+01	0.00E+00	0.00E+00
Fertilizers	6,515	1,129			6.21E+05	8.25E+04	0.00E+00	0.00E+00	1.11E+01	1.13E+01	0.00E+00	0.00E+00
Other Chemicals	3,697	-			3.52E+05	0.00E+00	0.00E+00	0.00E+00	6.28E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	1,329	-			1.27E+05	0.00E+00	0.00E+00	0.00E+00	2.26E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	7,828	-			7.46E+05	0.00E+00	0.00E+00	0.00E+00	1.33E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	832	3,326			7.93E+04	2.43E+05	0.00E+00	0.00E+00	1.41E+00	3.33E+01	0.00E+00	0.00E+00
Textiles	9,697	-			9.24E+05	0.00E+00	0.00E+00	0.00E+00	1.65E+01	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			1.95E+06	0.00E+00	0.00E+00	0.00E+00	3.48E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	45,230	869	581		4.31E+06	6.35E+04	0.00E+00	0.00E+00	7.69E+01	8.69E+00	9.29E+00	0.00E+00
TRANSPORT SECTOR	-	16,707	884	-	0.00E+00	1.22E+06	0.00E+00	0.00E+00	0.00E+00	1.67E+02	1.41E+01	0.00E+00
Road		14,528	884		0.00E+00	1.06E+06	0.00E+00	0.00E+00	0.00E+00	1.45E+02	1.41E+01	0.00E+00
Rail	-	779			0.00E+00	5.70E+04	0.00E+00	0.00E+00	0.00E+00	7.79E+00	0.00E+00	0.00E+00
Water	-	501			0.00E+00	3.66E+04	0.00E+00	0.00E+00	0.00E+00	5.01E+00	0.00E+00	0.00E+00
Air		899			0.00E+00	6.57E+04	0.00E+00	0.00E+00	0.00E+00	8.99E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	121,735	1,785	117,606	2,374	1.16E+07	1.30E+05	0.00E+00	0.00E+00	2.07E+02	1.79E+01	1.88E+03	4.43E+00
Urban	92,747	1,649	15,135	1,455	8.84E+06	1.20E+05	0.00E+00	0.00E+00	1.58E+02	1.65E+01	2.42E+02	2.72E+00
Rural	28,988	136	102,471	919	2.76E+06	9.96E+03	0.00E+00	0.00E+00	4.93E+01	1.36E+00	1.64E+03	1.72E+00
AGRICULTURAL SECTOR	3,183	1,319	14,674	-	3.03E+05	9.64E+04	0.00E+00	0.00E+00	5.41E+00	1.32E+01	2.35E+02	0.00E+00
Field Operations		690	-		0.00E+00	5.05E+04	0.00E+00	0.00E+00	0.00E+00	6.90E+00	0.00E+00	0.00E+00
Processing/Other	3,183	629	14,674		3.03E+05	4.60E+04	0.00E+00	0.00E+00	5.41E+00	6.29E+00	2.35E+02	0.00E+00
FISHERIES SECTOR	509	998	-	-	4.86E+04	7.29E+04	0.00E+00	0.00E+00	8.66E-01	9.98E+00	0.00E+00	0.00E+00
Large Ships	-	804	-		0.00E+00	5.88E+04	0.00E+00	0.00E+00	0.00E+00	8.04E+00	0.00E+00	0.00E+00
Processing/Other	509	193	-		4.86E+04	1.41E+04	0.00E+00	0.00E+00	8.66E-01	1.93E+00	0.00E+00	0.00E+00
MILITARY SECTOR	25,365	13,186	5,498	-	2.42E+06	9.64E+05	0.00E+00	0.00E+00	4.31E+01	1.32E+02	8.80E+01	0.00E+00
Trucks and other Transport		5,734	-		0.00E+00	4.19E+05	0.00E+00	0.00E+00	0.00E+00	5.73E+01	0.00E+00	0.00E+00
Armaments		211	-		0.00E+00	1.54E+04	0.00E+00	0.00E+00	0.00E+00	2.11E+00	0.00E+00	0.00E+00
Air Force		1,886	-		0.00E+00	1.38E+05	0.00E+00	0.00E+00	0.00E+00	1.89E+01	0.00E+00	0.00E+00
Naval Forces		5,261	-		0.00E+00	3.84E+05	0.00E+00	0.00E+00	0.00E+00	5.26E+01	0.00E+00	0.00E+00
Military Manufacturing	623	-	-		5.94E+04	0.00E+00	0.00E+00	0.00E+00	1.06E+00	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	24,742	95	5,498		2.36E+06	6.94E+03	0.00E+00	0.00E+00	4.21E+01	9.50E-01	8.80E+01	0.00E+00
PUBLIC/COMMERCIAL SECTORS	26,180	131	2,618	-	2.50E+06	9.57E+03	0.00E+00	0.00E+00	4.45E+01	1.31E+00	4.19E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,386	1,365	7,200		3.23E+05	1.04E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	682,118	38,578	161,880	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	682,630		148,292													
Imports	11,614	39,100	13,588													
Exports	12,125	521														
Inputs to International Marine Bunkers																
Stock Changes		6,412														
ENERGY TRANSFORMATION	(251,225)	11,979	(7,916)	2,375	1.09E+03	9.76E+01	0.00E+00	3.88E+01	1.48E+05	1.04E+04	0.00E+00	0.00E+00	9.24E+04	6.67E+03	0.00E+00	6.70E+02
Electricity Generation	(207,721)	(25,467)			9.35E+02	8.91E+01	0.00E+00	0.00E+00	1.27E+05	9.67E+03	0.00E+00	0.00E+00	7.90E+04	6.09E+03	0.00E+00	0.00E+00
Petroleum Refining	-	39,874				0.00E+00				0.00E+00				0.00E+00		
Coal Production/Preparation	(32,678)				1.47E+02				2.00E+04				1.24E+04			
Charcoal Production			(7,916)	2,375				3.88E+01				0.00E+00				6.70E+02
Coke Production																
District Heat Production	(2,468)	(163)			1.11E+01	5.71E-01	0.00E+00	0.00E+00	1.51E+03	6.20E+01	0.00E+00	0.00E+00	9.39E+02	3.90E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(2,266)			0.00E+00	7.93E+00	0.00E+00	0.00E+00	0.00E+00	6.78E+02	0.00E+00	0.00E+00	0.00E+00	5.41E+02	0.00E+00	0.00E+00
Losses	(8,358)															
FUELS FOR FINAL CONSUMPTION	430,893	50,558	153,964	2,375												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	430,897	44,146	149,061	2,374	1.92E+03	1.50E+02	9.93E+02	1.66E+01	2.61E+05	1.28E+04	0.00E+00	0.00E+00	1.63E+05	1.02E+04	1.72E+04	2.87E+02
INDUSTRIAL SECTOR	250,538	8,655	581	-	1.13E+03	3.03E+01	4.07E+00	0.00E+00	1.53E+05	2.59E+03	0.00E+00	0.00E+00	9.53E+04	2.07E+03	7.03E+01	0.00E+00
Iron and Steel	124,977	-			5.62E+02	0.00E+00	0.00E+00	0.00E+00	7.63E+04	0.00E+00	0.00E+00	0.00E+00	4.76E+04	0.00E+00	0.00E+00	0.00E+00
Cement	29,981	3,331			1.35E+02	1.17E+01	0.00E+00	0.00E+00	1.83E+04	9.96E+02	0.00E+00	0.00E+00	1.14E+04	7.96E+02	0.00E+00	0.00E+00
Fertilizers	6,515	1,129			2.93E+01	3.95E+00	0.00E+00	0.00E+00	3.98E+03	3.38E+02	0.00E+00	0.00E+00	2.48E+03	2.70E+02	0.00E+00	0.00E+00
Other Chemicals	3,697	-			1.66E+01	0.00E+00	0.00E+00	0.00E+00	2.26E+03	0.00E+00	0.00E+00	0.00E+00	1.41E+03	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	1,329	-			5.98E+00	0.00E+00	0.00E+00	0.00E+00	8.12E+02	0.00E+00	0.00E+00	0.00E+00	5.06E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	7,828	-			3.52E+01	0.00E+00	0.00E+00	0.00E+00	4.78E+03	0.00E+00	0.00E+00	0.00E+00	2.98E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	832	3,326			3.74E+00	1.16E+01	0.00E+00	0.00E+00	5.08E+02	9.95E+02	0.00E+00	0.00E+00	3.16E+02	7.95E+02	0.00E+00	0.00E+00
Textiles	9,697	-			4.36E+01	0.00E+00	0.00E+00	0.00E+00	5.92E+03	0.00E+00	0.00E+00	0.00E+00	3.69E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			9.20E+01	0.00E+00	0.00E+00	0.00E+00	1.25E+04	0.00E+00	0.00E+00	0.00E+00	7.78E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	45,230	869	581		2.04E+02	3.04E+00	4.07E+00	0.00E+00	2.76E+04	2.60E+02	0.00E+00	0.00E+00	1.72E+04	2.08E+02	7.03E+01	0.00E+00
TRANSPORT SECTOR	-	16,707	884	-	0.00E+00	5.85E+01	6.19E+00	0.00E+00	0.00E+00	5.00E+03	0.00E+00	0.00E+00	0.00E+00	3.99E+03	1.07E+02	0.00E+00
Road		14,528	884		0.00E+00	5.08E+01	6.19E+00	0.00E+00	0.00E+00	4.34E+03	0.00E+00	0.00E+00	0.00E+00	3.47E+03	1.07E+02	0.00E+00
Rail	-	779			0.00E+00	2.73E+00	0.00E+00	0.00E+00	0.00E+00	2.33E+02	0.00E+00	0.00E+00	0.00E+00	1.86E+02	0.00E+00	0.00E+00
Water	-	501			0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+02	0.00E+00	0.00E+00	0.00E+00	1.20E+02	0.00E+00	0.00E+00
Air		899			0.00E+00	3.15E+00	0.00E+00	0.00E+00	0.00E+00	2.69E+02	0.00E+00	0.00E+00	0.00E+00	2.15E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	121,735	1,785	117,606	2,374	5.48E+02	6.25E+00	8.23E+02	1.66E+01	7.44E+04	5.34E+02	0.00E+00	0.00E+00	4.63E+04	4.27E+02	1.42E+04	2.87E+02
Urban	92,747	1,649	15,135	1,455	4.17E+02	5.77E+00	1.06E+02	1.02E+01	5.66E+04	4.93E+02	0.00E+00	0.00E+00	3.53E+04	3.94E+02	1.83E+03	1.76E+02
Rural	28,988	136	102,471	919	1.30E+02	4.77E-01	7.17E+02	6.44E+00	1.77E+04	4.07E+01	0.00E+00	0.00E+00	1.10E+04	3.26E+01	1.24E+04	1.11E+02
AGRICULTURAL SECTOR	3,183	1,319	14,674	-	1.43E+01	4.62E+00	1.03E+02	0.00E+00	1.94E+03	3.95E+02	0.00E+00	0.00E+00	1.21E+03	3.15E+02	1.78E+03	0.00E+00
Field Operations		690	-		0.00E+00	2.42E+00	0.00E+00	0.00E+00	0.00E+00	2.06E+02	0.00E+00	0.00E+00	0.00E+00	1.65E+02	0.00E+00	0.00E+00
Processing/Other	3,183	629	14,674		1.43E+01	2.20E+00	1.03E+02	0.00E+00	1.94E+03	1.88E+02	0.00E+00	0.00E+00	1.21E+03	1.50E+02	1.78E+03	0.00E+00
FISHERIES SECTOR	509	998	-	-	2.29E+00	3.49E+00	0.00E+00	0.00E+00	3.11E+02	2.98E+02	0.00E+00	0.00E+00	1.94E+02	2.38E+02	0.00E+00	0.00E+00
Large Ships	-	804	-		0.00E+00	2.82E+00	0.00E+00	0.00E+00	0.00E+00	2.41E+02	0.00E+00	0.00E+00	0.00E+00	1.92E+02	0.00E+00	0.00E+00
Processing/Other	509	193	-		2.29E+00	6.77E-01	0.00E+00	0.00E+00	3.11E+02	5.79E+01	0.00E+00	0.00E+00	1.94E+02	4.62E+01	0.00E+00	0.00E+00
MILITARY SECTOR	25,365	13,186	5,498	-	1.14E+02	4.62E+01	3.85E+01	0.00E+00	1.55E+04	3.94E+03	0.00E+00	0.00E+00	9.65E+03	3.15E+03	6.65E+02	0.00E+00
Trucks and other Transport		5,734	-		0.00E+00	2.01E+01	0.00E+00	0.00E+00	0.00E+00	1.71E+03	0.00E+00	0.00E+00	0.00E+00	1.37E+03	0.00E+00	0.00E+00
Armaments		211	-		0.00E+00	7.37E-01	0.00E+00	0.00E+00	0.00E+00	6.30E+01	0.00E+00	0.00E+00	0.00E+00	5.03E+01	0.00E+00	0.00E+00
Air Force		1,886	-		0.00E+00	6.60E+00	0.00E+00	0.00E+00	0.00E+00	5.64E+02	0.00E+00	0.00E+00	0.00E+00	4.51E+02	0.00E+00	0.00E+00
Naval Forces		5,261	-		0.00E+00	1.84E+01	0.00E+00	0.00E+00	0.00E+00	1.57E+03	0.00E+00	0.00E+00	0.00E+00	1.26E+03	0.00E+00	0.00E+00
Military Manufacturing	623	-	-		2.80E+00	0.00E+00	0.00E+00	0.00E+00	3.81E+02	0.00E+00	0.00E+00	0.00E+00	2.37E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	24,742	95	5,498		1.11E+02	3.33E-01	3.85E+01	0.00E+00	1.51E+04	2.84E+01	0.00E+00	0.00E+00	9.41E+03	2.27E+01	6.65E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	26,180	131	2,618	-	1.18E+02	4.58E-01	1.83E+01	0.00E+00	1.60E+04	3.91E+01	0.00E+00	0.00E+00	9.96E+03	3.13E+01	3.17E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,386	1,365	7,200		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2000

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.70	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.388	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2000				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.19E+07**	**3.92E+06**	**0.00E+00**	**0.00E+00**	**3.58E+07**
Methane from Combustion	**5.67E+02**	**5.28E+02**	**2.36E+03**	**3.39E+00**	**3.46E+03**
Methane from Production	**1.84E+05**	**0.00E+00**	**0.00E+00**	**1.52E+02**	**1.85E+05**
Nitrous Oxide from Combustion	**1.50E+03**	**1.85E+02**	**1.03E+03**	**4.24E+01**	**2.76E+03**
Sulfur Oxides from Combustion	**2.04E+05**	**1.73E+04**	**0.00E+00**	**0.00E+00**	**2.21E+05**
Nitrogen Oxides from Combustion	**1.27E+05**	**1.26E+04**	**1.79E+04**	**7.33E+02**	**1.58E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.58E+07**	**1.88E+05**	**2.76E+03**	**2.21E+05**	**1.58E+05**
ENERGY SUPPLY	0.00E+00	1.84E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	1.79E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	4.97E+03	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	5.94E+06	4.11E+02	3.11E+02	3.65E+04	2.33E+04
Electricity Generation	4.21E+06	2.16E+02	1.99E+02	2.56E+04	1.59E+04
Coal Prod./Prep.	1.53E+06	2.74E+01	7.24E+01	9.83E+03	6.12E+03
Charcoal Production	0.00E+00	1.52E+02	2.97E+01	0.00E+00	5.13E+02
District Heat Production	1.23E+05	5.59E+00	5.82E+00	7.55E+02	4.69E+02
Own Use	7.31E+04	1.00E+01	3.50E+00	2.99E+02	2.39E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.99E+07	3.20E+03	2.45E+03	1.85E+05	1.35E+05
INDUSTRIAL	1.51E+07	3.77E+02	7.17E+02	9.49E+04	5.98E+04
TRANSPORT	6.14E+05	9.20E+01	3.29E+01	2.51E+03	2.07E+03
RESIDENTIAL	9.21E+06	2.13E+03	1.30E+03	5.87E+04	5.16E+04
AGRICULTURAL	3.40E+05	2.49E+02	1.19E+02	2.02E+03	3.08E+03
FISHERIES	1.01E+05	9.00E+00	4.80E+00	5.06E+02	3.59E+02
MILITARY	2.84E+06	2.65E+02	1.86E+02	1.63E+04	1.17E+04
PUBLIC/COMML	1.50E+06	7.74E+01	9.25E+01	9.57E+03	6.34E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.56E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	191	1.07	204	0.12
Diesel	278	1.035	288	0.4
Heavy Oil	638	0.96	612	1.5
Kerosene/Jet Fuel	39	1.045	41	0.032
LPG	145	1.13	164	0.00016
Aviation Gasoline	16	1.07	17	0.04
Weighted Average: Sulfur content in kg/GJ				**0.194**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.388**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	338,806	38,765	162,993	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	336,168		150,543						1.79E+05			
Imports	11,952	41,778	12,450									
Exports	9,314	3,013							4.97E+03			
Inputs to International Marine Bunkers												
Stock Changes		(1,245)										
ENERGY TRANSFORMATION	(52,861)	(721)	(6,051)	1,815	4.65E+06	1.30E+06	0.00E+00	0.00E+00	8.29E+01	1.76E+02	0.00E+00	1.52E+02
Electricity Generation	(31,665)	(16,206)			3.02E+06	1.19E+06	0.00E+00	0.00E+00	5.38E+01	1.62E+02	0.00E+00	0.00E+00
Petroleum Refining	-	16,877				0.00E+00				0.00E+00		
Coal Production/Preparation	(16,093)				1.53E+06				2.74E+01			
Charcoal Production			(6,051)	1,815								1.52E+02
Coke Production												
District Heat Production	(988)	(391)			9.42E+04	2.88E+04	0.00E+00	0.00E+00	1.68E+00	3.91E+00	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,001)			0.00E+00	7.31E+04	0.00E+00	0.00E+00	0.00E+00	1.00E+01	0.00E+00	0.00E+00
Losses	(4,116)											
FUELS FOR FINAL CONSUMPTION	285,945	38,044	156,942	1,815								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	285,944	39,290	153,590	1,818	2.73E+07	2.63E+06	0.00E+00	0.00E+00	4.84E+02	3.52E+02	2.36E+03	3.39E+00
INDUSTRIAL SECTOR	149,673	11,726	317	-	1.43E+07	8.57E+05	0.00E+00	0.00E+00	2.54E+02	1.17E+02	5.07E+00	0.00E+00
Iron and Steel	67,382	-			6.42E+06	0.00E+00	0.00E+00	0.00E+00	1.15E+02	0.00E+00	0.00E+00	0.00E+00
Cement	19,096	7,024			1.82E+06	5.13E+05	0.00E+00	0.00E+00	3.25E+01	7.02E+01	0.00E+00	0.00E+00
Fertilizers	2,070	343			1.97E+05	2.51E+04	0.00E+00	0.00E+00	3.52E+00	3.43E+00	0.00E+00	0.00E+00
Other Chemicals	2,325	-			2.22E+05	0.00E+00	0.00E+00	0.00E+00	3.95E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	836	-			7.97E+04	0.00E+00	0.00E+00	0.00E+00	1.42E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	4,924	-			4.69E+05	0.00E+00	0.00E+00	0.00E+00	8.37E+00	0.00E+00	0.00E+00	0.00E+00
Other Minerals	869	3,478			8.29E+04	2.54E+05	0.00E+00	0.00E+00	1.48E+00	3.48E+01	0.00E+00	0.00E+00
Textiles	6,100	-			5.81E+05	0.00E+00	0.00E+00	0.00E+00	1.04E+01	0.00E+00	0.00E+00	0.00E+00
Building Materials	21,383	-			2.04E+06	0.00E+00	0.00E+00	0.00E+00	3.64E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	24,689	882	317		2.35E+06	6.45E+04	0.00E+00	0.00E+00	4.20E+01	8.82E+00	5.07E+00	0.00E+00
TRANSPORT SECTOR	-	8,395	504	-	0.00E+00	6.14E+05	0.00E+00	0.00E+00	0.00E+00	8.39E+01	8.06E+00	0.00E+00
Road		6,548	504		0.00E+00	4.79E+05	0.00E+00	0.00E+00	0.00E+00	6.55E+01	8.06E+00	0.00E+00
Rail	-	585			0.00E+00	4.27E+04	0.00E+00	0.00E+00	0.00E+00	5.85E+00	0.00E+00	0.00E+00
Water	-	476			0.00E+00	3.48E+04	0.00E+00	0.00E+00	0.00E+00	4.76E+00	0.00E+00	0.00E+00
Air		786			0.00E+00	5.75E+04	0.00E+00	0.00E+00	0.00E+00	7.86E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	95,055	2,079	121,601	1,818	9.06E+06	1.52E+05	0.00E+00	0.00E+00	1.62E+02	2.08E+01	1.95E+03	3.39E+00
Urban	73,246	1,924	19,021	1,117	6.98E+06	1.41E+05	0.00E+00	0.00E+00	1.25E+02	1.92E+01	3.04E+02	2.09E+00
Rural	21,808	156	102,580	701	2.08E+06	1.14E+04	0.00E+00	0.00E+00	3.71E+01	1.56E+00	1.64E+03	1.31E+00
AGRICULTURAL SECTOR	2,827	968	14,663	-	2.70E+05	7.08E+04	0.00E+00	0.00E+00	4.81E+00	9.68E+00	2.35E+02	0.00E+00
Field Operations		507	-		0.00E+00	3.70E+04	0.00E+00	0.00E+00	0.00E+00	5.07E+00	0.00E+00	0.00E+00
Processing/Other	2,827	461	14,663		2.70E+05	3.37E+04	0.00E+00	0.00E+00	4.81E+00	4.61E+00	2.35E+02	0.00E+00
FISHERIES SECTOR	423	828	-	-	4.03E+04	6.05E+04	0.00E+00	0.00E+00	7.19E-01	8.28E+00	0.00E+00	0.00E+00
Large Ships	-	668	-		0.00E+00	4.88E+04	0.00E+00	0.00E+00	0.00E+00	6.68E+00	0.00E+00	0.00E+00
Processing/Other	423	161	-		4.03E+04	1.17E+04	0.00E+00	0.00E+00	7.19E-01	1.61E+00	0.00E+00	0.00E+00
MILITARY SECTOR	21,308	11,094	7,379	-	2.03E+06	8.11E+05	0.00E+00	0.00E+00	3.62E+01	1.11E+02	1.18E+02	0.00E+00
Trucks and other Transport		4,064	-		0.00E+00	2.97E+05	0.00E+00	0.00E+00	0.00E+00	4.06E+01	0.00E+00	0.00E+00
Armaments		148	-		0.00E+00	1.08E+04	0.00E+00	0.00E+00	0.00E+00	1.48E+00	0.00E+00	0.00E+00
Air Force		1,367	-		0.00E+00	9.99E+04	0.00E+00	0.00E+00	0.00E+00	1.37E+01	0.00E+00	0.00E+00
Naval Forces		5,430	-		0.00E+00	3.97E+05	0.00E+00	0.00E+00	0.00E+00	5.43E+01	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		3.82E+04	0.00E+00	0.00E+00	0.00E+00	6.81E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,908	85	7,379		1.99E+06	6.21E+03	0.00E+00	0.00E+00	3.55E+01	8.50E-01	1.18E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	15,629	78	3,126	-	1.49E+06	5.71E+03	0.00E+00	0.00E+00	2.66E+01	7.81E-01	5.00E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,029	4,121	6,000		9.81E+04	5.76E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	338,806	38,765	162,993	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	336,168		150,543													
Imports	11,952	41,778	12,450													
Exports	9,314	3,013														
Inputs to International Marine Bunkers																
Stock Changes		(1,245)														
ENERGY TRANSFORMATION	(52,861)	(721)	(6,051)	1,815	2.19E+02	6.16E+01	0.00E+00	2.97E+01	2.98E+04	6.73E+03	0.00E+00	0.00E+00	1.85E+04	4.21E+03	0.00E+00	5.13E+02
Electricity Generation	(31,665)	(16,206)			1.42E+02	5.67E+01	0.00E+00	0.00E+00	1.93E+04	6.28E+03	0.00E+00	0.00E+00	1.20E+04	3.87E+03	0.00E+00	0.00E+00
Petroleum Refining	-	16,877				0.00E+00				0.00E+00				0.00E+00		
Coal Production/Preparation	(16,093)				7.24E+01				9.83E+03				6.12E+03			
Charcoal Production			(6,051)	1,815				2.97E+01				0.00E+00				5.13E+02
Coke Production																
District Heat Production	(988)	(391)			4.45E+00	1.37E+00	0.00E+00	0.00E+00	6.04E+02	1.52E+02	0.00E+00	0.00E+00	3.76E+02	9.35E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,001)			0.00E+00	3.50E+00	0.00E+00	0.00E+00	0.00E+00	2.99E+02	0.00E+00	0.00E+00	0.00E+00	2.39E+02	0.00E+00	0.00E+00
Losses	(4,116)															
FUELS FOR FINAL CONSUMPTION	285,945	38,044	156,942	1,815												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	285,944	39,290	153,590	1,818	1.28E+03	1.23E+02	1.03E+03	1.27E+01	1.74E+05	1.05E+04	0.00E+00	0.00E+00	1.08E+05	8.41E+03	1.79E+04	2.20E+02
INDUSTRIAL SECTOR	149,673	11,726	317	-	6.74E+02	4.10E+01	2.22E+00	0.00E+00	9.14E+04	3.51E+03	0.00E+00	0.00E+00	5.70E+04	2.80E+03	3.84E+01	0.00E+00
Iron and Steel	67,382	-			3.03E+02	0.00E+00	0.00E+00	0.00E+00	4.12E+04	0.00E+00	0.00E+00	0.00E+00	2.56E+04	0.00E+00	0.00E+00	0.00E+00
Cement	19,096	7,024			8.59E+01	2.46E+01	0.00E+00	0.00E+00	1.17E+04	2.10E+03	0.00E+00	0.00E+00	7.27E+03	1.68E+03	0.00E+00	0.00E+00
Fertilizers	2,070	343			9.31E+00	1.20E+00	0.00E+00	0.00E+00	1.26E+03	1.03E+02	0.00E+00	0.00E+00	7.87E+02	8.20E+01	0.00E+00	0.00E+00
Other Chemicals	2,325	-			1.05E+01	0.00E+00	0.00E+00	0.00E+00	1.42E+03	0.00E+00	0.00E+00	0.00E+00	8.85E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	836	-			3.76E+00	0.00E+00	0.00E+00	0.00E+00	5.10E+02	0.00E+00	0.00E+00	0.00E+00	3.18E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	4,924	-			2.22E+01	0.00E+00	0.00E+00	0.00E+00	3.01E+03	0.00E+00	0.00E+00	0.00E+00	1.87E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	869	3,478			3.91E+00	1.22E+01	0.00E+00	0.00E+00	5.31E+02	1.04E+03	0.00E+00	0.00E+00	3.31E+02	8.31E+02	0.00E+00	0.00E+00
Textiles	6,100	-			2.74E+01	0.00E+00	0.00E+00	0.00E+00	3.73E+03	0.00E+00	0.00E+00	0.00E+00	2.32E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	21,383	-			9.62E+01	0.00E+00	0.00E+00	0.00E+00	1.31E+04	0.00E+00	0.00E+00	0.00E+00	8.14E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	24,689	882	317		1.11E+02	3.09E+00	2.22E+00	0.00E+00	1.51E+04	2.64E+02	0.00E+00	0.00E+00	9.39E+03	2.11E+02	3.84E+01	0.00E+00
TRANSPORT SECTOR	-	8,395	504	-	0.00E+00	2.94E+01	3.53E+00	0.00E+00	0.00E+00	2.51E+03	0.00E+00	0.00E+00	0.00E+00	2.01E+03	6.10E+01	0.00E+00
Road		6,548	504		0.00E+00	2.29E+01	3.53E+00	0.00E+00	0.00E+00	1.96E+03	0.00E+00	0.00E+00	0.00E+00	1.56E+03	6.10E+01	0.00E+00
Rail	-	585			0.00E+00	2.05E+00	0.00E+00	0.00E+00	0.00E+00	1.75E+02	0.00E+00	0.00E+00	0.00E+00	1.40E+02	0.00E+00	0.00E+00
Water	-	476			0.00E+00	1.67E+00	0.00E+00	0.00E+00	0.00E+00	1.42E+02	0.00E+00	0.00E+00	0.00E+00	1.14E+02	0.00E+00	0.00E+00
Air		786			0.00E+00	2.75E+00	0.00E+00	0.00E+00	0.00E+00	2.35E+02	0.00E+00	0.00E+00	0.00E+00	1.88E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	95,055	2,079	121,601	1,818	4.28E+02	7.28E+00	8.51E+02	1.27E+01	5.81E+04	6.22E+02	0.00E+00	0.00E+00	3.62E+04	4.97E+02	1.47E+04	2.20E+02
Urban	73,246	1,924	19,021	1,117	3.30E+02	6.73E+00	1.33E+02	7.82E+00	4.47E+04	5.75E+02	0.00E+00	0.00E+00	2.79E+04	4.60E+02	2.30E+03	1.35E+02
Rural	21,808	156	102,580	701	9.81E+01	5.45E-01	7.18E+02	4.91E+00	1.33E+04	4.66E+01	0.00E+00	0.00E+00	8.30E+03	3.72E+01	1.24E+04	8.48E+01
AGRICULTURAL SECTOR	2,827	968	14,663	-	1.27E+01	3.39E+00	1.03E+02	0.00E+00	1.73E+03	2.90E+02	0.00E+00	0.00E+00	1.08E+03	2.31E+02	1.77E+03	0.00E+00
Field Operations		507	-		0.00E+00	1.77E+00	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00	1.21E+02	0.00E+00	0.00E+00
Processing/Other	2,827	461	14,663		1.27E+01	1.62E+00	1.03E+02	0.00E+00	1.73E+03	1.38E+02	0.00E+00	0.00E+00	1.08E+03	1.10E+02	1.77E+03	0.00E+00
FISHERIES SECTOR	423	828	-	-	1.90E+00	2.90E+00	0.00E+00	0.00E+00	2.58E+02	2.48E+02	0.00E+00	0.00E+00	1.61E+02	1.98E+02	0.00E+00	0.00E+00
Large Ships	-	668	-		0.00E+00	2.34E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+02	0.00E+00	0.00E+00	0.00E+00	1.60E+02	0.00E+00	0.00E+00
Processing/Other	423	161	-		1.90E+00	5.62E-01	0.00E+00	0.00E+00	2.58E+02	4.80E+01	0.00E+00	0.00E+00	1.61E+02	3.84E+01	0.00E+00	0.00E+00
MILITARY SECTOR	21,308	11,094	7,379	-	9.59E+01	3.88E+01	5.17E+01	0.00E+00	1.30E+04	3.32E+03	0.00E+00	0.00E+00	8.11E+03	2.65E+03	8.93E+02	0.00E+00
Trucks and other Transport		4,064	-		0.00E+00	1.42E+01	0.00E+00	0.00E+00	0.00E+00	1.22E+03	0.00E+00	0.00E+00	0.00E+00	9.71E+02	0.00E+00	0.00E+00
Armaments		148	-		0.00E+00	5.16E-01	0.00E+00	0.00E+00	0.00E+00	4.41E+01	0.00E+00	0.00E+00	0.00E+00	3.53E+01	0.00E+00	0.00E+00
Air Force		1,367	-		0.00E+00	4.78E+00	0.00E+00	0.00E+00	0.00E+00	4.09E+02	0.00E+00	0.00E+00	0.00E+00	3.27E+02	0.00E+00	0.00E+00
Naval Forces		5,430	-		0.00E+00	1.90E+01	0.00E+00	0.00E+00	0.00E+00	1.62E+03	0.00E+00	0.00E+00	0.00E+00	1.30E+03	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		1.80E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,908	85	7,379		9.41E+01	2.98E-01	5.17E+01	0.00E+00	1.28E+04	2.54E+01	0.00E+00	0.00E+00	7.96E+03	2.03E+01	8.93E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	15,629	78	3,126	-	7.03E+01	2.74E-01	2.19E+01	0.00E+00	9.55E+03	2.34E+01	0.00E+00	0.00E+00	5.95E+03	1.87E+01	3.78E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,029	4,121	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2005

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.70	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.313	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2005				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.68E+07**	**3.37E+06**	**0.00E+00**	**0.00E+00**	**4.01E+07**
Methane from Combustion	**6.53E+02**	**4.53E+02**	**2.79E+03**	**3.43E+00**	**3.90E+03**
Methane from Production	**2.75E+05**	**0.00E+00**	**0.00E+00**	**1.55E+02**	**2.75E+05**
Nitrous Oxide from Combustion	**1.73E+03**	**1.59E+02**	**1.22E+03**	**4.30E+01**	**3.15E+03**
Sulfur Oxides from Combustion	**2.35E+05**	**1.37E+04**	**0.00E+00**	**0.00E+00**	**2.48E+05**
Nitrogen Oxides from Combustion	**1.46E+05**	**1.08E+04**	**2.11E+04**	**7.43E+02**	**1.79E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.01E+07**	**2.79E+05**	**3.15E+03**	**2.48E+05**	**1.79E+05**
ENERGY SUPPLY	0.00E+00	2.75E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.32E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	4.26E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.09E+07	4.35E+02	5.46E+02	6.84E+04	4.36E+04
Electricity Generation	8.65E+06	2.27E+02	4.09E+02	5.41E+04	3.41E+04
Coal Prod./Prep.	1.98E+06	3.54E+01	9.36E+01	1.27E+04	7.91E+03
Charcoal Production	0.00E+00	1.55E+02	3.01E+01	0.00E+00	5.21E+02
District Heat Production	1.86E+05	3.94E+00	8.80E+00	1.18E+03	7.40E+02
Own Use	9.68E+04	1.32E+01	4.63E+00	3.96E+02	3.16E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.92E+07	3.62E+03	2.60E+03	1.80E+05	1.35E+05
INDUSTRIAL	1.50E+07	3.46E+02	7.09E+02	9.44E+04	5.93E+04
TRANSPORT	8.20E+05	1.25E+02	4.50E+01	3.35E+03	2.78E+03
RESIDENTIAL	8.25E+06	2.32E+03	1.34E+03	5.25E+04	4.93E+04
AGRICULTURAL	5.89E+05	4.33E+02	2.08E+02	3.57E+03	5.41E+03
FISHERIES	1.11E+05	1.00E+01	5.27E+00	5.53E+02	3.93E+02
MILITARY	2.69E+06	2.72E+02	1.83E+02	1.53E+04	1.11E+04
PUBLIC/COMML	1.59E+06	1.09E+02	1.10E+02	1.01E+04	6.92E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.94E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	156	1.07	167	0.12
Diesel	381	1.035	394	0.4
Heavy Oil	334	0.96	321	1.5
Kerosene/Jet Fuel	71	1.045	74	0.032
LPG	58	1.13	65	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.157**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.313**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	390,916	23,196	189,208	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	434,409		182,194						2.32E+05			
Imports	36,405	23,383	7,014									
Exports	79,898	188							4.26E+04			
Inputs to International Marine Bunkers												
Stock Changes		(207)										
ENERGY TRANSFORMATION	(112,260)	12,764	(6,150)	1,845	1.02E+07	7.22E+05	0.00E+00	0.00E+00	1.82E+02	9.80E+01	0.00E+00	1.55E+02
Electricity Generation	(84,246)	(8,409)			8.03E+06	6.20E+05	0.00E+00	0.00E+00	1.43E+02	8.41E+01	0.00E+00	0.00E+00
Petroleum Refining	-	22,568				-2.68E-10				-3.64E-14		
Coal Production/Preparation	(20,795)				1.98E+06				3.54E+01			
Charcoal Production			(6,150)	1,845								1.55E+02
Coke Production												
District Heat Production	(1,900)	(71)			1.81E+05	5.21E+03	0.00E+00	0.00E+00	3.23E+00	7.07E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,324)			0.00E+00	9.68E+04	0.00E+00	0.00E+00	0.00E+00	1.32E+01	0.00E+00	0.00E+00
Losses	(5,319)											
FUELS FOR FINAL CONSUMPTION	278,657	35,959	183,058	1,845								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	278,654	36,166	180,244	1,836	2.66E+07	2.64E+06	0.00E+00	0.00E+00	4.71E+02	3.55E+02	2.79E+03	3.43E+00
INDUSTRIAL SECTOR	150,376	8,640	271	-	1.43E+07	6.31E+05	0.00E+00	0.00E+00	2.56E+02	8.64E+01	4.34E+00	0.00E+00
Iron and Steel	52,717	-			5.03E+06	0.00E+00	0.00E+00	0.00E+00	8.96E+01	0.00E+00	0.00E+00	0.00E+00
Cement	23,566	3,568			2.25E+06	2.61E+05	0.00E+00	0.00E+00	4.01E+01	3.57E+01	0.00E+00	0.00E+00
Fertilizers	3,010	512			2.87E+05	3.74E+04	0.00E+00	0.00E+00	5.12E+00	5.12E+00	0.00E+00	0.00E+00
Other Chemicals	2,265	-			2.16E+05	0.00E+00	0.00E+00	0.00E+00	3.85E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	814	-			7.76E+04	0.00E+00	0.00E+00	0.00E+00	1.38E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,940	-			1.52E+06	0.00E+00	0.00E+00	0.00E+00	2.71E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	3,528	3,528			3.36E+05	2.58E+05	0.00E+00	0.00E+00	6.00E+00	3.53E+01	0.00E+00	0.00E+00
Textiles	6,582	-			6.28E+05	0.00E+00	0.00E+00	0.00E+00	1.12E+01	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,825	-			1.99E+06	0.00E+00	0.00E+00	0.00E+00	3.54E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	21,128	1,032	271		2.01E+06	7.54E+04	0.00E+00	0.00E+00	3.59E+01	1.03E+01	4.34E+00	0.00E+00
TRANSPORT SECTOR	-	11,216	816	-	0.00E+00	8.20E+05	0.00E+00	0.00E+00	0.00E+00	1.12E+02	1.31E+01	0.00E+00
Road		8,958	816		0.00E+00	6.55E+05	0.00E+00	0.00E+00	0.00E+00	8.96E+01	1.31E+01	0.00E+00
Rail	-	935			0.00E+00	6.84E+04	0.00E+00	0.00E+00	0.00E+00	9.35E+00	0.00E+00	0.00E+00
Water	-	526			0.00E+00	3.85E+04	0.00E+00	0.00E+00	0.00E+00	5.26E+00	0.00E+00	0.00E+00
Air		797			0.00E+00	5.82E+04	0.00E+00	0.00E+00	0.00E+00	7.97E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	84,886	2,169	134,550	1,836	8.09E+06	1.58E+05	0.00E+00	0.00E+00	1.44E+02	2.17E+01	2.15E+03	3.43E+00
Urban	67,806	2,016	24,739	1,132	6.46E+06	1.47E+05	0.00E+00	0.00E+00	1.15E+02	2.02E+01	3.96E+02	2.11E+00
Rural	17,079	153	109,810	704	1.63E+06	1.12E+04	0.00E+00	0.00E+00	2.90E+01	1.53E+00	1.76E+03	1.31E+00
AGRICULTURAL SECTOR	5,282	1,164	25,784	-	5.04E+05	8.51E+04	0.00E+00	0.00E+00	8.98E+00	1.16E+01	4.13E+02	0.00E+00
Field Operations		609	-		0.00E+00	4.45E+04	0.00E+00	0.00E+00	0.00E+00	6.09E+00	0.00E+00	0.00E+00
Processing/Other	5,282	555	25,784		5.04E+05	4.06E+04	0.00E+00	0.00E+00	8.98E+00	5.55E+00	4.13E+02	0.00E+00
FISHERIES SECTOR	453	924	-	-	4.32E+04	6.75E+04	0.00E+00	0.00E+00	7.70E-01	9.24E+00	0.00E+00	0.00E+00
Large Ships	-	751	-		0.00E+00	5.49E+04	0.00E+00	0.00E+00	0.00E+00	7.51E+00	0.00E+00	0.00E+00
Processing/Other	453	173	-		4.32E+04	1.26E+04	0.00E+00	0.00E+00	7.70E-01	1.73E+00	0.00E+00	0.00E+00
MILITARY SECTOR	19,615	11,253	7,871	-	1.87E+06	8.22E+05	0.00E+00	0.00E+00	3.33E+01	1.13E+02	1.26E+02	0.00E+00
Trucks and other Transport		3,524	-		0.00E+00	2.58E+05	0.00E+00	0.00E+00	0.00E+00	3.52E+01	0.00E+00	0.00E+00
Armaments		129	-		0.00E+00	9.43E+03	0.00E+00	0.00E+00	0.00E+00	1.29E+00	0.00E+00	0.00E+00
Air Force		2,002	-		0.00E+00	1.46E+05	0.00E+00	0.00E+00	0.00E+00	2.00E+01	0.00E+00	0.00E+00
Naval Forces		5,513	-		0.00E+00	4.03E+05	0.00E+00	0.00E+00	0.00E+00	5.51E+01	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		3.82E+04	0.00E+00	0.00E+00	0.00E+00	6.81E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,215	85	7,871		1.83E+06	6.21E+03	0.00E+00	0.00E+00	3.27E+01	8.50E-01	1.26E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,506	165	4,952	-	1.57E+06	1.21E+04	0.00E+00	0.00E+00	2.81E+01	1.65E+00	7.92E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,536	635	6,000		1.46E+05	4.71E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	390,916	23,196	189,208	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	434,409		182,194													
Imports	36,405	23,383	7,014													
Exports	79,898	188														
Inputs to International Marine Bunkers																
Stock Changes		(207)														
ENERGY TRANSFORMATION	(112,260)	12,764	(6,150)	1,845	4.81E+02	3.43E+01	0.00E+00	3.01E+01	6.53E+04	3.05E+03	0.00E+00	0.00E+00	4.07E+04	2.34E+03	0.00E+00	5.21E+02
Electricity Generation	(84,246)	(8,409)			3.79E+02	2.94E+01	0.00E+00	0.00E+00	5.15E+04	2.63E+03	0.00E+00	0.00E+00	3.21E+04	2.01E+03	0.00E+00	0.00E+00
Petroleum Refining	-	22,568				-1.27E-14				-1.14E-12				-8.69E-13		
Coal Production/Preparation	(20,795)				9.36E+01				1.27E+04				7.91E+03			
Charcoal Production			(6,150)	1,845				3.01E+01				0.00E+00				5.21E+02
Coke Production																
District Heat Production	(1,900)	(71)			8.55E+00	2.47E-01	0.00E+00	0.00E+00	1.16E+03	2.21E+01	0.00E+00	0.00E+00	7.23E+02	1.69E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,324)			0.00E+00	4.63E+00	0.00E+00	0.00E+00	0.00E+00	3.96E+02	0.00E+00	0.00E+00	0.00E+00	3.16E+02	0.00E+00	0.00E+00
Losses	(5,319)															
FUELS FOR FINAL CONSUMPTION	278,657	35,959	183,058	1,845												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	278,654	36,166	180,244	1,836	1.25E+03	1.24E+02	1.22E+03	1.29E+01	1.69E+05	1.06E+04	0.00E+00	0.00E+00	1.05E+05	8.49E+03	2.11E+04	2.22E+02
INDUSTRIAL SECTOR	150,376	8,640	271	-	6.77E+02	3.02E+01	1.90E+00	0.00E+00	9.18E+04	2.58E+03	0.00E+00	0.00E+00	5.72E+04	2.07E+03	3.28E+01	0.00E+00
Iron and Steel	52,717	-			2.37E+02	0.00E+00	0.00E+00	0.00E+00	3.22E+04	0.00E+00	0.00E+00	0.00E+00	2.01E+04	0.00E+00	0.00E+00	0.00E+00
Cement	23,566	3,568			1.06E+02	1.25E+01	0.00E+00	0.00E+00	1.44E+04	1.07E+03	0.00E+00	0.00E+00	8.97E+03	8.53E+02	0.00E+00	0.00E+00
Fertilizers	3,010	512			1.35E+01	1.79E+00	0.00E+00	0.00E+00	1.84E+03	1.53E+02	0.00E+00	0.00E+00	1.15E+03	1.22E+02	0.00E+00	0.00E+00
Other Chemicals	2,265	-			1.02E+01	0.00E+00	0.00E+00	0.00E+00	1.38E+03	0.00E+00	0.00E+00	0.00E+00	8.62E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	814	-			3.66E+00	0.00E+00	0.00E+00	0.00E+00	4.97E+02	0.00E+00	0.00E+00	0.00E+00	3.10E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,940	-			7.17E+01	0.00E+00	0.00E+00	0.00E+00	9.74E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	3,528	3,528			1.59E+01	1.23E+01	0.00E+00	0.00E+00	2.15E+03	1.06E+03	0.00E+00	0.00E+00	1.34E+03	8.43E+02	0.00E+00	0.00E+00
Textiles	6,582	-			2.96E+01	0.00E+00	0.00E+00	0.00E+00	4.02E+03	0.00E+00	0.00E+00	0.00E+00	2.50E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,825	-			9.37E+01	0.00E+00	0.00E+00	0.00E+00	1.27E+04	0.00E+00	0.00E+00	0.00E+00	7.92E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	21,128	1,032	271		9.51E+01	3.61E+00	1.90E+00	0.00E+00	1.29E+04	3.09E+02	0.00E+00	0.00E+00	8.04E+03	2.47E+02	3.28E+01	0.00E+00
TRANSPORT SECTOR	-	11,216	816	-	0.00E+00	3.93E+01	5.72E+00	0.00E+00	0.00E+00	3.35E+03	0.00E+00	0.00E+00	0.00E+00	2.68E+03	9.88E+01	0.00E+00
Road		8,958	816		0.00E+00	3.14E+01	5.72E+00	0.00E+00	0.00E+00	2.68E+03	0.00E+00	0.00E+00	0.00E+00	2.14E+03	9.88E+01	0.00E+00
Rail	-	935			0.00E+00	3.27E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+02	0.00E+00	0.00E+00	0.00E+00	2.24E+02	0.00E+00	0.00E+00
Water	-	526			0.00E+00	1.84E+00	0.00E+00	0.00E+00	0.00E+00	1.57E+02	0.00E+00	0.00E+00	0.00E+00	1.26E+02	0.00E+00	0.00E+00
Air		797			0.00E+00	2.79E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+02	0.00E+00	0.00E+00	0.00E+00	1.90E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	84,886	2,169	134,550	1,836	3.82E+02	7.59E+00	9.42E+02	1.29E+01	5.18E+04	6.49E+02	0.00E+00	0.00E+00	3.23E+04	5.18E+02	1.63E+04	2.22E+02
Urban	67,806	2,016	24,739	1,132	3.05E+02	7.06E+00	1.73E+02	7.93E+00	4.14E+04	6.03E+02	0.00E+00	0.00E+00	2.58E+04	4.82E+02	2.99E+03	1.37E+02
Rural	17,079	153	109,810	704	7.69E+01	5.34E-01	7.69E+02	4.93E+00	1.04E+04	4.57E+01	0.00E+00	0.00E+00	6.50E+03	3.65E+01	1.33E+04	8.52E+01
AGRICULTURAL SECTOR	5,282	1,164	25,784	-	2.38E+01	4.08E+00	1.80E+02	0.00E+00	3.23E+03	3.48E+02	0.00E+00	0.00E+00	2.01E+03	2.78E+02	3.12E+03	0.00E+00
Field Operations		609	-		0.00E+00	2.13E+00	0.00E+00	0.00E+00	0.00E+00	1.82E+02	0.00E+00	0.00E+00	0.00E+00	1.46E+02	0.00E+00	0.00E+00
Processing/Other	5,282	555	25,784		2.38E+01	1.94E+00	1.80E+02	0.00E+00	3.23E+03	1.66E+02	0.00E+00	0.00E+00	2.01E+03	1.33E+02	3.12E+03	0.00E+00
FISHERIES SECTOR	453	924	-	-	2.04E+00	3.23E+00	0.00E+00	0.00E+00	2.77E+02	2.76E+02	0.00E+00	0.00E+00	1.72E+02	2.21E+02	0.00E+00	0.00E+00
Large Ships	-	751	-		0.00E+00	2.63E+00	0.00E+00	0.00E+00	0.00E+00	2.25E+02	0.00E+00	0.00E+00	0.00E+00	1.79E+02	0.00E+00	0.00E+00
Processing/Other	453	173	-		2.04E+00	6.05E-01	0.00E+00	0.00E+00	2.77E+02	5.17E+01	0.00E+00	0.00E+00	1.72E+02	4.13E+01	0.00E+00	0.00E+00
MILITARY SECTOR	19,615	11,253	7,871	-	8.83E+01	3.94E+01	5.51E+01	0.00E+00	1.20E+04	3.37E+03	0.00E+00	0.00E+00	7.46E+03	2.69E+03	9.52E+02	0.00E+00
Trucks and other Transport		3,524	-		0.00E+00	1.23E+01	0.00E+00	0.00E+00	0.00E+00	1.05E+03	0.00E+00	0.00E+00	0.00E+00	8.42E+02	0.00E+00	0.00E+00
Armaments		129	-		0.00E+00	4.51E-01	0.00E+00	0.00E+00	0.00E+00	3.86E+01	0.00E+00	0.00E+00	0.00E+00	3.08E+01	0.00E+00	0.00E+00
Air Force		2,002	-		0.00E+00	7.01E+00	0.00E+00	0.00E+00	0.00E+00	5.99E+02	0.00E+00	0.00E+00	0.00E+00	4.78E+02	0.00E+00	0.00E+00
Naval Forces		5,513	-		0.00E+00	1.93E+01	0.00E+00	0.00E+00	0.00E+00	1.65E+03	0.00E+00	0.00E+00	0.00E+00	1.32E+03	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		1.80E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,215	85	7,871		8.65E+01	2.98E-01	5.51E+01	0.00E+00	1.17E+04	2.54E+01	0.00E+00	0.00E+00	7.31E+03	2.03E+01	9.52E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,506	165	4,952	-	7.43E+01	5.78E-01	3.47E+01	0.00E+00	1.01E+04	4.94E+01	0.00E+00	0.00E+00	6.28E+03	3.94E+01	5.99E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,536	635	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2008

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.70	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.313	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2008				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.56E+07**	**3.55E+06**	**0.00E+00**	**0.00E+00**	**3.92E+07**
Methane from Combustion	**6.33E+02**	**4.79E+02**	**3.07E+03**	**3.29E+00**	**4.18E+03**
Methane from Production	**2.63E+05**	**0.00E+00**	**0.00E+00**	**1.48E+02**	**2.64E+05**
Nitrous Oxide from Combustion	**1.67E+03**	**1.68E+02**	**1.34E+03**	**4.11E+01**	**3.23E+03**
Sulfur Oxides from Combustion	**2.27E+05**	**1.45E+04**	**0.00E+00**	**0.00E+00**	**2.42E+05**
Nitrogen Oxides from Combustion	**1.42E+05**	**1.14E+04**	**2.32E+04**	**7.11E+02**	**1.77E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.92E+07**	**2.68E+05**	**3.23E+03**	**2.42E+05**	**1.77E+05**
ENERGY SUPPLY	0.00E+00	2.63E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.28E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	3.55E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.08E+07	4.63E+02	5.37E+02	6.67E+04	4.27E+04
Electricity Generation	8.55E+06	2.63E+02	4.04E+02	5.28E+04	3.34E+04
Coal Prod./Prep.	1.95E+06	3.47E+01	9.19E+01	1.25E+04	7.77E+03
Charcoal Production	0.00E+00	1.48E+02	2.88E+01	0.00E+00	4.97E+02
District Heat Production	1.66E+05	4.33E+00	7.82E+00	1.04E+03	6.52E+02
Own Use	9.78E+04	1.34E+01	4.68E+00	4.00E+02	3.20E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.84E+07	3.87E+03	2.69E+03	1.75E+05	1.34E+05
INDUSTRIAL	1.53E+07	3.41E+02	7.25E+02	9.69E+04	6.08E+04
TRANSPORT	8.97E+05	1.36E+02	4.89E+01	3.67E+03	3.04E+03
RESIDENTIAL	7.24E+06	2.60E+03	1.43E+03	4.60E+04	4.75E+04
AGRICULTURAL	5.59E+05	4.17E+02	2.00E+02	3.41E+03	5.19E+03
FISHERIES	1.05E+05	9.55E+00	4.98E+00	5.20E+02	3.71E+02
MILITARY	2.47E+06	2.48E+02	1.69E+02	1.42E+04	1.02E+04
PUBLIC/COMML	1.62E+06	1.12E+02	1.12E+02	1.04E+04	7.08E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.88E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	156	1.07	167	0.12
Diesel	381	1.035	394	0.4
Heavy Oil	334	0.96	321	1.5
Kerosene/Jet Fuel	71	1.045	74	0.032
LPG	58	1.13	65	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.157**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.313**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	378,844	25,671	205,752	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	426,842		199,729						2.28E+05			
Imports	18,558	29,658	6,024									
Exports	66,556	3,987							3.55E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(107,170)	8,615	(5,873)	1,762	9.72E+06	1.05E+06	0.00E+00	0.00E+00	1.73E+02	1.42E+02	0.00E+00	1.48E+02
Electricity Generation	(79,895)	(12,701)			7.62E+06	9.36E+05	0.00E+00	0.00E+00	1.36E+02	1.27E+02	0.00E+00	0.00E+00
Petroleum Refining	-	22,812				2.68E-10				3.64E-14		
Coal Production/Preparation	(20,433)				1.95E+06				3.47E+01			
Charcoal Production			(5,873)	1,762								1.48E+02
Coke Production												
District Heat Production	(1,615)	(158)			1.54E+05	1.17E+04	0.00E+00	0.00E+00	2.75E+00	1.58E+00	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,338)			0.00E+00	9.78E+04	0.00E+00	0.00E+00	0.00E+00	1.34E+01	0.00E+00	0.00E+00
Losses	(5,226)											
FUELS FOR FINAL CONSUMPTION	271,674	34,286	199,880	1,762								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	271,674	34,285	197,723	1,762	2.59E+07	2.51E+06	0.00E+00	0.00E+00	4.59E+02	3.37E+02	3.07E+03	3.29E+00
INDUSTRIAL SECTOR	155,101	7,349	260	-	1.48E+07	5.37E+05	0.00E+00	0.00E+00	2.64E+02	7.35E+01	4.16E+00	0.00E+00
Iron and Steel	51,776	-			4.94E+06	0.00E+00	0.00E+00	0.00E+00	8.80E+01	0.00E+00	0.00E+00	0.00E+00
Cement	30,144	3,168			2.87E+06	2.32E+05	0.00E+00	0.00E+00	5.12E+01	3.17E+01	0.00E+00	0.00E+00
Fertilizers	2,872	498			2.74E+05	3.64E+04	0.00E+00	0.00E+00	4.88E+00	4.98E+00	0.00E+00	0.00E+00
Other Chemicals	2,095	-			2.00E+05	0.00E+00	0.00E+00	0.00E+00	3.56E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	753	-			7.18E+04	0.00E+00	0.00E+00	0.00E+00	1.28E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	16,177	-			1.54E+06	0.00E+00	0.00E+00	0.00E+00	2.75E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,108	3,099			3.92E+05	2.26E+05	0.00E+00	0.00E+00	6.98E+00	3.10E+01	0.00E+00	0.00E+00
Textiles	6,465	-			6.16E+05	0.00E+00	0.00E+00	0.00E+00	1.10E+01	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			1.95E+06	0.00E+00	0.00E+00	0.00E+00	3.48E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	20,257	584	260		1.93E+06	4.27E+04	0.00E+00	0.00E+00	3.44E+01	5.84E+00	4.16E+00	0.00E+00
TRANSPORT SECTOR	-	12,274	843	-	0.00E+00	8.97E+05	0.00E+00	0.00E+00	0.00E+00	1.23E+02	1.35E+01	0.00E+00
Road		10,384	843		0.00E+00	7.59E+05	0.00E+00	0.00E+00	0.00E+00	1.04E+02	1.35E+01	0.00E+00
Rail	-	604			0.00E+00	4.41E+04	0.00E+00	0.00E+00	0.00E+00	6.04E+00	0.00E+00	0.00E+00
Water	-	414			0.00E+00	3.02E+04	0.00E+00	0.00E+00	0.00E+00	4.14E+00	0.00E+00	0.00E+00
Air		873			0.00E+00	6.38E+04	0.00E+00	0.00E+00	0.00E+00	8.73E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	74,302	2,100	153,322	1,762	7.08E+06	1.53E+05	0.00E+00	0.00E+00	1.26E+02	2.10E+01	2.45E+03	3.29E+00
Urban	61,212	1,916	34,093	1,089	5.84E+06	1.40E+05	0.00E+00	0.00E+00	1.04E+02	1.92E+01	5.45E+02	2.03E+00
Rural	13,090	184	119,228	673	1.25E+06	1.35E+04	0.00E+00	0.00E+00	2.23E+01	1.84E+00	1.91E+03	1.26E+00
AGRICULTURAL SECTOR	5,094	1,008	24,864	-	4.86E+05	7.36E+04	0.00E+00	0.00E+00	8.66E+00	1.01E+01	3.98E+02	0.00E+00
Field Operations		517	-		0.00E+00	3.78E+04	0.00E+00	0.00E+00	0.00E+00	5.17E+00	0.00E+00	0.00E+00
Processing/Other	5,094	491	24,864		4.86E+05	3.59E+04	0.00E+00	0.00E+00	8.66E+00	4.91E+00	3.98E+02	0.00E+00
FISHERIES SECTOR	419	884	-	-	3.99E+04	6.46E+04	0.00E+00	0.00E+00	7.12E-01	8.84E+00	0.00E+00	0.00E+00
Large Ships	-	724	-		0.00E+00	5.29E+04	0.00E+00	0.00E+00	0.00E+00	7.24E+00	0.00E+00	0.00E+00
Processing/Other	419	160	-		3.99E+04	1.17E+04	0.00E+00	0.00E+00	7.12E-01	1.60E+00	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	9,830	7,379	-	1.76E+06	7.18E+05	0.00E+00	0.00E+00	3.13E+01	9.83E+01	1.18E+02	0.00E+00
Trucks and other Transport		3,186	-		0.00E+00	2.33E+05	0.00E+00	0.00E+00	0.00E+00	3.19E+01	0.00E+00	0.00E+00
Armaments		101	-		0.00E+00	7.38E+03	0.00E+00	0.00E+00	0.00E+00	1.01E+00	0.00E+00	0.00E+00
Air Force		2,234	-		0.00E+00	1.63E+05	0.00E+00	0.00E+00	0.00E+00	2.23E+01	0.00E+00	0.00E+00
Naval Forces		4,227	-		0.00E+00	3.09E+05	0.00E+00	0.00E+00	0.00E+00	4.23E+01	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		3.82E+04	0.00E+00	0.00E+00	0.00E+00	6.81E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	82	7,379		1.72E+06	5.99E+03	0.00E+00	0.00E+00	3.06E+01	8.20E-01	1.18E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,850	239	5,055	-	1.61E+06	1.75E+04	0.00E+00	0.00E+00	2.86E+01	2.39E+00	8.09E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,493	600	6,000		1.42E+05	4.55E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	378,844	25,671	205,752	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	426,842		199,729													
Imports	18,558	29,658	6,024													
Exports	66,556	3,987														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(107,170)	8,615	(5,873)	1,762	4.59E+02	4.97E+01	0.00E+00	2.88E+01	6.23E+04	4.43E+03	0.00E+00	0.00E+00	3.88E+04	3.39E+03	0.00E+00	4.97E+02
Electricity Generation	(79,895)	(12,701)			3.60E+02	4.45E+01	0.00E+00	0.00E+00	4.88E+04	3.98E+03	0.00E+00	0.00E+00	3.04E+04	3.04E+03	0.00E+00	0.00E+00
Petroleum Refining	-	22,812				1.27E-14				1.14E-12				8.69E-13		
Coal Production/Preparation	(20,433)				9.19E+01				1.25E+04				7.77E+03			
Charcoal Production			(5,873)	1,762				2.88E+01				0.00E+00				4.97E+02
Coke Production																
District Heat Production	(1,615)	(158)			7.27E+00	5.53E-01	0.00E+00	0.00E+00	9.87E+02	4.95E+01	0.00E+00	0.00E+00	6.15E+02	3.78E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,338)			0.00E+00	4.68E+00	0.00E+00	0.00E+00	0.00E+00	4.00E+02	0.00E+00	0.00E+00	0.00E+00	3.20E+02	0.00E+00	0.00E+00
Losses	(5,226)															
FUELS FOR FINAL CONSUMPTION	271,674	34,286	199,880	1,762												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	271,674	34,285	197,723	1,762	1.22E+03	1.18E+02	1.34E+03	1.23E+01	1.65E+05	1.01E+04	0.00E+00	0.00E+00	1.03E+05	8.05E+03	2.32E+04	2.13E+02
INDUSTRIAL SECTOR	155,101	7,349	260	-	6.98E+02	2.57E+01	1.82E+00	0.00E+00	9.47E+04	2.20E+03	0.00E+00	0.00E+00	5.90E+04	1.76E+03	3.15E+01	0.00E+00
Iron and Steel	51,776	-			2.33E+02	0.00E+00	0.00E+00	0.00E+00	3.16E+04	0.00E+00	0.00E+00	0.00E+00	1.97E+04	0.00E+00	0.00E+00	0.00E+00
Cement	30,144	3,168			1.36E+02	1.11E+01	0.00E+00	0.00E+00	1.84E+04	9.47E+02	0.00E+00	0.00E+00	1.15E+04	7.57E+02	0.00E+00	0.00E+00
Fertilizers	2,872	498			1.29E+01	1.74E+00	0.00E+00	0.00E+00	1.75E+03	1.49E+02	0.00E+00	0.00E+00	1.09E+03	1.19E+02	0.00E+00	0.00E+00
Other Chemicals	2,095	-			9.43E+00	0.00E+00	0.00E+00	0.00E+00	1.28E+03	0.00E+00	0.00E+00	0.00E+00	7.97E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	753	-			3.39E+00	0.00E+00	0.00E+00	0.00E+00	4.60E+02	0.00E+00	0.00E+00	0.00E+00	2.86E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	16,177	-			7.28E+01	0.00E+00	0.00E+00	0.00E+00	9.88E+03	0.00E+00	0.00E+00	0.00E+00	6.16E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,108	3,099			1.85E+01	1.08E+01	0.00E+00	0.00E+00	2.51E+03	9.27E+02	0.00E+00	0.00E+00	1.56E+03	7.41E+02	0.00E+00	0.00E+00
Textiles	6,465	-			2.91E+01	0.00E+00	0.00E+00	0.00E+00	3.95E+03	0.00E+00	0.00E+00	0.00E+00	2.46E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			9.20E+01	0.00E+00	0.00E+00	0.00E+00	1.25E+04	0.00E+00	0.00E+00	0.00E+00	7.78E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	20,257	584	260		9.12E+01	2.04E+00	1.82E+00	0.00E+00	1.24E+04	1.75E+02	0.00E+00	0.00E+00	7.71E+03	1.40E+02	3.15E+01	0.00E+00
TRANSPORT SECTOR	-	12,274	843	-	0.00E+00	4.30E+01	5.90E+00	0.00E+00	0.00E+00	3.67E+03	0.00E+00	0.00E+00	0.00E+00	2.93E+03	1.02E+02	0.00E+00
Road		10,384	843		0.00E+00	3.63E+01	5.90E+00	0.00E+00	0.00E+00	3.11E+03	0.00E+00	0.00E+00	0.00E+00	2.48E+03	1.02E+02	0.00E+00
Rail	-	604			0.00E+00	2.11E+00	0.00E+00	0.00E+00	0.00E+00	1.81E+02	0.00E+00	0.00E+00	0.00E+00	1.44E+02	0.00E+00	0.00E+00
Water	-	414			0.00E+00	1.45E+00	0.00E+00	0.00E+00	0.00E+00	1.24E+02	0.00E+00	0.00E+00	0.00E+00	9.88E+01	0.00E+00	0.00E+00
Air		873			0.00E+00	3.06E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+02	0.00E+00	0.00E+00	0.00E+00	2.09E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	74,302	2,100	153,322	1,762	3.34E+02	7.35E+00	1.07E+03	1.23E+01	4.54E+04	6.28E+02	0.00E+00	0.00E+00	2.83E+04	5.02E+02	1.86E+04	2.13E+02
Urban	61,212	1,916	34,093	1,089	2.75E+02	6.71E+00	2.39E+02	7.62E+00	3.74E+04	5.73E+02	0.00E+00	0.00E+00	2.33E+04	4.58E+02	4.13E+03	1.32E+02
Rural	13,090	184	119,228	673	5.89E+01	6.44E-01	8.35E+02	4.71E+00	8.00E+03	5.50E+01	0.00E+00	0.00E+00	4.98E+03	4.40E+01	1.44E+04	8.14E+01
AGRICULTURAL SECTOR	5,094	1,008	24,864	-	2.29E+01	3.53E+00	1.74E+02	0.00E+00	3.11E+03	3.01E+02	0.00E+00	0.00E+00	1.94E+03	2.41E+02	3.01E+03	0.00E+00
Field Operations		517	-		0.00E+00	1.81E+00	0.00E+00	0.00E+00	0.00E+00	1.55E+02	0.00E+00	0.00E+00	0.00E+00	1.24E+02	0.00E+00	0.00E+00
Processing/Other	5,094	491	24,864		2.29E+01	1.72E+00	1.74E+02	0.00E+00	3.11E+03	1.47E+02	0.00E+00	0.00E+00	1.94E+03	1.17E+02	3.01E+03	0.00E+00
FISHERIES SECTOR	419	884	-	-	1.88E+00	3.09E+00	0.00E+00	0.00E+00	2.56E+02	2.64E+02	0.00E+00	0.00E+00	1.59E+02	2.11E+02	0.00E+00	0.00E+00
Large Ships	-	724	-		0.00E+00	2.53E+00	0.00E+00	0.00E+00	0.00E+00	2.17E+02	0.00E+00	0.00E+00	0.00E+00	1.73E+02	0.00E+00	0.00E+00
Processing/Other	419	160	-		1.88E+00	5.60E-01	0.00E+00	0.00E+00	2.56E+02	4.79E+01	0.00E+00	0.00E+00	1.59E+02	3.83E+01	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	9,830	7,379	-	8.29E+01	3.44E+01	5.17E+01	0.00E+00	1.12E+04	2.94E+03	0.00E+00	0.00E+00	7.01E+03	2.35E+03	8.93E+02	0.00E+00
Trucks and other Transport		3,186	-		0.00E+00	1.12E+01	0.00E+00	0.00E+00	0.00E+00	9.53E+02	0.00E+00	0.00E+00	0.00E+00	7.61E+02	0.00E+00	0.00E+00
Armaments		101	-		0.00E+00	3.53E-01	0.00E+00	0.00E+00	0.00E+00	3.02E+01	0.00E+00	0.00E+00	0.00E+00	2.41E+01	0.00E+00	0.00E+00
Air Force		2,234	-		0.00E+00	7.82E+00	0.00E+00	0.00E+00	0.00E+00	6.68E+02	0.00E+00	0.00E+00	0.00E+00	5.34E+02	0.00E+00	0.00E+00
Naval Forces		4,227	-		0.00E+00	1.48E+01	0.00E+00	0.00E+00	0.00E+00	1.26E+03	0.00E+00	0.00E+00	0.00E+00	1.01E+03	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		1.80E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	82	7,379		8.11E+01	2.87E-01	5.17E+01	0.00E+00	1.10E+04	2.45E+01	0.00E+00	0.00E+00	6.85E+03	1.96E+01	8.93E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,850	239	5,055	-	7.58E+01	8.37E-01	3.54E+01	0.00E+00	1.03E+04	7.16E+01	0.00E+00	0.00E+00	6.41E+03	5.72E+01	6.12E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,493	600	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2009

Prepared By David Von Hippel
Date Last Modified: 3/11/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	72.89	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.265	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2009				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.73E+07**	**2.59E+06**	**0.00E+00**	**0.00E+00**	**3.98E+07**
Methane from Combustion	**6.63E+02**	**3.49E+02**	**3.08E+03**	**3.34E+00**	**4.10E+03**
Methane from Production	**3.09E+05**	**0.00E+00**	**0.00E+00**	**1.50E+02**	**3.09E+05**
Nitrous Oxide from Combustion	**1.75E+03**	**1.22E+02**	**1.35E+03**	**4.18E+01**	**3.27E+03**
Sulfur Oxides from Combustion	**2.38E+05**	**1.02E+04**	**0.00E+00**	**0.00E+00**	**2.48E+05**
Nitrogen Oxides from Combustion	**1.48E+05**	**8.35E+03**	**2.33E+04**	**7.22E+02**	**1.81E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.98E+07**	**3.13E+05**	**3.27E+03**	**2.48E+05**	**1.81E+05**
ENERGY SUPPLY	0.00E+00	3.09E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.59E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	5.02E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	9.46E+06	3.90E+02	4.76E+02	5.90E+04	3.78E+04
Electricity Generation	6.98E+06	1.84E+02	3.30E+02	4.34E+04	2.75E+04
Coal Prod./Prep.	2.21E+06	3.94E+01	1.04E+02	1.42E+04	8.82E+03
Charcoal Production	0.00E+00	1.50E+02	2.92E+01	0.00E+00	5.05E+02
District Heat Production	1.68E+05	3.31E+00	7.94E+00	1.07E+03	6.70E+02
Own Use	9.60E+04	1.31E+01	4.60E+00	3.93E+02	3.14E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.04E+07	3.86E+03	2.79E+03	1.89E+05	1.43E+05
INDUSTRIAL	1.76E+07	3.57E+02	8.31E+02	1.12E+05	6.99E+04
TRANSPORT	6.92E+05	1.05E+02	3.76E+01	2.83E+03	2.34E+03
RESIDENTIAL	7.33E+06	2.64E+03	1.45E+03	4.67E+04	4.82E+04
AGRICULTURAL	5.31E+05	3.96E+02	1.90E+02	3.24E+03	4.93E+03
FISHERIES	9.77E+04	8.88E+00	4.65E+00	4.87E+02	3.47E+02
MILITARY	2.40E+06	2.38E+02	1.66E+02	1.39E+04	1.00E+04
PUBLIC/COMML	1.64E+06	1.13E+02	1.13E+02	1.04E+04	7.14E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	192	1.07	205	0.12
Diesel	238	1.035	246	0.4
Heavy Oil	207	0.96	198	1.5
Kerosene/Jet Fuel	58	1.045	61	0.032
LPG	57	1.13	64	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.133**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.265**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	396,765	13,334	206,783	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	484,287		202,014						2.59E+05			
Imports	6,543	13,506	4,769									
Exports	94,065	172							5.02E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(98,867)	14,209	(5,967)	1,790	8.86E+06	5.97E+05	0.00E+00	0.00E+00	1.58E+02	8.18E+01	0.00E+00	1.50E+02
Electricity Generation	(68,017)	(6,833)			6.48E+06	4.98E+05	0.00E+00	0.00E+00	1.16E+02	6.83E+01	0.00E+00	0.00E+00
Petroleum Refining	-	22,392				2.65E-10				3.64E-14		
Coal Production/Preparation	(23,183)				2.21E+06				3.94E+01			
Charcoal Production			(5,967)	1,790								1.50E+02
Coke Production												
District Heat Production	(1,738)	(36)			1.66E+05	2.62E+03	0.00E+00	0.00E+00	2.95E+00	3.59E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,314)			0.00E+00	9.60E+04	0.00E+00	0.00E+00	0.00E+00	1.31E+01	0.00E+00	0.00E+00
Losses	(5,929)											
FUELS FOR FINAL CONSUMPTION	297,899	27,543	200,816	1,790								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	297,901	27,542	198,686	1,791	2.84E+07	1.99E+06	0.00E+00	0.00E+00	5.05E+02	2.68E+02	3.08E+03	3.34E+00
INDUSTRIAL SECTOR	180,677	4,653	202	-	1.72E+07	3.40E+05	0.00E+00	0.00E+00	3.07E+02	4.65E+01	3.22E+00	0.00E+00
Iron and Steel	69,936	-			6.67E+06	0.00E+00	0.00E+00	0.00E+00	1.19E+02	0.00E+00	0.00E+00	0.00E+00
Cement	43,952	1,585			4.19E+06	1.16E+05	0.00E+00	0.00E+00	7.47E+01	1.58E+01	0.00E+00	0.00E+00
Fertilizers	1,903	330			1.81E+05	2.41E+04	0.00E+00	0.00E+00	3.23E+00	3.30E+00	0.00E+00	0.00E+00
Other Chemicals	1,848	-			1.76E+05	0.00E+00	0.00E+00	0.00E+00	3.14E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	664	-			6.33E+04	0.00E+00	0.00E+00	0.00E+00	1.13E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,916	-			1.52E+06	0.00E+00	0.00E+00	0.00E+00	2.71E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,816	2,114			4.59E+05	1.54E+05	0.00E+00	0.00E+00	8.19E+00	2.11E+01	0.00E+00	0.00E+00
Textiles	5,495	-			5.24E+05	0.00E+00	0.00E+00	0.00E+00	9.34E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			1.95E+06	0.00E+00	0.00E+00	0.00E+00	3.48E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	15,693	625	202		1.50E+06	4.57E+04	0.00E+00	0.00E+00	2.67E+01	6.25E+00	3.22E+00	0.00E+00
TRANSPORT SECTOR	-	9,463	641	-	0.00E+00	6.92E+05	0.00E+00	0.00E+00	0.00E+00	9.46E+01	1.03E+01	0.00E+00
Road		7,871	641		0.00E+00	5.75E+05	0.00E+00	0.00E+00	0.00E+00	7.87E+01	1.03E+01	0.00E+00
Rail	-	448			0.00E+00	3.28E+04	0.00E+00	0.00E+00	0.00E+00	4.48E+00	0.00E+00	0.00E+00
Water	-	351			0.00E+00	2.56E+04	0.00E+00	0.00E+00	0.00E+00	3.51E+00	0.00E+00	0.00E+00
Air		793			0.00E+00	5.79E+04	0.00E+00	0.00E+00	0.00E+00	7.93E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	75,642	1,691	155,758	1,791	7.21E+06	1.24E+05	0.00E+00	0.00E+00	1.29E+02	1.69E+01	2.49E+03	3.34E+00
Urban	62,349	1,549	34,685	1,108	5.94E+06	1.13E+05	0.00E+00	0.00E+00	1.06E+02	1.55E+01	5.55E+02	2.07E+00
Rural	13,292	142	121,072	683	1.27E+06	1.04E+04	0.00E+00	0.00E+00	2.26E+01	1.42E+00	1.94E+03	1.28E+00
AGRICULTURAL SECTOR	4,839	950	23,623	-	4.61E+05	6.95E+04	0.00E+00	0.00E+00	8.23E+00	9.50E+00	3.78E+02	0.00E+00
Field Operations		518	-		0.00E+00	3.79E+04	0.00E+00	0.00E+00	0.00E+00	5.18E+00	0.00E+00	0.00E+00
Processing/Other	4,839	432	23,623		4.61E+05	3.16E+04	0.00E+00	0.00E+00	8.23E+00	4.32E+00	3.78E+02	0.00E+00
FISHERIES SECTOR	396	820	-	-	3.78E+04	6.00E+04	0.00E+00	0.00E+00	6.74E-01	8.20E+00	0.00E+00	0.00E+00
Large Ships	-	670	-		0.00E+00	4.90E+04	0.00E+00	0.00E+00	0.00E+00	6.70E+00	0.00E+00	0.00E+00
Processing/Other	396	150	-		3.78E+04	1.10E+04	0.00E+00	0.00E+00	6.74E-01	1.50E+00	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	8,856	7,379	-	1.76E+06	6.47E+05	0.00E+00	0.00E+00	3.13E+01	8.86E+01	1.18E+02	0.00E+00
Trucks and other Transport		2,984	-		0.00E+00	2.18E+05	0.00E+00	0.00E+00	0.00E+00	2.98E+01	0.00E+00	0.00E+00
Armaments		101	-		0.00E+00	7.38E+03	0.00E+00	0.00E+00	0.00E+00	1.01E+00	0.00E+00	0.00E+00
Air Force		1,792	-		0.00E+00	1.31E+05	0.00E+00	0.00E+00	0.00E+00	1.79E+01	0.00E+00	0.00E+00
Naval Forces		3,901	-		0.00E+00	2.85E+05	0.00E+00	0.00E+00	0.00E+00	3.90E+01	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		3.82E+04	0.00E+00	0.00E+00	0.00E+00	6.81E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	78	7,379		1.72E+06	5.70E+03	0.00E+00	0.00E+00	3.06E+01	7.80E-01	1.18E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,944	330	5,083	-	1.62E+06	2.41E+04	0.00E+00	0.00E+00	2.88E+01	3.30E+00	8.13E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	989	779	6,000		9.43E+04	3.54E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	396,765	13,334	206,783	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	484,287		202,014													
Imports	6,543	13,506	4,769													
Exports	94,065	172														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(98,867)	14,209	(5,967)	1,790	4.18E+02	2.86E+01	0.00E+00	2.92E+01	5.68E+04	2.22E+03	0.00E+00	0.00E+00	3.54E+04	1.96E+03	0.00E+00	5.05E+02
Electricity Generation	(68,017)	(6,833)			3.06E+02	2.39E+01	0.00E+00	0.00E+00	4.15E+04	1.81E+03	0.00E+00	0.00E+00	2.59E+04	1.63E+03	0.00E+00	0.00E+00
Petroleum Refining	-	22,392				1.27E-14				9.65E-13				8.69E-13		
Coal Production/Preparation	(23,183)				1.04E+02				1.42E+04				8.82E+03			
Charcoal Production			(5,967)	1,790				2.92E+01				0.00E+00				5.05E+02
Coke Production																
District Heat Production	(1,738)	(36)			7.82E+00	1.26E-01	0.00E+00	0.00E+00	1.06E+03	9.53E+00	0.00E+00	0.00E+00	6.61E+02	8.58E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,314)			0.00E+00	4.60E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+02	0.00E+00	0.00E+00	0.00E+00	3.14E+02	0.00E+00	0.00E+00
Losses	(5,929)															
FUELS FOR FINAL CONSUMPTION	297,899	27,543	200,816	1,790												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	297,901	27,542	198,686	1,791	1.34E+03	9.37E+01	1.35E+03	1.25E+01	1.81E+05	8.00E+03	0.00E+00	0.00E+00	1.13E+05	6.40E+03	2.33E+04	2.17E+02
INDUSTRIAL SECTOR	180,677	4,653	202	-	8.13E+02	1.63E+01	1.41E+00	0.00E+00	1.10E+05	1.39E+03	0.00E+00	0.00E+00	6.87E+04	1.11E+03	2.44E+01	0.00E+00
Iron and Steel	69,936	-			3.15E+02	0.00E+00	0.00E+00	0.00E+00	4.27E+04	0.00E+00	0.00E+00	0.00E+00	2.66E+04	0.00E+00	0.00E+00	0.00E+00
Cement	43,952	1,585			1.98E+02	5.55E+00	0.00E+00	0.00E+00	2.68E+04	4.74E+02	0.00E+00	0.00E+00	1.67E+04	3.79E+02	0.00E+00	0.00E+00
Fertilizers	1,903	330			8.56E+00	1.15E+00	0.00E+00	0.00E+00	1.16E+03	9.86E+01	0.00E+00	0.00E+00	7.24E+02	7.88E+01	0.00E+00	0.00E+00
Other Chemicals	1,848	-			8.32E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+03	0.00E+00	0.00E+00	0.00E+00	7.03E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	664	-			2.99E+00	0.00E+00	0.00E+00	0.00E+00	4.06E+02	0.00E+00	0.00E+00	0.00E+00	2.53E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,916	-			7.16E+01	0.00E+00	0.00E+00	0.00E+00	9.72E+03	0.00E+00	0.00E+00	0.00E+00	6.06E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,816	2,114			2.17E+01	7.40E+00	0.00E+00	0.00E+00	2.94E+03	6.32E+02	0.00E+00	0.00E+00	1.83E+03	5.05E+02	0.00E+00	0.00E+00
Textiles	5,495	-			2.47E+01	0.00E+00	0.00E+00	0.00E+00	3.36E+03	0.00E+00	0.00E+00	0.00E+00	2.09E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	20,453	-			9.20E+01	0.00E+00	0.00E+00	0.00E+00	1.25E+04	0.00E+00	0.00E+00	0.00E+00	7.78E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	15,693	625	202		7.06E+01	2.19E+00	1.41E+00	0.00E+00	9.59E+03	1.87E+02	0.00E+00	0.00E+00	5.97E+03	1.49E+02	2.44E+01	0.00E+00
TRANSPORT SECTOR	-	9,463	641	-	0.00E+00	3.31E+01	4.49E+00	0.00E+00	0.00E+00	2.83E+03	0.00E+00	0.00E+00	0.00E+00	2.26E+03	7.76E+01	0.00E+00
Road		7,871	641		0.00E+00	2.75E+01	4.49E+00	0.00E+00	0.00E+00	2.35E+03	0.00E+00	0.00E+00	0.00E+00	1.88E+03	7.76E+01	0.00E+00
Rail	-	448			0.00E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+02	0.00E+00	0.00E+00	0.00E+00	1.07E+02	0.00E+00	0.00E+00
Water	-	351			0.00E+00	1.23E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+02	0.00E+00	0.00E+00	0.00E+00	8.39E+01	0.00E+00	0.00E+00
Air		793			0.00E+00	2.78E+00	0.00E+00	0.00E+00	0.00E+00	2.37E+02	0.00E+00	0.00E+00	0.00E+00	1.90E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	75,642	1,691	155,758	1,791	3.40E+02	5.92E+00	1.09E+03	1.25E+01	4.62E+04	5.06E+02	0.00E+00	0.00E+00	2.88E+04	4.04E+02	1.88E+04	2.17E+02
Urban	62,349	1,549	34,685	1,108	2.81E+02	5.42E+00	2.43E+02	7.75E+00	3.81E+04	4.63E+02	0.00E+00	0.00E+00	2.37E+04	3.70E+02	4.20E+03	1.34E+02
Rural	13,292	142	121,072	683	5.98E+01	4.96E-01	8.48E+02	4.78E+00	8.12E+03	4.24E+01	0.00E+00	0.00E+00	5.06E+03	3.39E+01	1.46E+04	8.27E+01
AGRICULTURAL SECTOR	4,839	950	23,623	-	2.18E+01	3.33E+00	1.65E+02	0.00E+00	2.96E+03	2.84E+02	0.00E+00	0.00E+00	1.84E+03	2.27E+02	2.86E+03	0.00E+00
Field Operations		518	-		0.00E+00	1.81E+00	0.00E+00	0.00E+00	0.00E+00	1.55E+02	0.00E+00	0.00E+00	0.00E+00	1.24E+02	0.00E+00	0.00E+00
Processing/Other	4,839	432	23,623		2.18E+01	1.51E+00	1.65E+02	0.00E+00	2.96E+03	1.29E+02	0.00E+00	0.00E+00	1.84E+03	1.03E+02	2.86E+03	0.00E+00
FISHERIES SECTOR	396	820	-	-	1.78E+00	2.87E+00	0.00E+00	0.00E+00	2.42E+02	2.45E+02	0.00E+00	0.00E+00	1.51E+02	1.96E+02	0.00E+00	0.00E+00
Large Ships	-	670	-		0.00E+00	2.35E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+02	0.00E+00	0.00E+00	0.00E+00	1.60E+02	0.00E+00	0.00E+00
Processing/Other	396	150	-		1.78E+00	5.26E-01	0.00E+00	0.00E+00	2.42E+02	4.49E+01	0.00E+00	0.00E+00	1.51E+02	3.59E+01	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	8,856	7,379	-	8.29E+01	3.10E+01	5.17E+01	0.00E+00	1.12E+04	2.65E+03	0.00E+00	0.00E+00	7.01E+03	2.12E+03	8.93E+02	0.00E+00
Trucks and other Transport		2,984	-		0.00E+00	1.04E+01	0.00E+00	0.00E+00	0.00E+00	8.92E+02	0.00E+00	0.00E+00	0.00E+00	7.13E+02	0.00E+00	0.00E+00
Armaments		101	-		0.00E+00	3.53E-01	0.00E+00	0.00E+00	0.00E+00	3.02E+01	0.00E+00	0.00E+00	0.00E+00	2.41E+01	0.00E+00	0.00E+00
Air Force		1,792	-		0.00E+00	6.27E+00	0.00E+00	0.00E+00	0.00E+00	5.36E+02	0.00E+00	0.00E+00	0.00E+00	4.28E+02	0.00E+00	0.00E+00
Naval Forces		3,901	-		0.00E+00	1.37E+01	0.00E+00	0.00E+00	0.00E+00	1.17E+03	0.00E+00	0.00E+00	0.00E+00	9.32E+02	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		1.80E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	78	7,379		8.11E+01	2.73E-01	5.17E+01	0.00E+00	1.10E+04	2.33E+01	0.00E+00	0.00E+00	6.85E+03	1.86E+01	8.93E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	16,944	330	5,083	-	7.62E+01	1.16E+00	3.56E+01	0.00E+00	1.03E+04	9.88E+01	0.00E+00	0.00E+00	6.45E+03	7.90E+01	6.15E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	989	779	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2010

Prepared By David Von Hippel
Date Last Modified: 3/13/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	72.77	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.254	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2010				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.60E+07**	**2.90E+06**	**0.00E+00**	**0.00E+00**	**3.89E+07**
Methane from Combustion	**6.40E+02**	**3.92E+02**	**3.13E+03**	**3.40E+00**	**4.17E+03**
Methane from Production	**3.27E+05**	**0.00E+00**	**0.00E+00**	**1.53E+02**	**3.28E+05**
Nitrous Oxide from Combustion	**1.69E+03**	**1.37E+02**	**1.37E+03**	**4.25E+01**	**3.24E+03**
Sulfur Oxides from Combustion	**2.30E+05**	**1.14E+04**	**0.00E+00**	**0.00E+00**	**2.41E+05**
Nitrogen Oxides from Combustion	**1.43E+05**	**9.38E+03**	**2.37E+04**	**7.34E+02**	**1.77E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.89E+07**	**3.32E+05**	**3.243E+03**	**2.41E+05**	**1.77E+05**
ENERGY SUPPLY	0.00E+00	3.27E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.62E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	6.50E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	8.55E+06	3.81E+02	4.339E+02	5.30E+04	3.42E+04
Electricity Generation	6.02E+06	1.69E+02	2.84E+02	3.70E+04	2.36E+04
Coal Prod./Prep.	2.24E+06	4.00E+01	1.06E+02	1.44E+04	8.96E+03
Charcoal Production	0.00E+00	1.53E+02	2.97E+01	0.00E+00	5.14E+02
District Heat Production	1.84E+05	3.58E+00	8.67E+00	1.17E+03	7.31E+02
Own Use	1.08E+05	1.48E+01	5.18E+00	4.43E+02	3.54E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.03E+07	3.94E+03	2.809E+03	1.88E+05	1.43E+05
INDUSTRIAL	1.71E+07	3.58E+02	8.11E+02	1.09E+05	6.82E+04
TRANSPORT	7.66E+05	1.16E+02	4.17E+01	3.14E+03	2.59E+03
RESIDENTIAL	7.49E+06	2.69E+03	1.47E+03	4.77E+04	4.92E+04
AGRICULTURAL	5.43E+05	4.02E+02	1.93E+02	3.31E+03	5.01E+03
FISHERIES	1.06E+05	9.62E+00	5.05E+00	5.29E+02	3.76E+02
MILITARY	2.49E+06	2.50E+02	1.70E+02	1.42E+04	1.03E+04
PUBLIC/COMML	1.65E+06	1.15E+02	1.14E+02	1.05E+04	7.20E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	211	1.07	226	0.12
Diesel	265	1.035	275	0.4
Heavy Oil	211	0.96	203	1.5
Kerosene/Jet Fuel	71	1.045	74	0.032
LPG	66	1.13	75	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.127**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.254**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	383,464	14,789	208,893	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	491,714		204,624						2.62E+05			
Imports	13,432	16,459	4,268									
Exports	121,681	1,670							6.50E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(89,126)	16,676	(6,067)	1,820	7.92E+06	6.29E+05	0.00E+00	0.00E+00	1.41E+02	8.63E+01	0.00E+00	1.53E+02
Electricity Generation	(57,667)	(7,118)			5.50E+06	5.18E+05	0.00E+00	0.00E+00	9.80E+01	7.12E+01	0.00E+00	0.00E+00
Petroleum Refining	-	25,309				-2.65E-10				-3.64E-14		
Coal Production/Preparation	(23,539)				2.24E+06				4.00E+01			
Charcoal Production			(6,067)	1,820								1.53E+02
Coke Production												
District Heat Production	(1,900)	(35)			1.81E+05	2.58E+03	0.00E+00	0.00E+00	3.23E+00	3.55E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,480)			0.00E+00	1.08E+05	0.00E+00	0.00E+00	0.00E+00	1.48E+01	0.00E+00	0.00E+00
Losses	(6,020)											
FUELS FOR FINAL CONSUMPTION	294,338	31,465	202,825	1,820								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	294,337	31,465	201,600	1,821	2.81E+07	2.27E+06	0.00E+00	0.00E+00	4.99E+02	3.06E+02	3.13E+03	3.40E+00
INDUSTRIAL SECTOR	175,522	5,688	194	-	1.67E+07	4.16E+05	0.00E+00	0.00E+00	2.98E+02	5.69E+01	3.10E+00	0.00E+00
Iron and Steel	69,197	-			6.60E+06	0.00E+00	0.00E+00	0.00E+00	1.18E+02	0.00E+00	0.00E+00	0.00E+00
Cement	43,099	2,278			4.11E+06	1.66E+05	0.00E+00	0.00E+00	7.33E+01	2.28E+01	0.00E+00	0.00E+00
Fertilizers	1,950	338			1.86E+05	2.47E+04	0.00E+00	0.00E+00	3.32E+00	3.38E+00	0.00E+00	0.00E+00
Other Chemicals	1,725	-			1.64E+05	0.00E+00	0.00E+00	0.00E+00	2.93E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	642	-			6.12E+04	0.00E+00	0.00E+00	0.00E+00	1.09E+00	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,133	-			1.44E+06	0.00E+00	0.00E+00	0.00E+00	2.57E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,423	2,381			4.22E+05	1.74E+05	0.00E+00	0.00E+00	7.52E+00	2.38E+01	0.00E+00	0.00E+00
Textiles	5,172	-			4.93E+05	0.00E+00	0.00E+00	0.00E+00	8.79E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	19,090	-			1.82E+06	0.00E+00	0.00E+00	0.00E+00	3.25E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	15,090	691	194		1.44E+06	5.05E+04	0.00E+00	0.00E+00	2.57E+01	6.91E+00	3.10E+00	0.00E+00
TRANSPORT SECTOR	-	10,485	712	-	0.00E+00	7.66E+05	0.00E+00	0.00E+00	0.00E+00	1.05E+02	1.14E+01	0.00E+00
Road		8,720	712		0.00E+00	6.37E+05	0.00E+00	0.00E+00	0.00E+00	8.72E+01	1.14E+01	0.00E+00
Rail	-	526			0.00E+00	3.84E+04	0.00E+00	0.00E+00	0.00E+00	5.26E+00	0.00E+00	0.00E+00
Water	-	376			0.00E+00	2.75E+04	0.00E+00	0.00E+00	0.00E+00	3.76E+00	0.00E+00	0.00E+00
Air		863			0.00E+00	6.31E+04	0.00E+00	0.00E+00	0.00E+00	8.63E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	77,012	2,071	158,248	1,821	7.34E+06	1.51E+05	0.00E+00	0.00E+00	1.31E+02	2.07E+01	2.53E+03	3.40E+00
Urban	63,513	1,894	35,291	1,127	6.05E+06	1.38E+05	0.00E+00	0.00E+00	1.08E+02	1.89E+01	5.65E+02	2.10E+00
Rural	13,499	177	122,957	694	1.29E+06	1.29E+04	0.00E+00	0.00E+00	2.29E+01	1.77E+00	1.97E+03	1.30E+00
AGRICULTURAL SECTOR	4,907	1,031	23,955	-	4.68E+05	7.53E+04	0.00E+00	0.00E+00	8.34E+00	1.03E+01	3.83E+02	0.00E+00
Field Operations		539	-		0.00E+00	3.94E+04	0.00E+00	0.00E+00	0.00E+00	5.39E+00	0.00E+00	0.00E+00
Processing/Other	4,907	491	23,955		4.68E+05	3.59E+04	0.00E+00	0.00E+00	8.34E+00	4.91E+00	3.83E+02	0.00E+00
FISHERIES SECTOR	430	889	-	-	4.10E+04	6.49E+04	0.00E+00	0.00E+00	7.31E-01	8.89E+00	0.00E+00	0.00E+00
Large Ships	-	724	-		0.00E+00	5.29E+04	0.00E+00	0.00E+00	0.00E+00	7.24E+00	0.00E+00	0.00E+00
Processing/Other	430	165	-		4.10E+04	1.20E+04	0.00E+00	0.00E+00	7.31E-01	1.65E+00	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	10,018	7,379	-	1.76E+06	7.32E+05	0.00E+00	0.00E+00	3.13E+01	1.00E+02	1.18E+02	0.00E+00
Trucks and other Transport		3,186	-		0.00E+00	2.33E+05	0.00E+00	0.00E+00	0.00E+00	3.19E+01	0.00E+00	0.00E+00
Armaments		103	-		0.00E+00	7.53E+03	0.00E+00	0.00E+00	0.00E+00	1.03E+00	0.00E+00	0.00E+00
Air Force		2,100	-		0.00E+00	1.53E+05	0.00E+00	0.00E+00	0.00E+00	2.10E+01	0.00E+00	0.00E+00
Naval Forces		4,553	-		0.00E+00	3.33E+05	0.00E+00	0.00E+00	0.00E+00	4.55E+01	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		3.82E+04	0.00E+00	0.00E+00	0.00E+00	6.81E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	76	7,379		1.72E+06	5.55E+03	0.00E+00	0.00E+00	3.06E+01	7.60E-01	1.18E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	17,037	417	5,111	-	1.62E+06	3.05E+04	0.00E+00	0.00E+00	2.90E+01	4.17E+00	8.18E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,014	866	6,000		9.43E+04	3.53E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	383,464	14,789	208,893	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	491,714		204,624													
Imports	13,432	16,459	4,268													
Exports	121,681	1,670														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(89,126)	16,676	(6,067)	1,820	3.74E+02	3.02E+01	0.00E+00	2.97E+01	5.08E+04	2.26E+03	0.00E+00	0.00E+00	3.16E+04	2.06E+03	0.00E+00	5.14E+02
Electricity Generation	(57,667)	(7,118)			2.60E+02	2.49E+01	0.00E+00	0.00E+00	3.52E+04	1.81E+03	0.00E+00	0.00E+00	2.19E+04	1.70E+03	0.00E+00	0.00E+00
Petroleum Refining	-	25,309				-1.27E-14				-9.24E-13				-8.69E-13		
Coal Production/Preparation	(23,539)				1.06E+02				1.44E+04				8.96E+03			
Charcoal Production			(6,067)	1,820				2.97E+01				0.00E+00				5.14E+02
Coke Production																
District Heat Production	(1,900)	(35)			8.55E+00	1.24E-01	0.00E+00	0.00E+00	1.16E+03	9.01E+00	0.00E+00	0.00E+00	7.23E+02	8.48E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,480)			0.00E+00	5.18E+00	0.00E+00	0.00E+00	0.00E+00	4.43E+02	0.00E+00	0.00E+00	0.00E+00	3.54E+02	0.00E+00	0.00E+00
Losses	(6,020)															
FUELS FOR FINAL CONSUMPTION	294,338	31,465	202,825	1,820												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	294,337	31,465	201,600	1,821	1.32E+03	1.07E+02	1.37E+03	1.27E+01	1.79E+05	9.15E+03	0.00E+00	0.00E+00	1.12E+05	7.31E+03	2.37E+04	2.20E+02
INDUSTRIAL SECTOR	175,522	5,688	194	-	7.90E+02	1.99E+01	1.36E+00	0.00E+00	1.07E+05	1.70E+03	0.00E+00	0.00E+00	6.68E+04	1.36E+03	2.34E+01	0.00E+00
Iron and Steel	69,197	-			3.11E+02	0.00E+00	0.00E+00	0.00E+00	4.23E+04	0.00E+00	0.00E+00	0.00E+00	2.63E+04	0.00E+00	0.00E+00	0.00E+00
Cement	43,099	2,278			1.94E+02	7.97E+00	0.00E+00	0.00E+00	2.63E+04	6.81E+02	0.00E+00	0.00E+00	1.64E+04	5.44E+02	0.00E+00	0.00E+00
Fertilizers	1,950	338			8.78E+00	1.18E+00	0.00E+00	0.00E+00	1.19E+03	1.01E+02	0.00E+00	0.00E+00	7.42E+02	8.07E+01	0.00E+00	0.00E+00
Other Chemicals	1,725	-			7.76E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+03	0.00E+00	0.00E+00	0.00E+00	6.56E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	642	-			2.89E+00	0.00E+00	0.00E+00	0.00E+00	3.92E+02	0.00E+00	0.00E+00	0.00E+00	2.44E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	15,133	-			6.81E+01	0.00E+00	0.00E+00	0.00E+00	9.24E+03	0.00E+00	0.00E+00	0.00E+00	5.76E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,423	2,381			1.99E+01	8.33E+00	0.00E+00	0.00E+00	2.70E+03	7.12E+02	0.00E+00	0.00E+00	1.68E+03	5.69E+02	0.00E+00	0.00E+00
Textiles	5,172	-			2.33E+01	0.00E+00	0.00E+00	0.00E+00	3.16E+03	0.00E+00	0.00E+00	0.00E+00	1.97E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	19,090	-			8.59E+01	0.00E+00	0.00E+00	0.00E+00	1.17E+04	0.00E+00	0.00E+00	0.00E+00	7.26E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	15,090	691	194		6.79E+01	2.42E+00	1.36E+00	0.00E+00	9.22E+03	2.07E+02	0.00E+00	0.00E+00	5.74E+03	1.65E+02	2.34E+01	0.00E+00
TRANSPORT SECTOR	-	10,485	712	-	0.00E+00	3.67E+01	4.99E+00	0.00E+00	0.00E+00	3.14E+03	0.00E+00	0.00E+00	0.00E+00	2.51E+03	8.62E+01	0.00E+00
Road		8,720	712		0.00E+00	3.05E+01	4.99E+00	0.00E+00	0.00E+00	2.61E+03	0.00E+00	0.00E+00	0.00E+00	2.08E+03	8.62E+01	0.00E+00
Rail	-	526			0.00E+00	1.84E+00	0.00E+00	0.00E+00	0.00E+00	1.57E+02	0.00E+00	0.00E+00	0.00E+00	1.26E+02	0.00E+00	0.00E+00
Water	-	376			0.00E+00	1.32E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+02	0.00E+00	0.00E+00	0.00E+00	8.98E+01	0.00E+00	0.00E+00
Air		863			0.00E+00	3.02E+00	0.00E+00	0.00E+00	0.00E+00	2.58E+02	0.00E+00	0.00E+00	0.00E+00	2.06E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	77,012	2,071	158,248	1,821	3.47E+02	7.25E+00	1.11E+03	1.27E+01	4.70E+04	6.19E+02	0.00E+00	0.00E+00	2.93E+04	4.95E+02	1.91E+04	2.20E+02
Urban	63,513	1,894	35,291	1,127	2.86E+02	6.63E+00	2.47E+02	7.89E+00	3.88E+04	5.67E+02	0.00E+00	0.00E+00	2.42E+04	4.53E+02	4.27E+03	1.36E+02
Rural	13,499	177	122,957	694	6.07E+01	6.19E-01	8.61E+02	4.86E+00	8.25E+03	5.29E+01	0.00E+00	0.00E+00	5.14E+03	4.23E+01	1.49E+04	8.40E+01
AGRICULTURAL SECTOR	4,907	1,031	23,955	-	2.21E+01	3.61E+00	1.68E+02	0.00E+00	3.00E+03	3.08E+02	0.00E+00	0.00E+00	1.87E+03	2.46E+02	2.90E+03	0.00E+00
Field Operations		539	-		0.00E+00	1.89E+00	0.00E+00	0.00E+00	0.00E+00	1.61E+02	0.00E+00	0.00E+00	0.00E+00	1.29E+02	0.00E+00	0.00E+00
Processing/Other	4,907	491	23,955		2.21E+01	1.72E+00	1.68E+02	0.00E+00	3.00E+03	1.47E+02	0.00E+00	0.00E+00	1.87E+03	1.17E+02	2.90E+03	0.00E+00
FISHERIES SECTOR	430	889	-	-	1.94E+00	3.11E+00	0.00E+00	0.00E+00	2.63E+02	2.66E+02	0.00E+00	0.00E+00	1.64E+02	2.12E+02	0.00E+00	0.00E+00
Large Ships	-	724	-		0.00E+00	2.53E+00	0.00E+00	0.00E+00	0.00E+00	2.17E+02	0.00E+00	0.00E+00	0.00E+00	1.73E+02	0.00E+00	0.00E+00
Processing/Other	430	165	-		1.94E+00	5.76E-01	0.00E+00	0.00E+00	2.63E+02	4.92E+01	0.00E+00	0.00E+00	1.64E+02	3.94E+01	0.00E+00	0.00E+00
MILITARY SECTOR	18,415	10,018	7,379	-	8.29E+01	3.51E+01	5.17E+01	0.00E+00	1.12E+04	3.00E+03	0.00E+00	0.00E+00	7.01E+03	2.39E+03	8.93E+02	0.00E+00
Trucks and other Transport		3,186	-		0.00E+00	1.12E+01	0.00E+00	0.00E+00	0.00E+00	9.53E+02	0.00E+00	0.00E+00	0.00E+00	7.61E+02	0.00E+00	0.00E+00
Armaments		103	-		0.00E+00	3.60E-01	0.00E+00	0.00E+00	0.00E+00	3.08E+01	0.00E+00	0.00E+00	0.00E+00	2.46E+01	0.00E+00	0.00E+00
Air Force		2,100	-		0.00E+00	7.35E+00	0.00E+00	0.00E+00	0.00E+00	6.28E+02	0.00E+00	0.00E+00	0.00E+00	5.02E+02	0.00E+00	0.00E+00
Naval Forces		4,553	-		0.00E+00	1.59E+01	0.00E+00	0.00E+00	0.00E+00	1.36E+03	0.00E+00	0.00E+00	0.00E+00	1.09E+03	0.00E+00	0.00E+00
Military Manufacturing	401	-	-		1.80E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.52E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,014	76	7,379		8.11E+01	2.66E-01	5.17E+01	0.00E+00	1.10E+04	2.27E+01	0.00E+00	0.00E+00	6.85E+03	1.82E+01	8.93E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	17,037	417	5,111	-	7.67E+01	1.46E+00	3.58E+01	0.00E+00	1.04E+04	1.25E+02	0.00E+00	0.00E+00	6.48E+03	9.98E+01	6.18E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,014	866	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2014

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Date Last Modified: 4/20/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	Notes
Carbon Dioxide from Combustion	95.3	72.69	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.261	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2014				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.24E+07**	**3.28E+06**	**0.00E+00**	**0.00E+00**	**4.57E+07**
Methane from Combustion	**7.54E+02**	**4.44E+02**	**3.12E+03**	**3.71E+00**	**4.33E+03**
Methane from Production	**6.69E+05**	**0.00E+00**	**0.00E+00**	**1.67E+02**	**6.69E+05**
Nitrous Oxide from Combustion	**2.00E+03**	**1.55E+02**	**1.37E+03**	**4.64E+01**	**3.57E+03**
Sulfur Oxides from Combustion	**2.71E+05**	**1.28E+04**	**0.00E+00**	**0.00E+00**	**2.84E+05**
Nitrogen Oxides from Combustion	**1.69E+05**	**1.06E+04**	**2.36E+04**	**8.02E+02**	**2.04E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.57E+07**	**6.74E+05**	**3.566E+03**	**2.84E+05**	**2.04E+05**
ENERGY SUPPLY	0.00E+00	6.69E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	4.55E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	2.15E+05	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.46E+07	5.43E+02	7.220E+02	9.08E+04	5.81E+04
Electricity Generation	1.05E+07	2.93E+02	4.94E+02	6.45E+04	4.11E+04
Coal Prod./Prep.	3.89E+06	6.93E+01	1.83E+02	2.49E+04	1.55E+04
Charcoal Production	0.00E+00	1.67E+02	3.25E+01	0.00E+00	5.61E+02
District Heat Production	1.72E+05	3.36E+00	8.12E+00	1.10E+03	6.85E+02
Own Use	1.06E+05	1.45E+01	5.09E+00	4.35E+02	3.48E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.11E+07	3.95E+03	2.844E+03	1.93E+05	1.46E+05
INDUSTRIAL	1.63E+07	3.48E+02	7.70E+02	1.03E+05	6.47E+04
TRANSPORT	7.54E+05	1.16E+02	4.17E+01	3.09E+03	2.56E+03
RESIDENTIAL	8.80E+06	2.67E+03	1.52E+03	5.60E+04	5.41E+04
AGRICULTURAL	5.88E+05	4.42E+02	2.13E+02	3.60E+03	5.49E+03
FISHERIES	1.30E+05	1.30E+01	6.21E+00	6.28E+02	4.56E+02
MILITARY	2.52E+06	2.42E+02	1.69E+02	1.45E+04	1.04E+04
PUBLIC/COMML	1.88E+06	1.18E+02	1.24E+02	1.19E+04	8.08E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	218	1.07	233	0.12
Diesel	254	1.035	262	0.4
Heavy Oil	228	0.96	219	1.5
Kerosene/Jet Fuel	62	1.045	65	0.032
LPG	78	1.13	88	0.00016
Aviation Gasoline	12	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.130**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.261**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	457,195	20,582	209,966	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.69E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	851,489		205,333						4.55E+05			
Imports	7,823	21,708	4,633									
Exports	402,116	1,126							2.15E+05			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(153,313)	11,128	(6,627)	1,988	1.36E+07	9.68E+05	0.00E+00	0.00E+00	2.43E+02	1.33E+02	0.00E+00	1.67E+02
Electricity Generation	(100,347)	(12,254)			9.57E+06	8.91E+05	0.00E+00	0.00E+00	1.71E+02	1.23E+02	0.00E+00	0.00E+00
Petroleum Refining	-	24,870				-3.19E+04				-4.39E+00		
Coal Production/Preparation	(40,761)				3.89E+06				6.93E+01			
Charcoal Production			(6,627)	1,988								1.67E+02
Coke Production												
District Heat Production	(1,780)	(33)			1.70E+05	2.42E+03	0.00E+00	0.00E+00	3.03E+00	3.33E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,455)			0.00E+00	1.06E+05	0.00E+00	0.00E+00	0.00E+00	1.45E+01	0.00E+00	0.00E+00
Losses	(10,425)											
FUELS FOR FINAL CONSUMPTION	303,882	31,711	203,339	1,988								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	303,883	31,710	201,308	1,988	2.88E+07	2.31E+06	0.00E+00	0.00E+00	5.11E+02	3.11E+02	3.12E+03	3.71E+00
INDUSTRIAL SECTOR	165,869	6,398	141	-	1.58E+07	4.68E+05	0.00E+00	0.00E+00	2.82E+02	6.40E+01	2.25E+00	0.00E+00
Iron and Steel	66,005	-			6.29E+06	0.00E+00	0.00E+00	0.00E+00	1.12E+02	0.00E+00	0.00E+00	0.00E+00
Cement	44,330	2,530			4.23E+06	1.85E+05	0.00E+00	0.00E+00	7.54E+01	2.53E+01	0.00E+00	0.00E+00
Fertilizers	5,841	1,031			5.57E+05	7.53E+04	0.00E+00	0.00E+00	9.93E+00	1.03E+01	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,568	-			1.29E+06	0.00E+00	0.00E+00	0.00E+00	2.31E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,484	2,320			4.27E+05	1.70E+05	0.00E+00	0.00E+00	7.62E+00	2.32E+01	0.00E+00	0.00E+00
Textiles	3,879	-			3.70E+05	0.00E+00	0.00E+00	0.00E+00	6.59E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			1.43E+06	0.00E+00	0.00E+00	0.00E+00	2.55E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	516	141		1.05E+06	3.77E+04	0.00E+00	0.00E+00	1.86E+01	5.16E+00	2.25E+00	0.00E+00
TRANSPORT SECTOR	-	10,320	794	-	0.00E+00	7.54E+05	0.00E+00	0.00E+00	0.00E+00	1.03E+02	1.27E+01	0.00E+00
Road		8,610	794		0.00E+00	6.29E+05	0.00E+00	0.00E+00	0.00E+00	8.61E+01	1.27E+01	0.00E+00
Rail	-	525			0.00E+00	3.84E+04	0.00E+00	0.00E+00	0.00E+00	5.25E+00	0.00E+00	0.00E+00
Water	-	338			0.00E+00	2.47E+04	0.00E+00	0.00E+00	0.00E+00	3.38E+00	0.00E+00	0.00E+00
Air		846			0.00E+00	6.18E+04	0.00E+00	0.00E+00	0.00E+00	8.46E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	90,615	2,186	155,810	1,988	8.64E+06	1.60E+05	0.00E+00	0.00E+00	1.54E+02	2.19E+01	2.49E+03	3.71E+00
Urban	73,032	2,004	34,289	1,234	6.96E+06	1.46E+05	0.00E+00	0.00E+00	1.24E+02	2.00E+01	5.49E+02	2.30E+00
Rural	17,583	183	121,521	754	1.68E+06	1.34E+04	0.00E+00	0.00E+00	2.99E+01	1.83E+00	1.94E+03	1.41E+00
AGRICULTURAL SECTOR	5,410	983	26,410	-	5.16E+05	7.19E+04	0.00E+00	0.00E+00	9.20E+00	9.83E+00	4.23E+02	0.00E+00
Field Operations		515	-		0.00E+00	3.76E+04	0.00E+00	0.00E+00	0.00E+00	5.15E+00	0.00E+00	0.00E+00
Processing/Other	5,410	469	26,410		5.16E+05	3.43E+04	0.00E+00	0.00E+00	9.20E+00	4.69E+00	4.23E+02	0.00E+00
FISHERIES SECTOR	430	1,222	-	-	4.10E+04	8.93E+04	0.00E+00	0.00E+00	7.31E-01	1.22E+01	0.00E+00	0.00E+00
Large Ships	-	1,048	-		0.00E+00	7.66E+04	0.00E+00	0.00E+00	0.00E+00	1.05E+01	0.00E+00	0.00E+00
Processing/Other	430	174	-		4.10E+04	1.27E+04	0.00E+00	0.00E+00	7.31E-01	1.74E+00	0.00E+00	0.00E+00
MILITARY SECTOR	19,144	9,522	7,130	-	1.83E+06	6.96E+05	0.00E+00	0.00E+00	3.25E+01	9.52E+01	1.14E+02	0.00E+00
Trucks and other Transport		3,527	-		0.00E+00	2.58E+05	0.00E+00	0.00E+00	0.00E+00	3.53E+01	0.00E+00	0.00E+00
Armaments		96	-		0.00E+00	6.98E+03	0.00E+00	0.00E+00	0.00E+00	9.56E-01	0.00E+00	0.00E+00
Air Force		1,899	-		0.00E+00	1.39E+05	0.00E+00	0.00E+00	0.00E+00	1.90E+01	0.00E+00	0.00E+00
Naval Forces		3,923	-		0.00E+00	2.87E+05	0.00E+00	0.00E+00	0.00E+00	3.92E+01	0.00E+00	0.00E+00
Military Manufacturing	427	-	-		4.07E+04	0.00E+00	0.00E+00	0.00E+00	7.26E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,717	78	7,130		1.78E+06	5.70E+03	0.00E+00	0.00E+00	3.18E+01	7.80E-01	1.14E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	19,322	491	5,024	-	1.84E+06	3.59E+04	0.00E+00	0.00E+00	3.28E+01	4.91E+00	8.04E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,092	589	6,000		9.43E+04	3.53E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	457,195	20,582	209,966	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	851,489		205,333													
Imports	7,823	21,708	4,633													
Exports	402,116	1,126														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(153,313)	11,128	(6,627)	1,988	6.43E+02	4.66E+01	0.00E+00	3.25E+01	8.73E+04	3.52E+03	0.00E+00	0.00E+00	5.44E+04	3.18E+03	0.00E+00	5.61E+02
Electricity Generation	(100,347)	(12,254)			4.52E+02	4.29E+01	0.00E+00	0.00E+00	6.13E+04	3.19E+03	0.00E+00	0.00E+00	3.82E+04	2.93E+03	0.00E+00	0.00E+00
Petroleum Refining	-	24,870				-1.54E+00				-1.15E+02				-1.05E+02		
Coal Production/Preparation	(40,761)				1.83E+02				2.49E+04				1.55E+04			
Charcoal Production			(6,627)	1,988				3.25E+01				0.00E+00				5.61E+02
Coke Production																
District Heat Production	(1,780)	(33)			8.01E+00	1.16E-01	0.00E+00	0.00E+00	1.09E+03	8.67E+00	0.00E+00	0.00E+00	6.77E+02	7.95E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,455)			0.00E+00	5.09E+00	0.00E+00	0.00E+00	0.00E+00	4.35E+02	0.00E+00	0.00E+00	0.00E+00	3.48E+02	0.00E+00	0.00E+00
Losses	(10,425)															
FUELS FOR FINAL CONSUMPTION	303,882	31,711	203,339	1,988												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	303,883	31,710	201,308	1,988	1.35E+03	1.09E+02	1.37E+03	1.39E+01	1.84E+05	9.31E+03	0.00E+00	0.00E+00	1.14E+05	7.44E+03	2.36E+04	2.41E+02
INDUSTRIAL SECTOR	165,869	6,398	141	-	7.46E+02	2.24E+01	9.86E-01	0.00E+00	1.01E+05	1.91E+03	0.00E+00	0.00E+00	6.31E+04	1.53E+03	1.70E+01	0.00E+00
Iron and Steel	66,005	-			2.97E+02	0.00E+00	0.00E+00	0.00E+00	4.03E+04	0.00E+00	0.00E+00	0.00E+00	2.51E+04	0.00E+00	0.00E+00	0.00E+00
Cement	44,330	2,530			1.99E+02	8.86E+00	0.00E+00	0.00E+00	2.71E+04	7.57E+02	0.00E+00	0.00E+00	1.69E+04	6.05E+02	0.00E+00	0.00E+00
Fertilizers	5,841	1,031			2.63E+01	3.61E+00	0.00E+00	0.00E+00	3.57E+03	3.08E+02	0.00E+00	0.00E+00	2.22E+03	2.46E+02	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,568	-			6.11E+01	0.00E+00	0.00E+00	0.00E+00	8.29E+03	0.00E+00	0.00E+00	0.00E+00	5.16E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,484	2,320			2.02E+01	8.12E+00	0.00E+00	0.00E+00	2.74E+03	6.94E+02	0.00E+00	0.00E+00	1.71E+03	5.55E+02	0.00E+00	0.00E+00
Textiles	3,879	-			1.75E+01	0.00E+00	0.00E+00	0.00E+00	2.37E+03	0.00E+00	0.00E+00	0.00E+00	1.48E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			6.75E+01	0.00E+00	0.00E+00	0.00E+00	9.16E+03	0.00E+00	0.00E+00	0.00E+00	5.71E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	516	141		4.93E+01	1.81E+00	9.86E-01	0.00E+00	6.70E+03	1.54E+02	0.00E+00	0.00E+00	4.17E+03	1.23E+02	1.70E+01	0.00E+00
TRANSPORT SECTOR	-	10,320	794	-	0.00E+00	3.61E+01	5.56E+00	0.00E+00	0.00E+00	3.09E+03	0.00E+00	0.00E+00	0.00E+00	2.47E+03	9.61E+01	0.00E+00
Road		8,610	794		0.00E+00	3.01E+01	5.56E+00	0.00E+00	0.00E+00	2.58E+03	0.00E+00	0.00E+00	0.00E+00	2.06E+03	9.61E+01	0.00E+00
Rail	-	525			0.00E+00	1.84E+00	0.00E+00	0.00E+00	0.00E+00	1.57E+02	0.00E+00	0.00E+00	0.00E+00	1.26E+02	0.00E+00	0.00E+00
Water	-	338			0.00E+00	1.18E+00	0.00E+00	0.00E+00	0.00E+00	1.01E+02	0.00E+00	0.00E+00	0.00E+00	8.09E+01	0.00E+00	0.00E+00
Air		846			0.00E+00	2.96E+00	0.00E+00	0.00E+00	0.00E+00	2.53E+02	0.00E+00	0.00E+00	0.00E+00	2.02E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	90,615	2,186	155,810	1,988	4.08E+02	7.65E+00	1.09E+03	1.39E+01	5.53E+04	6.54E+02	0.00E+00	0.00E+00	3.45E+04	5.23E+02	1.89E+04	2.41E+02
Urban	73,032	2,004	34,289	1,234	3.29E+02	7.01E+00	2.40E+02	8.64E+00	4.46E+04	5.99E+02	0.00E+00	0.00E+00	2.78E+04	4.79E+02	4.15E+03	1.49E+02
Rural	17,583	183	121,521	754	7.91E+01	6.39E-01	8.51E+02	5.28E+00	1.07E+04	5.46E+01	0.00E+00	0.00E+00	6.69E+03	4.37E+01	1.47E+04	9.13E+01
AGRICULTURAL SECTOR	5,410	983	26,410	-	2.43E+01	3.44E+00	1.85E+02	0.00E+00	3.30E+03	2.94E+02	0.00E+00	0.00E+00	2.06E+03	2.35E+02	3.20E+03	0.00E+00
Field Operations		515	-		0.00E+00	1.80E+00	0.00E+00	0.00E+00	0.00E+00	1.54E+02	0.00E+00	0.00E+00	0.00E+00	1.23E+02	0.00E+00	0.00E+00
Processing/Other	5,410	469	26,410		2.43E+01	1.64E+00	1.85E+02	0.00E+00	3.30E+03	1.40E+02	0.00E+00	0.00E+00	2.06E+03	1.12E+02	3.20E+03	0.00E+00
FISHERIES SECTOR	430	1,222	-	-	1.94E+00	4.28E+00	0.00E+00	0.00E+00	2.63E+02	3.66E+02	0.00E+00	0.00E+00	1.64E+02	2.92E+02	0.00E+00	0.00E+00
Large Ships	-	1,048	-		0.00E+00	3.67E+00	0.00E+00	0.00E+00	0.00E+00	3.13E+02	0.00E+00	0.00E+00	0.00E+00	2.50E+02	0.00E+00	0.00E+00
Processing/Other	430	174	-		1.94E+00	6.10E-01	0.00E+00	0.00E+00	2.63E+02	5.21E+01	0.00E+00	0.00E+00	1.64E+02	4.16E+01	0.00E+00	0.00E+00
MILITARY SECTOR	19,144	9,522	7,130	-	8.62E+01	3.33E+01	4.99E+01	0.00E+00	1.17E+04	2.85E+03	0.00E+00	0.00E+00	7.28E+03	2.28E+03	8.63E+02	0.00E+00
Trucks and other Transport		3,527	-		0.00E+00	1.23E+01	0.00E+00	0.00E+00	0.00E+00	1.05E+03	0.00E+00	0.00E+00	0.00E+00	8.43E+02	0.00E+00	0.00E+00
Armaments		96	-		0.00E+00	3.35E-01	0.00E+00	0.00E+00	0.00E+00	2.86E+01	0.00E+00	0.00E+00	0.00E+00	2.28E+01	0.00E+00	0.00E+00
Air Force		1,899	-		0.00E+00	6.65E+00	0.00E+00	0.00E+00	0.00E+00	5.68E+02	0.00E+00	0.00E+00	0.00E+00	4.54E+02	0.00E+00	0.00E+00
Naval Forces		3,923	-		0.00E+00	1.37E+01	0.00E+00	0.00E+00	0.00E+00	1.17E+03	0.00E+00	0.00E+00	0.00E+00	9.38E+02	0.00E+00	0.00E+00
Military Manufacturing	427	-	-		1.92E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+02	0.00E+00	0.00E+00	0.00E+00	1.63E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	18,717	78	7,130		8.42E+01	2.73E-01	4.99E+01	0.00E+00	1.14E+04	2.33E+01	0.00E+00	0.00E+00	7.12E+03	1.86E+01	8.63E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	19,322	491	5,024	-	8.69E+01	1.72E+00	3.52E+01	0.00E+00	1.18E+04	1.47E+02	0.00E+00	0.00E+00	7.35E+03	1.17E+02	6.08E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,092	589	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2015

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	Notes
Carbon Dioxide from Combustion	95.3	72.65	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.263	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2015				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.29E+07**	**4.03E+06**	**0.00E+00**	**0.00E+00**	**4.69E+07**
Methane from Combustion	**7.63E+02**	**5.48E+02**	**3.06E+03**	**3.85E+00**	**4.37E+03**
Methane from Production	**7.83E+05**	**0.00E+00**	**0.00E+00**	**1.73E+02**	**7.83E+05**
Nitrous Oxide from Combustion	**2.02E+03**	**1.92E+02**	**1.34E+03**	**4.82E+01**	**3.60E+03**
Sulfur Oxides from Combustion	**2.74E+05**	**1.57E+04**	**0.00E+00**	**0.00E+00**	**2.90E+05**
Nitrogen Oxides from Combustion	**1.71E+05**	**1.31E+04**	**2.31E+04**	**8.32E+02**	**2.08E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.69E+07**	**7.87E+05**	**3.597E+03**	**2.90E+05**	**2.08E+05**
ENERGY SUPPLY	0.00E+00	7.83E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	5.07E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	2.76E+05	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.56E+07	6.32E+02	7.707E+02	9.57E+04	6.17E+04
Electricity Generation	1.08E+07	3.37E+02	5.10E+02	6.57E+04	4.22E+04
Coal Prod./Prep.	4.34E+06	7.73E+01	2.05E+02	2.78E+04	1.73E+04
Charcoal Production	0.00E+00	1.73E+02	3.37E+01	0.00E+00	5.83E+02
District Heat Production	1.76E+05	3.45E+00	8.30E+00	1.12E+03	7.00E+02
Own Use	1.18E+05	1.62E+01	5.66E+00	4.84E+02	3.87E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.13E+07	3.91E+03	2.826E+03	1.94E+05	1.46E+05
INDUSTRIAL	1.55E+07	3.47E+02	7.33E+02	9.80E+04	6.15E+04
TRANSPORT	7.73E+05	1.19E+02	4.27E+01	3.16E+03	2.63E+03
RESIDENTIAL	9.60E+06	2.62E+03	1.53E+03	6.11E+04	5.67E+04
AGRICULTURAL	6.08E+05	4.56E+02	2.19E+02	3.72E+03	5.67E+03
FISHERIES	9.46E+04	9.09E+00	4.51E+00	4.62E+02	3.33E+02
MILITARY	2.62E+06	2.45E+02	1.72E+02	1.51E+04	1.07E+04
PUBLIC/COMML	1.99E+06	1.23E+02	1.29E+02	1.26E+04	8.51E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	229	1.07	245	0.12
Diesel	251	1.035	260	0.4
Heavy Oil	256	0.96	246	1.5
Kerosene/Jet Fuel	78	1.045	81	0.032
LPG	91	1.13	103	0.00016
Aviation Gasoline	13	1.07	14	0.04
Weighted Average: Sulfur content in kg/GJ				**0.132**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.263**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	463,146	25,293	206,626	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.83E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	949,915		201,836						5.07E+05			
Imports	29,620	25,482	4,790									
Exports	516,389	190							2.76E+05			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(159,267)	9,407	(6,880)	2,064	1.41E+07	1.51E+06	0.00E+00	0.00E+00	2.51E+02	2.08E+02	0.00E+00	1.73E+02
Electricity Generation	(100,347)	(16,673)			9.57E+06	1.21E+06	0.00E+00	0.00E+00	1.71E+02	1.67E+02	0.00E+00	0.00E+00
Petroleum Refining	-	27,734				1.76E+05				2.42E+01		
Coal Production/Preparation	(45,473)				4.34E+06				7.73E+01			
Charcoal Production			(6,880)	2,064								1.73E+02
Coke Production												
District Heat Production	(1,816)	(36)			1.73E+05	2.61E+03	0.00E+00	0.00E+00	3.09E+00	3.59E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,618)			0.00E+00	1.18E+05	0.00E+00	0.00E+00	0.00E+00	1.62E+01	0.00E+00	0.00E+00
Losses	(11,630)											
FUELS FOR FINAL CONSUMPTION	303,879	34,699	199,746	2,064								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	303,880	34,700	197,163	2,063	2.88E+07	2.52E+06	0.00E+00	0.00E+00	5.12E+02	3.41E+02	3.06E+03	3.85E+00
INDUSTRIAL SECTOR	156,549	7,812	141	-	1.49E+07	5.71E+05	0.00E+00	0.00E+00	2.66E+02	7.81E+01	2.25E+00	0.00E+00
Iron and Steel	58,377	-			5.57E+06	0.00E+00	0.00E+00	0.00E+00	9.92E+01	0.00E+00	0.00E+00	0.00E+00
Cement	43,254	3,761			4.12E+06	2.75E+05	0.00E+00	0.00E+00	7.35E+01	3.76E+01	0.00E+00	0.00E+00
Fertilizers	5,430	958			5.18E+05	7.00E+04	0.00E+00	0.00E+00	9.23E+00	9.58E+00	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,568	-			1.29E+06	0.00E+00	0.00E+00	0.00E+00	2.31E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,280	2,524			4.08E+05	1.84E+05	0.00E+00	0.00E+00	7.28E+00	2.52E+01	0.00E+00	0.00E+00
Textiles	3,879	-			3.70E+05	0.00E+00	0.00E+00	0.00E+00	6.59E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			1.43E+06	0.00E+00	0.00E+00	0.00E+00	2.55E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	568	141		1.05E+06	4.15E+04	0.00E+00	0.00E+00	1.86E+01	5.68E+00	2.25E+00	0.00E+00
TRANSPORT SECTOR	-	10,573	812	-	0.00E+00	7.73E+05	0.00E+00	0.00E+00	0.00E+00	1.06E+02	1.30E+01	0.00E+00
Road		8,755	812		0.00E+00	6.40E+05	0.00E+00	0.00E+00	0.00E+00	8.76E+01	1.30E+01	0.00E+00
Rail	-	535			0.00E+00	3.91E+04	0.00E+00	0.00E+00	0.00E+00	5.35E+00	0.00E+00	0.00E+00
Water	-	351			0.00E+00	2.56E+04	0.00E+00	0.00E+00	0.00E+00	3.51E+00	0.00E+00	0.00E+00
Air		932			0.00E+00	6.81E+04	0.00E+00	0.00E+00	0.00E+00	9.32E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	98,616	2,753	151,122	2,063	9.40E+06	2.01E+05	0.00E+00	0.00E+00	1.68E+02	2.75E+01	2.42E+03	3.85E+00
Urban	78,328	2,528	32,981	1,282	7.47E+06	1.85E+05	0.00E+00	0.00E+00	1.33E+02	2.53E+01	5.28E+02	2.39E+00
Rural	20,289	224	118,141	782	1.93E+06	1.64E+04	0.00E+00	0.00E+00	3.45E+01	2.24E+00	1.89E+03	1.46E+00
AGRICULTURAL SECTOR	5,581	1,042	27,243	-	5.32E+05	7.62E+04	0.00E+00	0.00E+00	9.49E+00	1.04E+01	4.36E+02	0.00E+00
Field Operations		546	-		0.00E+00	3.99E+04	0.00E+00	0.00E+00	0.00E+00	5.46E+00	0.00E+00	0.00E+00
Processing/Other	5,581	497	27,243		5.32E+05	3.63E+04	0.00E+00	0.00E+00	9.49E+00	4.97E+00	4.36E+02	0.00E+00
FISHERIES SECTOR	340	851	-	-	3.24E+04	6.22E+04	0.00E+00	0.00E+00	5.77E-01	8.51E+00	0.00E+00	0.00E+00
Large Ships	-	717	-		0.00E+00	5.24E+04	0.00E+00	0.00E+00	0.00E+00	7.17E+00	0.00E+00	0.00E+00
Processing/Other	340	134	-		3.24E+04	9.81E+03	0.00E+00	0.00E+00	5.77E-01	1.34E+00	0.00E+00	0.00E+00
MILITARY SECTOR	19,622	10,310	6,771	-	1.87E+06	7.53E+05	0.00E+00	0.00E+00	3.34E+01	1.03E+02	1.08E+02	0.00E+00
Trucks and other Transport		3,874	-		0.00E+00	2.83E+05	0.00E+00	0.00E+00	0.00E+00	3.87E+01	0.00E+00	0.00E+00
Armaments		102	-		0.00E+00	7.46E+03	0.00E+00	0.00E+00	0.00E+00	1.02E+00	0.00E+00	0.00E+00
Air Force		2,310	-		0.00E+00	1.69E+05	0.00E+00	0.00E+00	0.00E+00	2.31E+01	0.00E+00	0.00E+00
Naval Forces		3,944	-		0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00	3.94E+01	0.00E+00	0.00E+00
Military Manufacturing	436	-	-		4.16E+04	0.00E+00	0.00E+00	0.00E+00	7.42E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,186	79	6,771		1.83E+06	5.77E+03	0.00E+00	0.00E+00	3.26E+01	7.90E-01	1.08E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	20,297	710	5,074	-	1.94E+06	5.19E+04	0.00E+00	0.00E+00	3.45E+01	7.10E+00	8.12E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	2,874	648	6,000		9.43E+04	3.53E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	463,146	25,293	206,626	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	949,915		201,836													
Imports	29,620	25,482	4,790													
Exports	516,389	190														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(159,267)	9,407	(6,880)	2,064	6.64E+02	7.26E+01	0.00E+00	3.37E+01	9.02E+04	5.52E+03	0.00E+00	0.00E+00	5.62E+04	4.96E+03	0.00E+00	5.83E+02
Electricity Generation	(100,347)	(16,673)			4.52E+02	5.84E+01	0.00E+00	0.00E+00	6.13E+04	4.39E+03	0.00E+00	0.00E+00	3.82E+04	3.99E+03	0.00E+00	0.00E+00
Petroleum Refining	-	27,734				8.48E+00				6.38E+02				5.79E+02		
Coal Production/Preparation	(45,473)				2.05E+02				2.78E+04				1.73E+04			
Charcoal Production			(6,880)	2,064				3.37E+01				0.00E+00				5.83E+02
Coke Production																
District Heat Production	(1,816)	(36)			8.17E+00	1.26E-01	0.00E+00	0.00E+00	1.11E+03	9.46E+00	0.00E+00	0.00E+00	6.91E+02	8.59E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,618)			0.00E+00	5.66E+00	0.00E+00	0.00E+00	0.00E+00	4.84E+02	0.00E+00	0.00E+00	0.00E+00	3.87E+02	0.00E+00	0.00E+00
Losses	(11,630)															
FUELS FOR FINAL CONSUMPTION	303,879	34,699	199,746	2,064												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	303,880	34,700	197,163	2,063	1.35E+03	1.19E+02	1.34E+03	1.44E+01	1.84E+05	1.02E+04	0.00E+00	0.00E+00	1.15E+05	8.14E+03	2.31E+04	2.50E+02
INDUSTRIAL SECTOR	156,549	7,812	141	-	7.04E+02	2.73E+01	9.86E-01	0.00E+00	9.56E+04	2.34E+03	0.00E+00	0.00E+00	5.96E+04	1.87E+03	1.70E+01	0.00E+00
Iron and Steel	58,377	-			2.63E+02	0.00E+00	0.00E+00	0.00E+00	3.57E+04	0.00E+00	0.00E+00	0.00E+00	2.22E+04	0.00E+00	0.00E+00	0.00E+00
Cement	43,254	3,761			1.95E+02	1.32E+01	0.00E+00	0.00E+00	2.64E+04	1.12E+03	0.00E+00	0.00E+00	1.65E+04	8.99E+02	0.00E+00	0.00E+00
Fertilizers	5,430	958			2.44E+01	3.35E+00	0.00E+00	0.00E+00	3.32E+03	2.87E+02	0.00E+00	0.00E+00	2.07E+03	2.29E+02	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,568	-			6.11E+01	0.00E+00	0.00E+00	0.00E+00	8.29E+03	0.00E+00	0.00E+00	0.00E+00	5.16E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,280	2,524			1.93E+01	8.83E+00	0.00E+00	0.00E+00	2.61E+03	7.55E+02	0.00E+00	0.00E+00	1.63E+03	6.03E+02	0.00E+00	0.00E+00
Textiles	3,879	-			1.75E+01	0.00E+00	0.00E+00	0.00E+00	2.37E+03	0.00E+00	0.00E+00	0.00E+00	1.48E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			6.75E+01	0.00E+00	0.00E+00	0.00E+00	9.16E+03	0.00E+00	0.00E+00	0.00E+00	5.71E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	568	141		4.93E+01	1.99E+00	9.86E-01	0.00E+00	6.70E+03	1.70E+02	0.00E+00	0.00E+00	4.17E+03	1.36E+02	1.70E+01	0.00E+00
TRANSPORT SECTOR	-	10,573	812	-	0.00E+00	3.70E+01	5.68E+00	0.00E+00	0.00E+00	3.16E+03	0.00E+00	0.00E+00	0.00E+00	2.53E+03	9.82E+01	0.00E+00
Road		8,755	812		0.00E+00	3.06E+01	5.68E+00	0.00E+00	0.00E+00	2.62E+03	0.00E+00	0.00E+00	0.00E+00	2.09E+03	9.82E+01	0.00E+00
Rail	-	535			0.00E+00	1.87E+00	0.00E+00	0.00E+00	0.00E+00	1.60E+02	0.00E+00	0.00E+00	0.00E+00	1.28E+02	0.00E+00	0.00E+00
Water	-	351			0.00E+00	1.23E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+02	0.00E+00	0.00E+00	0.00E+00	8.39E+01	0.00E+00	0.00E+00
Air		932			0.00E+00	3.26E+00	0.00E+00	0.00E+00	0.00E+00	2.79E+02	0.00E+00	0.00E+00	0.00E+00	2.23E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	98,616	2,753	151,122	2,063	4.44E+02	9.63E+00	1.06E+03	1.44E+01	6.02E+04	8.23E+02	0.00E+00	0.00E+00	3.75E+04	6.58E+02	1.83E+04	2.50E+02
Urban	78,328	2,528	32,981	1,282	3.52E+02	8.85E+00	2.31E+02	8.97E+00	4.78E+04	7.56E+02	0.00E+00	0.00E+00	2.98E+04	6.04E+02	3.99E+03	1.55E+02
Rural	20,289	224	118,141	782	9.13E+01	7.86E-01	8.27E+02	5.47E+00	1.24E+04	6.71E+01	0.00E+00	0.00E+00	7.72E+03	5.37E+01	1.43E+04	9.46E+01
AGRICULTURAL SECTOR	5,581	1,042	27,243	-	2.51E+01	3.65E+00	1.91E+02	0.00E+00	3.41E+03	3.12E+02	0.00E+00	0.00E+00	2.12E+03	2.49E+02	3.30E+03	0.00E+00
Field Operations		546	-		0.00E+00	1.91E+00	0.00E+00	0.00E+00	0.00E+00	1.63E+02	0.00E+00	0.00E+00	0.00E+00	1.30E+02	0.00E+00	0.00E+00
Processing/Other	5,581	497	27,243		2.51E+01	1.74E+00	1.91E+02	0.00E+00	3.41E+03	1.49E+02	0.00E+00	0.00E+00	2.12E+03	1.19E+02	3.30E+03	0.00E+00
FISHERIES SECTOR	340	851	-	-	1.53E+00	2.98E+00	0.00E+00	0.00E+00	2.07E+02	2.55E+02	0.00E+00	0.00E+00	1.29E+02	2.04E+02	0.00E+00	0.00E+00
Large Ships	-	717	-		0.00E+00	2.51E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+02	0.00E+00	0.00E+00	0.00E+00	1.71E+02	0.00E+00	0.00E+00
Processing/Other	340	134	-		1.53E+00	4.70E-01	0.00E+00	0.00E+00	2.07E+02	4.02E+01	0.00E+00	0.00E+00	1.29E+02	3.21E+01	0.00E+00	0.00E+00
MILITARY SECTOR	19,622	10,310	6,771	-	8.83E+01	3.61E+01	4.74E+01	0.00E+00	1.20E+04	3.08E+03	0.00E+00	0.00E+00	7.47E+03	2.46E+03	8.19E+02	0.00E+00
Trucks and other Transport		3,874	-		0.00E+00	1.36E+01	0.00E+00	0.00E+00	0.00E+00	1.16E+03	0.00E+00	0.00E+00	0.00E+00	9.26E+02	0.00E+00	0.00E+00
Armaments		102	-		0.00E+00	3.57E-01	0.00E+00	0.00E+00	0.00E+00	3.05E+01	0.00E+00	0.00E+00	0.00E+00	2.44E+01	0.00E+00	0.00E+00
Air Force		2,310	-		0.00E+00	8.09E+00	0.00E+00	0.00E+00	0.00E+00	6.91E+02	0.00E+00	0.00E+00	0.00E+00	5.52E+02	0.00E+00	0.00E+00
Naval Forces		3,944	-		0.00E+00	1.38E+01	0.00E+00	0.00E+00	0.00E+00	1.18E+03	0.00E+00	0.00E+00	0.00E+00	9.43E+02	0.00E+00	0.00E+00
Military Manufacturing	436	-	-		1.96E+00	0.00E+00	0.00E+00	0.00E+00	2.66E+02	0.00E+00	0.00E+00	0.00E+00	1.66E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,186	79	6,771		8.63E+01	2.77E-01	4.74E+01	0.00E+00	1.17E+04	2.36E+01	0.00E+00	0.00E+00	7.30E+03	1.89E+01	8.19E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	20,297	710	5,074	-	9.13E+01	2.49E+00	3.55E+01	0.00E+00	1.24E+04	2.12E+02	0.00E+00	0.00E+00	7.72E+03	1.70E+02	6.14E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	2,874	648	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2016

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	Notes
Carbon Dioxide from Combustion	95.3	72.68	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.262	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2016				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.41E+07**	**4.52E+06**	**0.00E+00**	**0.00E+00**	**4.86E+07**
Methane from Combustion	**7.84E+02**	**6.14E+02**	**2.93E+03**	**4.00E+00**	**4.34E+03**
Methane from Production	**8.56E+05**	**0.00E+00**	**0.00E+00**	**1.80E+02**	**8.56E+05**
Nitrous Oxide from Combustion	**2.08E+03**	**2.15E+02**	**1.28E+03**	**5.00E+01**	**3.62E+03**
Sulfur Oxides from Combustion	**2.82E+05**	**1.75E+04**	**0.00E+00**	**0.00E+00**	**2.99E+05**
Nitrogen Oxides from Combustion	**1.75E+05**	**1.47E+04**	**2.22E+04**	**8.64E+02**	**2.13E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.86E+07**	**8.61E+05**	**3.624E+03**	**2.99E+05**	**2.13E+05**
ENERGY SUPPLY	0.00E+00	8.56E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	5.44E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	3.12E+05	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.53E+07	6.70E+02	7.611E+02	9.33E+04	6.06E+04
Electricity Generation	1.01E+07	3.52E+02	4.80E+02	6.10E+04	3.95E+04
Coal Prod./Prep.	4.65E+06	8.30E+01	2.20E+02	2.98E+04	1.86E+04
Charcoal Production	0.00E+00	1.80E+02	3.50E+01	0.00E+00	6.05E+02
District Heat Production	1.76E+05	3.44E+00	8.30E+00	1.12E+03	7.00E+02
Own Use	1.23E+05	1.68E+01	5.88E+00	5.03E+02	4.02E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.32E+07	3.85E+03	2.863E+03	2.06E+05	1.53E+05
INDUSTRIAL	1.64E+07	3.68E+02	7.74E+02	1.03E+05	6.49E+04
TRANSPORT	8.05E+05	1.24E+02	4.47E+01	3.30E+03	2.74E+03
RESIDENTIAL	1.04E+07	2.56E+03	1.53E+03	6.63E+04	5.94E+04
AGRICULTURAL	5.58E+05	4.10E+02	1.97E+02	3.39E+03	5.12E+03
FISHERIES	1.48E+05	1.54E+01	7.06E+00	7.00E+02	5.13E+02
MILITARY	2.71E+06	2.45E+02	1.73E+02	1.55E+04	1.10E+04
PUBLIC/COMML	2.09E+06	1.26E+02	1.34E+02	1.32E+04	8.91E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	234	1.07	250	0.12
Diesel	278	1.035	288	0.4
Heavy Oil	268	0.96	257	1.5
Kerosene/Jet Fuel	87	1.045	91	0.032
LPG	96	1.13	108	0.00016
Aviation Gasoline	13	1.07	14	0.04
Weighted Average: Sulfur content in kg/GJ				**0.131**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.262**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	476,927	29,614	198,667	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.56E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	1,019,644		194,495						5.44E+05			
Imports	41,430	29,634	4,172									
Exports	584,146	20							3.12E+05			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(154,503)	7,510	(7,137)	2,141	1.35E+07	1.81E+06	0.00E+00	0.00E+00	2.41E+02	2.49E+02	0.00E+00	1.80E+02
Electricity Generation	(91,391)	(19,615)			8.71E+06	1.43E+06	0.00E+00	0.00E+00	1.55E+02	1.96E+02	0.00E+00	0.00E+00
Petroleum Refining	-	28,840				2.57E+05				3.53E+01		
Coal Production/Preparation	(48,811)				4.65E+06				8.30E+01			
Charcoal Production			(7,137)	2,141								1.80E+02
Coke Production												
District Heat Production	(1,817)	(35)			1.73E+05	2.58E+03	0.00E+00	0.00E+00	3.09E+00	3.55E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,681)			0.00E+00	1.23E+05	0.00E+00	0.00E+00	0.00E+00	1.68E+01	0.00E+00	0.00E+00
Losses	(12,484)											
FUELS FOR FINAL CONSUMPTION	322,425	37,124	191,530	2,141								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	322,424	37,123	189,388	2,141	3.05E+07	2.71E+06	0.00E+00	0.00E+00	5.43E+02	3.66E+02	2.93E+03	4.00E+00
INDUSTRIAL SECTOR	165,190	8,454	141	-	1.57E+07	6.18E+05	0.00E+00	0.00E+00	2.81E+02	8.45E+01	2.25E+00	0.00E+00
Iron and Steel	65,238	-			6.22E+06	0.00E+00	0.00E+00	0.00E+00	1.11E+02	0.00E+00	0.00E+00	0.00E+00
Cement	44,481	4,228			4.24E+06	3.09E+05	0.00E+00	0.00E+00	7.56E+01	4.23E+01	0.00E+00	0.00E+00
Fertilizers	6,156	1,096			5.87E+05	8.01E+04	0.00E+00	0.00E+00	1.05E+01	1.10E+01	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,444	-			1.28E+06	0.00E+00	0.00E+00	0.00E+00	2.29E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,230	2,511			4.03E+05	1.84E+05	0.00E+00	0.00E+00	7.19E+00	2.51E+01	0.00E+00	0.00E+00
Textiles	3,879	-			3.70E+05	0.00E+00	0.00E+00	0.00E+00	6.59E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			1.43E+06	0.00E+00	0.00E+00	0.00E+00	2.55E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	619	141		1.05E+06	4.52E+04	0.00E+00	0.00E+00	1.86E+01	6.19E+00	2.25E+00	0.00E+00
TRANSPORT SECTOR	-	11,020	881	-	0.00E+00	8.05E+05	0.00E+00	0.00E+00	0.00E+00	1.10E+02	1.41E+01	0.00E+00
Road		9,115	881		0.00E+00	6.66E+05	0.00E+00	0.00E+00	0.00E+00	9.11E+01	1.41E+01	0.00E+00
Rail	-	554			0.00E+00	4.05E+04	0.00E+00	0.00E+00	0.00E+00	5.54E+00	0.00E+00	0.00E+00
Water	-	363			0.00E+00	2.66E+04	0.00E+00	0.00E+00	0.00E+00	3.63E+00	0.00E+00	0.00E+00
Air		988			0.00E+00	7.22E+04	0.00E+00	0.00E+00	0.00E+00	9.88E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	107,093	2,993	146,422	2,141	1.02E+07	2.19E+05	0.00E+00	0.00E+00	1.82E+02	2.99E+01	2.34E+03	4.00E+00
Urban	83,880	2,728	31,668	1,331	8.00E+06	1.99E+05	0.00E+00	0.00E+00	1.43E+02	2.73E+01	5.07E+02	2.48E+00
Rural	23,213	266	114,754	810	2.21E+06	1.94E+04	0.00E+00	0.00E+00	3.95E+01	2.66E+00	1.84E+03	1.51E+00
AGRICULTURAL SECTOR	5,004	1,106	24,428	-	4.77E+05	8.08E+04	0.00E+00	0.00E+00	8.51E+00	1.11E+01	3.91E+02	0.00E+00
Field Operations		579	-		0.00E+00	4.23E+04	0.00E+00	0.00E+00	0.00E+00	5.79E+00	0.00E+00	0.00E+00
Processing/Other	5,004	527	24,428		4.77E+05	3.85E+04	0.00E+00	0.00E+00	8.51E+00	5.27E+00	3.91E+02	0.00E+00
FISHERIES SECTOR	430	1,463	-	-	4.10E+04	1.07E+05	0.00E+00	0.00E+00	7.31E-01	1.46E+01	0.00E+00	0.00E+00
Large Ships	-	1,282	-		0.00E+00	9.37E+04	0.00E+00	0.00E+00	0.00E+00	1.28E+01	0.00E+00	0.00E+00
Processing/Other	430	181	-		4.10E+04	1.32E+04	0.00E+00	0.00E+00	7.31E-01	1.81E+00	0.00E+00	0.00E+00
MILITARY SECTOR	20,106	10,805	6,401	-	1.92E+06	7.90E+05	0.00E+00	0.00E+00	3.42E+01	1.08E+02	1.02E+02	0.00E+00
Trucks and other Transport		3,999	-		0.00E+00	2.92E+05	0.00E+00	0.00E+00	0.00E+00	4.00E+01	0.00E+00	0.00E+00
Armaments		111	-		0.00E+00	8.09E+03	0.00E+00	0.00E+00	0.00E+00	1.11E+00	0.00E+00	0.00E+00
Air Force		2,567	-		0.00E+00	1.88E+05	0.00E+00	0.00E+00	0.00E+00	2.57E+01	0.00E+00	0.00E+00
Naval Forces		4,049	-		0.00E+00	2.96E+05	0.00E+00	0.00E+00	0.00E+00	4.05E+01	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		4.24E+04	0.00E+00	0.00E+00	0.00E+00	7.57E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,660	80	6,401		1.87E+06	5.85E+03	0.00E+00	0.00E+00	3.34E+01	8.00E-01	1.02E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	21,312	746	5,115	-	2.03E+06	5.45E+04	0.00E+00	0.00E+00	3.62E+01	7.46E+00	8.18E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,289	537	6,000		9.43E+04	3.53E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	476,927	29,614	198,667	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	1,019,644		194,495													
Imports	41,430	29,634	4,172													
Exports	584,146	20														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(154,503)	7,510	(7,137)	2,141	6.39E+02	8.70E+01	0.00E+00	3.50E+01	8.67E+04	6.57E+03	0.00E+00	0.00E+00	5.40E+04	5.94E+03	0.00E+00	6.05E+02
Electricity Generation	(91,391)	(19,615)			4.11E+02	6.87E+01	0.00E+00	0.00E+00	5.58E+04	5.14E+03	0.00E+00	0.00E+00	3.48E+04	4.69E+03	0.00E+00	0.00E+00
Petroleum Refining	-	28,840				1.24E+01				9.25E+02				8.44E+02		
Coal Production/Preparation	(48,811)				2.20E+02				2.98E+04				1.86E+04			
Charcoal Production			(7,137)	2,141				3.50E+01				0.00E+00				6.05E+02
Coke Production																
District Heat Production	(1,817)	(35)			8.18E+00	1.24E-01	0.00E+00	0.00E+00	1.11E+03	9.29E+00	0.00E+00	0.00E+00	6.91E+02	8.48E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,681)			0.00E+00	5.88E+00	0.00E+00	0.00E+00	0.00E+00	5.03E+02	0.00E+00	0.00E+00	0.00E+00	4.02E+02	0.00E+00	0.00E+00
Losses	(12,484)															
FUELS FOR FINAL CONSUMPTION	322,425	37,124	191,530	2,141												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	322,424	37,123	189,388	2,141	1.44E+03	1.28E+02	1.28E+03	1.50E+01	1.95E+05	1.09E+04	0.00E+00	0.00E+00	1.21E+05	8.74E+03	2.22E+04	2.59E+02
INDUSTRIAL SECTOR	165,190	8,454	141	-	7.43E+02	2.96E+01	9.86E-01	0.00E+00	1.01E+05	2.53E+03	0.00E+00	0.00E+00	6.29E+04	2.02E+03	1.70E+01	0.00E+00
Iron and Steel	65,238	-			2.94E+02	0.00E+00	0.00E+00	0.00E+00	3.98E+04	0.00E+00	0.00E+00	0.00E+00	2.48E+04	0.00E+00	0.00E+00	0.00E+00
Cement	44,481	4,228			2.00E+02	1.48E+01	0.00E+00	0.00E+00	2.72E+04	1.26E+03	0.00E+00	0.00E+00	1.69E+04	1.01E+03	0.00E+00	0.00E+00
Fertilizers	6,156	1,096			2.77E+01	3.84E+00	0.00E+00	0.00E+00	3.76E+03	3.28E+02	0.00E+00	0.00E+00	2.34E+03	2.62E+02	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	13,444	-			6.05E+01	0.00E+00	0.00E+00	0.00E+00	8.21E+03	0.00E+00	0.00E+00	0.00E+00	5.12E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,230	2,511			1.90E+01	8.79E+00	0.00E+00	0.00E+00	2.58E+03	7.51E+02	0.00E+00	0.00E+00	1.61E+03	6.00E+02	0.00E+00	0.00E+00
Textiles	3,879	-			1.75E+01	0.00E+00	0.00E+00	0.00E+00	2.37E+03	0.00E+00	0.00E+00	0.00E+00	1.48E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,999	-			6.75E+01	0.00E+00	0.00E+00	0.00E+00	9.16E+03	0.00E+00	0.00E+00	0.00E+00	5.71E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	10,965	619	141		4.93E+01	2.17E+00	9.86E-01	0.00E+00	6.70E+03	1.85E+02	0.00E+00	0.00E+00	4.17E+03	1.48E+02	1.70E+01	0.00E+00
TRANSPORT SECTOR	-	11,020	881	-	0.00E+00	3.86E+01	6.16E+00	0.00E+00	0.00E+00	3.30E+03	0.00E+00	0.00E+00	0.00E+00	2.63E+03	1.07E+02	0.00E+00
Road		9,115	881		0.00E+00	3.19E+01	6.16E+00	0.00E+00	0.00E+00	2.73E+03	0.00E+00	0.00E+00	0.00E+00	2.18E+03	1.07E+02	0.00E+00
Rail	-	554			0.00E+00	1.94E+00	0.00E+00	0.00E+00	0.00E+00	1.66E+02	0.00E+00	0.00E+00	0.00E+00	1.32E+02	0.00E+00	0.00E+00
Water	-	363			0.00E+00	1.27E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+02	0.00E+00	0.00E+00	0.00E+00	8.69E+01	0.00E+00	0.00E+00
Air		988			0.00E+00	3.46E+00	0.00E+00	0.00E+00	0.00E+00	2.95E+02	0.00E+00	0.00E+00	0.00E+00	2.36E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	107,093	2,993	146,422	2,141	4.82E+02	1.05E+01	1.02E+03	1.50E+01	6.54E+04	8.95E+02	0.00E+00	0.00E+00	4.07E+04	7.15E+02	1.77E+04	2.59E+02
Urban	83,880	2,728	31,668	1,331	3.77E+02	9.55E+00	2.22E+02	9.31E+00	5.12E+04	8.16E+02	0.00E+00	0.00E+00	3.19E+04	6.52E+02	3.83E+03	1.61E+02
Rural	23,213	266	114,754	810	1.04E+02	9.30E-01	8.03E+02	5.67E+00	1.42E+04	7.95E+01	0.00E+00	0.00E+00	8.83E+03	6.35E+01	1.39E+04	9.80E+01
AGRICULTURAL SECTOR	5,004	1,106	24,428	-	2.25E+01	3.87E+00	1.71E+02	0.00E+00	3.06E+03	3.31E+02	0.00E+00	0.00E+00	1.90E+03	2.64E+02	2.96E+03	0.00E+00
Field Operations		579	-		0.00E+00	2.03E+00	0.00E+00	0.00E+00	0.00E+00	1.73E+02	0.00E+00	0.00E+00	0.00E+00	1.38E+02	0.00E+00	0.00E+00
Processing/Other	5,004	527	24,428		2.25E+01	1.84E+00	1.71E+02	0.00E+00	3.06E+03	1.58E+02	0.00E+00	0.00E+00	1.90E+03	1.26E+02	2.96E+03	0.00E+00
FISHERIES SECTOR	430	1,463	-	-	1.94E+00	5.12E+00	0.00E+00	0.00E+00	2.63E+02	4.38E+02	0.00E+00	0.00E+00	1.64E+02	3.50E+02	0.00E+00	0.00E+00
Large Ships	-	1,282	-		0.00E+00	4.49E+00	0.00E+00	0.00E+00	0.00E+00	3.83E+02	0.00E+00	0.00E+00	0.00E+00	3.06E+02	0.00E+00	0.00E+00
Processing/Other	430	181	-		1.94E+00	6.34E-01	0.00E+00	0.00E+00	2.63E+02	5.41E+01	0.00E+00	0.00E+00	1.64E+02	4.33E+01	0.00E+00	0.00E+00
MILITARY SECTOR	20,106	10,805	6,401	-	9.05E+01	3.78E+01	4.48E+01	0.00E+00	1.23E+04	3.23E+03	0.00E+00	0.00E+00	7.65E+03	2.58E+03	7.75E+02	0.00E+00
Trucks and other Transport		3,999	-		0.00E+00	1.40E+01	0.00E+00	0.00E+00	0.00E+00	1.20E+03	0.00E+00	0.00E+00	0.00E+00	9.56E+02	0.00E+00	0.00E+00
Armaments		111	-		0.00E+00	3.87E-01	0.00E+00	0.00E+00	0.00E+00	3.31E+01	0.00E+00	0.00E+00	0.00E+00	2.65E+01	0.00E+00	0.00E+00
Air Force		2,567	-		0.00E+00	8.98E+00	0.00E+00	0.00E+00	0.00E+00	7.68E+02	0.00E+00	0.00E+00	0.00E+00	6.13E+02	0.00E+00	0.00E+00
Naval Forces		4,049	-		0.00E+00	1.42E+01	0.00E+00	0.00E+00	0.00E+00	1.21E+03	0.00E+00	0.00E+00	0.00E+00	9.68E+02	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,660	80	6,401		8.85E+01	2.80E-01	4.48E+01	0.00E+00	1.20E+04	2.39E+01	0.00E+00	0.00E+00	7.48E+03	1.91E+01	7.75E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	21,312	746	5,115	-	9.59E+01	2.61E+00	3.58E+01	0.00E+00	1.30E+04	2.23E+02	0.00E+00	0.00E+00	8.11E+03	1.78E+02	6.19E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	3,289	537	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2017

Prepared By David Von Hippel
Date Last Modified: 4/20/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	71.56	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.192	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2017				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.30E+07**	**3.33E+06**	**0.00E+00**	**0.00E+00**	**4.64E+07**
Methane from Combustion	**7.66E+02**	**4.54E+02**	**2.53E+03**	**3.98E+00**	**3.75E+03**
Methane from Production	**3.76E+05**	**0.00E+00**	**0.00E+00**	**1.79E+02**	**3.76E+05**
Nitrous Oxide from Combustion	**2.03E+03**	**1.59E+02**	**1.11E+03**	**4.97E+01**	**3.34E+03**
Sulfur Oxides from Combustion	**2.75E+05**	**1.21E+04**	**0.00E+00**	**0.00E+00**	**2.87E+05**
Nitrogen Oxides from Combustion	**1.71E+05**	**1.09E+04**	**1.91E+04**	**8.59E+02**	**2.02E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.64E+07**	**3.79E+05**	**3.342E+03**	**2.87E+05**	**2.02E+05**
ENERGY SUPPLY	0.00E+00	3.76E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	3.03E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	7.30E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.24E+07	5.36E+02	6.233E+02	7.56E+04	4.95E+04
Electricity Generation	9.36E+06	2.67E+02	4.43E+02	5.69E+04	3.68E+04
Coal Prod./Prep.	2.59E+06	4.61E+01	1.22E+02	1.66E+04	1.03E+04
Charcoal Production	0.00E+00	1.79E+02	3.48E+01	0.00E+00	6.02E+02
District Heat Production	1.87E+05	3.55E+00	8.84E+00	1.19E+03	7.46E+02
Own Use	1.18E+05	1.62E+01	5.66E+00	4.84E+02	3.87E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.39E+07	3.40E+03	2.719E+03	2.12E+05	1.53E+05
INDUSTRIAL	1.54E+07	3.13E+02	7.26E+02	9.76E+04	6.11E+04
TRANSPORT	7.34E+05	1.14E+02	4.10E+01	3.00E+03	2.50E+03
RESIDENTIAL	1.22E+07	2.22E+03	1.45E+03	7.77E+04	6.37E+04
AGRICULTURAL	5.01E+05	3.74E+02	1.80E+02	3.06E+03	4.65E+03
FISHERIES	1.41E+05	1.47E+01	6.75E+00	6.69E+02	4.91E+02
MILITARY	2.63E+06	2.32E+02	1.70E+02	1.52E+04	1.08E+04
PUBLIC/COMML	2.24E+06	1.32E+02	1.43E+02	1.42E+04	9.53E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	232	1.07	248	0.12
Diesel	226	1.035	234	0.4
Heavy Oil	131	0.96	126	1.5
Kerosene/Jet Fuel	64	1.045	66	0.032
LPG	120	1.13	136	0.00016
Aviation Gasoline	12	1.07	13	0.04
Weighted Average: Sulfur content in kg/GJ				**0.096**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.192**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	459,521	16,543	172,691	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.76E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	566,806		168,898						3.03E+05			
Imports	29,480	16,543	3,794									
Exports	136,765	0							7.30E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(125,611)	14,597	(7,103)	2,131	1.13E+07	1.12E+06	0.00E+00	0.00E+00	2.02E+02	1.56E+02	0.00E+00	1.79E+02
Electricity Generation	(89,592)	(11,499)			8.54E+06	8.23E+05	0.00E+00	0.00E+00	1.52E+02	1.15E+02	0.00E+00	0.00E+00
Petroleum Refining	-	27,738				1.74E+05				2.43E+01		
Coal Production/Preparation	(27,133)				2.59E+06				4.61E+01			
Charcoal Production			(7,103)	2,131								1.79E+02
Coke Production												
District Heat Production	(1,946)	(24)			1.86E+05	1.74E+03	0.00E+00	0.00E+00	3.31E+00	2.44E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,618)			0.00E+00	1.18E+05	0.00E+00	0.00E+00	0.00E+00	1.62E+01	0.00E+00	0.00E+00
Losses	(6,939)											
FUELS FOR FINAL CONSUMPTION	333,910	31,140	165,589	2,131								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	333,910	31,140	164,155	2,130	3.17E+07	2.22E+06	0.00E+00	0.00E+00	5.64E+02	2.99E+02	2.53E+03	3.98E+00
INDUSTRIAL SECTOR	157,796	4,229	150	-	1.50E+07	3.09E+05	0.00E+00	0.00E+00	2.68E+02	4.23E+01	2.39E+00	0.00E+00
Iron and Steel	58,972	-			5.62E+06	0.00E+00	0.00E+00	0.00E+00	1.00E+02	0.00E+00	0.00E+00	0.00E+00
Cement	45,605	1,930			4.35E+06	1.41E+05	0.00E+00	0.00E+00	7.75E+01	1.93E+01	0.00E+00	0.00E+00
Fertilizers	4,215	744			4.02E+05	5.43E+04	0.00E+00	0.00E+00	7.16E+00	7.44E+00	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			1.22E+06	0.00E+00	0.00E+00	0.00E+00	2.17E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			4.67E+05	8.95E+04	0.00E+00	0.00E+00	8.33E+00	1.22E+01	0.00E+00	0.00E+00
Textiles	3,556	-			3.39E+05	0.00E+00	0.00E+00	0.00E+00	6.04E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,317	-			1.36E+06	0.00E+00	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	11,650	331	150		1.11E+06	2.42E+04	0.00E+00	0.00E+00	1.98E+01	3.31E+00	2.39E+00	0.00E+00
TRANSPORT SECTOR	-	10,044	836	-	0.00E+00	7.34E+05	0.00E+00	0.00E+00	0.00E+00	1.00E+02	1.34E+01	0.00E+00
Road		8,317	836		0.00E+00	6.08E+05	0.00E+00	0.00E+00	0.00E+00	8.32E+01	1.34E+01	0.00E+00
Rail	-	516			0.00E+00	3.77E+04	0.00E+00	0.00E+00	0.00E+00	5.16E+00	0.00E+00	0.00E+00
Water	-	338			0.00E+00	2.47E+04	0.00E+00	0.00E+00	0.00E+00	3.38E+00	0.00E+00	0.00E+00
Air		873			0.00E+00	6.38E+04	0.00E+00	0.00E+00	0.00E+00	8.73E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	125,722	3,023	123,108	2,130	1.20E+07	2.21E+05	0.00E+00	0.00E+00	2.14E+02	3.02E+01	1.97E+03	3.98E+00
Urban	95,433	2,748	25,401	1,325	9.10E+06	2.01E+05	0.00E+00	0.00E+00	1.62E+02	2.75E+01	4.06E+02	2.47E+00
Rural	30,289	275	97,706	805	2.89E+06	2.01E+04	0.00E+00	0.00E+00	5.15E+01	2.75E+00	1.56E+03	1.50E+00
AGRICULTURAL SECTOR	4,574	887	22,330	-	4.36E+05	6.49E+04	0.00E+00	0.00E+00	7.78E+00	8.87E+00	3.57E+02	0.00E+00
Field Operations		464	-		0.00E+00	3.39E+04	0.00E+00	0.00E+00	0.00E+00	4.64E+00	0.00E+00	0.00E+00
Processing/Other	4,574	423	22,330		4.36E+05	3.09E+04	0.00E+00	0.00E+00	7.78E+00	4.23E+00	3.57E+02	0.00E+00
FISHERIES SECTOR	408	1,404	-	-	3.89E+04	1.03E+05	0.00E+00	0.00E+00	6.93E-01	1.40E+01	0.00E+00	0.00E+00
Large Ships	-	1,232	-		0.00E+00	9.00E+04	0.00E+00	0.00E+00	0.00E+00	1.23E+01	0.00E+00	0.00E+00
Processing/Other	408	172	-		3.89E+04	1.26E+04	0.00E+00	0.00E+00	6.93E-01	1.72E+00	0.00E+00	0.00E+00
MILITARY SECTOR	20,355	9,391	6,482	-	1.94E+06	6.86E+05	0.00E+00	0.00E+00	3.46E+01	9.39E+01	1.04E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	2.95E+05	0.00E+00	0.00E+00	0.00E+00	4.03E+01	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	6.25E+03	0.00E+00	0.00E+00	0.00E+00	8.55E-01	0.00E+00	0.00E+00
Air Force		2,119	-		0.00E+00	1.55E+05	0.00E+00	0.00E+00	0.00E+00	2.12E+01	0.00E+00	0.00E+00
Naval Forces		3,072	-		0.00E+00	2.25E+05	0.00E+00	0.00E+00	0.00E+00	3.07E+01	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		4.24E+04	0.00E+00	0.00E+00	0.00E+00	7.57E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,909	80	6,482		1.90E+06	5.85E+03	0.00E+00	0.00E+00	3.38E+01	8.00E-01	1.04E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	22,825	872	5,250	-	2.18E+06	6.37E+04	0.00E+00	0.00E+00	3.88E+01	8.72E+00	8.40E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	2,231	1,290	6,000		9.43E+04	3.47E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	459,521	16,543	172,691	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	566,806		168,898													
Imports	29,480	16,543	3,794													
Exports	136,765	0														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(125,611)	14,597	(7,103)	2,131	5.34E+02	5.45E+01	0.00E+00	3.48E+01	7.25E+04	3.16E+03	0.00E+00	0.00E+00	4.52E+04	3.72E+03	0.00E+00	6.02E+02
Electricity Generation	(89,592)	(11,499)			4.03E+02	4.02E+01	0.00E+00	0.00E+00	5.47E+04	2.21E+03	0.00E+00	0.00E+00	3.41E+04	2.75E+03	0.00E+00	0.00E+00
Petroleum Refining	-	27,738				8.50E+00				4.66E+02				5.80E+02		
Coal Production/Preparation	(27,133)				1.22E+02				1.66E+04				1.03E+04			
Charcoal Production			(7,103)	2,131				3.48E+01				0.00E+00				6.02E+02
Coke Production																
District Heat Production	(1,946)	(24)			8.76E+00	8.53E-02	0.00E+00	0.00E+00	1.19E+03	4.68E+00	0.00E+00	0.00E+00	7.41E+02	5.83E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,618)			0.00E+00	5.66E+00	0.00E+00	0.00E+00	0.00E+00	4.84E+02	0.00E+00	0.00E+00	0.00E+00	3.87E+02	0.00E+00	0.00E+00
Losses	(6,939)															
FUELS FOR FINAL CONSUMPTION	333,910	31,140	165,589	2,131												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	333,910	31,140	164,155	2,130	1.49E+03	1.04E+02	1.11E+03	1.49E+01	2.03E+05	8.93E+03	0.00E+00	0.00E+00	1.26E+05	7.13E+03	1.91E+04	2.58E+02
INDUSTRIAL SECTOR	157,796	4,229	150	-	7.10E+02	1.48E+01	1.05E+00	0.00E+00	9.64E+04	1.26E+03	0.00E+00	0.00E+00	6.00E+04	1.01E+03	1.81E+01	0.00E+00
Iron and Steel	58,972	-			2.65E+02	0.00E+00	0.00E+00	0.00E+00	3.60E+04	0.00E+00	0.00E+00	0.00E+00	2.24E+04	0.00E+00	0.00E+00	0.00E+00
Cement	45,605	1,930			2.05E+02	6.75E+00	0.00E+00	0.00E+00	2.79E+04	5.77E+02	0.00E+00	0.00E+00	1.74E+04	4.61E+02	0.00E+00	0.00E+00
Fertilizers	4,215	744			1.90E+01	2.60E+00	0.00E+00	0.00E+00	2.57E+03	2.22E+02	0.00E+00	0.00E+00	1.60E+03	1.78E+02	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			5.75E+01	0.00E+00	0.00E+00	0.00E+00	7.81E+03	0.00E+00	0.00E+00	0.00E+00	4.86E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			2.20E+01	4.29E+00	0.00E+00	0.00E+00	2.99E+03	3.66E+02	0.00E+00	0.00E+00	1.86E+03	2.93E+02	0.00E+00	0.00E+00
Textiles	3,556	-			1.60E+01	0.00E+00	0.00E+00	0.00E+00	2.17E+03	0.00E+00	0.00E+00	0.00E+00	1.35E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	14,317	-			6.44E+01	0.00E+00	0.00E+00	0.00E+00	8.74E+03	0.00E+00	0.00E+00	0.00E+00	5.45E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	11,650	331	150		5.24E+01	1.16E+00	1.05E+00	0.00E+00	7.12E+03	9.89E+01	0.00E+00	0.00E+00	4.43E+03	7.91E+01	1.81E+01	0.00E+00
TRANSPORT SECTOR	-	10,044	836	-	0.00E+00	3.52E+01	5.85E+00	0.00E+00	0.00E+00	3.00E+03	0.00E+00	0.00E+00	0.00E+00	2.40E+03	1.01E+02	0.00E+00
Road		8,317	836		0.00E+00	2.91E+01	5.85E+00	0.00E+00	0.00E+00	2.49E+03	0.00E+00	0.00E+00	0.00E+00	1.99E+03	1.01E+02	0.00E+00
Rail	-	516			0.00E+00	1.80E+00	0.00E+00	0.00E+00	0.00E+00	1.54E+02	0.00E+00	0.00E+00	0.00E+00	1.23E+02	0.00E+00	0.00E+00
Water	-	338			0.00E+00	1.18E+00	0.00E+00	0.00E+00	0.00E+00	1.01E+02	0.00E+00	0.00E+00	0.00E+00	8.09E+01	0.00E+00	0.00E+00
Air		873			0.00E+00	3.06E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+02	0.00E+00	0.00E+00	0.00E+00	2.09E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	125,722	3,023	123,108	2,130	5.66E+02	1.06E+01	8.62E+02	1.49E+01	7.68E+04	9.04E+02	0.00E+00	0.00E+00	4.78E+04	7.23E+02	1.49E+04	2.58E+02
Urban	95,433	2,748	25,401	1,325	4.29E+02	9.62E+00	1.78E+02	9.27E+00	5.83E+04	8.22E+02	0.00E+00	0.00E+00	3.63E+04	6.57E+02	3.07E+03	1.60E+02
Rural	30,289	275	97,706	805	1.36E+02	9.64E-01	6.84E+02	5.64E+00	1.85E+04	8.24E+01	0.00E+00	0.00E+00	1.15E+04	6.58E+01	1.18E+04	9.74E+01
AGRICULTURAL SECTOR	4,574	887	22,330	-	2.06E+01	3.11E+00	1.56E+02	0.00E+00	2.79E+03	2.65E+02	0.00E+00	0.00E+00	1.74E+03	2.12E+02	2.70E+03	0.00E+00
Field Operations		464	-		0.00E+00	1.63E+00	0.00E+00	0.00E+00	0.00E+00	1.39E+02	0.00E+00	0.00E+00	0.00E+00	1.11E+02	0.00E+00	0.00E+00
Processing/Other	4,574	423	22,330		2.06E+01	1.48E+00	1.56E+02	0.00E+00	2.79E+03	1.27E+02	0.00E+00	0.00E+00	1.74E+03	1.01E+02	2.70E+03	0.00E+00
FISHERIES SECTOR	408	1,404	-	-	1.83E+00	4.91E+00	0.00E+00	0.00E+00	2.49E+02	4.20E+02	0.00E+00	0.00E+00	1.55E+02	3.36E+02	0.00E+00	0.00E+00
Large Ships	-	1,232	-		0.00E+00	4.31E+00	0.00E+00	0.00E+00	0.00E+00	3.69E+02	0.00E+00	0.00E+00	0.00E+00	2.94E+02	0.00E+00	0.00E+00
Processing/Other	408	172	-		1.83E+00	6.02E-01	0.00E+00	0.00E+00	2.49E+02	5.15E+01	0.00E+00	0.00E+00	1.55E+02	4.11E+01	0.00E+00	0.00E+00
MILITARY SECTOR	20,355	9,391	6,482	-	9.16E+01	3.29E+01	4.54E+01	0.00E+00	1.24E+04	2.81E+03	0.00E+00	0.00E+00	7.74E+03	2.24E+03	7.84E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	1.41E+01	0.00E+00	0.00E+00	0.00E+00	1.21E+03	0.00E+00	0.00E+00	0.00E+00	9.64E+02	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	2.99E-01	0.00E+00	0.00E+00	0.00E+00	2.56E+01	0.00E+00	0.00E+00	0.00E+00	2.04E+01	0.00E+00	0.00E+00
Air Force		2,119	-		0.00E+00	7.42E+00	0.00E+00	0.00E+00	0.00E+00	6.34E+02	0.00E+00	0.00E+00	0.00E+00	5.06E+02	0.00E+00	0.00E+00
Naval Forces		3,072	-		0.00E+00	1.08E+01	0.00E+00	0.00E+00	0.00E+00	9.19E+02	0.00E+00	0.00E+00	0.00E+00	7.34E+02	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	19,909	80	6,482		8.96E+01	2.80E-01	4.54E+01	0.00E+00	1.22E+04	2.39E+01	0.00E+00	0.00E+00	7.58E+03	1.91E+01	7.84E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	22,825	872	5,250	-	1.03E+02	3.05E+00	3.67E+01	0.00E+00	1.39E+04	2.61E+02	0.00E+00	0.00E+00	8.68E+03	2.08E+02	6.35E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	2,231	1,290	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2018

Prepared By David Von Hippel
Date Last Modified: 6/26/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	71.53	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.200	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2018				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.22E+07**	**3.52E+06**	**0.00E+00**	**0.00E+00**	**4.57E+07**
Methane from Combustion	**7.51E+02**	**4.80E+02**	**2.43E+03**	**4.04E+00**	**3.66E+03**
Methane from Production	**3.27E+05**	**0.00E+00**	**0.00E+00**	**1.82E+02**	**3.27E+05**
Nitrous Oxide from Combustion	**1.99E+03**	**1.68E+02**	**1.06E+03**	**5.05E+01**	**3.27E+03**
Sulfur Oxides from Combustion	**2.70E+05**	**1.27E+04**	**0.00E+00**	**0.00E+00**	**2.82E+05**
Nitrogen Oxides from Combustion	**1.68E+05**	**1.15E+04**	**1.83E+04**	**8.73E+02**	**1.99E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.57E+07**	**3.31E+05**	**3.267E+03**	**2.82E+05**	**1.99E+05**
ENERGY SUPPLY	0.00E+00	3.27E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.83E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	4.38E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.09E+07	5.42E+02	5.535E+02	6.53E+04	4.33E+04
Electricity Generation	7.80E+06	2.42E+02	3.70E+02	4.69E+04	3.06E+04
Coal Prod./Prep.	2.42E+06	4.32E+01	1.14E+02	1.55E+04	9.67E+03
Charcoal Production	0.00E+00	1.82E+02	3.53E+01	0.00E+00	6.11E+02
District Heat Production	1.87E+05	3.66E+00	8.83E+00	1.19E+03	7.45E+02
Own Use	1.31E+05	1.79E+01	6.25E+00	5.34E+02	4.27E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.48E+07	3.30E+03	2.714E+03	2.17E+05	1.55E+05
INDUSTRIAL	1.51E+07	3.08E+02	7.13E+02	9.58E+04	5.99E+04
TRANSPORT	7.07E+05	1.09E+02	3.94E+01	2.89E+03	2.41E+03
RESIDENTIAL	1.33E+07	2.15E+03	1.46E+03	8.46E+04	6.73E+04
AGRICULTURAL	4.72E+05	3.56E+02	1.72E+02	2.90E+03	4.42E+03
FISHERIES	1.03E+05	1.08E+01	4.90E+00	4.83E+02	3.55E+02
MILITARY	2.65E+06	2.33E+02	1.72E+02	1.55E+04	1.09E+04
PUBLIC/COMML	2.37E+06	1.36E+02	1.49E+02	1.50E+04	1.01E+04
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	226	1.07	241	0.12
Diesel	207	1.035	215	0.4
Heavy Oil	141	0.96	135	1.5
Kerosene/Jet Fuel	53	1.045	56	0.032
LPG	128	1.13	145	0.00016
Aviation Gasoline	12	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.100**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.200**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	449,406	13,020	165,467	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	531,112		161,383						2.83E+05			
Imports	301	13,027	4,085									
Exports	82,006	7							4.38E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(106,873)	17,092	(7,212)	2,164	9.57E+06	1.36E+06	0.00E+00	0.00E+00	1.71E+02	1.90E+02	0.00E+00	1.82E+02
Electricity Generation	(73,012)	(11,790)			6.96E+06	8.43E+05	0.00E+00	0.00E+00	1.24E+02	1.18E+02	0.00E+00	0.00E+00
Petroleum Refining	-	30,705				3.86E+05				5.40E+01		
Coal Production/Preparation	(25,425)				2.42E+06				4.32E+01			
Charcoal Production			(7,212)	2,164								1.82E+02
Coke Production												
District Heat Production	(1,934)	(37)			1.84E+05	2.64E+03	0.00E+00	0.00E+00	3.29E+00	3.68E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,786)			0.00E+00	1.31E+05	0.00E+00	0.00E+00	0.00E+00	1.79E+01	0.00E+00	0.00E+00
Losses	(6,502)											
FUELS FOR FINAL CONSUMPTION	342,534	30,112	158,255	2,164								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	342,534	30,112	157,599	2,163	3.26E+07	2.16E+06	0.00E+00	0.00E+00	5.80E+02	2.90E+02	2.43E+03	4.04E+00
INDUSTRIAL SECTOR	154,873	4,161	211	-	1.48E+07	3.04E+05	0.00E+00	0.00E+00	2.63E+02	4.16E+01	3.38E+00	0.00E+00
Iron and Steel	55,184	-			5.26E+06	0.00E+00	0.00E+00	0.00E+00	9.38E+01	0.00E+00	0.00E+00	0.00E+00
Cement	42,164	2,186			4.02E+06	1.60E+05	0.00E+00	0.00E+00	7.17E+01	2.19E+01	0.00E+00	0.00E+00
Fertilizers	2,359	416			2.25E+05	3.04E+04	0.00E+00	0.00E+00	4.01E+00	4.16E+00	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			1.22E+06	0.00E+00	0.00E+00	0.00E+00	2.17E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			4.67E+05	8.95E+04	0.00E+00	0.00E+00	8.33E+00	1.22E+01	0.00E+00	0.00E+00
Textiles	3,556	-			3.39E+05	0.00E+00	0.00E+00	0.00E+00	6.04E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	15,681	-			1.49E+06	0.00E+00	0.00E+00	0.00E+00	2.67E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	333	211		1.57E+06	2.44E+04	0.00E+00	0.00E+00	2.80E+01	3.33E+00	3.38E+00	0.00E+00
TRANSPORT SECTOR	-	9,668	792	-	0.00E+00	7.07E+05	0.00E+00	0.00E+00	0.00E+00	9.67E+01	1.27E+01	0.00E+00
Road		7,984	792		0.00E+00	5.84E+05	0.00E+00	0.00E+00	0.00E+00	7.98E+01	1.27E+01	0.00E+00
Rail	-	491			0.00E+00	3.59E+04	0.00E+00	0.00E+00	0.00E+00	4.91E+00	0.00E+00	0.00E+00
Water	-	320			0.00E+00	2.34E+04	0.00E+00	0.00E+00	0.00E+00	3.20E+00	0.00E+00	0.00E+00
Air		873			0.00E+00	6.38E+04	0.00E+00	0.00E+00	0.00E+00	8.73E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	136,783	3,371	117,314	2,163	1.30E+07	2.46E+05	0.00E+00	0.00E+00	2.33E+02	3.37E+01	1.88E+03	4.04E+00
Urban	103,341	3,060	23,242	1,346	9.85E+06	2.24E+05	0.00E+00	0.00E+00	1.76E+02	3.06E+01	3.72E+02	2.51E+00
Rural	33,442	311	94,072	817	3.19E+06	2.27E+04	0.00E+00	0.00E+00	5.69E+01	3.11E+00	1.51E+03	1.52E+00
AGRICULTURAL SECTOR	4,370	757	21,331	-	4.17E+05	5.53E+04	0.00E+00	0.00E+00	7.43E+00	7.57E+00	3.41E+02	0.00E+00
Field Operations		396	-		0.00E+00	2.90E+04	0.00E+00	0.00E+00	0.00E+00	3.96E+00	0.00E+00	0.00E+00
Processing/Other	4,370	361	21,331		4.17E+05	2.64E+04	0.00E+00	0.00E+00	7.43E+00	3.61E+00	3.41E+02	0.00E+00
FISHERIES SECTOR	285	1,032	-	-	2.72E+04	7.54E+04	0.00E+00	0.00E+00	4.85E-01	1.03E+01	0.00E+00	0.00E+00
Large Ships	-	910	-		0.00E+00	6.65E+04	0.00E+00	0.00E+00	0.00E+00	9.10E+00	0.00E+00	0.00E+00
Processing/Other	285	122	-		2.72E+04	8.90E+03	0.00E+00	0.00E+00	4.85E-01	1.22E+00	0.00E+00	0.00E+00
MILITARY SECTOR	20,852	9,078	6,644	-	1.99E+06	6.63E+05	0.00E+00	0.00E+00	3.54E+01	9.08E+01	1.06E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	2.95E+05	0.00E+00	0.00E+00	0.00E+00	4.03E+01	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	6.25E+03	0.00E+00	0.00E+00	0.00E+00	8.55E-01	0.00E+00	0.00E+00
Air Force		2,015	-		0.00E+00	1.47E+05	0.00E+00	0.00E+00	0.00E+00	2.01E+01	0.00E+00	0.00E+00
Naval Forces		2,867	-		0.00E+00	2.10E+05	0.00E+00	0.00E+00	0.00E+00	2.87E+01	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		4.24E+04	0.00E+00	0.00E+00	0.00E+00	7.57E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,407	76	6,644		1.95E+06	5.55E+03	0.00E+00	0.00E+00	3.47E+01	7.60E-01	1.06E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	24,122	965	5,307	-	2.30E+06	7.05E+04	0.00E+00	0.00E+00	4.10E+01	9.65E+00	8.49E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,248	1,080	6,000		9.43E+04	3.47E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	449,406	13,020	165,467	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	531,112		161,383													
Imports	301	13,027	4,085													
Exports	82,006	7														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(106,873)	17,092	(7,212)	2,164	4.52E+02	6.65E+01	0.00E+00	3.53E+01	6.13E+04	3.97E+03	0.00E+00	0.00E+00	3.82E+04	4.54E+03	0.00E+00	6.11E+02
Electricity Generation	(73,012)	(11,790)			3.29E+02	4.13E+01	0.00E+00	0.00E+00	4.46E+04	2.35E+03	0.00E+00	0.00E+00	2.78E+04	2.82E+03	0.00E+00	0.00E+00
Petroleum Refining	-	30,705				1.89E+01				1.08E+03				1.29E+03		
Coal Production/Preparation	(25,425)				1.14E+02				1.55E+04				9.67E+03			
Charcoal Production			(7,212)	2,164				3.53E+01				0.00E+00				6.11E+02
Coke Production																
District Heat Production	(1,934)	(37)			8.70E+00	1.29E-01	0.00E+00	0.00E+00	1.18E+03	7.36E+00	0.00E+00	0.00E+00	7.36E+02	8.81E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,786)			0.00E+00	6.25E+00	0.00E+00	0.00E+00	0.00E+00	5.34E+02	0.00E+00	0.00E+00	0.00E+00	4.27E+02	0.00E+00	0.00E+00
Losses	(6,502)															
FUELS FOR FINAL CONSUMPTION	342,534	30,112	158,255	2,164												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	342,534	30,112	157,599	2,163	1.54E+03	1.02E+02	1.06E+03	1.51E+01	2.08E+05	8.68E+03	0.00E+00	0.00E+00	1.30E+05	6.94E+03	1.83E+04	2.62E+02
INDUSTRIAL SECTOR	154,873	4,161	211	-	6.97E+02	1.46E+01	1.48E+00	0.00E+00	9.46E+04	1.24E+03	0.00E+00	0.00E+00	5.89E+04	9.94E+02	2.56E+01	0.00E+00
Iron and Steel	55,184	-			2.48E+02	0.00E+00	0.00E+00	0.00E+00	3.37E+04	0.00E+00	0.00E+00	0.00E+00	2.10E+04	0.00E+00	0.00E+00	0.00E+00
Cement	42,164	2,186			1.90E+02	7.65E+00	0.00E+00	0.00E+00	2.58E+04	6.54E+02	0.00E+00	0.00E+00	1.60E+04	5.23E+02	0.00E+00	0.00E+00
Fertilizers	2,359	416			1.06E+01	1.46E+00	0.00E+00	0.00E+00	1.44E+03	1.24E+02	0.00E+00	0.00E+00	8.97E+02	9.95E+01	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			5.75E+01	0.00E+00	0.00E+00	0.00E+00	7.81E+03	0.00E+00	0.00E+00	0.00E+00	4.86E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			2.20E+01	4.29E+00	0.00E+00	0.00E+00	2.99E+03	3.66E+02	0.00E+00	0.00E+00	1.86E+03	2.93E+02	0.00E+00	0.00E+00
Textiles	3,556	-			1.60E+01	0.00E+00	0.00E+00	0.00E+00	2.17E+03	0.00E+00	0.00E+00	0.00E+00	1.35E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	15,681	-			7.06E+01	0.00E+00	0.00E+00	0.00E+00	9.58E+03	0.00E+00	0.00E+00	0.00E+00	5.97E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	333	211		7.40E+01	1.17E+00	1.48E+00	0.00E+00	1.00E+04	9.97E+01	0.00E+00	0.00E+00	6.26E+03	7.97E+01	2.56E+01	0.00E+00
TRANSPORT SECTOR	-	9,668	792	-	0.00E+00	3.38E+01	5.55E+00	0.00E+00	0.00E+00	2.89E+03	0.00E+00	0.00E+00	0.00E+00	2.31E+03	9.59E+01	0.00E+00
Road		7,984	792		0.00E+00	2.79E+01	5.55E+00	0.00E+00	0.00E+00	2.39E+03	0.00E+00	0.00E+00	0.00E+00	1.91E+03	9.59E+01	0.00E+00
Rail	-	491			0.00E+00	1.72E+00	0.00E+00	0.00E+00	0.00E+00	1.47E+02	0.00E+00	0.00E+00	0.00E+00	1.17E+02	0.00E+00	0.00E+00
Water	-	320			0.00E+00	1.12E+00	0.00E+00	0.00E+00	0.00E+00	9.56E+01	0.00E+00	0.00E+00	0.00E+00	7.64E+01	0.00E+00	0.00E+00
Air		873			0.00E+00	3.06E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+02	0.00E+00	0.00E+00	0.00E+00	2.09E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	136,783	3,371	117,314	2,163	6.16E+02	1.18E+01	8.21E+02	1.51E+01	8.35E+04	1.01E+03	0.00E+00	0.00E+00	5.20E+04	8.06E+02	1.42E+04	2.62E+02
Urban	103,341	3,060	23,242	1,346	4.65E+02	1.07E+01	1.63E+02	9.42E+00	6.31E+04	9.15E+02	0.00E+00	0.00E+00	3.93E+04	7.31E+02	2.81E+03	1.63E+02
Rural	33,442	311	94,072	817	1.50E+02	1.09E+00	6.59E+02	5.72E+00	2.04E+04	9.30E+01	0.00E+00	0.00E+00	1.27E+04	7.43E+01	1.14E+04	9.88E+01
AGRICULTURAL SECTOR	4,370	757	21,331	-	1.97E+01	2.65E+00	1.49E+02	0.00E+00	2.67E+03	2.26E+02	0.00E+00	0.00E+00	1.66E+03	1.81E+02	2.58E+03	0.00E+00
Field Operations		396	-		0.00E+00	1.39E+00	0.00E+00	0.00E+00	0.00E+00	1.18E+02	0.00E+00	0.00E+00	0.00E+00	9.47E+01	0.00E+00	0.00E+00
Processing/Other	4,370	361	21,331		1.97E+01	1.26E+00	1.49E+02	0.00E+00	2.67E+03	1.08E+02	0.00E+00	0.00E+00	1.66E+03	8.62E+01	2.58E+03	0.00E+00
FISHERIES SECTOR	285	1,032	-	-	1.28E+00	3.61E+00	0.00E+00	0.00E+00	1.74E+02	3.09E+02	0.00E+00	0.00E+00	1.09E+02	2.47E+02	0.00E+00	0.00E+00
Large Ships	-	910	-		0.00E+00	3.19E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	2.18E+02	0.00E+00	0.00E+00
Processing/Other	285	122	-		1.28E+00	4.26E-01	0.00E+00	0.00E+00	1.74E+02	3.64E+01	0.00E+00	0.00E+00	1.09E+02	2.91E+01	0.00E+00	0.00E+00
MILITARY SECTOR	20,852	9,078	6,644	-	9.38E+01	3.18E+01	4.65E+01	0.00E+00	1.27E+04	2.72E+03	0.00E+00	0.00E+00	7.93E+03	2.17E+03	8.04E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	1.41E+01	0.00E+00	0.00E+00	0.00E+00	1.21E+03	0.00E+00	0.00E+00	0.00E+00	9.64E+02	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	2.99E-01	0.00E+00	0.00E+00	0.00E+00	2.56E+01	0.00E+00	0.00E+00	0.00E+00	2.04E+01	0.00E+00	0.00E+00
Air Force		2,015	-		0.00E+00	7.05E+00	0.00E+00	0.00E+00	0.00E+00	6.03E+02	0.00E+00	0.00E+00	0.00E+00	4.82E+02	0.00E+00	0.00E+00
Naval Forces		2,867	-		0.00E+00	1.00E+01	0.00E+00	0.00E+00	0.00E+00	8.58E+02	0.00E+00	0.00E+00	0.00E+00	6.85E+02	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,407	76	6,644		9.18E+01	2.66E-01	4.65E+01	0.00E+00	1.25E+04	2.27E+01	0.00E+00	0.00E+00	7.76E+03	1.82E+01	8.04E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	24,122	965	5,307	-	1.09E+02	3.38E+00	3.71E+01	0.00E+00	1.47E+04	2.89E+02	0.00E+00	0.00E+00	9.18E+03	2.31E+02	6.42E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,248	1,080	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2019

Prepared By David Von Hippel
Date Last Modified: 7/2/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	Notes
Carbon Dioxide from Combustion	95.3	71.56	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.196	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2018				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**4.28E+07**	**3.59E+06**	**0.00E+00**	**0.00E+00**	**4.64E+07**
Methane from Combustion	**7.62E+02**	**4.91E+02**	**2.41E+03**	**4.10E+00**	**3.67E+03**
Methane from Production	**4.17E+05**	**0.00E+00**	**0.00E+00**	**1.84E+02**	**4.17E+05**
Nitrous Oxide from Combustion	**2.02E+03**	**1.72E+02**	**1.06E+03**	**5.12E+01**	**3.29E+03**
Sulfur Oxides from Combustion	**2.74E+05**	**1.28E+04**	**0.00E+00**	**0.00E+00**	**2.86E+05**
Nitrogen Oxides from Combustion	**1.70E+05**	**1.17E+04**	**1.82E+04**	**8.86E+02**	**2.01E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.64E+07**	**4.21E+05**	**3.294E+03**	**2.86E+05**	**2.01E+05**
ENERGY SUPPLY	0.00E+00	4.17E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	3.30E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	8.68E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.14E+07	5.62E+02	5.763E+02	6.80E+04	4.52E+04
Electricity Generation	7.87E+06	2.51E+02	3.73E+02	4.71E+04	3.08E+04
Coal Prod./Prep.	2.83E+06	5.04E+01	1.33E+02	1.81E+04	1.13E+04
Charcoal Production	0.00E+00	1.84E+02	3.59E+01	0.00E+00	6.20E+02
District Heat Production	1.87E+05	3.65E+00	8.83E+00	1.19E+03	7.45E+02
Own Use	1.31E+05	1.79E+01	6.25E+00	5.34E+02	4.27E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.50E+07	3.29E+03	2.718E+03	2.18E+05	1.56E+05
INDUSTRIAL	1.51E+07	3.08E+02	7.13E+02	9.58E+04	6.00E+04
TRANSPORT	7.06E+05	1.09E+02	3.93E+01	2.89E+03	2.40E+03
RESIDENTIAL	1.35E+07	2.18E+03	1.49E+03	8.59E+04	6.84E+04
AGRICULTURAL	4.20E+05	3.13E+02	1.51E+02	2.56E+03	3.89E+03
FISHERIES	1.03E+05	1.08E+01	4.90E+00	4.83E+02	3.55E+02
MILITARY	2.67E+06	2.34E+02	1.73E+02	1.55E+04	1.10E+04
PUBLIC/COMML	2.41E+06	1.38E+02	1.52E+02	1.53E+04	1.02E+04
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	221	1.07	236	0.12
Diesel	213	1.035	220	0.4
Heavy Oil	134	0.96	129	1.5
Kerosene/Jet Fuel	55	1.045	58	0.032
LPG	128	1.13	145	0.00016
Aviation Gasoline	12	1.07	13	0.04
Weighted Average: Sulfur content in kg/GJ				**0.098**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.196**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	456,851	14,048	164,524	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.17E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	619,098		160,907						3.30E+05			
Imports	301	14,127	3,616									
Exports	162,548	79							8.68E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(112,177)	16,178	(7,321)	2,196	9.97E+06	1.43E+06	0.00E+00	0.00E+00	1.78E+02	1.99E+02	0.00E+00	1.84E+02
Electricity Generation	(73,027)	(12,705)			6.96E+06	9.09E+05	0.00E+00	0.00E+00	1.24E+02	1.27E+02	0.00E+00	0.00E+00
Petroleum Refining	-	30,705				3.86E+05				5.40E+01		
Coal Production/Preparation	(29,637)				2.83E+06				5.04E+01			
Charcoal Production			(7,321)	2,196								1.84E+02
Coke Production												
District Heat Production	(1,934)	(36)			1.84E+05	2.61E+03	0.00E+00	0.00E+00	3.29E+00	3.65E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,786)			0.00E+00	1.31E+05	0.00E+00	0.00E+00	0.00E+00	1.79E+01	0.00E+00	0.00E+00
Losses	(7,580)											
FUELS FOR FINAL CONSUMPTION	344,674	30,226	157,203	2,196								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	344,674	30,226	156,760	2,196	3.28E+07	2.16E+06	0.00E+00	0.00E+00	5.84E+02	2.91E+02	2.41E+03	4.10E+00
INDUSTRIAL SECTOR	154,886	4,147	211	-	1.48E+07	3.03E+05	0.00E+00	0.00E+00	2.63E+02	4.15E+01	3.38E+00	0.00E+00
Iron and Steel	55,184	-			5.26E+06	0.00E+00	0.00E+00	0.00E+00	9.38E+01	0.00E+00	0.00E+00	0.00E+00
Cement	42,177	2,173			4.02E+06	1.59E+05	0.00E+00	0.00E+00	7.17E+01	2.17E+01	0.00E+00	0.00E+00
Fertilizers	2,359	416			2.25E+05	3.04E+04	0.00E+00	0.00E+00	4.01E+00	4.16E+00	0.00E+00	0.00E+00
Other Chemicals	1,356	-			1.29E+05	0.00E+00	0.00E+00	0.00E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			4.22E+04	0.00E+00	0.00E+00	0.00E+00	7.53E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			1.22E+06	0.00E+00	0.00E+00	0.00E+00	2.17E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			4.67E+05	8.95E+04	0.00E+00	0.00E+00	8.33E+00	1.22E+01	0.00E+00	0.00E+00
Textiles	3,556	-			3.39E+05	0.00E+00	0.00E+00	0.00E+00	6.04E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	15,681	-			1.49E+06	0.00E+00	0.00E+00	0.00E+00	2.67E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	333	211		1.57E+06	2.44E+04	0.00E+00	0.00E+00	2.80E+01	3.33E+00	3.38E+00	0.00E+00
TRANSPORT SECTOR	-	9,662	785	-	0.00E+00	7.06E+05	0.00E+00	0.00E+00	0.00E+00	9.66E+01	1.26E+01	0.00E+00
Road		7,988	785		0.00E+00	5.84E+05	0.00E+00	0.00E+00	0.00E+00	7.99E+01	1.26E+01	0.00E+00
Rail	-	496			0.00E+00	3.63E+04	0.00E+00	0.00E+00	0.00E+00	4.96E+00	0.00E+00	0.00E+00
Water	-	320			0.00E+00	2.34E+04	0.00E+00	0.00E+00	0.00E+00	3.20E+00	0.00E+00	0.00E+00
Air		858			0.00E+00	6.27E+04	0.00E+00	0.00E+00	0.00E+00	8.58E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	139,060	3,300	119,048	2,196	1.33E+07	2.41E+05	0.00E+00	0.00E+00	2.36E+02	3.30E+01	1.90E+03	4.10E+00
Urban	105,137	2,998	23,621	1,368	1.00E+07	2.19E+05	0.00E+00	0.00E+00	1.79E+02	3.00E+01	3.78E+02	2.55E+00
Rural	33,924	301	95,427	828	3.23E+06	2.20E+04	0.00E+00	0.00E+00	5.77E+01	3.01E+00	1.53E+03	1.55E+00
AGRICULTURAL SECTOR	3,826	749	18,678	-	3.65E+05	5.47E+04	0.00E+00	0.00E+00	6.50E+00	7.49E+00	2.99E+02	0.00E+00
Field Operations		396	-		0.00E+00	2.90E+04	0.00E+00	0.00E+00	0.00E+00	3.96E+00	0.00E+00	0.00E+00
Processing/Other	3,826	353	18,678		3.65E+05	2.58E+04	0.00E+00	0.00E+00	6.50E+00	3.53E+00	2.99E+02	0.00E+00
FISHERIES SECTOR	285	1,032	-	-	2.72E+04	7.54E+04	0.00E+00	0.00E+00	4.85E-01	1.03E+01	0.00E+00	0.00E+00
Large Ships	-	910	-		0.00E+00	6.65E+04	0.00E+00	0.00E+00	0.00E+00	9.10E+00	0.00E+00	0.00E+00
Processing/Other	285	122	-		2.72E+04	8.90E+03	0.00E+00	0.00E+00	4.85E-01	1.22E+00	0.00E+00	0.00E+00
MILITARY SECTOR	20,852	9,272	6,644	-	1.99E+06	6.78E+05	0.00E+00	0.00E+00	3.54E+01	9.27E+01	1.06E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	2.95E+05	0.00E+00	0.00E+00	0.00E+00	4.03E+01	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	6.25E+03	0.00E+00	0.00E+00	0.00E+00	8.55E-01	0.00E+00	0.00E+00
Air Force		2,209	-		0.00E+00	1.61E+05	0.00E+00	0.00E+00	0.00E+00	2.21E+01	0.00E+00	0.00E+00
Naval Forces		2,867	-		0.00E+00	2.10E+05	0.00E+00	0.00E+00	0.00E+00	2.87E+01	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		4.24E+04	0.00E+00	0.00E+00	0.00E+00	7.57E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,407	76	6,644		1.95E+06	5.55E+03	0.00E+00	0.00E+00	3.47E+01	7.60E-01	1.06E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	24,515	981	5,393	-	2.34E+06	7.17E+04	0.00E+00	0.00E+00	4.17E+01	9.81E+00	8.63E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,248	1,083	6,000		9.43E+04	3.47E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	456,851	14,048	164,524	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	619,098		160,907													
Imports	301	14,127	3,616													
Exports	162,548	79														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(112,177)	16,178	(7,321)	2,196	4.71E+02	6.97E+01	0.00E+00	3.59E+01	6.39E+04	4.08E+03	0.00E+00	0.00E+00	3.98E+04	4.76E+03	0.00E+00	6.20E+02
Electricity Generation	(73,027)	(12,705)			3.29E+02	4.45E+01	0.00E+00	0.00E+00	4.46E+04	2.48E+03	0.00E+00	0.00E+00	2.78E+04	3.04E+03	0.00E+00	0.00E+00
Petroleum Refining	-	30,705				1.89E+01				1.06E+03				1.29E+03		
Coal Production/Preparation	(29,637)				1.33E+02				1.81E+04				1.13E+04			
Charcoal Production			(7,321)	2,196				3.59E+01				0.00E+00				6.20E+02
Coke Production																
District Heat Production	(1,934)	(36)			8.70E+00	1.28E-01	0.00E+00	0.00E+00	1.18E+03	7.13E+00	0.00E+00	0.00E+00	7.36E+02	8.71E+00	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,786)			0.00E+00	6.25E+00	0.00E+00	0.00E+00	0.00E+00	5.34E+02	0.00E+00	0.00E+00	0.00E+00	4.27E+02	0.00E+00	0.00E+00
Losses	(7,580)															
FUELS FOR FINAL CONSUMPTION	344,674	30,226	157,203	2,196												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	344,674	30,226	156,760	2,196	1.55E+03	1.02E+02	1.06E+03	1.54E+01	2.10E+05	8.72E+03	0.00E+00	0.00E+00	1.31E+05	6.97E+03	1.82E+04	2.66E+02
INDUSTRIAL SECTOR	154,886	4,147	211	-	6.97E+02	1.45E+01	1.48E+00	0.00E+00	9.46E+04	1.24E+03	0.00E+00	0.00E+00	5.89E+04	9.91E+02	2.56E+01	0.00E+00
Iron and Steel	55,184	-			2.48E+02	0.00E+00	0.00E+00	0.00E+00	3.37E+04	0.00E+00	0.00E+00	0.00E+00	2.10E+04	0.00E+00	0.00E+00	0.00E+00
Cement	42,177	2,173			1.90E+02	7.61E+00	0.00E+00	0.00E+00	2.58E+04	6.50E+02	0.00E+00	0.00E+00	1.60E+04	5.19E+02	0.00E+00	0.00E+00
Fertilizers	2,359	416			1.06E+01	1.46E+00	0.00E+00	0.00E+00	1.44E+03	1.24E+02	0.00E+00	0.00E+00	8.97E+02	9.95E+01	0.00E+00	0.00E+00
Other Chemicals	1,356	-			6.10E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+02	0.00E+00	0.00E+00	0.00E+00	5.16E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	443	-			1.99E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	12,785	-			5.75E+01	0.00E+00	0.00E+00	0.00E+00	7.81E+03	0.00E+00	0.00E+00	0.00E+00	4.86E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	4,899	1,225			2.20E+01	4.29E+00	0.00E+00	0.00E+00	2.99E+03	3.66E+02	0.00E+00	0.00E+00	1.86E+03	2.93E+02	0.00E+00	0.00E+00
Textiles	3,556	-			1.60E+01	0.00E+00	0.00E+00	0.00E+00	2.17E+03	0.00E+00	0.00E+00	0.00E+00	1.35E+03	0.00E+00	0.00E+00	0.00E+00
Building Materials	15,681	-			7.06E+01	0.00E+00	0.00E+00	0.00E+00	9.58E+03	0.00E+00	0.00E+00	0.00E+00	5.97E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	333	211		7.40E+01	1.17E+00	1.48E+00	0.00E+00	1.00E+04	9.97E+01	0.00E+00	0.00E+00	6.26E+03	7.97E+01	2.56E+01	0.00E+00
TRANSPORT SECTOR	-	9,662	785	-	0.00E+00	3.38E+01	5.50E+00	0.00E+00	0.00E+00	2.89E+03	0.00E+00	0.00E+00	0.00E+00	2.31E+03	9.50E+01	0.00E+00
Road		7,988	785		0.00E+00	2.80E+01	5.50E+00	0.00E+00	0.00E+00	2.39E+03	0.00E+00	0.00E+00	0.00E+00	1.91E+03	9.50E+01	0.00E+00
Rail	-	496			0.00E+00	1.74E+00	0.00E+00	0.00E+00	0.00E+00	1.48E+02	0.00E+00	0.00E+00	0.00E+00	1.19E+02	0.00E+00	0.00E+00
Water	-	320			0.00E+00	1.12E+00	0.00E+00	0.00E+00	0.00E+00	9.56E+01	0.00E+00	0.00E+00	0.00E+00	7.64E+01	0.00E+00	0.00E+00
Air		858			0.00E+00	3.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E+02	0.00E+00	0.00E+00	0.00E+00	2.05E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	139,060	3,300	119,048	2,196	6.26E+02	1.15E+01	8.33E+02	1.54E+01	8.49E+04	9.87E+02	0.00E+00	0.00E+00	5.29E+04	7.89E+02	1.44E+04	2.66E+02
Urban	105,137	2,998	23,621	1,368	4.73E+02	1.05E+01	1.65E+02	9.58E+00	6.42E+04	8.97E+02	0.00E+00	0.00E+00	4.00E+04	7.17E+02	2.86E+03	1.66E+02
Rural	33,924	301	95,427	828	1.53E+02	1.05E+00	6.68E+02	5.80E+00	2.07E+04	9.02E+01	0.00E+00	0.00E+00	1.29E+04	7.20E+01	1.15E+04	1.00E+02
AGRICULTURAL SECTOR	3,826	749	18,678	-	1.72E+01	2.62E+00	1.31E+02	0.00E+00	2.34E+03	2.24E+02	0.00E+00	0.00E+00	1.46E+03	1.79E+02	2.26E+03	0.00E+00
Field Operations		396	-		0.00E+00	1.39E+00	0.00E+00	0.00E+00	0.00E+00	1.18E+02	0.00E+00	0.00E+00	0.00E+00	9.47E+01	0.00E+00	0.00E+00
Processing/Other	3,826	353	18,678		1.72E+01	1.23E+00	1.31E+02	0.00E+00	2.34E+03	1.05E+02	0.00E+00	0.00E+00	1.46E+03	8.43E+01	2.26E+03	0.00E+00
FISHERIES SECTOR	285	1,032	-	-	1.28E+00	3.61E+00	0.00E+00	0.00E+00	1.74E+02	3.09E+02	0.00E+00	0.00E+00	1.09E+02	2.47E+02	0.00E+00	0.00E+00
Large Ships	-	910	-		0.00E+00	3.19E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	2.18E+02	0.00E+00	0.00E+00
Processing/Other	285	122	-		1.28E+00	4.26E-01	0.00E+00	0.00E+00	1.74E+02	3.64E+01	0.00E+00	0.00E+00	1.09E+02	2.91E+01	0.00E+00	0.00E+00
MILITARY SECTOR	20,852	9,272	6,644	-	9.38E+01	3.25E+01	4.65E+01	0.00E+00	1.27E+04	2.77E+03	0.00E+00	0.00E+00	7.93E+03	2.22E+03	8.04E+02	0.00E+00
Trucks and other Transport		4,035	-		0.00E+00	1.41E+01	0.00E+00	0.00E+00	0.00E+00	1.21E+03	0.00E+00	0.00E+00	0.00E+00	9.64E+02	0.00E+00	0.00E+00
Armaments		85	-		0.00E+00	2.99E-01	0.00E+00	0.00E+00	0.00E+00	2.56E+01	0.00E+00	0.00E+00	0.00E+00	2.04E+01	0.00E+00	0.00E+00
Air Force		2,209	-		0.00E+00	7.73E+00	0.00E+00	0.00E+00	0.00E+00	6.61E+02	0.00E+00	0.00E+00	0.00E+00	5.28E+02	0.00E+00	0.00E+00
Naval Forces		2,867	-		0.00E+00	1.00E+01	0.00E+00	0.00E+00	0.00E+00	8.58E+02	0.00E+00	0.00E+00	0.00E+00	6.85E+02	0.00E+00	0.00E+00
Military Manufacturing	445	-	-		2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+02	0.00E+00	0.00E+00	0.00E+00	1.69E+02	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	20,407	76	6,644		9.18E+01	2.66E-01	4.65E+01	0.00E+00	1.25E+04	2.27E+01	0.00E+00	0.00E+00	7.76E+03	1.82E+01	8.04E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	24,515	981	5,393	-	1.10E+02	3.43E+00	3.78E+01	0.00E+00	1.50E+04	2.93E+02	0.00E+00	0.00E+00	9.33E+03	2.34E+02	6.53E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	1,248	1,083	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2020 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2020

Prepared By David Von Hippel
Date Last Modified: 7/2/2020

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	71.75	0	0	*1,4,7*
Methane from Combustion	0.0017	0.01	0.016	0.0018667	*1,2*
Methane from Production	0.534	0	0	0.084	*1,3*
Nitrous Oxide from Combustion	0.0045	0.0035	0.007	0.007	*1,2*
Sulfur Oxides from Combustion	0.611	0.226	0	0	*4,5*
Nitrogen Oxides from Combustion	0.38	0.24	0.121	0.121	*1,2,6*

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Fuel

	2018				
GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	TOTAL
Carbon Dioxide from Combustion	**3.56E+07**	**3.29E+06**	**0.00E+00**	**0.00E+00**	**3.89E+07**
Methane from Combustion	**6.33E+02**	**4.48E+02**	**2.40E+03**	**4.16E+00**	**3.48E+03**
Methane from Production	**2.90E+05**	**0.00E+00**	**0.00E+00**	**1.87E+02**	**2.90E+05**
Nitrous Oxide from Combustion	**1.68E+03**	**1.57E+02**	**1.05E+03**	**5.20E+01**	**2.93E+03**
Sulfur Oxides from Combustion	**2.27E+05**	**1.20E+04**	**0.00E+00**	**0.00E+00**	**2.39E+05**
Nitrogen Oxides from Combustion	**1.42E+05**	**1.07E+04**	**1.81E+04**	**9.00E+02**	**1.71E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.89E+07**	**2.93E+05**	**2.934E+03**	**2.39E+05**	**1.71E+05**
ENERGY SUPPLY	0.00E+00	2.90E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.46E+05	0.00E+00	0.00E+00	0.00E+00
Imports	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exports	0.00E+00	4.38E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	7.93E+06	5.17E+02	4.130E+02	4.59E+04	3.12E+04
Electricity Generation	5.01E+06	2.01E+02	2.38E+02	2.91E+04	1.94E+04
Coal Prod./Prep.	2.10E+06	3.75E+01	9.92E+01	1.35E+04	8.39E+03
Charcoal Production	0.00E+00	1.87E+02	3.64E+01	0.00E+00	6.30E+02
District Heat Production	1.87E+05	3.81E+00	8.81E+00	1.18E+03	7.42E+02
Own Use	1.37E+05	1.87E+01	6.55E+00	5.60E+02	4.47E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	3.09E+07	3.15E+03	2.521E+03	1.94E+05	1.40E+05
INDUSTRIAL	1.23E+07	2.61E+02	5.81E+02	7.78E+04	4.87E+04
TRANSPORT	5.29E+05	8.16E+01	2.94E+01	2.16E+03	1.80E+03
RESIDENTIAL	1.37E+07	2.21E+03	1.51E+03	8.74E+04	6.95E+04
AGRICULTURAL	4.00E+05	2.97E+02	1.43E+02	2.44E+03	3.70E+03
FISHERIES	9.24E+04	9.73E+00	4.41E+00	4.35E+02	3.20E+02
MILITARY	2.07E+06	1.93E+02	1.44E+02	1.23E+04	8.76E+03
PUBLIC/COMML	1.74E+06	9.94E+01	1.09E+02	1.10E+04	7.37E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Notes/Sources:

1 *Carbon dioxide emission factors for coal and refined products, and all wood and charcoal factors From Greenhouse Gas Inventory Workbook: IPCC Draft Guidelines for National Greenhouse Gas Inventories, Volume 2. IPCC/OCED Joint Programme, published by UNEP/WMO. "Final Draft" Version*

2 *Most non-CO_2 emission factors derived from a variety of sources used by the authors in earlier work.*

3 *Production of methane from coal mining assumes a mid range estimate (from source 1) for production and post-mining emissions of 14 cubic meters methane per tonne of coal.*

4 *SOx, CO2 emission factors for wood/biomass and charcoal considered to be zero on the assumption that biomass fuels are used sustainably in the DPRK and have negligible sulfur contents.*

5 *SOx emission factor for petroleum products estimated as shown below. SOx emission factor for coal combustion assumes that lignite coal is 0.5% sulfur, anthracite is 0.75% sulfur by weight. Analyses of coal from the Anju field (lignite) show sulfur contents ranging from 0.2 to 1.2 %S (Document in authors' files [HA1-VO1]). All of the sulfur in both oil-based and coal fuels is assumed to be emitted as SOx. Sulfur contents for petroleum products are generally taken from Kato, et al (1991) Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (COx, NOx, and CO2) in Asia. NISTEP Report No. 21, page 37.*

6 *NOx emission factors for coal are derived from Kato et al, 1991 (reference as in 5, p. 39) assuming NOx factors of 7.5 kg/te for anthracite, 6.38 kg/te for brown coal. These are listed as factors for industry, and are assumed to be representative. NOx factors for coal-fired utility boilers are shown in the source document as somewhat higher than these figures, and factors for residential coal consumption are lower. NOx emission factors for petroleum products were assumed to be 10 kg/te. NOx emission factors vary considerably by fuel type and usage (NOx from transport fuels is an order of magnitude higher than from residential fuels, for example); the figure used here is a central estimate of factors listed in Kato et al, 1991, page 41.*

7 *Use of coal and oil for fertilizer production, accounted for in the energy balances under "non-energy" products, emit CO_2 to the atmosphere either during fertilizer production or (in the case of Urea), shortly after application. As a consequence, CO_2 from non-energy consumption of fuels for fertilizer use is accoiunted for by using the coal and petroleum emission factors above. See, for example, A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie, Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting, dated June 2004, and available as* http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf. *Other non-energy uses of oil were assumed to be mainly lubricants, with a carbon content that is* 20% *oxidized to CO_2. This is not quite accurate, as some non-energy uses or oil are for asphalt, and those uses emit relatively little CO_2 directly, but produce NMVOCs (non-methane volatile organic compounds) that oxidize to carbon dioxide in the atmosphere. We thus use the 20% factor, from "Chapter 5: Non-Energy Products from Fuels and Solvent Use", of 2006 IPCC The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3, Industrial Processes and Product Use, available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf. It is recognized that there will likely be some non-CO_2 emissions related to the use of non-energy products, perhaps especially sulfur oxide emissions from coal use in fertilizer production, but providing an estimate of those emissions depends on knowledge of how the sulfur component of coal is managed in coal-based fertilizer production--for example, is it captured for use in products such as sulfuric acid, or emitted?--that is currently unavailable to us, so these non-CO_2 emissions are set at zero for now.*

ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	160	1.07	171	0.12
Diesel	151	1.035	156	0.4
Heavy Oil	144	0.96	139	1.5
Kerosene/Jet Fuel	37	1.045	39	0.032
LPG	117	1.13	132	0.00016
Aviation Gasoline	9	1.07	9	0.04
Weighted Average: Sulfur content in kg/GJ				**0.113**
Fraction of Sulfur emitted as SO_x				100%
Mass ratio of SO_x (as SO_2) to S				2
Weighted Average SO_x emission factor: kg/GJ				**0.226**

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	378,623	6,629	163,652	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	460,509		151,597						2.46E+05			
Imports	120	6,629	12,055									
Exports	82,006	-							4.38E+04			
Inputs to International Marine Bunkers												
Stock Changes		-										
ENERGY TRANSFORMATION	(72,547)	17,511	(7,435)	2,231	6.38E+06	1.55E+06	0.00E+00	0.00E+00	1.14E+02	2.16E+02	0.00E+00	1.87E+02
Electricity Generation	(42,949)	(12,758)			4.09E+06	9.15E+05	0.00E+00	0.00E+00	7.30E+01	1.28E+02	0.00E+00	0.00E+00
Petroleum Refining	-	32,196				4.94E+05				6.89E+01		
Coal Production/Preparation	(22,045)				2.10E+06				3.75E+01			
Charcoal Production			(7,435)	2,231								1.87E+02
Coke Production												
District Heat Production	(1,915)	(55)			1.83E+05	3.96E+03	0.00E+00	0.00E+00	3.26E+00	5.52E-01	0.00E+00	0.00E+00
Other Transformation												
Own Use	-	(1,871)			0.00E+00	1.37E+05	0.00E+00	0.00E+00	0.00E+00	1.87E+01	0.00E+00	0.00E+00
Losses	(5,638)											
FUELS FOR FINAL CONSUMPTION	306,076	24,141	156,217	2,231								

* Emissions from domestic production and production for export are counted in supply emissions total, since those emissions occur in the DPRK. Emissions associated with imports are not counted here.

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***CARBON DIOXIDE EMISSIONS UNITS: TONNES (TE)***				***METHANE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	306,075	24,141	155,863	2,231	2.92E+07	1.74E+06	0.00E+00	0.00E+00	5.19E+02	2.33E+02	2.40E+03	4.16E+00
INDUSTRIAL SECTOR	125,183	4,498	211	-	1.19E+07	3.29E+05	0.00E+00	0.00E+00	2.13E+02	4.50E+01	3.38E+00	0.00E+00
Iron and Steel	47,069	-			4.49E+06	0.00E+00	0.00E+00	0.00E+00	8.00E+01	0.00E+00	0.00E+00	0.00E+00
Cement	32,188	2,986			3.07E+06	2.18E+05	0.00E+00	0.00E+00	5.47E+01	2.99E+01	0.00E+00	0.00E+00
Fertilizers	1,179	208			1.12E+05	1.52E+04	0.00E+00	0.00E+00	2.00E+00	2.08E+00	0.00E+00	0.00E+00
Other Chemicals	986	-			9.40E+04	0.00E+00	0.00E+00	0.00E+00	1.68E+00	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	354	-			3.38E+04	0.00E+00	0.00E+00	0.00E+00	6.02E-01	0.00E+00	0.00E+00	0.00E+00
Other Metals	9,654	-			9.20E+05	0.00E+00	0.00E+00	0.00E+00	1.64E+01	0.00E+00	0.00E+00	0.00E+00
Other Minerals	3,810	953			3.63E+05	6.96E+04	0.00E+00	0.00E+00	6.48E+00	9.53E+00	0.00E+00	0.00E+00
Textiles	2,586	-			2.47E+05	0.00E+00	0.00E+00	0.00E+00	4.40E+00	0.00E+00	0.00E+00	0.00E+00
Building Materials	10,908	-			1.04E+06	0.00E+00	0.00E+00	0.00E+00	1.85E+01	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	351	211		1.57E+06	2.57E+04	0.00E+00	0.00E+00	2.80E+01	3.51E+00	3.38E+00	0.00E+00
TRANSPORT SECTOR	-	7,233	582	-	0.00E+00	5.29E+05	0.00E+00	0.00E+00	0.00E+00	7.23E+01	9.31E+00	0.00E+00
Road		6,111	582		0.00E+00	4.47E+05	0.00E+00	0.00E+00	0.00E+00	6.11E+01	9.31E+00	0.00E+00
Rail	-	374			0.00E+00	2.74E+04	0.00E+00	0.00E+00	0.00E+00	3.74E+00	0.00E+00	0.00E+00
Water	-	200			0.00E+00	1.47E+04	0.00E+00	0.00E+00	0.00E+00	2.00E+00	0.00E+00	0.00E+00
Air		547			0.00E+00	4.00E+04	0.00E+00	0.00E+00	0.00E+00	5.47E+00	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	141,394	3,437	120,823	2,231	1.35E+07	2.51E+05	0.00E+00	0.00E+00	2.40E+02	3.44E+01	1.93E+03	4.16E+00
Urban	106,977	3,127	24,009	1,390	1.02E+07	2.29E+05	0.00E+00	0.00E+00	1.82E+02	3.13E+01	3.84E+02	2.60E+00
Rural	34,417	310	96,814	840	3.28E+06	2.27E+04	0.00E+00	0.00E+00	5.85E+01	3.10E+00	1.55E+03	1.57E+00
AGRICULTURAL SECTOR	3,629	741	17,713	-	3.46E+05	5.41E+04	0.00E+00	0.00E+00	6.17E+00	7.41E+00	2.83E+02	0.00E+00
Field Operations		396	-		0.00E+00	2.90E+04	0.00E+00	0.00E+00	0.00E+00	3.96E+00	0.00E+00	0.00E+00
Processing/Other	3,629	344	17,713		3.46E+05	2.52E+04	0.00E+00	0.00E+00	6.17E+00	3.44E+00	2.83E+02	0.00E+00
FISHERIES SECTOR	257	929	-	-	2.45E+04	6.79E+04	0.00E+00	0.00E+00	4.36E-01	9.29E+00	0.00E+00	0.00E+00
Large Ships	-	819	-		0.00E+00	5.99E+04	0.00E+00	0.00E+00	0.00E+00	8.19E+00	0.00E+00	0.00E+00
Processing/Other	257	110	-		2.45E+04	8.01E+03	0.00E+00	0.00E+00	4.36E-01	1.10E+00	0.00E+00	0.00E+00
MILITARY SECTOR	17,308	5,731	6,644	-	1.65E+06	4.19E+05	0.00E+00	0.00E+00	2.94E+01	5.73E+01	1.06E+02	0.00E+00
Trucks and other Transport		2,409	-		0.00E+00	1.76E+05	0.00E+00	0.00E+00	0.00E+00	2.41E+01	0.00E+00	0.00E+00
Armaments		47	-		0.00E+00	3.47E+03	0.00E+00	0.00E+00	0.00E+00	4.75E-01	0.00E+00	0.00E+00
Air Force		1,653	-		0.00E+00	1.21E+05	0.00E+00	0.00E+00	0.00E+00	1.65E+01	0.00E+00	0.00E+00
Naval Forces		1,556	-		0.00E+00	1.14E+05	0.00E+00	0.00E+00	0.00E+00	1.56E+01	0.00E+00	0.00E+00
Military Manufacturing	223	-	-		2.12E+04	0.00E+00	0.00E+00	0.00E+00	3.78E-01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	17,085	65	6,644		1.63E+06	4.78E+03	0.00E+00	0.00E+00	2.90E+01	6.54E-01	1.06E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	17,682	707	3,890	-	1.69E+06	5.17E+04	0.00E+00	0.00E+00	3.01E+01	7.07E+00	6.22E+01	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	624	866	6,000		9.43E+04	3.48E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY SUPPLY*	378,623	6,629	163,652	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Domestic Production	460,509		151,597													
Imports	120	6,629	12,055													
Exports	82,006	-														
Inputs to International Marine Bunkers																
Stock Changes		-														
ENERGY TRANSFORMATION	(72,547)	17,511	(7,435)	2,231	3.01E+02	7.55E+01	0.00E+00	3.64E+01	4.09E+04	5.02E+03	0.00E+00	0.00E+00	2.55E+04	5.16E+03	0.00E+00	6.30E+02
Electricity Generation	(42,949)	(12,758)			1.93E+02	4.47E+01	0.00E+00	0.00E+00	2.62E+04	2.89E+03	0.00E+00	0.00E+00	1.63E+04	3.05E+03	0.00E+00	0.00E+00
Petroleum Refining	-	32,196				2.41E+01				1.56E+03				1.65E+03		
Coal Production/Preparation	(22,045)				9.92E+01				1.35E+04				8.39E+03			
Charcoal Production			(7,435)	2,231				3.64E+01				0.00E+00				6.30E+02
Coke Production																
District Heat Production	(1,915)	(55)			8.62E+00	1.93E-01	0.00E+00	0.00E+00	1.17E+03	1.25E+01	0.00E+00	0.00E+00	7.29E+02	1.32E+01	0.00E+00	0.00E+00
Other Transformation																
Own Use	-	(1,871)			0.00E+00	6.55E+00	0.00E+00	0.00E+00	0.00E+00	5.60E+02	0.00E+00	0.00E+00	0.00E+00	4.47E+02	0.00E+00	0.00E+00
Losses	(5,638)															
FUELS FOR FINAL CONSUMPTION	306,076	24,141	156,217	2,231												

EMISSIONS CALCULATIONS

	FUELS PRODUCTION/USE UNITS: TERAJOULES (TJ)				***NITROUS OXIDE EMISSIONS UNITS: TONNES (TE)***				***SULFUR OXIDE EMISSIONS UNITS: TONNES (TE)***				***NITROGEN OXIDE EMISSIONS UNITS: TONNES (TE)***			
BALANCE CATEGORY	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL
ENERGY DEMAND	306,075	24,141	155,863	2,231	1.37E+03	8.15E+01	1.05E+03	1.56E+01	1.87E+05	6.96E+03	0.00E+00	0.00E+00	1.16E+05	5.56E+03	1.81E+04	2.70E+02
INDUSTRIAL SECTOR	125,183	4,498	211	-	5.63E+02	1.57E+01	1.48E+00	0.00E+00	7.65E+04	1.35E+03	0.00E+00	0.00E+00	4.76E+04	1.08E+03	2.56E+01	0.00E+00
Iron and Steel	47,069	-			2.12E+02	0.00E+00	0.00E+00	0.00E+00	2.87E+04	0.00E+00	0.00E+00	0.00E+00	1.79E+04	0.00E+00	0.00E+00	0.00E+00
Cement	32,188	2,986			1.45E+02	1.05E+01	0.00E+00	0.00E+00	1.97E+04	8.93E+02	0.00E+00	0.00E+00	1.22E+04	7.14E+02	0.00E+00	0.00E+00
Fertilizers	1,179	208			5.31E+00	7.28E-01	0.00E+00	0.00E+00	7.20E+02	6.22E+01	0.00E+00	0.00E+00	4.49E+02	4.97E+01	0.00E+00	0.00E+00
Other Chemicals	986	-			4.44E+00	0.00E+00	0.00E+00	0.00E+00	6.02E+02	0.00E+00	0.00E+00	0.00E+00	3.75E+02	0.00E+00	0.00E+00	0.00E+00
Pulp and Paper	354	-			1.59E+00	0.00E+00	0.00E+00	0.00E+00	2.16E+02	0.00E+00	0.00E+00	0.00E+00	1.35E+02	0.00E+00	0.00E+00	0.00E+00
Other Metals	9,654	-			4.34E+01	0.00E+00	0.00E+00	0.00E+00	5.90E+03	0.00E+00	0.00E+00	0.00E+00	3.67E+03	0.00E+00	0.00E+00	0.00E+00
Other Minerals	3,810	953			1.71E+01	3.33E+00	0.00E+00	0.00E+00	2.33E+03	2.85E+02	0.00E+00	0.00E+00	1.45E+03	2.28E+02	0.00E+00	0.00E+00
Textiles	2,586	-			1.16E+01	0.00E+00	0.00E+00	0.00E+00	1.58E+03	0.00E+00	0.00E+00	0.00E+00	9.84E+02	0.00E+00	0.00E+00	0.00E+00
Building Materials	10,908	-			4.91E+01	0.00E+00	0.00E+00	0.00E+00	6.66E+03	0.00E+00	0.00E+00	0.00E+00	4.15E+03	0.00E+00	0.00E+00	0.00E+00
Non-specified Industry	16,447	351	211		7.40E+01	1.23E+00	1.48E+00	0.00E+00	1.00E+04	1.05E+02	0.00E+00	0.00E+00	6.26E+03	8.40E+01	2.56E+01	0.00E+00
TRANSPORT SECTOR	-	7,233	582	-	0.00E+00	2.53E+01	4.07E+00	0.00E+00	0.00E+00	2.16E+03	0.00E+00	0.00E+00	0.00E+00	1.73E+03	7.04E+01	0.00E+00
Road		6,111	582		0.00E+00	2.14E+01	4.07E+00	0.00E+00	0.00E+00	1.83E+03	0.00E+00	0.00E+00	0.00E+00	1.46E+03	7.04E+01	0.00E+00
Rail	-	374			0.00E+00	1.31E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+02	0.00E+00	0.00E+00	0.00E+00	8.95E+01	0.00E+00	0.00E+00
Water	-	200			0.00E+00	7.02E-01	0.00E+00	0.00E+00	0.00E+00	6.00E+01	0.00E+00	0.00E+00	0.00E+00	4.79E+01	0.00E+00	0.00E+00
Air		547			0.00E+00	1.91E+00	0.00E+00	0.00E+00	0.00E+00	1.64E+02	0.00E+00	0.00E+00	0.00E+00	1.31E+02	0.00E+00	0.00E+00
Non-Specified		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RESIDENTIAL SECTOR	141,394	3,437	120,823	2,231	6.36E+02	1.20E+01	8.46E+02	1.56E+01	8.64E+04	1.03E+03	0.00E+00	0.00E+00	5.38E+04	8.21E+02	1.46E+04	2.70E+02
Urban	106,977	3,127	24,009	1,390	4.81E+02	1.09E+01	1.68E+02	9.73E+00	6.53E+04	9.35E+02	0.00E+00	0.00E+00	4.07E+04	7.47E+02	2.91E+03	1.68E+02
Rural	34,417	310	96,814	840	1.55E+02	1.08E+00	6.78E+02	5.88E+00	2.10E+04	9.27E+01	0.00E+00	0.00E+00	1.31E+04	7.41E+01	1.17E+04	1.02E+02
AGRICULTURAL SECTOR	3,629	741	17,713	-	1.63E+01	2.59E+00	1.24E+02	0.00E+00	2.22E+03	2.21E+02	0.00E+00	0.00E+00	1.38E+03	1.77E+02	2.14E+03	0.00E+00
Field Operations		396	-		0.00E+00	1.39E+00	0.00E+00	0.00E+00	0.00E+00	1.18E+02	0.00E+00	0.00E+00	0.00E+00	9.47E+01	0.00E+00	0.00E+00
Processing/Other	3,629	344	17,713		1.63E+01	1.21E+00	1.24E+02	0.00E+00	2.22E+03	1.03E+02	0.00E+00	0.00E+00	1.38E+03	8.23E+01	2.14E+03	0.00E+00
FISHERIES SECTOR	257	929	-	-	1.16E+00	3.25E+00	0.00E+00	0.00E+00	1.57E+02	2.78E+02	0.00E+00	0.00E+00	9.77E+01	2.22E+02	0.00E+00	0.00E+00
Large Ships	-	819	-		0.00E+00	2.87E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+02	0.00E+00	0.00E+00	0.00E+00	1.96E+02	0.00E+00	0.00E+00
Processing/Other	257	110	-		1.16E+00	3.84E-01	0.00E+00	0.00E+00	1.57E+02	3.28E+01	0.00E+00	0.00E+00	9.77E+01	2.62E+01	0.00E+00	0.00E+00
MILITARY SECTOR	17,308	5,731	6,644	-	7.79E+01	2.01E+01	4.65E+01	0.00E+00	1.06E+04	1.71E+03	0.00E+00	0.00E+00	6.59E+03	1.37E+03	8.04E+02	0.00E+00
Trucks and other Transport		2,409	-		0.00E+00	8.43E+00	0.00E+00	0.00E+00	0.00E+00	7.20E+02	0.00E+00	0.00E+00	0.00E+00	5.76E+02	0.00E+00	0.00E+00
Armaments		47	-		0.00E+00	1.66E-01	0.00E+00	0.00E+00	0.00E+00	1.42E+01	0.00E+00	0.00E+00	0.00E+00	1.13E+01	0.00E+00	0.00E+00
Air Force		1,653	-		0.00E+00	5.79E+00	0.00E+00	0.00E+00	0.00E+00	4.94E+02	0.00E+00	0.00E+00	0.00E+00	3.95E+02	0.00E+00	0.00E+00
Naval Forces		1,556	-		0.00E+00	5.45E+00	0.00E+00	0.00E+00	0.00E+00	4.65E+02	0.00E+00	0.00E+00	0.00E+00	3.72E+02	0.00E+00	0.00E+00
Military Manufacturing	223	-	-		1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E+02	0.00E+00	0.00E+00	0.00E+00	8.47E+01	0.00E+00	0.00E+00	0.00E+00
Buildings and Other	17,085	65	6,644		7.69E+01	2.29E-01	4.65E+01	0.00E+00	1.04E+04	1.95E+01	0.00E+00	0.00E+00	6.50E+03	1.56E+01	8.04E+02	0.00E+00
PUBLIC/COMMERCIAL SECTORS	17,682	707	3,890	-	7.96E+01	2.48E+00	2.72E+01	0.00E+00	1.08E+04	2.12E+02	0.00E+00	0.00E+00	6.73E+03	1.69E+02	4.71E+02	0.00E+00
NON-SPECIFIED/OTHER SECTORS		-			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY USE	624	866	6,000		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2020 UPDATE

SUMMARY GHG AND ACID GAS EMISSIONS FROM FUELS

PRODUCTION AND COMBUSTION FOR THE YEARS 1996, 2000, 2005, 2008 - 2010, and 2014 - 2020

Estimate of Sulfur Oxide Emissions, Thousand Tonnes of Sulfur Dioxide

	YEAR													
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	186.7	136.5	25.6	54.1	52.8	43.4	37.0	64.5	65.7	61.0	56.9	46.9	47.1	29.1
District Heat Production	2.1	1.6	0.8	1.2	1.0	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Coal Production/Preparation	38.5	20.0	9.8	12.7	12.5	14.2	14.4	24.9	27.8	29.8	16.6	15.5	18.1	13.5
Own Use	1.8	0.7	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6
Industrial Sector	418.7	155.6	94.9	94.4	96.9	111.7	108.9	103.2	98.0	103.4	97.6	95.8	95.8	77.8
Transport Sector	11.3	5.0	2.5	3.4	3.7	2.8	3.1	3.1	3.2	3.3	3.0	2.9	2.9	2.2
Residential Sector	117.6	74.9	58.7	52.5	46.0	46.7	47.7	56.0	61.1	66.3	77.7	84.6	85.9	87.4
Agricultural Sector	7.5	2.3	2.0	3.6	3.4	3.2	3.3	3.6	3.7	3.4	3.1	2.9	2.6	2.4
Fisheries Sector	1.6	0.6	0.5	0.6	0.5	0.5	0.5	0.6	0.5	0.7	0.7	0.5	0.5	0.4
Military Sector	23.2	19.4	16.3	15.3	14.2	13.9	14.2	14.5	15.1	15.5	15.2	15.5	15.5	12.3
Public/Commercial	20.0	16.0	9.6	10.1	10.4	10.4	10.5	11.9	12.6	13.2	14.2	15.0	15.3	11.0
TOTAL*	830.8	432.7	221.1	248.3	241.8	248.3	241.3	283.9	289.1	298.3	286.7	281.3	285.4	237.9

* Total for 1990 includes emissions from non-specified consumption at 1.8 thousand tonnes.

Estimate of Nitrogen Oxide Emissions, Thousand Tonnes

	YEAR													
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	117.5	85.1	15.9	34.1	33.4	27.5	23.6	41.1	42.2	39.5	36.8	30.6	30.8	19.4
District Heat Production	1.3	1.0	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Coal Production/Preparation	24.0	12.4	6.1	7.9	7.8	8.8	9.0	15.5	17.3	18.6	10.3	9.7	11.3	8.4
Own Use	1.4	0.5	0.2	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Charcoal Production	0.8	0.7	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Industrial Sector	262.5	97.5	59.8	59.3	60.8	69.9	68.2	64.7	61.5	64.9	61.1	59.9	60.0	48.7
Transport Sector	9.3	4.1	2.1	2.8	3.0	2.3	2.6	2.6	2.6	2.7	2.5	2.4	2.4	1.8
Residential Sector	84.4	61.3	51.6	49.3	47.5	48.2	49.2	54.1	56.7	59.4	63.7	67.3	68.4	69.5
Agricultural Sector	10.3	3.3	3.1	5.4	5.2	4.9	5.0	5.5	5.7	5.1	4.7	4.4	3.9	3.7
Fisheries Sector	1.2	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.3	0.5	0.5	0.4	0.4	0.3
Military Sector	15.3	13.5	11.7	11.1	10.2	10.0	10.3	10.4	10.7	11.0	10.8	10.9	11.0	8.8
Public/Commercial	12.6	10.3	6.3	6.9	7.1	7.1	7.2	8.1	8.5	8.9	9.5	10.1	10.2	7.4
TOTAL*	542.1	290.1	158.2	178.8	176.9	180.7	177.0	204.0	207.2	212.4	201.6	197.5	200.0	169.8

* Value for 1990 includes emissions from non-specified consumption at 1.4 thousand tonnes.

Estimate of Carbon Dioxide Emissions, Million Tonnes

	YEAR													
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	29.7	21.7	4.2	8.7	8.6	7.0	6.0	10.5	10.8	10.1	9.4	7.8	7.9	5.0
District Heat Production	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Coal Production/Preparation	6.0	3.1	1.5	2.0	1.9	2.2	2.2	3.9	4.3	4.7	2.6	2.4	2.8	2.1
Own Use	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Industrial Sector	66.1	24.5	15.1	15.0	15.3	17.6	17.1	16.3	15.5	16.4	15.4	15.1	15.1	12.3
Transport Sector	2.8	1.2	0.6	0.8	0.9	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.5
Residential Sector	18.5	11.7	9.2	8.3	7.2	7.3	7.5	8.8	9.6	10.4	12.2	13.3	13.5	13.7
Agricultural Sector	1.3	0.4	0.3	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.4
Fisheries Sector	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Military Sector	4.1	3.4	2.8	2.7	2.5	2.4	2.5	2.5	2.6	2.7	2.6	2.7	2.7	2.1
Public/Commercial	3.1	2.5	1.5	1.6	1.6	1.6	1.7	1.9	2.0	2.1	2.2	2.4	2.4	1.7
Non-Energy	1.7	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL*	134.9	69.5	35.8	40.1	39.2	39.8	38.9	45.7	46.7	48.3	46.2	45.3	46.0	38.4

* Value for 1990 includes emissions from non-specified consumption at 0.4 million tonnes.

Estimate of Methane Emissions, Thousand Tonnes

	YEAR													
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	0.7	0.6	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.4	0.3	0.2	0.3	0.2
District Heat Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production/Preparation	718.3	370.9	184.4	274.6	263.4	308.8	327.5	669.2	782.8	856.2	375.6	327.3	417.3	289.6
Own Use	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal Production	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Industrial Sector	1.5	0.5	0.4	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.3
Transport Sector	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential Sector	1.8	2.1	2.1	2.3	2.6	2.6	2.7	2.7	2.6	2.6	2.2	2.1	2.2	2.2
Agricultural Sector	0.8	0.3	0.2	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.3	0.3
Fisheries Sector	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Military Sector	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Public/Commercial	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL*	724.1	375.2	188.0	278.6	267.7	313.0	331.7	673.6	787.2	860.6	379.5	331.1	421.0	293.2

* Value for 1990 includes emissions from non-specified consumption at 0.06 thousand tonnes.

Estimate of Nitrous Oxide Emissions, Thousand Tonnes

	YEAR													
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	1.40	1.02	0.20	0.41	0.40	0.33	0.28	0.49	0.51	0.48	0.44	0.37	0.37	0.24
District Heat Production	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Coal Production/Preparation	0.28	0.15	0.07	0.09	0.09	0.10	0.11	0.18	0.20	0.22	0.12	0.11	0.13	0.10
Own Use	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Charcoal Production	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Industrial Sector	3.13	1.16	0.72	0.71	0.73	0.83	0.81	0.77	0.73	0.77	0.73	0.71	0.71	0.58
Transport Sector	0.14	0.06	0.03	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03
Residential Sector	1.50	1.39	1.30	1.34	1.43	1.45	1.47	1.52	1.53	1.53	1.45	1.46	1.49	1.51
Agricultural Sector	0.38	0.12	0.12	0.21	0.20	0.19	0.19	0.21	0.22	0.20	0.18	0.17	0.15	0.14
Fisheries Sector	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Military Sector	0.19	0.20	0.19	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.14
Public/Commercial	0.16	0.14	0.09	0.11	0.11	0.11	0.11	0.12	0.13	0.13	0.14	0.15	0.15	0.11
TOTAL*	7.31	4.31	2.76	3.15	3.23	3.27	3.24	3.57	3.59	3.61	3.33	3.25	3.28	2.91

* Value for 1990 includes emissions from non-specified consumption at 0.02 thousand tonnes.

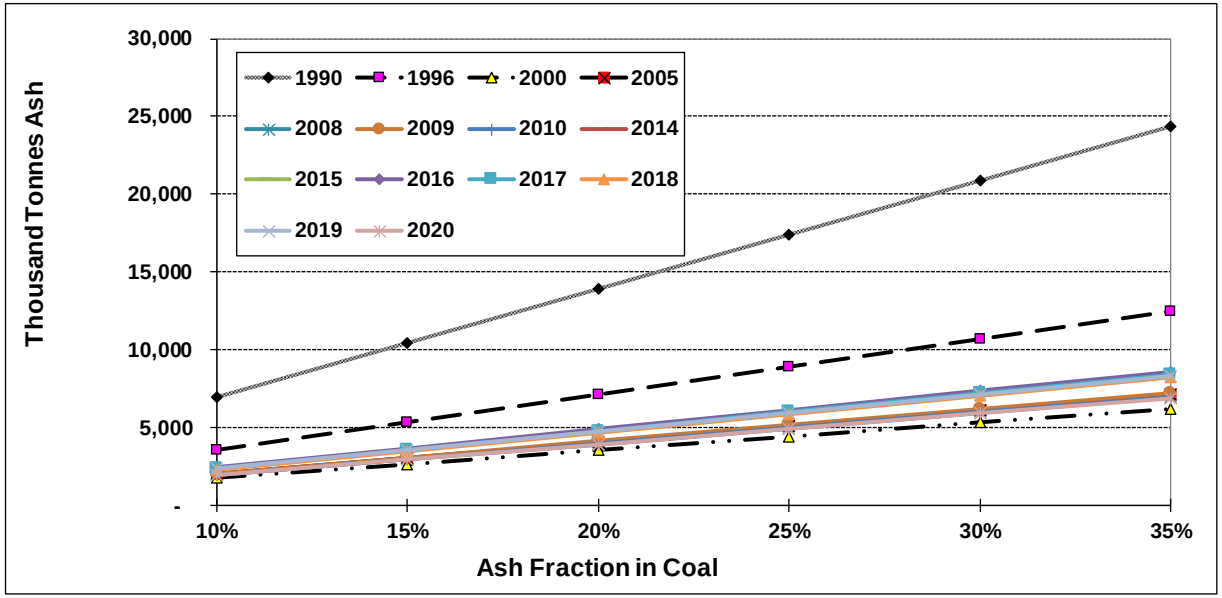
Estimate of Coal Ash Production, Thousand Tonnes

Assumes that coal is on average	**20%** ash

	YEAR													
Source of Emissions	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Electricity Generation	3,133	2,207	336	895	849	723	613	1,066	1,066	971	952	776	776	456
District Heat Production	36	26	10	20	17	18	20	19	19	19	21	21	21	20
Coal Production/Preparation	670	347	171	221	217	246	250	433	483	518	288	270	315	234
Industrial Sector	7,135	2,661	1,590	1,597	1,648	1,919	1,864	1,762	1,663	1,755	1,676	1,645	1,645	1,330
Residential Sector	2,011	1,293	1,010	902	789	804	818	963	1,048	1,138	1,335	1,453	1,477	1,502
Agricultural Sector	104	34	30	56	54	51	52	57	59	53	49	46	41	39
Military Sector	317	269	226	208	196	196	196	203	208	214	216	222	222	184
Public/Commercial	347	278	166	175	179	180	181	205	216	226	242	256	260	188
Non-Energy	146	36	11	16	16	11	11	33	31	35	24	13	13	7
TOTAL	13,898	7,152	3,551	4,091	3,964	4,147	4,005	4,741	4,793	4,929	4,803	4,702	4,769	3,959
Solid Wastes from SO_x controls (dry weight $CaSO_4$)						-	-	-	-	-	-	-	-	-

Sensitivity Analysis: Total Coal Ash (Thousand Tonnes) vs. Ash Fraction Assumed

Ash Fraction	YEAR													
	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
	13,898	**7,152**	**3,551**	**4,091**	**3,964**	**4,147**	**4,005**	**4,741**	**4,793**	**4,929**	**4,803**	**4,702**	**4,769**	**3,959**
10%	6,949	3,576	1,775	2,046	1,982	2,074	2,002	2,371	2,396	2,464	2,402	2,351	2,385	1,980
15%	10,423	5,364	2,663	3,068	2,973	3,111	3,004	3,556	3,594	3,697	3,602	3,526	3,577	2,969
20%	13,898	7,152	3,551	4,091	3,964	4,147	4,005	4,741	4,793	4,929	4,803	4,702	4,769	3,959
25%	17,372	8,940	4,438	5,114	4,955	5,184	5,006	5,927	5,991	6,161	6,004	5,877	5,962	4,949
30%	20,846	10,727	5,326	6,137	5,946	6,221	6,007	7,112	7,189	7,393	7,205	7,053	7,154	5,939
35%	24,321	12,515	6,214	7,160	6,938	7,258	7,008	8,297	8,387	8,626	8,406	8,228	8,346	6,929



SUMMARY OF ACID GAS AND CO_2 EMISSIONS

YEAR	Sulfur Oxides (thousand tonnes)	Nitrogen Oxides (thousand tonnes)	Carbon Dioxide (million tonnes)
1990	831	542	135
1996	433	290	70
2000	221	158	36
2005	248	179	40
2008	242	177	39
2009	248	181	40
2010	241	177	39
2014	284	204	46
2015	289	207	47
2016	298	212	48
2017	287	202	46
2018	281	197	45
2019	285	200	46
2020	238	170	38

GLOBAL WARMING POTENTIAL FROM IPCC FIFTH ASSESSMENT REPORT (AR5)

Source: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

Carbon Dioxide	1
Methane	28
Nitrous Oxide	265

SUMMARY OF SO_x and NO_x Emissions, 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020

Units: Thousand Tonnes	**SULFUR OXIDES**													
	1990	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TOTAL	**830.8**	**432.7**	**221.1**	**248.3**	**241.8**	**248.3**	**241.3**	**283.8**	**289.7**	**299.2**	**287.2**	**282.4**	**286.4**	**239.4**
ENERGY TRANSFORMATION	229.1	158.8	36.5	68.4	66.7	59.0	53.0	90.8	95.7	93.3	75.6	65.3	68.0	45.9
Electricity Generation	186.7	136.5	25.6	54.1	52.8	43.4	37.0	64.5	65.7	61.0	56.9	46.9	47.1	29.1
District Heat Production	2.1	1.6	0.8	1.2	1.0	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Coal Production/Preparation	38.5	20.0	9.8	12.7	12.5	14.2	14.4	24.9	27.8	29.8	16.6	15.5	18.1	13.5
Own Use	1.8	0.7	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6
Charcoal Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENERGY DEMAND	601.6	273.9	184.5	179.9	175.1	189.4	188.3	193.0	194.0	205.9	211.5	217.1	218.5	193.5
INDUSTRIAL	418.7	155.6	94.9	94.4	96.9	111.7	108.9	103.2	98.0	103.4	97.6	95.8	95.8	77.8
TRANSPORT	11.3	5.0	2.5	3.4	3.7	2.8	3.1	3.1	3.2	3.3	3.0	2.9	2.9	2.2
RESIDENTIAL	117.6	74.9	58.7	52.5	46.0	46.7	47.7	56.0	61.1	66.3	77.7	84.6	85.9	87.4
AGRICULTURAL	7.5	2.3	2.0	3.6	3.4	3.2	3.3	3.6	3.7	3.4	3.1	2.9	2.6	2.4
FISHERIES	1.6	0.6	0.5	0.6	0.5	0.5	0.5	0.6	0.5	0.7	0.7	0.5	0.5	0.4
MILITARY	23.2	19.4	16.3	15.3	14.2	13.9	14.2	14.5	15.1	15.5	15.2	15.5	15.5	12.3
PUBLIC/COMML	20.0	16.0	9.6	10.1	10.4	10.4	10.5	11.9	12.6	13.2	14.2	15.0	15.3	11.0
NON-SPECIFIED	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-
NON-ENERGY	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	NITROGEN OXIDES													
	1990	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TOTAL	**542.1**	**290.1**	**158.2**	**178.8**	**176.9**	**180.7**	**177.0**	**203.9**	**207.8**	**213.2**	**202.2**	**198.7**	**201.3**	**171.4**
ENERGY TRANSFORMATION	145.1	99.7	23.3	43.6	42.7	37.8	34.2	58.1	61.7	60.6	49.5	43.3	45.2	31.2
	-	-	-											
Electricity Generation	117.5	85.1	15.9	34.1	33.4	27.5	23.6	41.1	42.2	39.5	36.8	30.6	30.8	19.4
District Heat Production	1.3	1.0	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Coal Production/Preparation	24.0	12.4	6.1	7.9	7.8	8.8	9.0	15.5	17.3	18.6	10.3	9.7	11.3	8.4
Own Use	1.4	0.5	0.2	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Charcoal Production	0.8	0.7	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Own Use	1.4	0.5	0.2	-	-	-	-	-	-	-	-	-	-	-
Losses	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENERGY DEMAND	397.1	190.3	134.9	-	-	-	-	-	-	-	-	-	-	-
INDUSTRIAL	262.5	97.5	59.8	59.3	60.8	69.9	68.2	64.7	61.5	64.9	61.1	59.9	60.0	48.7
TRANSPORT	9.3	4.1	2.1	2.8	3.0	2.3	2.6	2.6	2.6	2.7	2.5	2.4	2.4	1.8
RESIDENTIAL	84.4	61.3	51.6	49.3	47.5	48.2	49.2	54.1	56.7	59.4	63.7	67.3	68.4	69.5
AGRICULTURAL	10.3	3.3	3.1	5.4	5.2	4.9	5.0	5.5	5.7	5.1	4.7	4.4	3.9	3.7
FISHERIES	1.2	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.3	0.5	0.5	0.4	0.4	0.3
MILITARY	15.3	13.5	11.7	11.1	10.2	10.0	10.3	10.4	10.7	11.0	10.8	10.9	11.0	8.8
PUBLIC/COMML	12.6	10.3	6.3	6.9	7.1	7.1	7.2	8.1	8.5	8.9	9.5	10.1	10.2	7.4
NON-SPECIFIED	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-
NON-ENERGY	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SUMMARY OF SO_x and NO_x Emissions, 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020

Units: Thousand Tonnes	CARBON DIOXIDE													
	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
TOTAL	134,869	69,522	35,831	40,126	39,171	39,848	38,881	45,669	46,897	48,574	46,361	45,718	46,399	38,879
ENERGY TRANSFORMATION	36,502	25,213	5,943	10,917	10,764	9,457	8,551	14,590	15,583	15,347	12,430	10,931	11,400	7,929
Electricity Generation	29,720	21,685	4,213	8,651	8,553	6,982	6,016	10,457	10,778	10,138	9,364	7,804	7,871	5,010
District Heat Production	331	247	123	186	166	168	184	172	176	176	187	187	187	187
Coal Production/Preparation	6,015	3,115	1,534	1,982	1,948	2,210	2,244	3,886	4,335	4,653	2,587	2,424	2,825	2,102
Own Use	436	166	73	97	98	96	108	106	118	123	118	131	131	137
Charcoal Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENERGY DEMAND	98,368	44,309	29,888	29,209	28,407	30,391	30,329	31,079	31,314	33,228	33,931	34,787	34,999	30,950
INDUSTRIAL	66,107	24,517	15,126	14,967	15,323	17,565	17,149	16,280	15,495	16,366	15,352	15,069	15,069	12,263
TRANSPORT	2,770	1,221	614	820	897	692	766	754	773	805	734	707	706	529
RESIDENTIAL	18,526	11,736	9,214	8,251	7,237	7,335	7,493	8,798	9,603	10,428	12,206	13,286	13,498	13,731
AGRICULTURAL	1,295	400	340	589	559	531	543	588	608	558	501	472	420	400
FISHERIES	337	121	101	111	105	98	106	130	95	148	141	103	103	92
MILITARY	4,052	3,382	2,842	2,692	2,474	2,403	2,488	2,521	2,624	2,706	2,627	2,651	2,666	2,069
PUBLIC/COMML	3,119	2,505	1,496	1,586	1,624	1,639	1,655	1,878	1,987	2,086	2,240	2,370	2,409	1,737
NON-SPECIFIED	435	-	-	-	-	-	-	-	-	-	-	-	-	-

	METHANE													
	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
TOTAL	724.09	375.17	188.02	278.58	267.70	312.96	331.74	673.64	787.23	860.59	379.48	331.11	421.08	293.25
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENERGY TRANSFORMATION	1.14	0.89	0.41	0.43	0.46	0.39	0.38	0.54	0.63	0.67	0.54	0.54	0.56	0.52
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity Generation	0.72	0.61	0.22	0.23	0.26	0.18	0.17	0.29	0.34	0.35	0.27	0.24	0.25	0.20
District Heat Production	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Production/Preparation	718.25	370.90	184.44	274.56	263.40	308.75	327.46	669.22	782.76	856.15	375.60	327.31	417.28	289.62
Own Use	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Charcoal Production	0.25	0.20	0.15	0.15	0.15	0.15	0.15	0.17	0.17	0.18	0.18	0.18	0.18	0.19
ENERGY DEMAND	4.81	3.43	3.20	3.62	3.87	3.86	3.94	3.95	3.91	3.85	3.40	3.30	3.29	3.15
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INDUSTRIAL	1.45	0.52	0.38	0.35	0.34	0.36	0.36	0.35	0.35	0.37	0.31	0.31	0.31	0.26
TRANSPORT	0.41	0.18	0.09	0.13	0.14	0.10	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.08
RESIDENTIAL	1.77	2.11	2.13	2.32	2.60	2.64	2.69	2.67	2.62	2.56	2.22	2.15	2.18	2.21
AGRICULTURAL	0.79	0.25	0.25	0.43	0.42	0.40	0.40	0.44	0.46	0.41	0.37	0.36	0.31	0.30
FISHERIES	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
MILITARY	0.22	0.26	0.27	0.27	0.25	0.24	0.25	0.24	0.24	0.24	0.23	0.23	0.23	0.19
PUBLIC/COMML	0.08	0.09	0.08	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.10
NON-SPECIFIED	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-

Units: Thousand Tonnes	NITROUS OXIDE													
	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
TOTAL	7.31	4.31	2.76	3.15	3.23	3.27	3.24	3.57	3.60	3.62	3.34	3.27	3.29	2.93
ENERGY TRANSFORMATION	1.77	1.23	0.31	0.55	0.54	0.48	0.43	0.72	0.77	0.76	0.62	0.55	0.58	0.41
Electricity Generation	1.40	1.02	0.20	0.41	0.40	0.33	0.28	0.49	0.51	0.48	0.44	0.37	0.37	0.24
District Heat Production	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Coal Production/Preparation	0.28	0.15	0.07	0.09	0.09	0.10	0.11	0.18	0.20	0.22	0.12	0.11	0.13	0.10
Own Use	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Charcoal Production	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
ENERGY DEMAND	5.54	3.08	2.45	2.60	2.69	2.79	2.81	2.84	2.83	2.86	2.72	2.71	2.72	2.52
INDUSTRIAL	3.13	1.16	0.72	0.71	0.73	0.83	0.81	0.77	0.73	0.77	0.73	0.71	0.71	0.58
TRANSPORT	0.14	0.06	0.03	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03
RESIDENTIAL	1.50	1.39	1.30	1.34	1.43	1.45	1.47	1.52	1.53	1.53	1.45	1.46	1.49	1.51
AGRICULTURAL	0.38	0.12	0.12	0.21	0.20	0.19	0.19	0.21	0.22	0.20	0.18	0.17	0.15	0.14
FISHERIES	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
MILITARY	0.19	0.20	0.19	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.14
PUBLIC/COMML	0.16	0.14	0.09	0.11	0.11	0.11	0.11	0.12	0.13	0.13	0.14	0.15	0.15	0.11
NON-SPECIFIED	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-

	CARBON DIOXIDE EQUIVALENTS (Thousand Tonnes CO_2e)													
	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
TOTAL	157,082	81,170	41,828	48,760	47,521	49,477	49,029	65,476	69,893	73,631	57,872	55,855	58,189	47,090
ENERGY TRANSFORMATION	37,004	25,564	6,037	11,074	10,920	9,594	8,677	14,796	15,805	15,567	12,610	11,093	11,416	7,943
Electricity Generation	30,112	21,973	4,272	8,766	8,667	7,075	6,096	10,596	10,922	10,275	9,489	7,909	7,878	5,016
District Heat Production	335	251	125	189	168	170	186	174	178	178	190	189	187	187
Coal Production/Preparation	26,201	13,539	6,718	9,695	9,348	10,883	11,441	22,673	26,307	28,684	13,136	11,619	14,509	10,211
Own Use	443	168	74	98	99	98	110	108	120	125	120	133	131	137
Charcoal Production	20	16	12	12	12	12	12	13	14	14	14	14	5	5
ENERGY DEMAND	99,970	45,222	30,627	30,000	29,227	31,239	31,184	31,944	32,173	34,094	34,746	35,598	35,091	31,038
INDUSTRIAL	66,978	24,840	15,326	15,165	15,525	17,795	17,374	16,494	15,699	16,581	15,553	15,266	15,078	12,270
TRANSPORT	2,819	1,243	625	835	914	704	781	768	787	821	748	720	709	531
RESIDENTIAL	18,973	12,164	9,618	8,672	7,688	7,793	7,959	9,276	10,080	10,906	12,654	13,734	13,559	13,793
AGRICULTURAL	1,417	439	379	656	624	592	606	656	679	622	559	527	428	408
FISHERIES	342	123	102	112	106	99	108	132	96	150	144	104	103	93
MILITARY	4,109	3,442	2,899	2,748	2,526	2,453	2,540	2,573	2,677	2,759	2,678	2,703	2,672	2,074
PUBLIC/COMML	3,164	2,544	1,522	1,618	1,657	1,673	1,688	1,914	2,025	2,125	2,281	2,413	2,413	1,740
NON-SPECIFIED	442	-	-	-	-	-	-	-	-	-	-	-	-	-

Estimates of DPRK Air Pollutant Emissions in 2010, Thousand Tonnes

Source of Emissions	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	Methane	Nitrous Oxide
Electricity Generation	37.0	23.6	6,016	0.17	0.28
District Heat Production	1.2	0.7	184	0.00	0.01
Coal Production/Preparation	14.4	9.0	2,244	327.46	0.11
Own Use	0.4	0.4	108	0.01	0.01
Charcoal Production	-	0.5	-	0.15	0.03
Industrial Sector	108.9	68.2	17,149	0.36	0.81
Transport Sector	3.1	2.6	766	0.12	0.04
Residential Sector	47.7	49.2	7,493	2.69	1.47
Agricultural Sector	3.3	5.0	543	0.40	0.19
Fisheries Sector	0.5	0.4	106	0.01	0.01
Military Sector	14.2	10.3	2,488	0.25	0.17
Public/Commercial	10.5	7.2	1,655	0.11	0.11
TOTAL	**241.3**	**177.0**	**38,751**	**331.7**	**3.24**

Estimates of DPRK Air Pollutant Emissions in 2017, Thousand Tonnes

Source of Emissions	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	Methane	Nitrous Oxide
Electricity Generation	56.9	36.8	9,364	0.27	0.44
District Heat Production	1.1	0.7	176	0.00	0.01
Coal Production/Preparation	29.8	10.3	4,653	375.60	0.12
Own Use	0.5	0.4	123	0.02	0.01
Charcoal Production	-	0.6	-	0.18	0.03
Industrial Sector	97.6	61.1	15,352	0.31	0.73
Transport Sector	3.0	2.5	734	0.11	0.04
Residential Sector	77.7	63.7	12,206	2.22	1.45
Agricultural Sector	3.1	4.7	501	0.37	0.18
Fisheries Sector	0.7	0.5	141	0.01	0.01
Military Sector	15.2	10.8	2,627	0.23	0.17
Public/Commercial	14.2	9.5	2,240	0.13	0.14
TOTAL	**299.9**	**201.6**	**48,117**	**379.5**	**3.33**

Estimates of DPRK Air Pollutant Emissions in 2018, Thousand Tonnes

Source of Emissions	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	Methane	Nitrous Oxide
Electricity Generation	46.9	30.6	7,804	0.24	0.37
District Heat Production	1.2	0.7	187	0.00	0.01
Coal Production/Preparation	16.6	9.7	2,587	327.31	0.11
Own Use	0.5	0.4	118	0.02	0.01
Charcoal Production	-	0.6	-	0.18	0.04
Industrial Sector	95.8	59.9	15,069	0.31	0.71
Transport Sector	2.9	2.4	707	0.11	0.04
Residential Sector	84.6	67.3	13,286	2.15	1.46
Agricultural Sector	2.9	4.4	472	0.36	0.17
Fisheries Sector	0.5	0.4	103	0.01	0.00
Military Sector	15.5	10.9	2,651	0.23	0.17
Public/Commercial	15.0	10.1	2,370	0.14	0.15
TOTAL	**282.3**	**197.5**	**45,354**	**331.1**	**3.25**

Estimates of DPRK Air Pollutant Emissions in 2019, Thousand Tonnes

Source of Emissions	Sulfur	Nitrogen	Carbon	Methane	Nitrous
Electricity Generation	47.1	30.8	7,871	0.25	0.37
District Heat Production	1.2	0.7	187	0.00	0.01
Coal Production/Preparation	15.5	11.3	2,424	417.28	0.13
Own Use	0.5	0.4	131	0.02	0.01
Charcoal Production	-	0.6	-	0.18	0.04
Industrial Sector	95.8	60.0	15,069	0.31	0.71
Transport Sector	2.9	2.4	706	0.11	0.04
Residential Sector	85.9	68.4	13,498	2.18	1.49
Agricultural Sector	2.6	3.9	420	0.31	0.15
Fisheries Sector	0.5	0.4	103	0.01	0.00
Military Sector	15.5	11.0	2,666	0.23	0.17
Public/Commercial	15.3	10.2	2,409	0.14	0.15
TOTAL	**282.8**	**200.0**	**45,482**	**421.0**	**3.28**

Estimates of DPRK Air Pollutant Emissions in 2020, Thousand Tonnes

Source of Emissions	Sulfur	Nitrogen	Carbon	Methane	Nitrous
Electricity Generation	29.1	19.4	5,010	0.20	0.24
District Heat Production	1.2	0.7	187	0.00	0.01
Coal Production/Preparation	18.1	8.4	2,825	289.62	0.10
Own Use	0.5	0.4	131	0.02	0.01
Charcoal Production	-	0.6	-	0.19	0.04
Industrial Sector	77.8	48.7	12,263	0.26	0.58
Transport Sector	2.2	1.8	529	0.08	0.03
Residential Sector	87.4	69.5	13,731	2.21	1.51
Agricultural Sector	2.4	3.7	400	0.30	0.14
Fisheries Sector	0.4	0.3	92	0.01	0.00
Military Sector	12.3	8.8	2,069	0.19	0.14
Public/Commercial	11.0	7.4	1,737	0.10	0.11
TOTAL	**242.5**	**169.8**	**38,973**	**293.2**	**2.91**

Estimates of DPRK CO_2e Emissions from Deforestation

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016
Reduction in Above-ground Biomass, Million Tonnes	2.85	2.70	2.59	2.77	2.78	2.74	2.71	1.34	1.03	1.02
Ratio of Below-ground Biomass to Above-ground Biomass	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Assumed Net Loss in Soil Carbon Due to Deforestation (relative to above-ground biomass)	0	0	0	0	0	0	0	0	0	0
Fraction of Carbon Assumed Lost	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Conversion Factor, Tonnes Carbon per Tonne Biomass	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Conversion Factor, Tonnes CO2 per Tonne Carbon	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67
Annual Estimated Carbon Dioxide Equivalent Emissions from Deforestation (Mt CO_2e)	6.32	5.99	5.74	6.15	6.16	6.08	6.00	2.98	2.27	2.26

Estimates of DPRK CO_2e Emissions from Deforestation

	2017	2018	2019	2020	*Notes*
Reduction in Above-ground Biomass, Million Tonnes	1.01	1.01	1.00	1.00	Calculated from values in "Biomass" worksheet
Ratio of Below-ground Biomass to Above-ground Biomass	0.43	0.43	0.43	0.43	See ***Note 1***
Assumed Net Loss in Soil Carbon Due to Deforestation (relative to above-ground biomass)	0	0	0	0	Unknown, but assumed to be zero based on IPCC Tier 1 Method (Source in ***Note 1***)
Fraction of Carbon Assumed Lost	90%	90%	90%	90%	Assumption
Conversion Factor, Tonnes Carbon per Tonne Biomass	0.47	0.47	0.47	0.47	From Source in ***Note 1***
Conversion Factor, Tonnes CO2 per Tonne Carbon	3.67	3.67	3.67	3.67	From Source in ***Note 1***
Annual Estimated Carbon Dioxide Equivalent Emissions from Deforestation (Mt CO_2e)	2.25	2.24	2.23	2.22	Calculated

Estimates of DPRK CO_2 Emissions from Cement Manufacture (non-energy emissions only)

	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016
Production of Cement, Million Tonnes	11.00	4.40	3.30	3.52	4.40	6.13	6.28	6.68	6.70	7.08
Fraction of Cement Weight as Clinker	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Implied Clinker Production (Mt)	9.35	3.74	2.81	2.99	3.74	5.21	5.34	5.67	5.69	6.02
Emission Factor, t CO2 per t Clinker	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507
Implied CO2 emissions from Cement Manufacture	4.74	1.90	1.42	1.52	1.90	2.64	2.71	2.88	2.89	3.05

Estimates of DPRK CO_2 Emissions from Cement Manufacture (non-energy emissions only)

	2017	2018	2019	2020	*Notes*
Production of Cement, Million Tonnes	6.84	6.38	6.38	5.06	Calculated from values in "Industry" and "Industry-96-on" worksheets
Fraction of Cement Weight as Clinker	0.85	0.85	0.85	0.85	From DPRK INDC document, 2016
Implied Clinker Production (Mt)	5.81	5.42	5.42	4.30	Calculated
Emission Factor, t CO2 per t Clinker	0.507	0.507	0.507	0.507	From Source in ***Note 2***
Implied CO2 emissions from Cement Manufacture	2.95	2.75	2.75	2.18	

Estimates of DPRK CO_2e Emissions from Rice Farming

	1990	1996	2000	2005	2008	2009	2010
Hectares of Rice Paddies, DPRK (see *Note 5* and "Agriculture" worksheet in this workbook)	600000	645000	535000	583400	570390	569000	570000
Assumed IPCC Tier 1 Emission Factor (kg/ha-day) (See *Note 3*)	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Estimated Weighted Average Days of Rice Cropping per year (See *Note 4*)	168.75	168.75	168.75	168.75	168.75	168.75	168.75
Implied Methane Emissions from Rice Paddies, thousand tonnes CH_4	131.63	141.50	117.37	127.98	125.13	124.82	125.04
Implied Methane Emissions from Rice Paddies, thousand tonnes CO_2e	3,686	3,962	3,286	3,584	3,504	3,495	3,501
FAO Methane Emissions Estimates from Rice Paddies (*Note 5*), thousand tonnes CH_4	106.82	103.26	95.25	103.87	101.55	101.30	101.48
FAO Methane Emissions Estimates from Rice Paddies (*Note 5*), thousand tonnes CO_2e	2,243	2,169	2,000	2,181	2,133	2,127	2,131

Estimates of DPRK CO_2e Emissions from Rice Farming

	2014	2015	2016	2017	2018	2019	2020
Hectares of Rice Paddies, DPRK (see *Note 5* and "Agriculture" worksheet in this workbook)	525000	465200	468700	475158	460591.85	460591.8	460591.8
Assumed IPCC Tier 1 Emission Factor (kg/ha-day) (See *Note 3*)	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Estimated Weighted Average Days of Rice Cropping per year (See *Note 4*)	168.75	168.75	168.75	168.75	168.75	168.75	168.75
Implied Methane Emissions from Rice Paddies, thousand tonnes CH_4	115.17	102.05	102.82	104.24	101.04	101.04	101.04
Implied Methane Emissions from Rice Paddies, thousand tonnes CO_2e	3,225	2,857	2,879	2,919	2,829	2,829	2,829
FAO Methane Emissions Estimates from Rice Paddies (*Note 5*), thousand tonnes CH_4	93.47	82.82	83.45	84.60			
FAO Methane Emissions Estimates from Rice Paddies (*Note 5*), thousand tonnes CO_2e	1,963	1,739	1,752	1,777			

Notes and Sources

1 Calculation of below-ground biomass lost based on factors from Table 4.4 of the IPCC Landuse change emissions methods document 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4, Forest Lands,
available as http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf.
We assume an average of low-stocked temperate conifer and "other broadleaf" forests.
Note that not all below-ground biomass is immediately lost when a forest area is cleared, but as the rate of deforestation in the DPRK seems to have been more or less constant, we assume that over time the average rate of below-ground biomass (root biomass) loss will sum to effectively 100 percent, that is, annual biomass loss from areas deforested in previous years. will effectively sum to an average of the below-ground biomass present in the areas deforested in any given year.

2 Calculated based on IPCC document "CO2 EMISSIONS FROM CEMENT PRODUCTION"*, undated,*
chapter in *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* , chapter by Michael J. Gibbs, Peter Soyka and David Conneely,
available as http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/3_1_Cement_Production.pdf

3 Assumes value and emissions estimation approach from ***2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Agriculture, Forestry and Other Land Use****, Chapter 5, "Cropland", available as https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf/*

4 Assumes 75% "Pyongyang" variety with a cropping period of 180 days/yr and 25% "Yongzu" variety with a cropping period of 135 days/yr. Source: Woon-Keun Kim (1998), "THE AGRICULTURAL *SITUATION OF NORTH KOREA", available as https://www.fftc.org.tw/htmlarea_file/library/20110726131553/eb475.pdf.*

5 The following data for rice cultivation and estimated emissions from rice cultivation in the DPRK were downloaded from the United Nations Food and Agriculture Organizatinon's FAOSTAT, http://www.fao.org/faostat/en/#data/GR, 7/8/2020.

Area of Rice harvested

Year	Unit	Value	Flag	Flag Description
1961	ha	420000	F	FAO estimate
1962	ha	440000	F	FAO estimate
1963	ha	450000	F	FAO estimate
1964	ha	480000	F	FAO estimate
1965	ha	480000	F	FAO estimate
1966	ha	500000	F	FAO estimate
1967	ha	500000	F	FAO estimate
1968	ha	500000	F	FAO estimate
1969	ha	530000	F	FAO estimate
1970	ha	530000	F	FAO estimate
1971	ha	530000	F	FAO estimate
1972	ha	530000	F	FAO estimate
1973	ha	570000	F	FAO estimate
1974	ha	600000	F	FAO estimate
1975	ha	625000	F	FAO estimate
1976	ha	630000	F	FAO estimate
1977	ha	650000	F	FAO estimate
1978	ha	657000	F	FAO estimate
1979	ha	660000	F	FAO estimate
1980	ha	650000	F	FAO estimate
1981	ha	670000	F	FAO estimate
1982	ha	640000		Official data
1983	ha	645000		Official data
1984	ha	645000		Official data
1985	ha	645000		Official data
1986	ha	645000		Official data
1987	ha	645000		Official data
1988	ha	645000		Official data
1989	ha	630000		Official data
1990	ha	600000		Official data
1991	ha	588000		Official data
1992	ha	592000		Official data
1993	ha	589000		Official data
1994	ha	583000		Official data
1995	ha	582000		Official data
1996	ha	580000		Official data
1997	ha	611000		Official data
1998	ha	580000		Official data
1999	ha	580000		Official data
2000	ha	535000		Official data
2001	ha	572000		Official data
2002	ha	582857		Official data
2003	ha	584000		Official data
2004	ha	583000		Official data
2005	ha	583400		Official data
2006	ha	583400		Official data
2007	ha	583400		Official data
2008	ha	570390		Official data
2009	ha	569000		Official data
2010	ha	570000		Official data
2011	ha	571000		Official data
2012	ha	563000		Official data
2013	ha	547000		Official data
2014	ha	525000		Official data
2015	ha	465200	*	Unofficial figure
2016	ha	468700	*	Unofficial figure
2017	ha	475158		Official data

Implied emission factor for CH4 (Rice cultivation)

Year	Unit	Value	Flag	Flag Description
1961	g CH4/m2	17.8038	Fc	Calculated data
1962	g CH4/m2	17.8038	Fc	Calculated data
1963	g CH4/m2	17.8038	Fc	Calculated data
1964	g CH4/m2	17.8038	Fc	Calculated data
1965	g CH4/m2	17.8038	Fc	Calculated data
1966	g CH4/m2	17.8038	Fc	Calculated data
1967	g CH4/m2	17.8038	Fc	Calculated data
1968	g CH4/m2	17.8038	Fc	Calculated data
1969	g CH4/m2	17.8038	Fc	Calculated data
1970	g CH4/m2	17.8038	Fc	Calculated data
1971	g CH4/m2	17.8038	Fc	Calculated data
1972	g CH4/m2	17.8038	Fc	Calculated data
1973	g CH4/m2	17.8038	Fc	Calculated data
1974	g CH4/m2	17.8038	Fc	Calculated data
1975	g CH4/m2	17.8038	Fc	Calculated data
1976	g CH4/m2	17.8038	Fc	Calculated data
1977	g CH4/m2	17.8038	Fc	Calculated data
1978	g CH4/m2	17.8038	Fc	Calculated data
1979	g CH4/m2	17.8038	Fc	Calculated data
1980	g CH4/m2	17.8038	Fc	Calculated data
1981	g CH4/m2	17.8038	Fc	Calculated data
1982	g CH4/m2	17.8038	Fc	Calculated data
1983	g CH4/m2	17.8038	Fc	Calculated data
1984	g CH4/m2	17.8038	Fc	Calculated data
1985	g CH4/m2	17.8038	Fc	Calculated data
1986	g CH4/m2	17.8038	Fc	Calculated data
1987	g CH4/m2	17.8038	Fc	Calculated data
1988	g CH4/m2	17.8038	Fc	Calculated data
1989	g CH4/m2	17.8038	Fc	Calculated data
1990	g CH4/m2	17.8038	Fc	Calculated data
1991	g CH4/m2	17.8038	Fc	Calculated data
1992	g CH4/m2	17.8038	Fc	Calculated data
1993	g CH4/m2	17.8038	Fc	Calculated data
1994	g CH4/m2	17.8038	Fc	Calculated data
1995	g CH4/m2	17.8038	Fc	Calculated data
1996	g CH4/m2	17.8038	Fc	Calculated data
1997	g CH4/m2	17.8038	Fc	Calculated data
1998	g CH4/m2	17.8038	Fc	Calculated data
1999	g CH4/m2	17.8038	Fc	Calculated data
2000	g CH4/m2	17.8038	Fc	Calculated data
2001	g CH4/m2	17.8038	Fc	Calculated data
2002	g CH4/m2	17.8038	Fc	Calculated data
2003	g CH4/m2	17.8038	Fc	Calculated data
2004	g CH4/m2	17.8038	Fc	Calculated data
2005	g CH4/m2	17.8038	Fc	Calculated data
2006	g CH4/m2	17.8038	Fc	Calculated data
2007	g CH4/m2	17.8038	Fc	Calculated data
2008	g CH4/m2	17.8038	Fc	Calculated data
2009	g CH4/m2	17.8038	Fc	Calculated data
2010	g CH4/m2	17.8038	Fc	Calculated data
2011	g CH4/m2	17.8038	Fc	Calculated data
2012	g CH4/m2	17.8038	Fc	Calculated data
2013	g CH4/m2	17.8038	Fc	Calculated data
2014	g CH4/m2	17.8038	Fc	Calculated data
2015	g CH4/m2	17.8038	Fc	Calculated data
2016	g CH4/m2	17.8038	Fc	Calculated data
2017	g CH4/m2	17.8038	Fc	Calculated data

Emissions (CH4) (Rice cultivation)

Year	Unit	Value	Flag	Flag Description
1961	gigagrams	74.776	Fc	Calculated data
1962	gigagrams	78.3367	Fc	Calculated data
1963	gigagrams	80.1171	Fc	Calculated data
1964	gigagrams	85.4582	Fc	Calculated data
1965	gigagrams	85.4582	Fc	Calculated data
1966	gigagrams	89.019	Fc	Calculated data
1967	gigagrams	89.019	Fc	Calculated data
1968	gigagrams	89.019	Fc	Calculated data
1969	gigagrams	94.3601	Fc	Calculated data
1970	gigagrams	94.3601	Fc	Calculated data
1971	gigagrams	94.3601	Fc	Calculated data
1972	gigagrams	94.3601	Fc	Calculated data
1973	gigagrams	101.4817	Fc	Calculated data
1974	gigagrams	106.8228	Fc	Calculated data
1975	gigagrams	111.2737	Fc	Calculated data
1976	gigagrams	112.1639	Fc	Calculated data
1977	gigagrams	115.7247	Fc	Calculated data
1978	gigagrams	116.971	Fc	Calculated data
1979	gigagrams	117.5051	Fc	Calculated data
1980	gigagrams	115.7247	Fc	Calculated data
1981	gigagrams	119.2855	Fc	Calculated data
1982	gigagrams	113.9443	Fc	Calculated data
1983	gigagrams	114.8345	Fc	Calculated data
1984	gigagrams	114.8345	Fc	Calculated data
1985	gigagrams	114.8345	Fc	Calculated data
1986	gigagrams	114.8345	Fc	Calculated data
1987	gigagrams	114.8345	Fc	Calculated data
1988	gigagrams	114.8345	Fc	Calculated data
1989	gigagrams	112.1639	Fc	Calculated data
1990	gigagrams	106.8228	Fc	Calculated data
1991	gigagrams	104.6863	Fc	Calculated data
1992	gigagrams	105.3985	Fc	Calculated data
1993	gigagrams	104.8644	Fc	Calculated data
1994	gigagrams	103.7962	Fc	Calculated data
1995	gigagrams	103.6181	Fc	Calculated data
1996	gigagrams	103.262	Fc	Calculated data
1997	gigagrams	108.7812	Fc	Calculated data
1998	gigagrams	103.262	Fc	Calculated data
1999	gigagrams	103.262	Fc	Calculated data
2000	gigagrams	95.2503	Fc	Calculated data
2001	gigagrams	101.8377	Fc	Calculated data
2002	gigagrams	103.7707	Fc	Calculated data
2003	gigagrams	103.9742	Fc	Calculated data
2004	gigagrams	103.7962	Fc	Calculated data
2005	gigagrams	103.8674	Fc	Calculated data
2006	gigagrams	103.8674	Fc	Calculated data
2007	gigagrams	103.8674	Fc	Calculated data
2008	gigagrams	101.5511	Fc	Calculated data
2009	gigagrams	101.3036	Fc	Calculated data
2010	gigagrams	101.4817	Fc	Calculated data
2011	gigagrams	101.6597	Fc	Calculated data
2012	gigagrams	100.2354	Fc	Calculated data
2013	gigagrams	97.3868	Fc	Calculated data
2014	gigagrams	93.4699	Fc	Calculated data
2015	gigagrams	82.8233	Fc	Calculated data
2016	gigagrams	83.4464	Fc	Calculated data
2017	gigagrams	84.5961	Fc	Calculated data

Emissions (CO2eq) (Rice cultivation)

Year	Unit	Value	Flag	Flag Description
1961	gigagrams	1570.2952	Fc	Calculated data
1962	gigagrams	1645.0711	Fc	Calculated data
1963	gigagrams	1682.4591	Fc	Calculated data
1964	gigagrams	1794.623	Fc	Calculated data
1965	gigagrams	1794.623	Fc	Calculated data
1966	gigagrams	1869.399	Fc	Calculated data
1967	gigagrams	1869.399	Fc	Calculated data
1968	gigagrams	1869.399	Fc	Calculated data
1969	gigagrams	1981.5629	Fc	Calculated data
1970	gigagrams	1981.5629	Fc	Calculated data
1971	gigagrams	1981.5629	Fc	Calculated data
1972	gigagrams	1981.5629	Fc	Calculated data
1973	gigagrams	2131.1149	Fc	Calculated data
1974	gigagrams	2243.2788	Fc	Calculated data
1975	gigagrams	2336.7487	Fc	Calculated data
1976	gigagrams	2355.4427	Fc	Calculated data
1977	gigagrams	2430.2187	Fc	Calculated data
1978	gigagrams	2456.3903	Fc	Calculated data
1979	gigagrams	2467.6067	Fc	Calculated data
1980	gigagrams	2430.2187	Fc	Calculated data
1981	gigagrams	2504.9947	Fc	Calculated data
1982	gigagrams	2392.8307	Fc	Calculated data
1983	gigagrams	2411.5247	Fc	Calculated data
1984	gigagrams	2411.5247	Fc	Calculated data
1985	gigagrams	2411.5247	Fc	Calculated data
1986	gigagrams	2411.5247	Fc	Calculated data
1987	gigagrams	2411.5247	Fc	Calculated data
1988	gigagrams	2411.5247	Fc	Calculated data
1989	gigagrams	2355.4427	Fc	Calculated data
1990	gigagrams	2243.2788	Fc	Calculated data
1991	gigagrams	2198.4132	Fc	Calculated data
1992	gigagrams	2213.3684	Fc	Calculated data
1993	gigagrams	2202.152	Fc	Calculated data
1994	gigagrams	2179.7192	Fc	Calculated data
1995	gigagrams	2175.9804	Fc	Calculated data
1996	gigagrams	2168.5028	Fc	Calculated data
1997	gigagrams	2284.4056	Fc	Calculated data
1998	gigagrams	2168.5028	Fc	Calculated data
1999	gigagrams	2168.5028	Fc	Calculated data
2000	gigagrams	2000.2569	Fc	Calculated data
2001	gigagrams	2138.5925	Fc	Calculated data
2002	gigagrams	2179.1846	Fc	Calculated data
2003	gigagrams	2183.458	Fc	Calculated data
2004	gigagrams	2179.7192	Fc	Calculated data
2005	gigagrams	2181.2148	Fc	Calculated data
2006	gigagrams	2181.2148	Fc	Calculated data
2007	gigagrams	2181.2148	Fc	Calculated data
2008	gigagrams	2132.573	Fc	Calculated data
2009	gigagrams	2127.3761	Fc	Calculated data
2010	gigagrams	2131.1149	Fc	Calculated data
2011	gigagrams	2134.8537	Fc	Calculated data
2012	gigagrams	2104.9433	Fc	Calculated data
2013	gigagrams	2045.1225	Fc	Calculated data
2014	gigagrams	1962.8689	Fc	Calculated data
2015	gigagrams	1739.2888	Fc	Calculated data
2016	gigagrams	1752.3746	Fc	Calculated data
2017	gigagrams	1776.519	Fc	Calculated data

Estimates of Nuclear Waste Generation (for Simpo Reactors, if Built)

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

Estimates of Nuclear Waste Generation

Assumptions for Calculation of Low-Level Wastes

(Data from sources 1 through 3)

	Cu.m./GW cap./yr		Curies/cu.m.		Curies/GW cap/yr	
Reactor Type	High Est.	Low Est.	High Est.	Low Est.	High Est.	Low Est.
PWR	750	439	6.45	1.5	4000	1,139

Assuming an annual capacity factor of	75%	
Annual Generation per GW cap./yr =	6.57	TWhe

Low-Level Waste Ranges per TWh_e

	Cubic Meters		Curies	
Reactor Type	High Est.	Low Est.	High Est.	Low Est.
PWR	114	67	609	173

Estimates of Mass/Ci of Isotopes in Spent Fuel for Range of Fuel Consumption

(Assumptions primarily from F. von Hippel, personal communication)

Assumptions

Mass fraction Pu in PWR/BWR spent fuel	1%	
Mass fraction Pu in HWR spent fuel	0.4%	
Grams U-235 fissioned per MW_{th}-day	1.0	
Power plant efficiency (TWh_e/TWh_{th})	33.3%	
Curies Strontium-90 per gm U235 fissioned	3.0	
Curies Cesium-137 per gm U235 fissioned	3.0	
Grams Pu fissioned per gm Pu in spent fuel	1.0	
Curies Strontium-90 per gm Pu fissioned	1.0	
Curies Cesium-137 per gm Pu fissioned	3.0	
MW_e-days/TWh_e	41,667	
MW_{th}-days/TWh_e	125,125	
Grams U235 fissioned per TWhe	125,125	
Curies Strontium-90 from U235 per TWhe	3.75E+05	
Curies Cesium-137 from U235 per TWhe	3.75E+05	
For DRY CASK STORAGE OF SPENT FUEL:		
Tonnes of Heavy Metal per Assembly	0.46	*Source 4*
Assemblies per Cask	21	*Source 4*
Tonnes of Heavy Metal Spent Fuel per Cask	9.7	

For PWRs

Years	MW_{th}-days/ Te Heavy Metal	Te Heavy Metal per MW_{th}-day	Te Heavy Metal per TWhe	kg Pu in Spent fuel per TWhe
2000 - 2009	44,000	2.27E-05	2.84	28.4

kg Pu Fissioned per TWhe	Ci Str-90 from Pu per TWhe	Ci Cs-137 from Pu per TWhe	Total Ci Str-90 per TWhe	Total Ci Cs-137 per TWhe
28.4	28,438	85,313	4.04E+05	4.61E+05

Sources/Notes:

1 Lipschutz, R.D. (1980), Radioactive Waste: Politics, Technology, and Risk. Ballinger, Cambridge, MA, USA.

2 Reviews of Modern Physics, 1978;

3 The Nuclear Almanac (J. Dennis, Ed.)

4 Data from US Department of Energy (1994), Multi-purpose Canister Evaluation: A Systems Engineering Approach. Report DOE/RW-0445, September, 1994. Multipurpose canister (interim storage, transport, and final disposal) designed for PWR spent fuel.

Calculation of DPRK nuclear resource

4.5	million tonnes U ore		
0.20%	Average % U in ore		
9,000	Implied total U in Ore		
50000	MWth-days/te heavy metal, or	4320000	GJ/tHM
4%	Enrichment (U235 in fuel)		
0.711%	Fraction U235 in Natural U		
6.91E+09	GJ Implied thermal U resource, or		
633,501	GWHe, or		
72.32	GW-yr electric		

Illustrative Estimate of Cost to the DPRK of Energy Used During 2010

2020 UPDATE

ESTIMATE OF THE COSTS TO THE DPRK OF ENERGY CONSUMED DURING 2010

Prepared By David Von Hippel
Date Last Modified: **10/30/2012**

			Average Cost (2010 USD/GJ)		Estimated Total Cost (2010 thousand USD)		
Fuel Type/Energy Product	2010 Estimated Consumption (TJ)		High Estimate	Low Estimate	High Estimate	Low Estimate	*Notes/ Sources*
Crude Oil	25,309		$ -	$ 14.48	$ -	$ 366,410	*1*
Imported Diesel	9,955		$ 16.39	$ 16.39	$ 163,139	$ 163,139	*6*
Imported Gasoline	3,649		$ 16.65	$ 16.65	$ 60,767	$ 60,767	*6*
Imported Heavy Fuel Oil	684		$ 12.37	$ 12.37	$ 8,460	$ 8,460	*6*
Imported Kerosene	1,741		$ 16.62	$ 16.62	$ 28,932	$ 28,932	*6*
Imported LPG/Other	430		$ 17.76	$ 17.76	$ 7,640	$ 7,640	*6*
Domestic Diesel less exports	4,581		$ 16.39	$ -	$ 75,066	$ -	*6*
Domestic Gasoline	5,813		$ 16.65	$ -	$ 96,797	$ -	*6*
Domestic Heavy Fuel Oil less exports	8,200		$ 12.37	$ -	$ 101,439	$ -	*6*
Domestic Kerosene	1,218		$ 16.62	$ -	$ 20,242	$ -	*6*
Domestic LPG/Other less exports	3,828		$ 17.76	$ -	$ 68,005	$ -	*6*
Imported Coal	13,432		$ 6.62	$ 6.62	$ 88,856	$ 88,856	*4*
Domestic Coal (less Exports)	370,033		$ 3.24	$ 3.24	$ 1,199,827	$ 1,199,827	*3*
Imported Electricity	1,053		$ 33.46	$ 33.46	$ 35,229	$ 35,229	*2*
Domestic Hydro Electricity	42,864		$ 8.99	$ -	$ 385,426	$ -	*2*
Domestic Thermal Electricity	12,372		$ 8.99	$ -	$ 111,249	$ -	*2*
(less--value of thermal electricity fuels in above)	(64,786)		$ 4.47	$ -	$ (289,271)	$ -	*7*
Domestic and Imported Fuelwood and Biomass	208,309		$ 1.62	$ 0.81	$ 337,720	$ 168,860	*5*
TOTAL VALUE OF 2010 ENERGY USED					**$ 2,499,523**	**$ 2,128,120**	

Sources/Notes:

1 *Low estimate for crude oil cost based on 2010 unit costs of imports from China. High cost set at zero because values of domestic refined products are evaluated individually; and including crude oil costs as well would double-count crude oil value.*

2 *Low estimates assume the "cost" of domestic hydro and of domestic thermal power at zero, based on the fact that existing plants are old and fully amortized, and that running costs (beyond fuel costs) are minimal. High estimates use as a placeholder the value per unit of electricity sold to China in 2010, as calculated based on China Customs statistics data compiled by N. Aden. A summary of the average value of electricity imported to and exported from the DPRK in 2010 and 2011 is provided below.*

	USD per kWh	
	2010	2011
Exports from the DPRK	$ 0.032	$ 0.034
Imports to the DPRK	$ 0.120	$ 0.117

3 *Domestic coal is valued at its average export price to China, which in 2010 was* $ 84.11 per tonne, or *about* $ 3.24 *per GJ, again based on China customs statistics.*

4 *Imported coal is valued at its average export price to China, which in 2010 was* $ 173.27 per tonne, or *about* $ 6.62 *per GJ, again based on China customs statistics.*

5 *As placeholder estimates, wood and biomass is valued at* 50% *of the export value of coal, on a per-GJ basis, or about* $ 1.62 *per GJ as a "high" estimate, and* 25% of the export *value of coal, or* $ 0.81 *per GJ as a "low" estimate.*

6 *China customs statistics yield the following average cost for oil products imported into the DPRK in 2010:*

HS Number	Product Description	Cost per tonne	Cost per GJ	
27101911	Aviation Kerosene	$ 718	$ 16.62	
27101921	Light Diesel Oil	$ 708	$ 16.39	
27101922	Fuel Oils No. 5	$ 513	$ 12.37	
27101991	Lubricating Oil	$ 1,357	$ 32.42	
27101993	Basic Oils For [Lubrication]	$ 1,156	$ 27.60	
27101992	Lubricating Grease	$ 1,290	$ 30.82	
271011	Light Oils & Preparations (Not Crude)	$ 732	$ 16.65	*(almost all of these imports were gasoline)*
2711	Petroleum, Other Gases	$ 753	$ 17.76	

Given that oil products have international markets, we assume these values are valid for both imported and domestically-refined oil products in the DPRK.

7 *Values the fuels input to electricity generation at their import (or export, for coal) prices to avoid double-counting for their value when estimating the value of electricity generated from thermal sources.*

Additional Summary Results Tables and Graphs

NAUTILUS INSTITUTE

ENERGY EFFICIENCY SCOPING STUDY
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

ADDITIONAL GRAPHS AND FIGURES

Prepared By David Von Hippel
Date Last Modified: 7/9/2020

DPRK Industrial Energy Demand By Subsector: 1990 and 1996

Units: Terajoules (TJ)	**1990**				**1996**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	324,615	-	-	17,388	124,977	-	-	6,694
Cement	68,139	7,571	-	4,356	29,981	3,331	-	1,917
Fertilizers	23,994	4,573	-	18,891	6,515	1,129	-	5,130
Other Chemicals	11,203	-	-	6,616	3,697	-	-	2,183
Pulp and Paper	4,026	-	4,026	932	1,329	-	1,329	308
Other Metals	23,720	-	-	4,126	7,828	-	-	1,362
Other Minerals	-	12,600	-	396	832	3,326	-	131
Textiles	29,385	-	-	2,497	9,697	-	-	824
Building Materials	61,980			189	20,453	-	-	62
Non-specified Industry	124,600	3,650	1,600	14,850	45,230	869	581	5,391
TOTAL	671,661	28,393	5,626	70,242	250,538	8,655	1,909	24,001

DPRK Industrial Energy Demand By Subsector: 2000 and 2005

Units: Terajoules (TJ)	**2000**				**2005**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	67,382	-	-	3,609	52,717	-	-	2,824
Cement	19,096	7,024	-	1,503	23,566	3,568	-	1,561
Fertilizers	2,070	343	-	1,629	3,010	512	-	2,370
Other Chemicals	2,325	-	-	1,373	2,265	-	-	1,338
Pulp and Paper	836	-	836	194	814	-	814	188
Other Metals	4,924	-	-	857	15,940	-	-	2,773
Other Minerals	869	3,478	-	137	3,528	3,528	-	222
Textiles	6,100	-	-	518	6,582	-	-	559
Building Materials	21,383			65	20,825			64
Non-specified Industry	24,689	882	317	2,942	21,128	1,032	271	2,780
TOTAL	149,673	11,726	1,153	12,828	150,376	8,640	1,085	14,679

DPRK Industrial Energy Demand By Subsector: 2008 and 2009

Units: Terajoules (TJ)	**2008**				**2009**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	51,776	-	-	2,773	69,936	-	-	3,746
Cement	30,144	3,168	-	1,917	43,952	1,585	-	2,620
Fertilizers	2,872	498	-	2,261	1,903	330	-	1,498
Other Chemicals	2,095	-	-	1,237	1,848	-	-	1,092
Pulp and Paper	753	-	753	174	664	-	664	154
Other Metals	16,177	-	-	2,814	15,916	-	-	2,769
Other Minerals	4,108	3,099	-	227	4,816	2,114	-	218
Textiles	6,465	-	-	549	5,495	-	-	467
Building Materials	20,453	-	-	62	20,453	-	-	62
Non-specified Industry	20,257	584	260	3,224	15,693	625	202	2,696
TOTAL	155,101	7,349	1,013	15,239	180,677	4,653	866	15,322

DPRK Industrial Energy Demand By Subsector: 2010 and 2014

Units: Terajoules (TJ)	**2010**				**2014**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	69,197	-	-	3,707	66,005	-	-	3,536
Cement	43,099	2,278	-	2,611	44,330	2,530	-	2,696
Fertilizers	1,950	338	-	1,535	5,841	1,031	-	4,599
Other Chemicals	1,725	-	-	1,019	1,356	-	-	801
Pulp and Paper	642	-	642	149	443	-	443	103
Other Metals	15,133	-	-	2,633	13,568	-	-	2,360
Other Minerals	4,423	2,381	-	214	4,484	2,320	-	214
Textiles	5,172	-	-	439	3,879	-	-	330
Building Materials	19,090	-	-	58	14,999	-	-	46
Non-specified Industry	15,090	691	194	2,839	10,965	516	141	2,569
TOTAL	175,522	5,688	836	15,204	165,869	6,398	584	17,252

DPRK Industrial Energy Demand By Subsector: 2015 and 2016

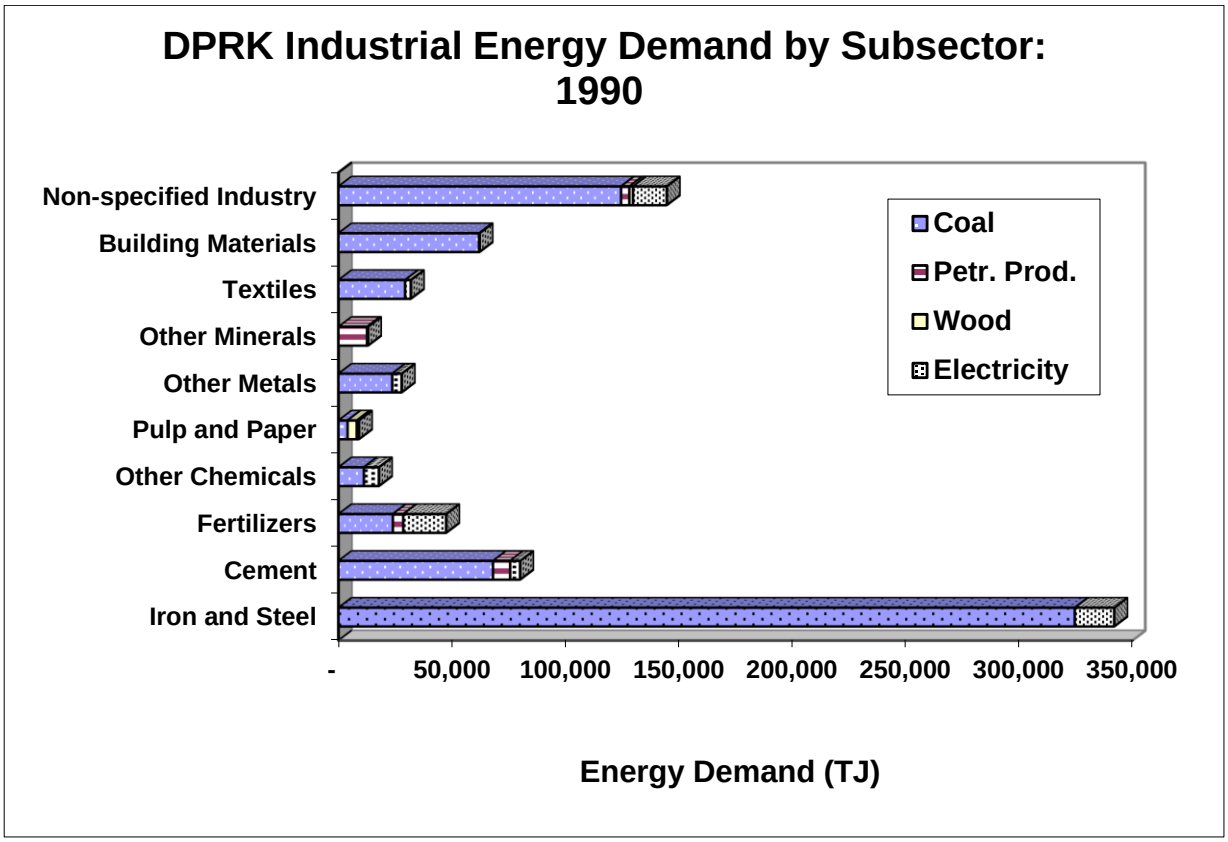
Units: Terajoules (TJ)	**2015**				**2016**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	58,377	-	-	3,127	65,238	-	-	3,494
Cement	43,254	3,761	-	2,705	44,481	4,228	-	2,802
Fertilizers	5,430	958	-	4,275	6,156	1,096	-	4,846
Other Chemicals	1,356	-	-	801	1,356	-	-	801
Pulp and Paper	443	-	443	103	443	-	443	103
Other Metals	13,568	-	-	2,360	13,444	-	-	2,339
Other Minerals	4,280	2,524	-	214	4,230	2,511	-	212
Textiles	3,879	-	-	330	3,879	-	-	330
Building Materials	14,999	-	-	46	14,999	-	-	46
Non-specified Industry	10,965	568	141	2,884	10,965	619	141	1,500
TOTAL	156,549	7,812	584	16,844	165,190	8,454	584	16,472

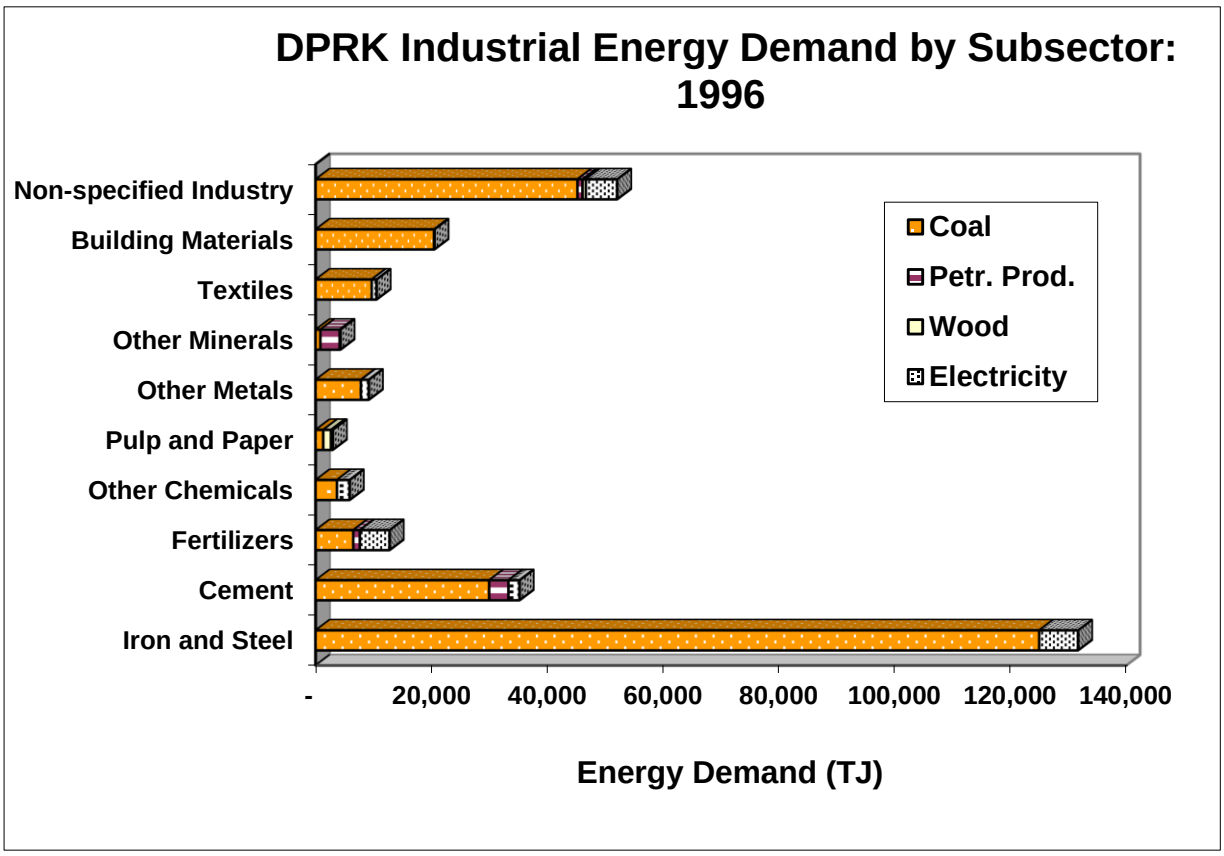
DPRK Industrial Energy Demand By Subsector: 2017 and 2018

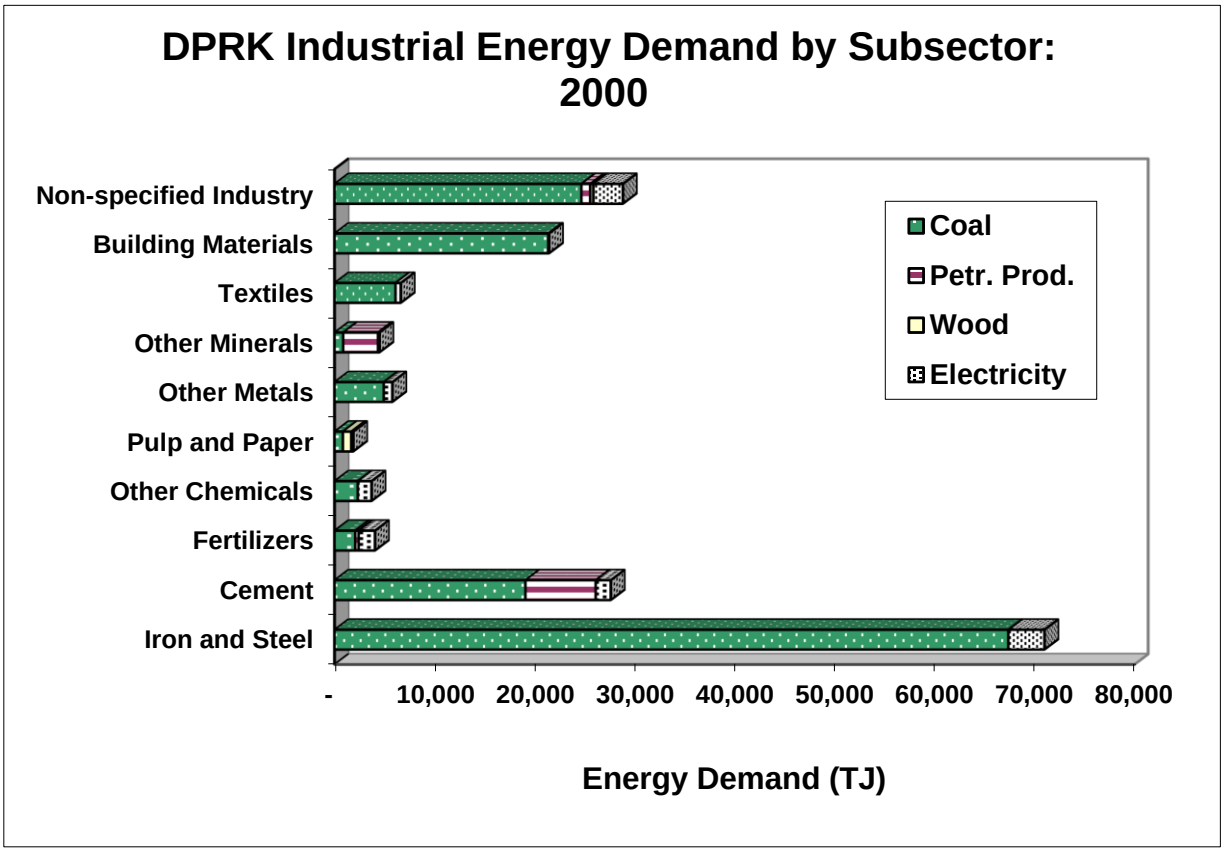
Units: Terajoules (TJ)	**2017**				**2018**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	58,972	-	-	3,159	55,184	-	-	2,956
Cement	45,605	1,930	-	2,735	42,164	2,186	-	2,552
Fertilizers	4,215	744	-	3,318	2,359	416	-	1,857
Other Chemicals	1,356	-	-	801	1,356	-	-	801
Pulp and Paper	443	-	443	103	443	-	443	103
Other Metals	12,785	-	-	2,224	12,785	-	-	2,224
Other Minerals	4,899	1,225	-	192	4,899	1,225	-	192
Textiles	3,556	-	-	302	3,556	-	-	302
Building Materials	14,317	-	-	44	15,681	-	-	48
Non-specified Industry	11,650	331	150	1,388	16,447	333	211	1,960
TOTAL	157,796	4,229	592	14,266	154,873	4,161	654	12,995

DPRK Industrial Energy Demand By Subsector: 2019 and 2020

Units: Terajoules (TJ)	**2019**				**2020**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	55,184	-	-	2,956	47,069	-	-	2,521
Cement	42,177	2,173	-	2,552	32,188	2,986	-	2,024
Fertilizers	2,359	416	-	1,857	1,179	208	-	928
Other Chemicals	1,356	-	-	801	986	-	-	582
Pulp and Paper	443	-	443	103	354	-	354	82
Other Metals	12,785	-	-	2,224	9,654	-	-	1,679
Other Minerals	4,899	1,225	-	192	3,810	953	-	150
Textiles	3,556	-	-	302	2,586	-	-	220
Building Materials	15,681	-	-	48	10,908	-	-	33
Non-specified Industry	16,447	333	211	1,960	16,447	351	211	1,960
TOTAL	154,886	4,147	654	12,995	125,183	4,498	566	10,180


DPRK Industrial Energy Demand by Subsector: 1990
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
50,000
100,000
150,000
200,000
250,000
300,000
350,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 1996
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2000
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
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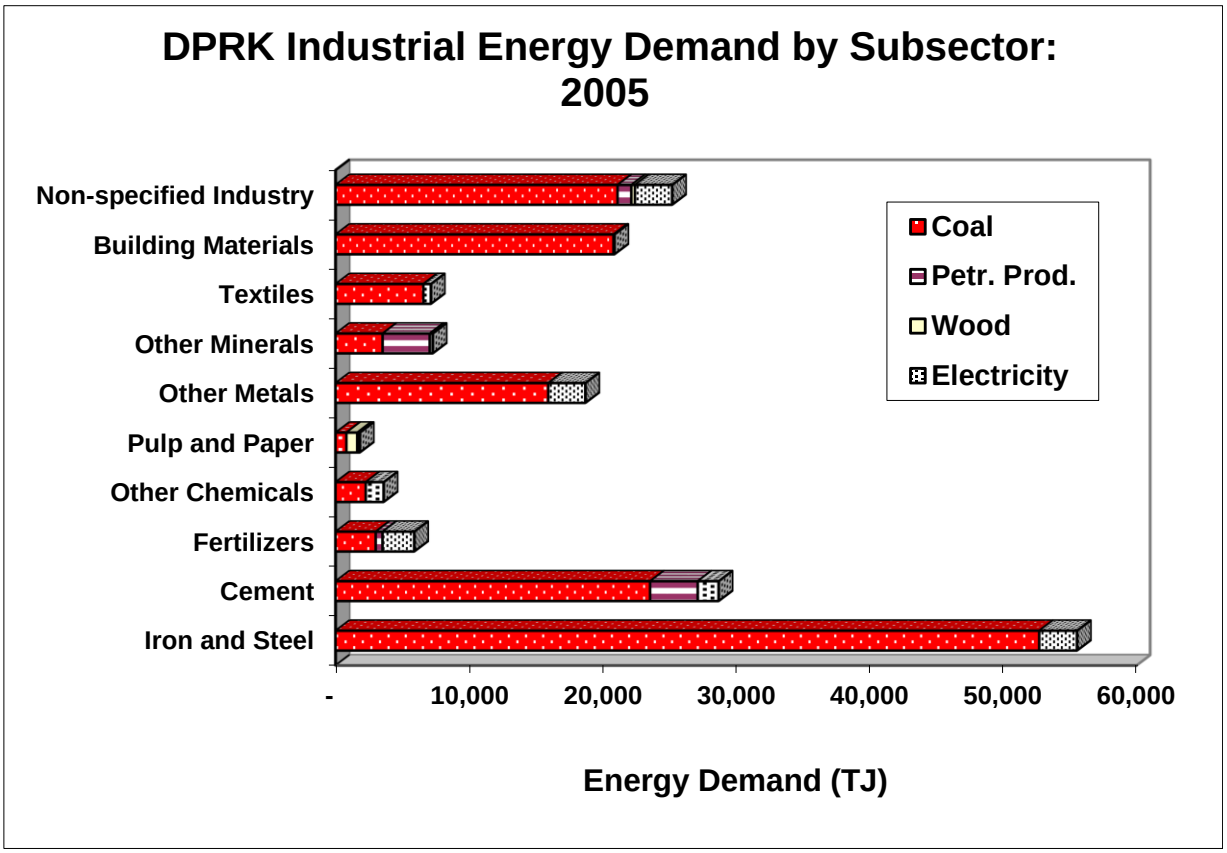
40,000
50,000
60,000
70,000
80,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2005
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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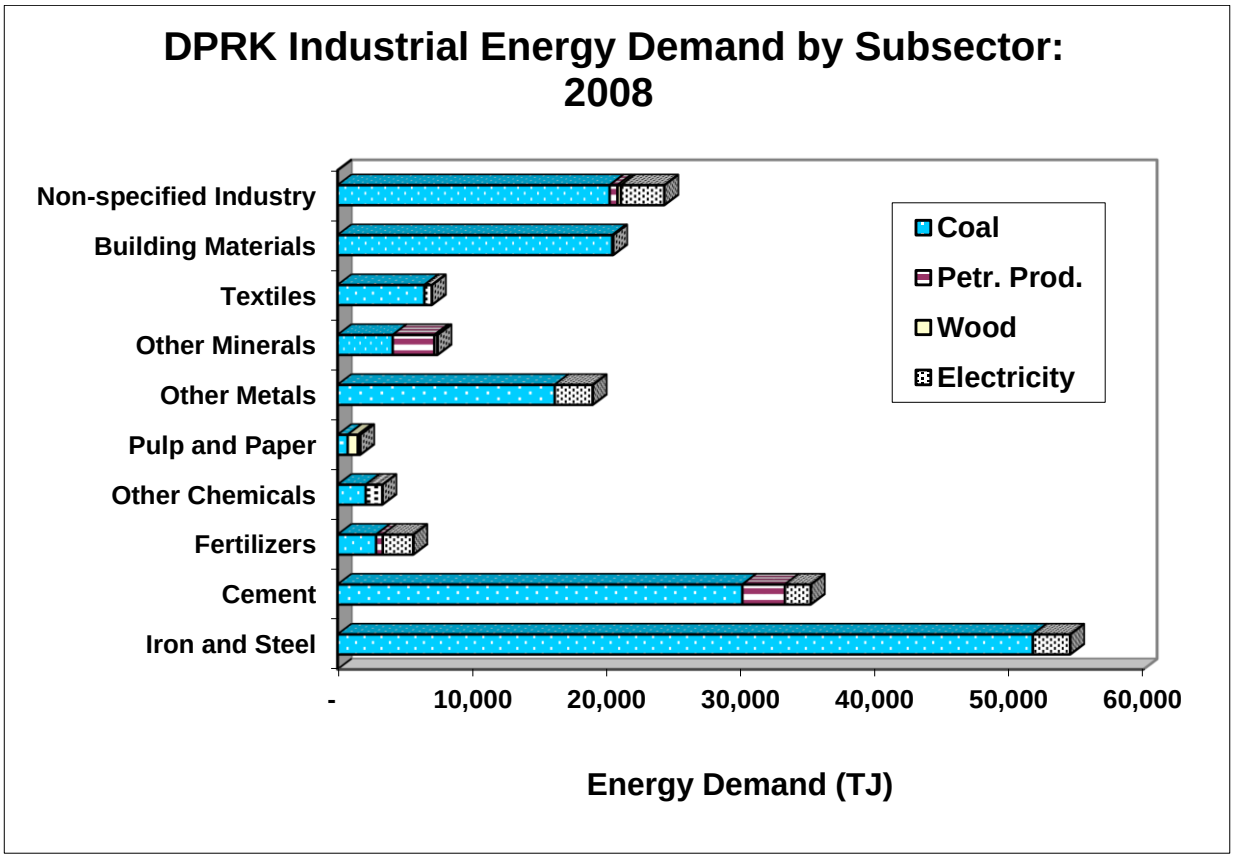
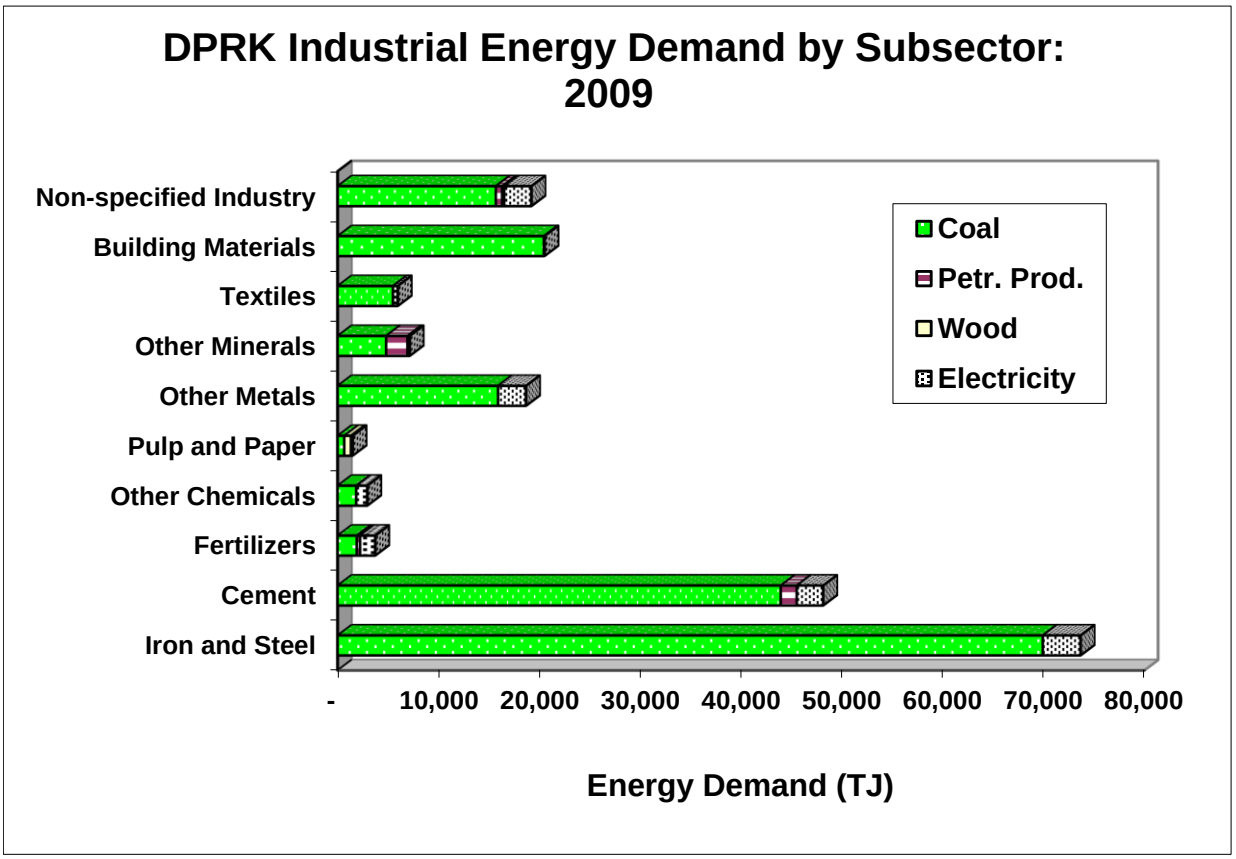
20,000
30,000
40,000
50,000
60,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2008
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2009
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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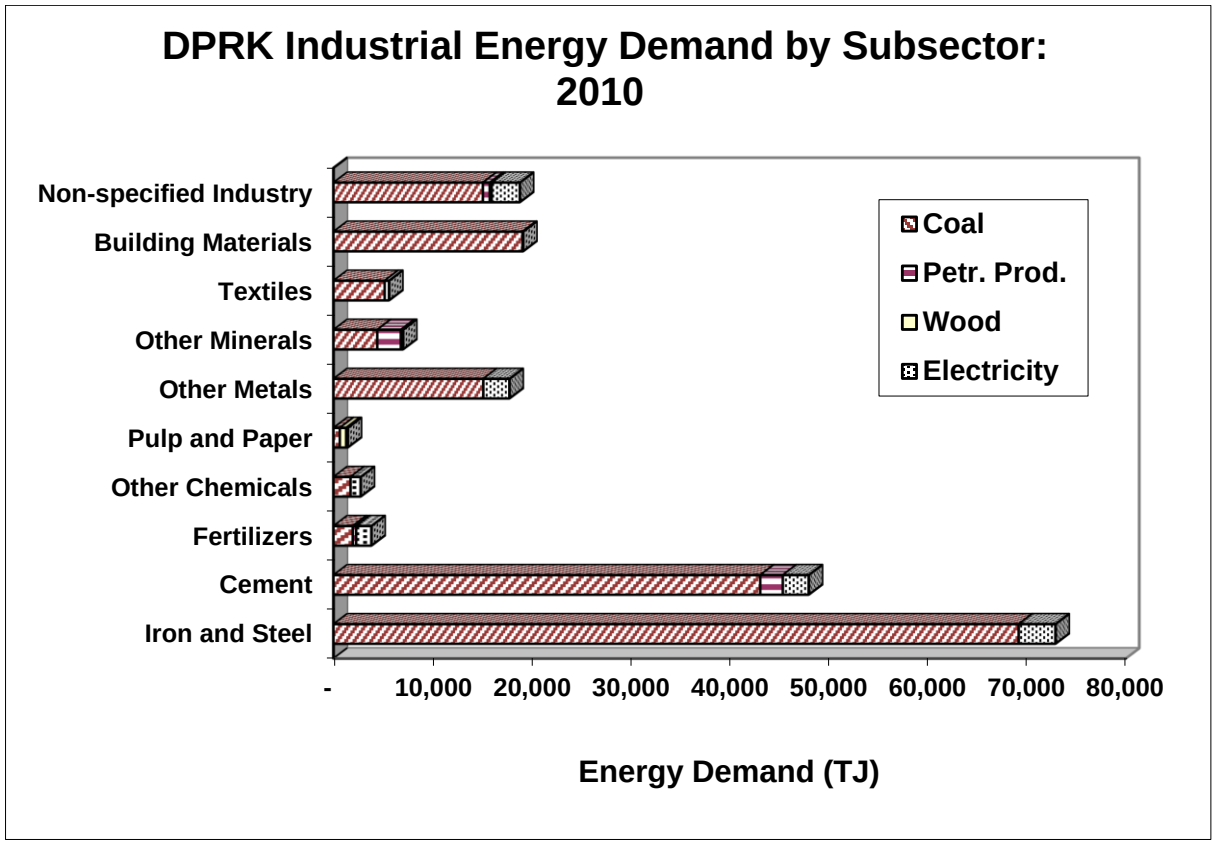
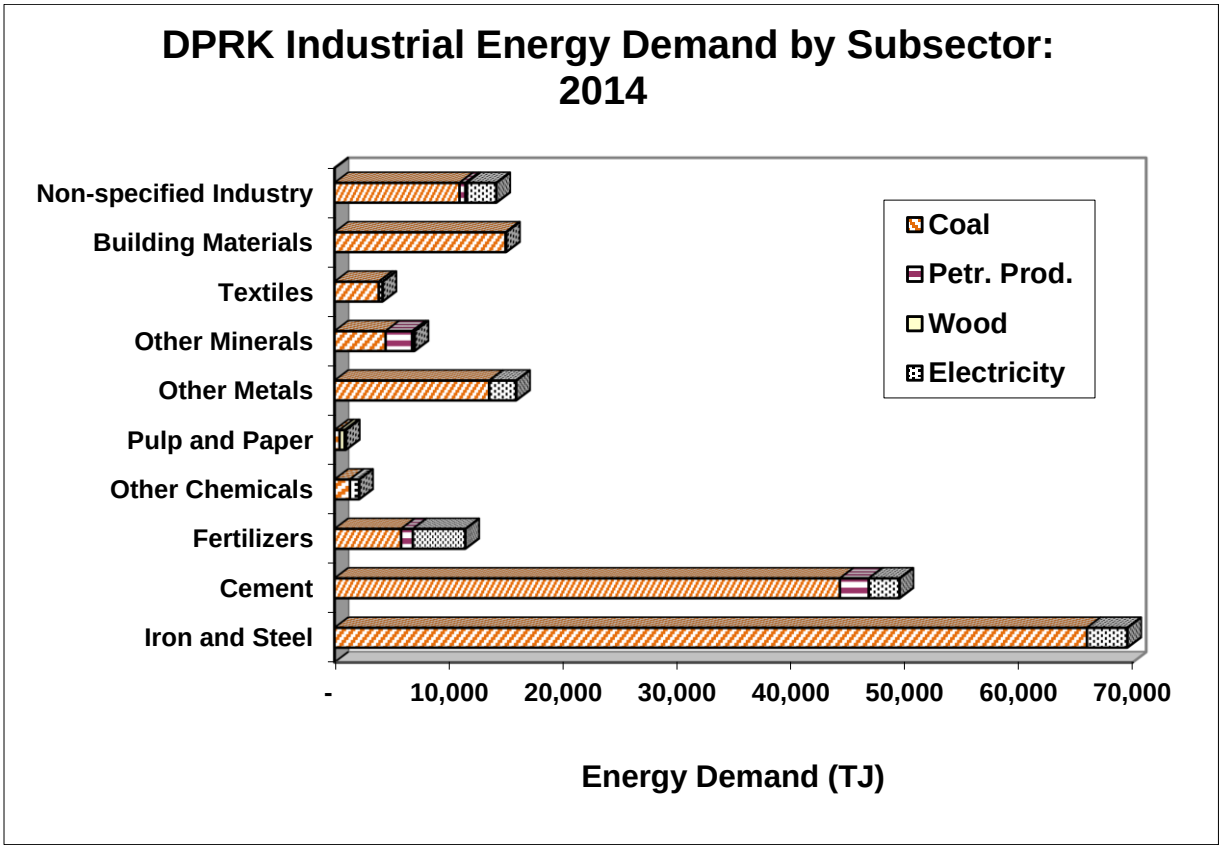
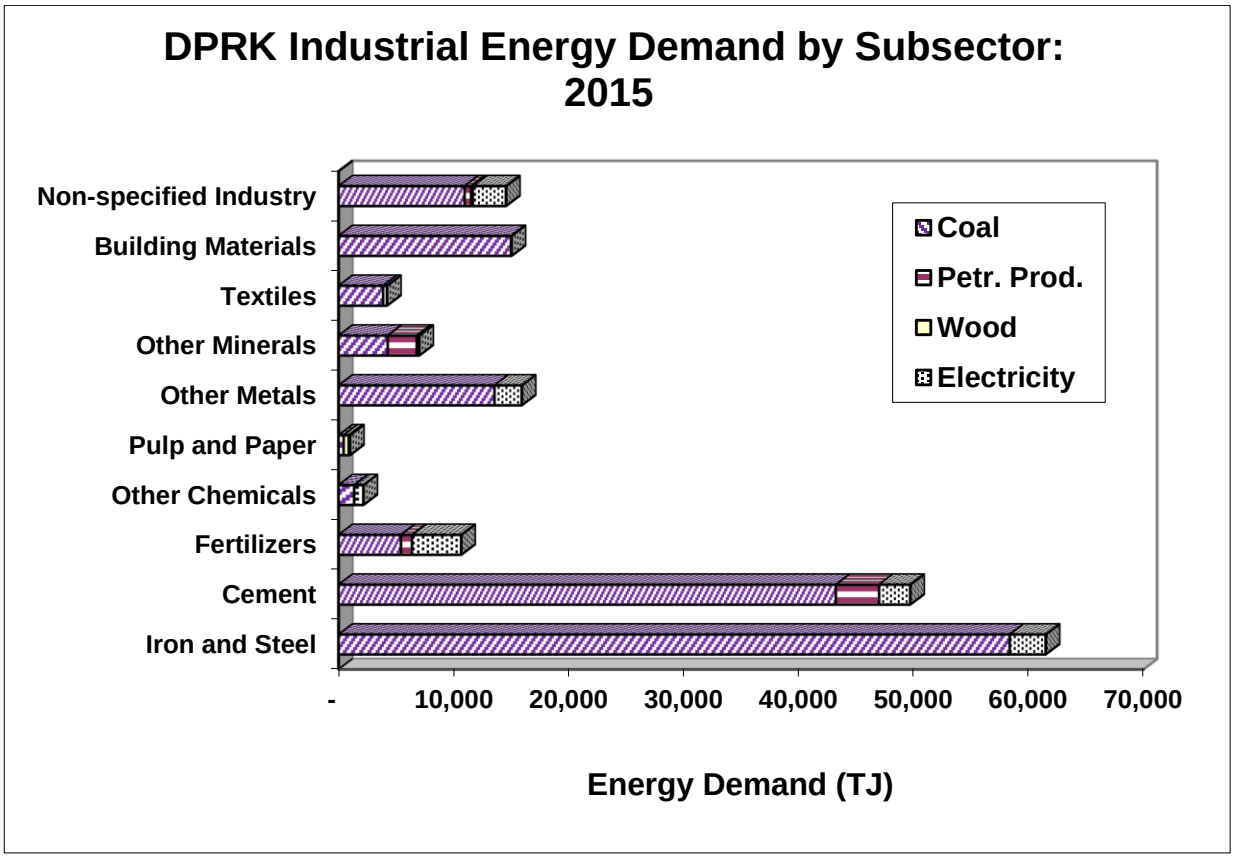
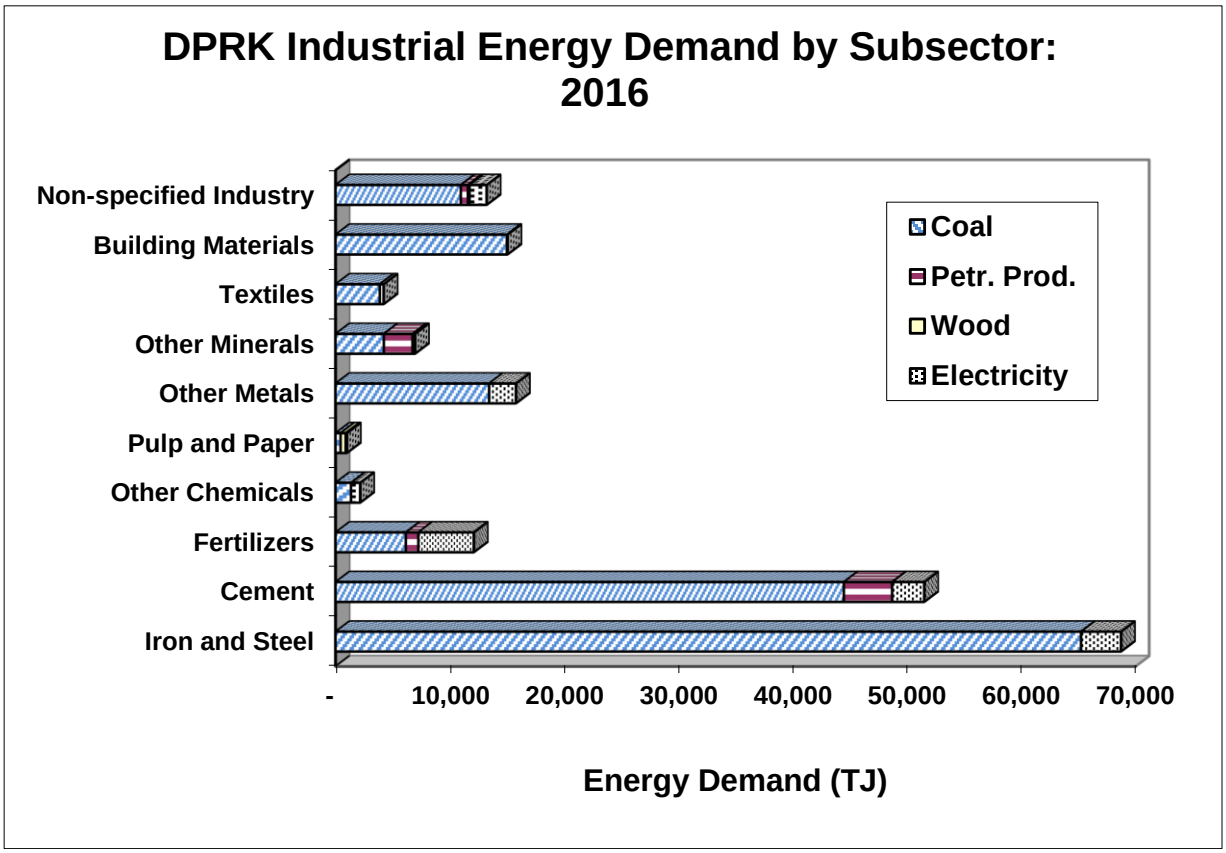
30,000
40,000
50,000
60,000
70,000
80,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2010
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2014
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
70,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2015
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
70,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2016
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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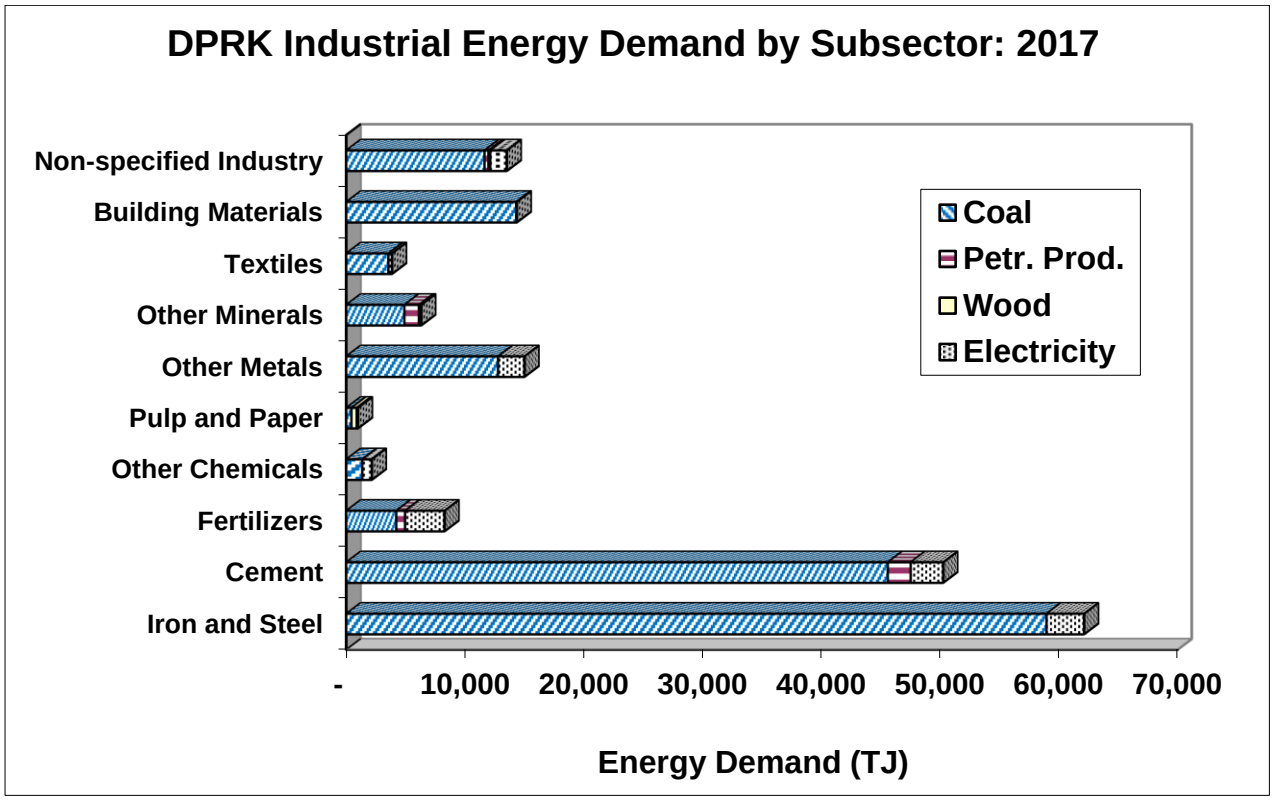
50,000
60,000
70,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2017
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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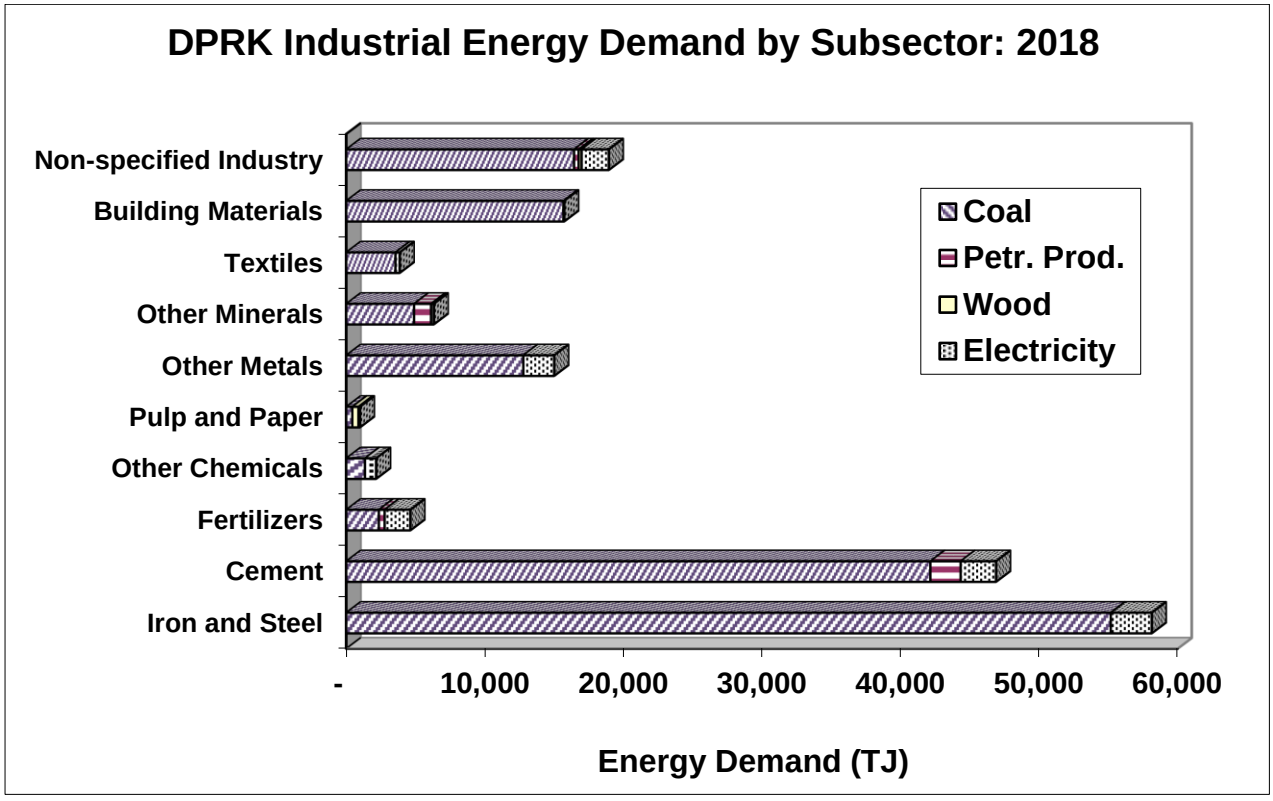
60,000
70,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2018
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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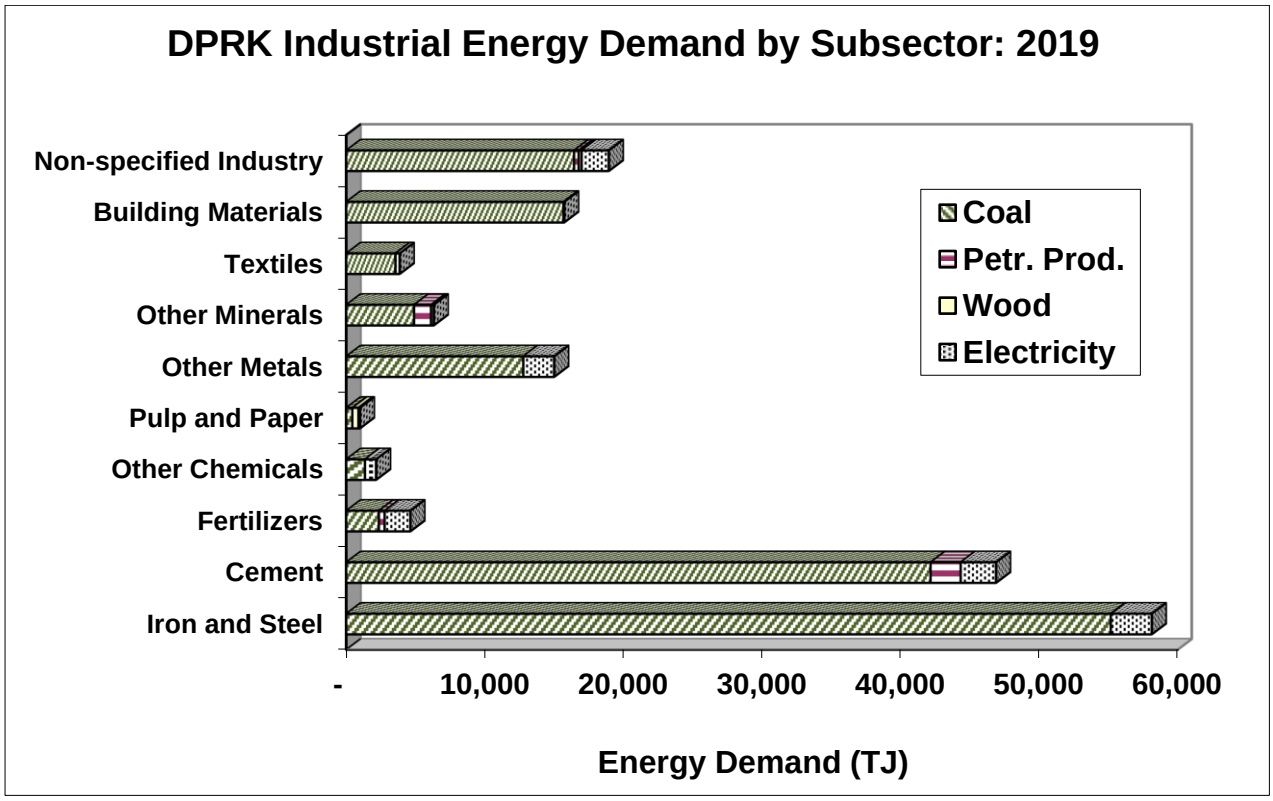
60,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2019
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
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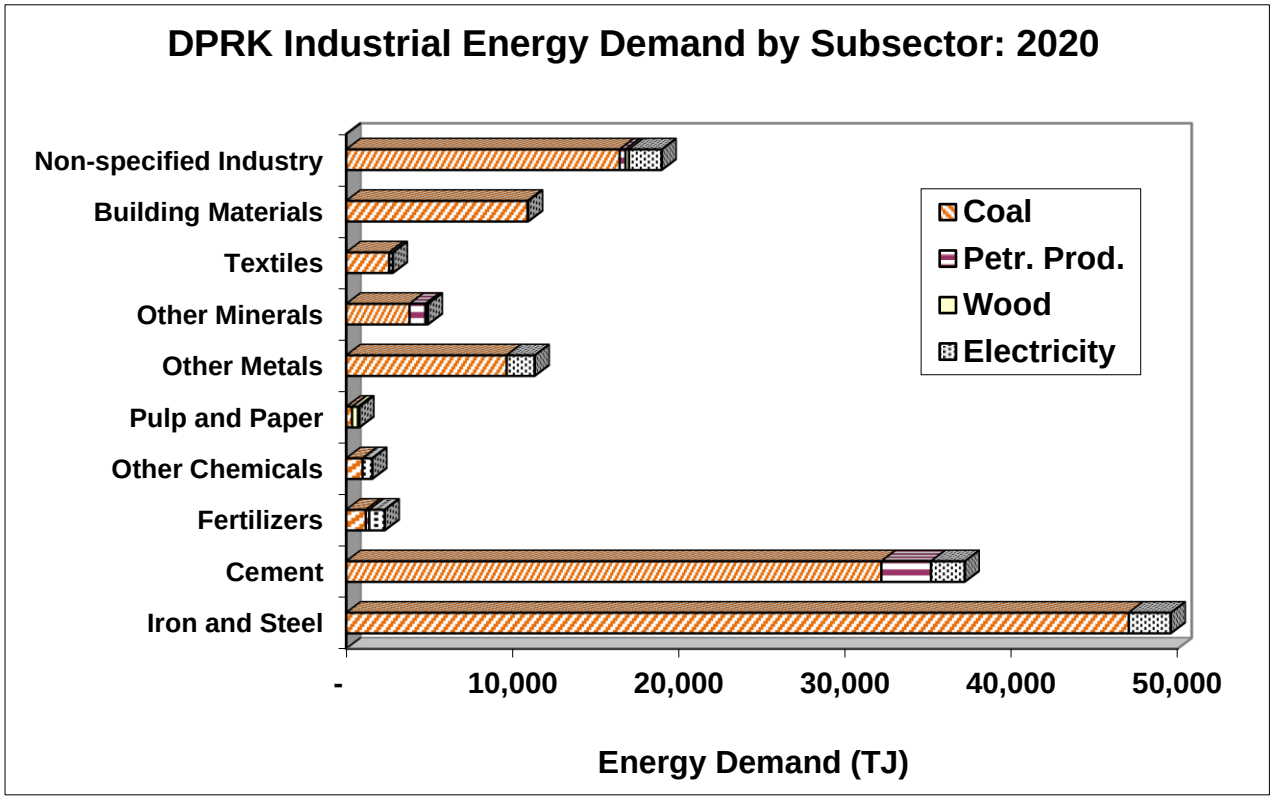
60,000
Energy Demand (TJ)


DPRK Industrial Energy Demand by Subsector: 2020
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
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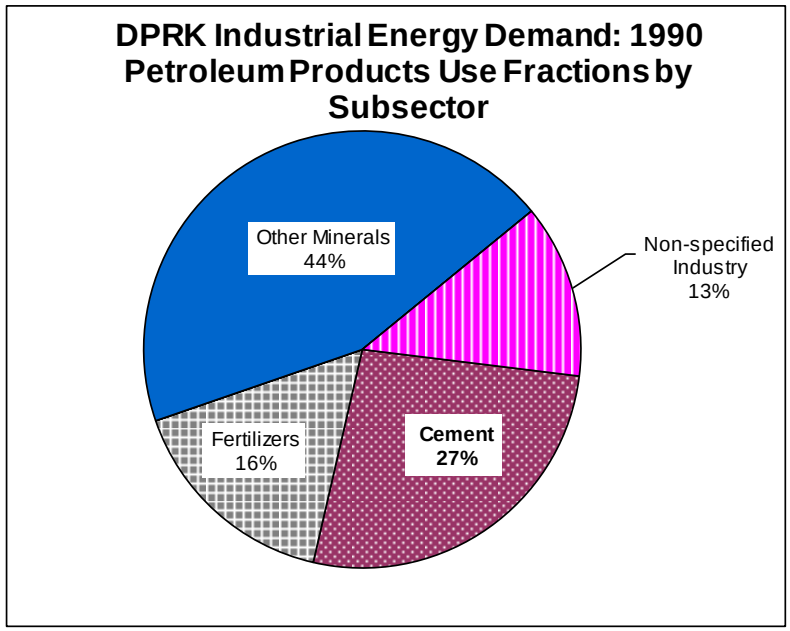
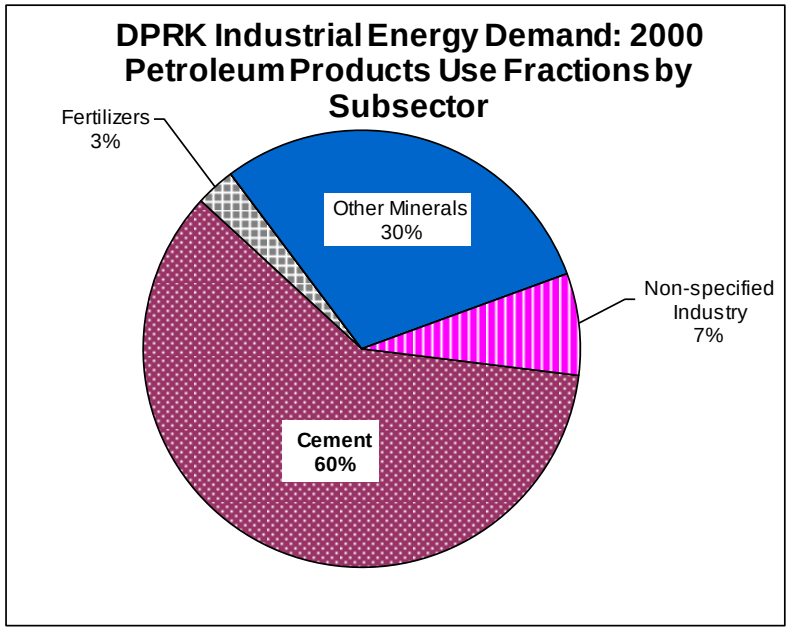
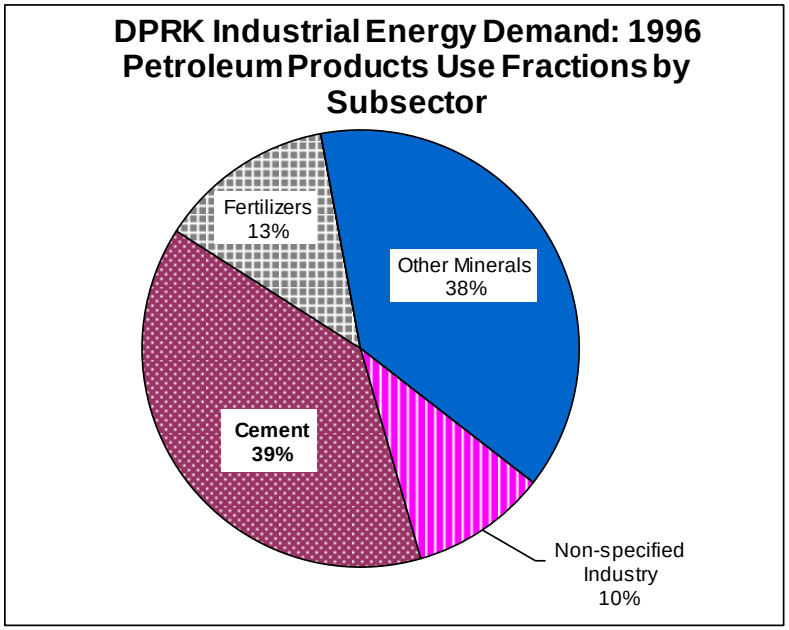
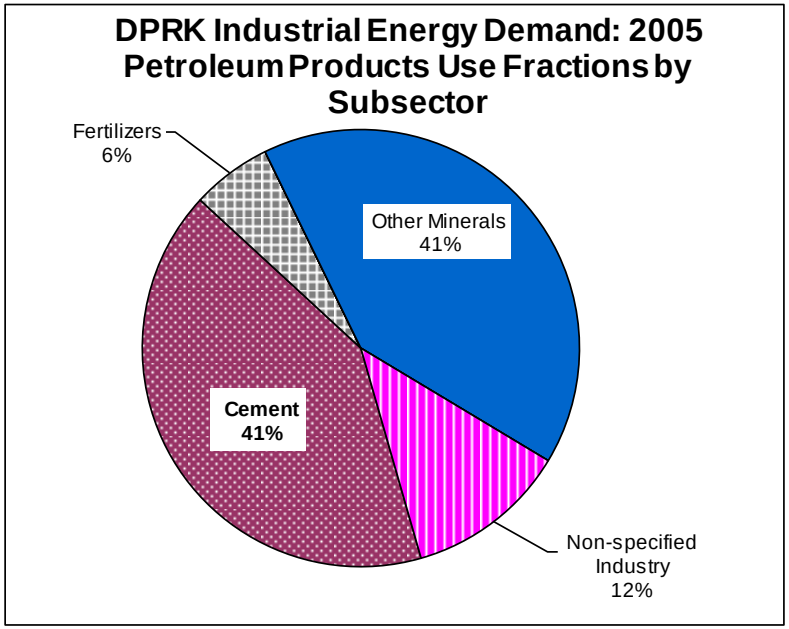
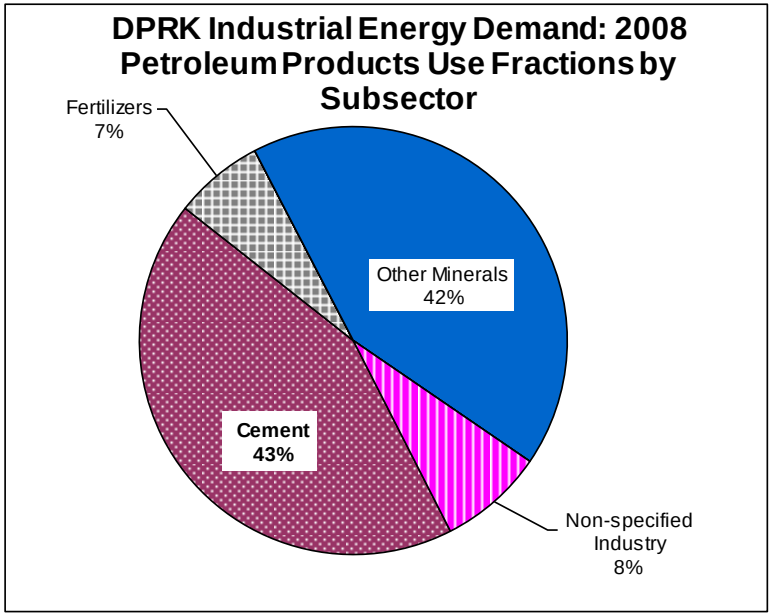
40,000
50,000
Energy Demand (TJ)

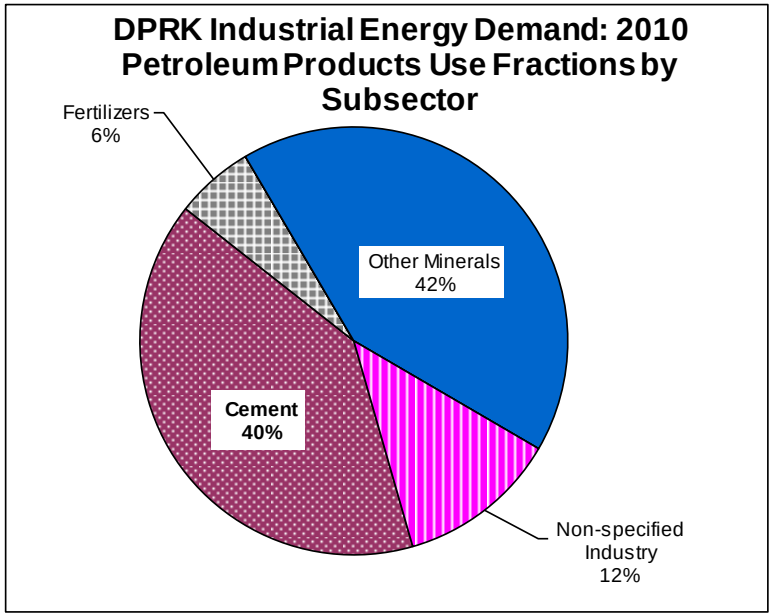

DPRK Industrial Energy Demand: 1990
Petroleum Products Use Fractions by Subsector
Other Minerals 44%
Non-specified Industry 13%
Fertilizers 16%
Cement 27%

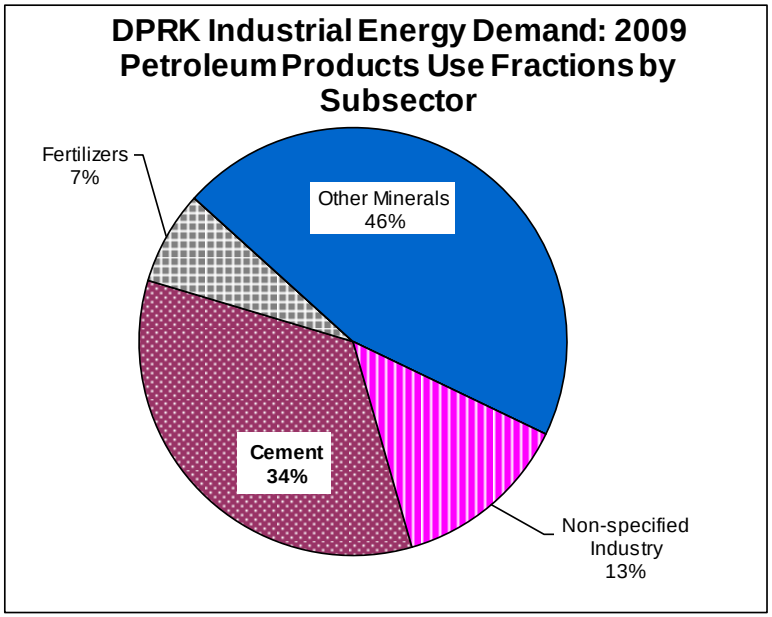

DPRK Industrial Energy Demand: 2000
Petroleum Products Use Fractions by Subsector
Fertilizers 3%
Other Minerals 30%
Non-specified Industry 7%
Cement 60%

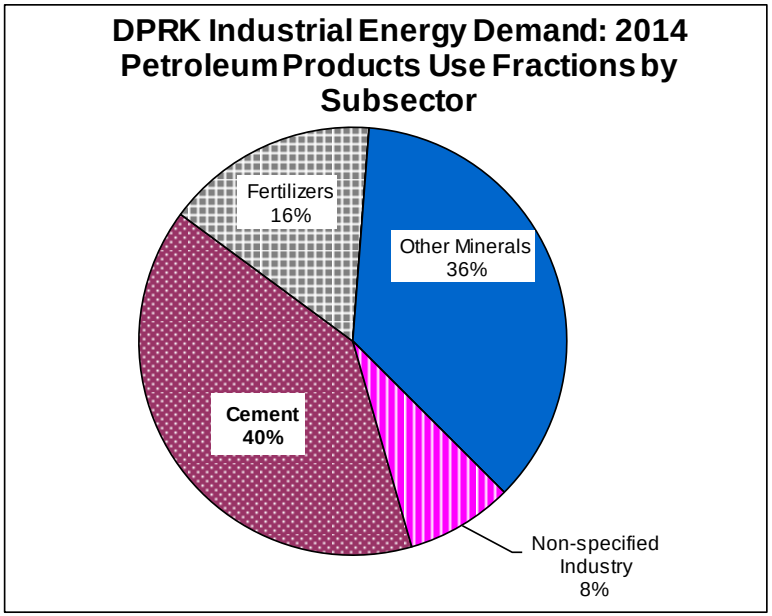

DPRK Industrial Energy Demand: 1996
Petroleum Products Use Fractions by Subsector
Fertilizers 13%
Other Minerals 38%
Cement 39%
Non-specified Industry 10%

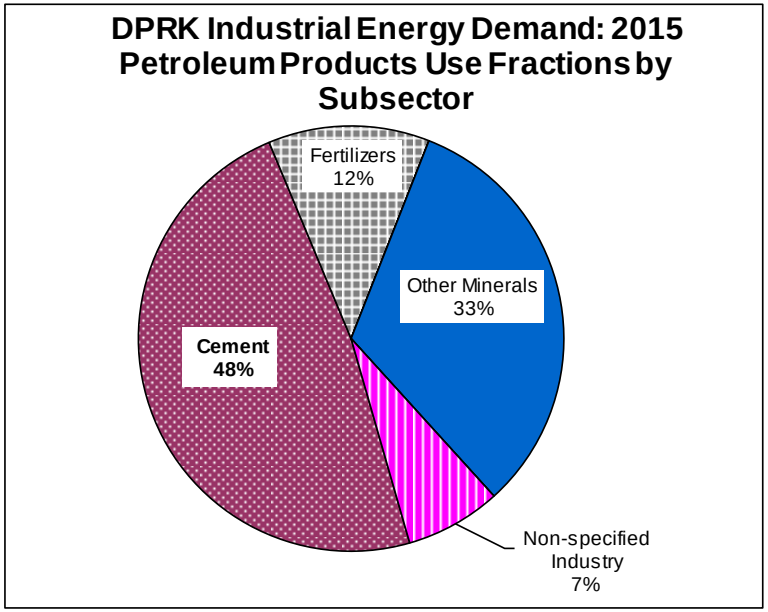

DPRK Industrial Energy Demand: 2005
Petroleum Products Use Fractions by Subsector
Fertilizers 6%
Other Minerals 41%
Cement 41%
Non-specified Industry 12%

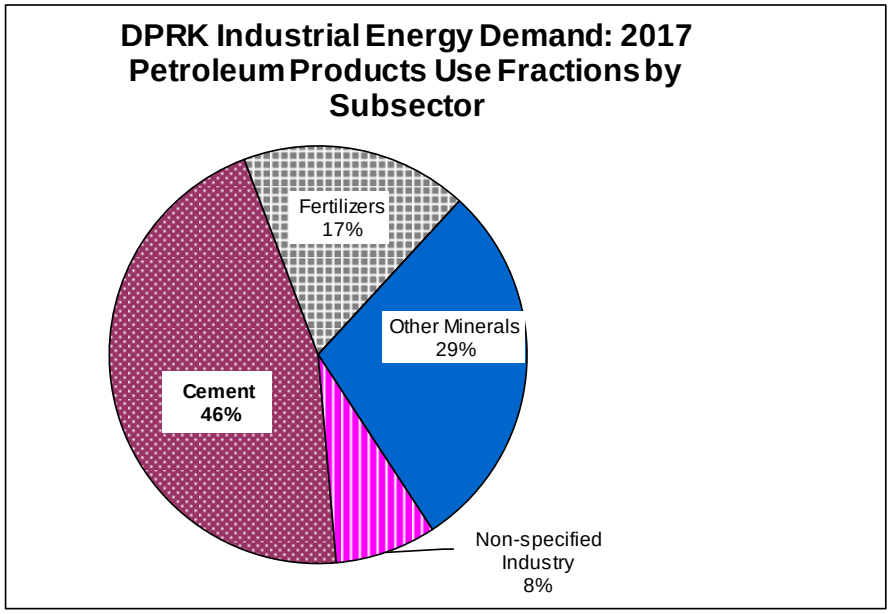

DPRK Industrial Energy Demand: 2008
Petroleum Products Use Fractions by Subsector
Fertilizers 7%
Other Minerals 42%
Cement 43%
Non-specified Industry 8%

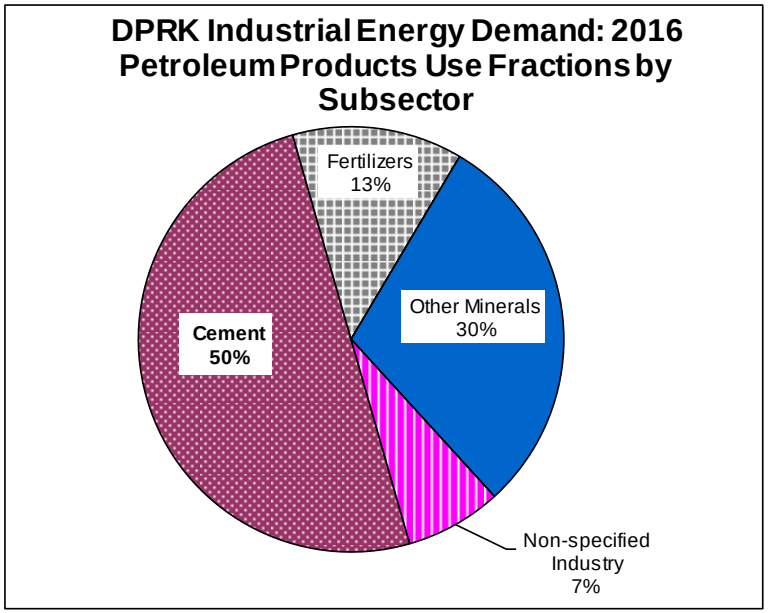

DPRK Industrial Energy Demand: 2010
Petroleum Products Use Fractions by Subsector
Fertilizers 6%
Other Minerals 42%
Cement 40%
Non-specified Industry 12%

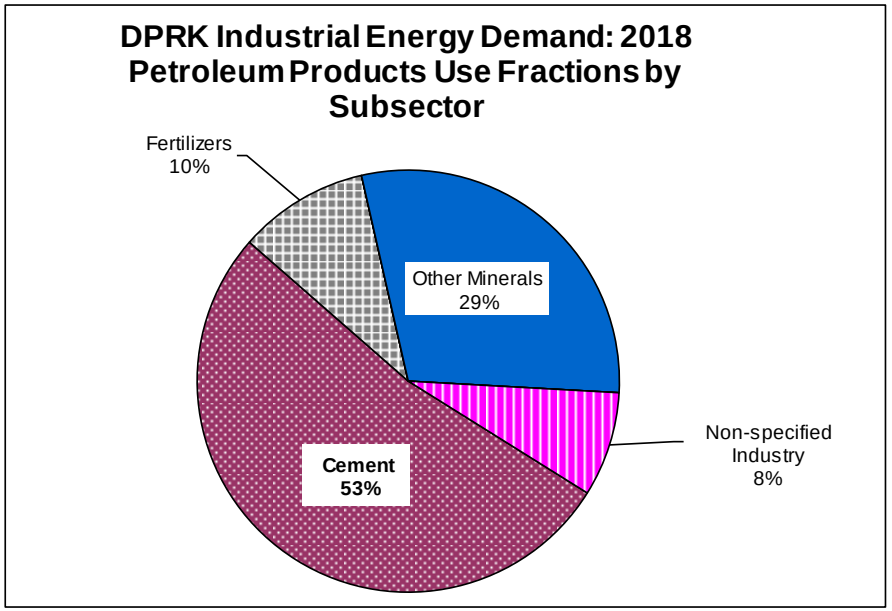

DPRK Industrial Energy Demand: 2009
Petroleum Products Use Fractions by Subsector
Fertilizers 7%
Other Minerals 46%
Cement 34%
Non-specified Industry 13%

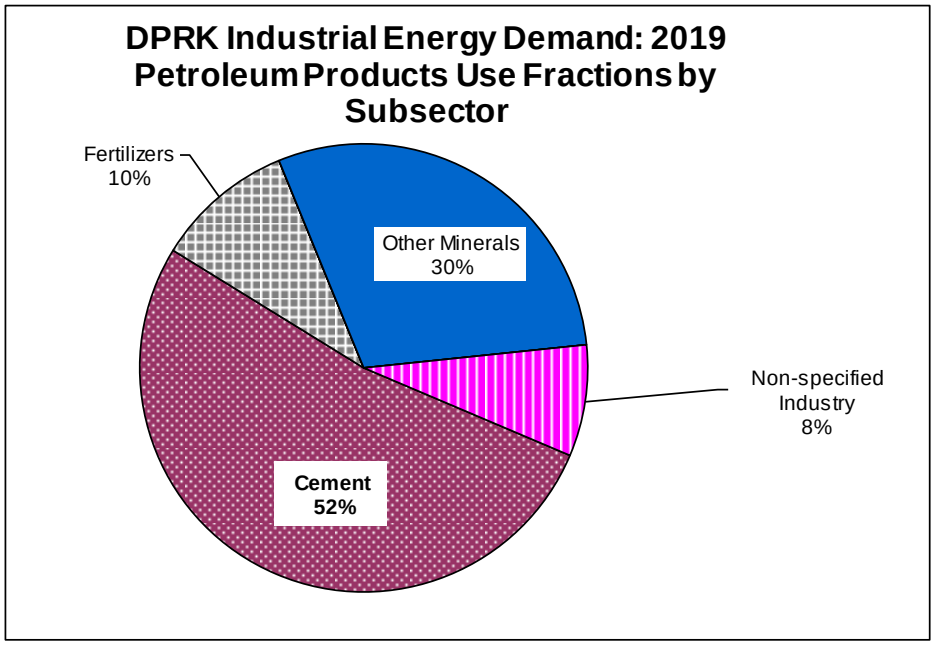

DPRK Industrial Energy Demand: 2014
Petroleum Products Use Fractions by Subsector
Fertilizers 16%
Other Minerals 36%
Cement 40%
Non-specified Industry 8%

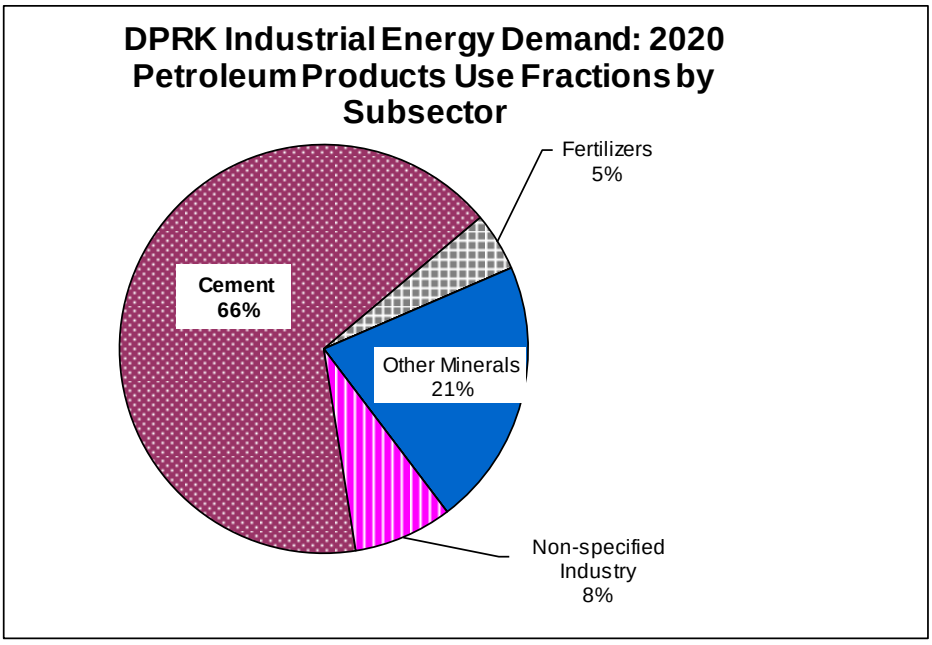

DPRK Industrial Energy Demand: 2015
Petroleum Products Use Fractions by Subsector
Fertilizers 12%
Other Minerals 33%
Cement 48%
Non-specified Industry 7%

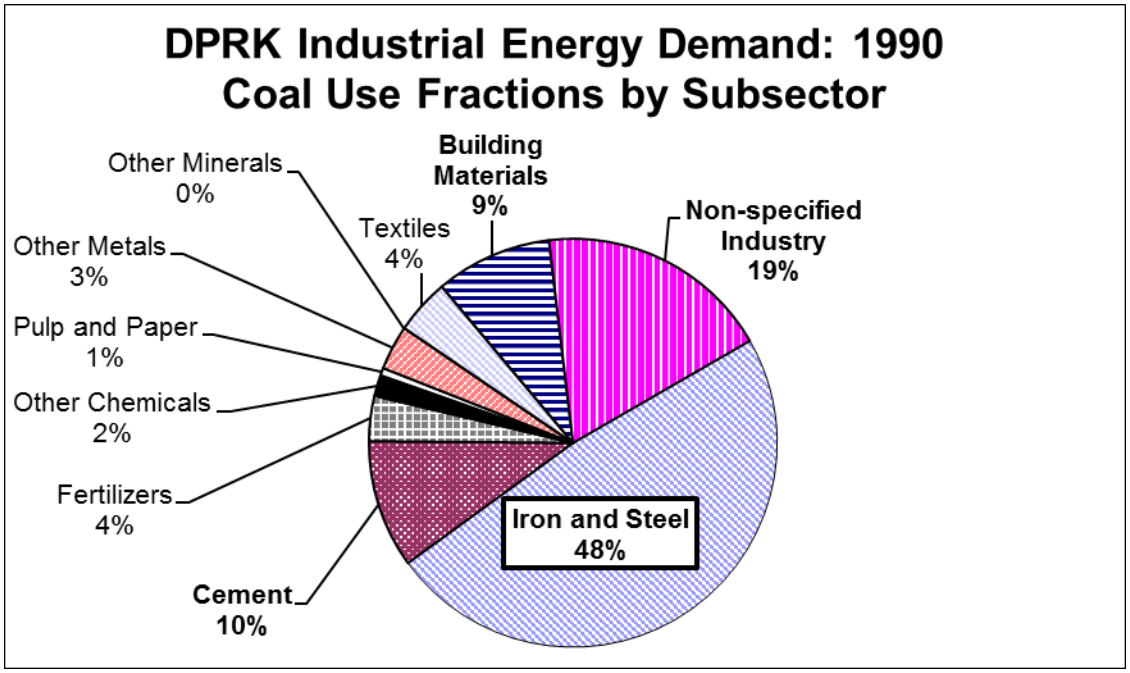

DPRK Industrial Energy Demand: 2017
Petroleum Products Use Fractions by Subsector
Fertilizers 17%
Other Minerals 29%
Cement 46%
Non-specified Industry 8%

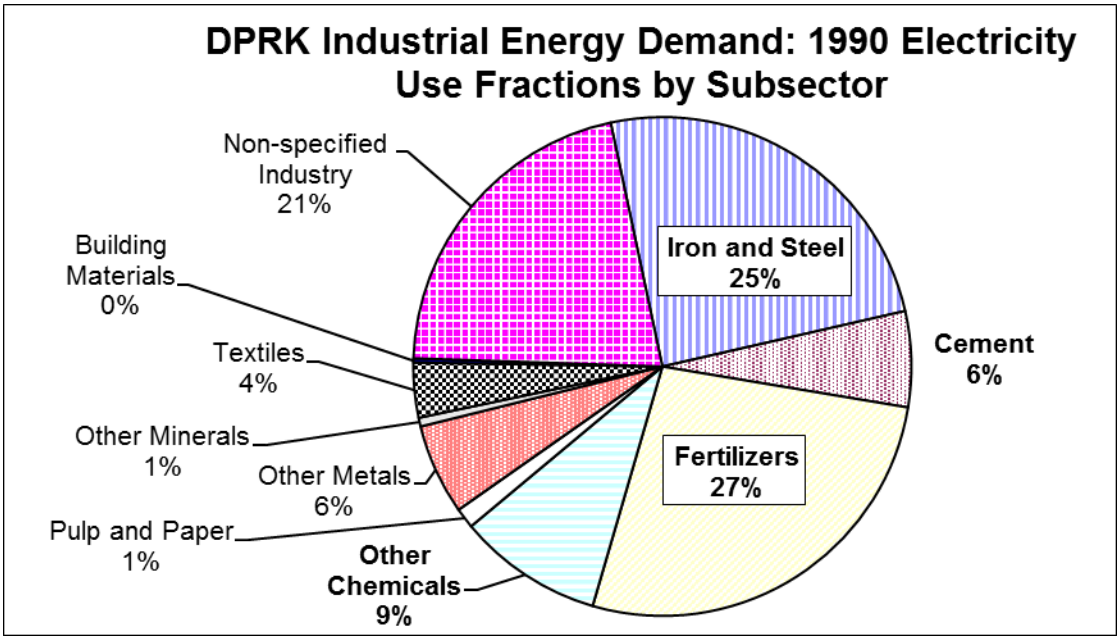

DPRK Industrial Energy Demand: 2016
Petroleum Products Use Fractions by Subsector
Fertilizers 13%
Other Minerals 30%
Cement 50%
Non-specified Industry 7%

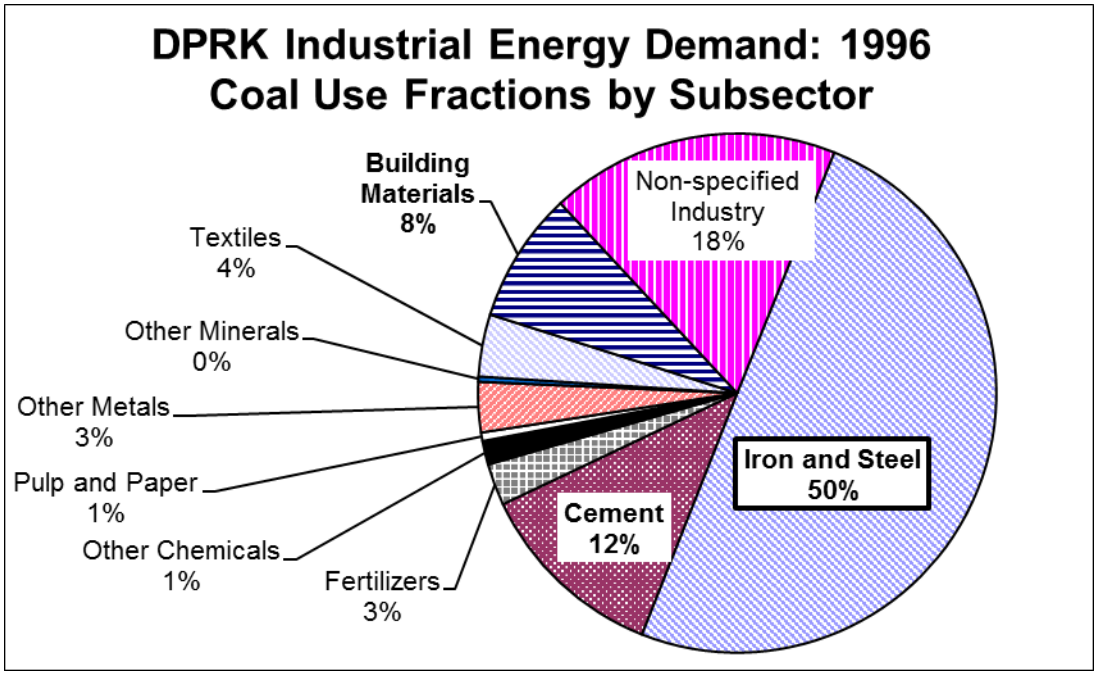

DPRK Industrial Energy Demand: 2018
Petroleum Products Use Fractions by Subsector
Fertilizers 10%
Other Minerals 29%
Cement 53%
Non-specified Industry 8%

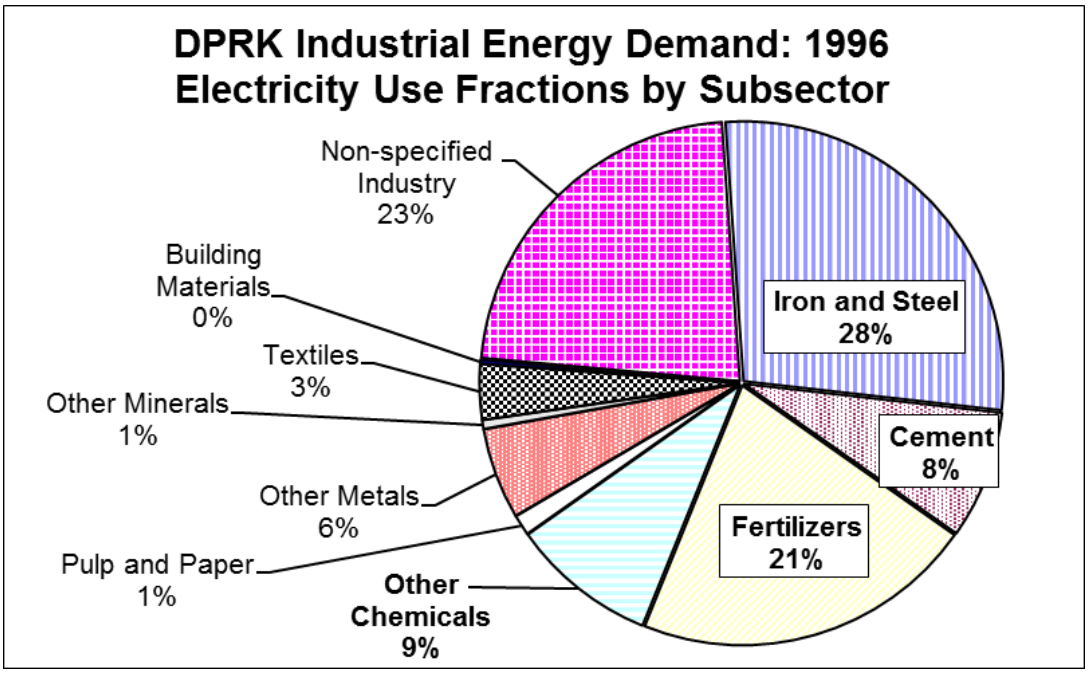

DPRK Industrial Energy Demand: 2019
Petroleum Products Use Fractions by Subsector
Fertilizers 10%
Other Minerals 30%
Non-specified Industry 8%
Cement 52%

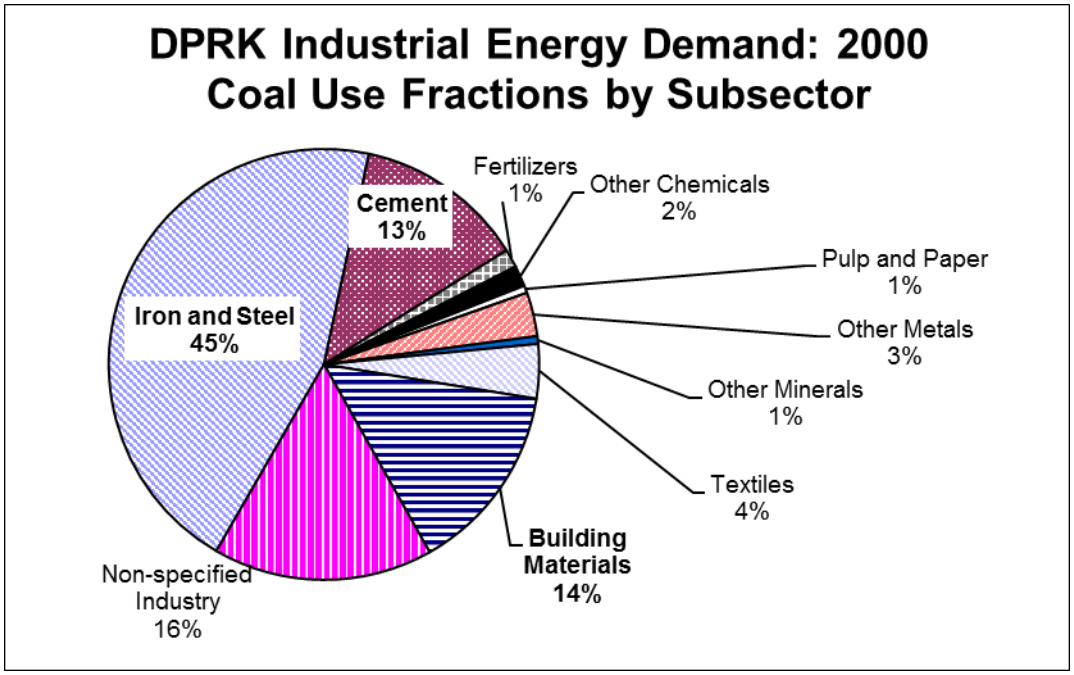

DPRK Industrial Energy Demand: 2020
Petroleum Products Use Fractions by Subsector
Fertilizers 5%
Cement 66%
Other Minerals 21%
Non-specified Industry 8%

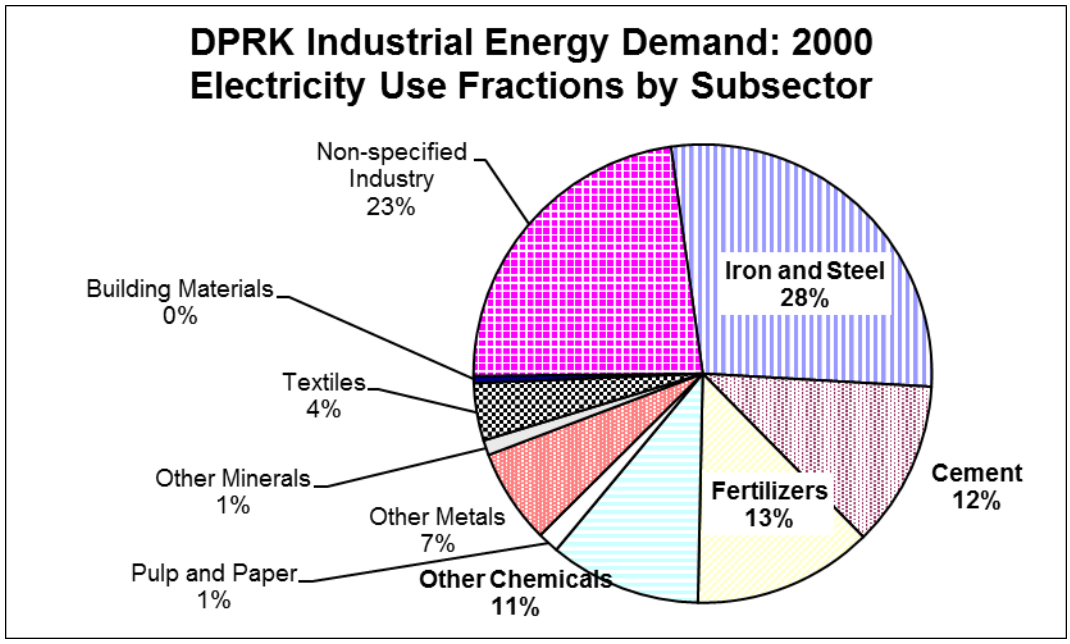

DPRK Industrial Energy Demand: 1990
Coal Use Fractions by Subsector
Other Minerals 0%
Building Materials 9%
Non-specified Industry 19%
Textiles 4%
Other Metals 3%
Pulp and Paper 1%
Other Chemicals 2%
Fertilizers 4%
Iron and Steel 48%
Cement 10%

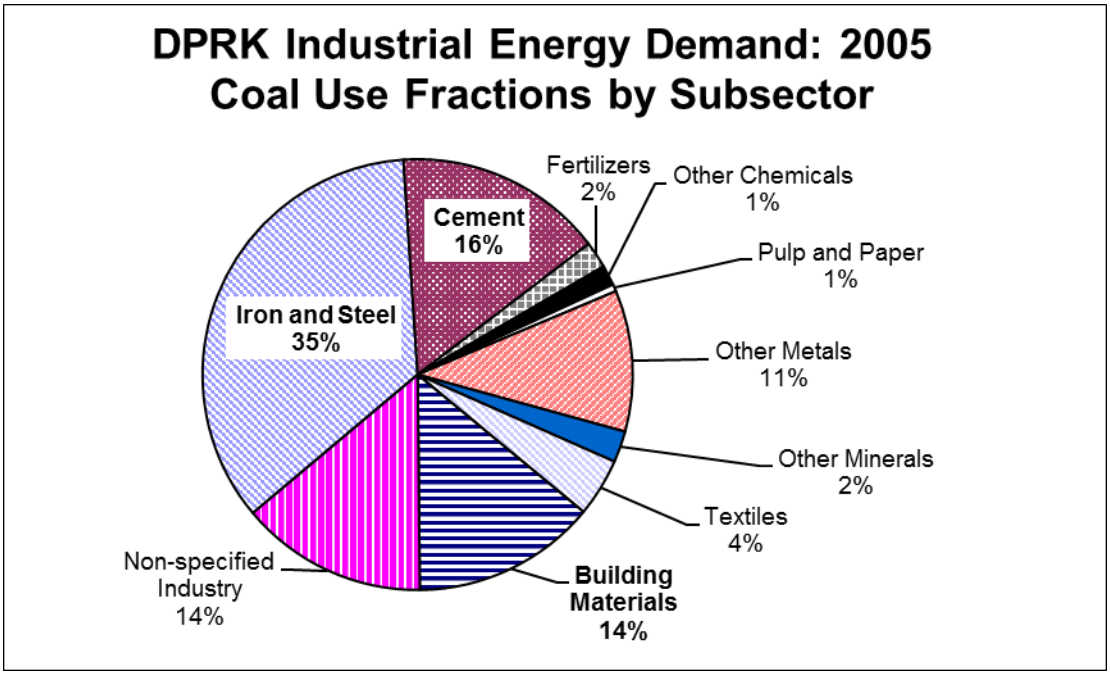

DPRK Industrial Energy Demand: 1990 Electricity
Use Fractions by Subsector
Non-specified Industry 21%
Iron and Steel 25%
Building Materials 0%
Cement 6%
Textiles 4%
Other Minerals 1%
Fertilizers 27%
Other Metals 6%
Pulp and Paper 1%
Other Chemicals 9%

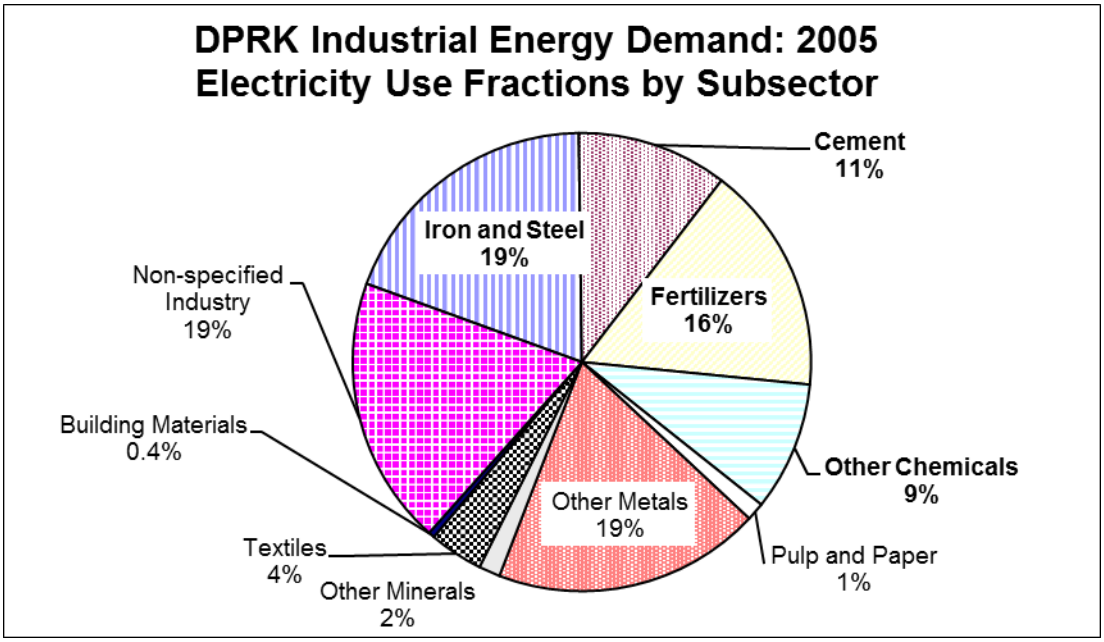

DPRK Industrial Energy Demand: 1996
Coal Use Fractions by Subsector
Building Materials 8%
Textiles 4%
Other Minerals 0%
Other Metals 3%
Pulp and Paper 1%
Other Chemicals 1%
Fertilizers 3%
Cement 12%
Iron and Steel 50%
Non-specified Industry 18%

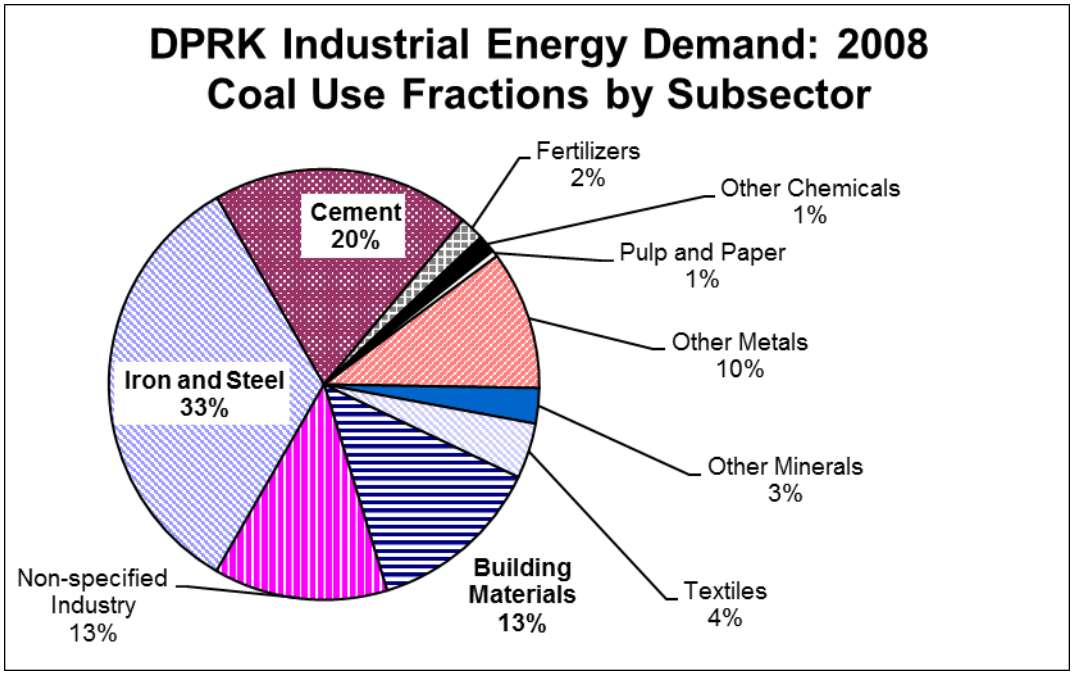

DPRK Industrial Energy Demand: 1996
Electricity Use Fractions by Subsector
Non-specified Industry 23%
Building Materials 0%
Textiles 3%
Other Minerals 1%
Other Metals 6%
Pulp and Paper 1%
Other Chemicals 9%
Fertilizers 21%
Cement 8%
Iron and Steel 28%

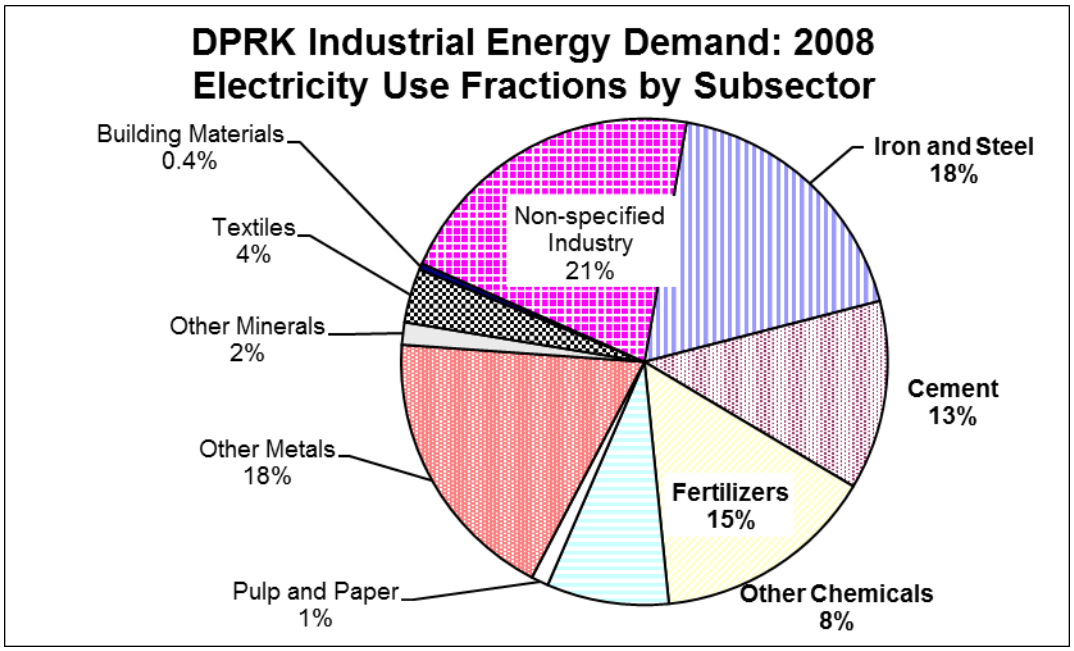

DPRK Industrial Energy Demand: 2000
Coal Use Fractions by Subsector
Cement 13%
Fertilizers 1%
Other Chemicals 2%
Pulp and Paper 1%
Other Metals 3%
Other Minerals 1%
Textiles 4%
Building Materials 14%
Non-specified Industry 16%
Iron and Steel 45%

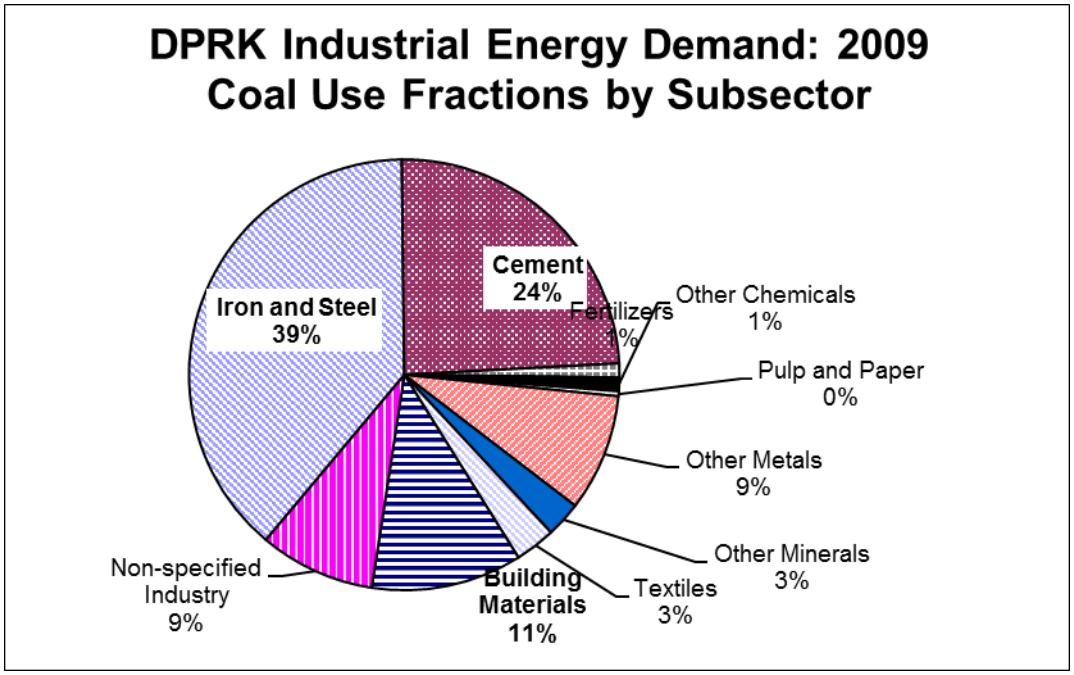

DPRK Industrial Energy Demand: 2000
Electricity Use Fractions by Subsector
Non-specified Industry 23%
Iron and Steel 28%
Building Materials 0%
Textiles 4%
Other Minerals 1%
Other Metals 7%
Pulp and Paper 1%
Other Chemicals 11%
Fertilizers 13%
Cement 12%

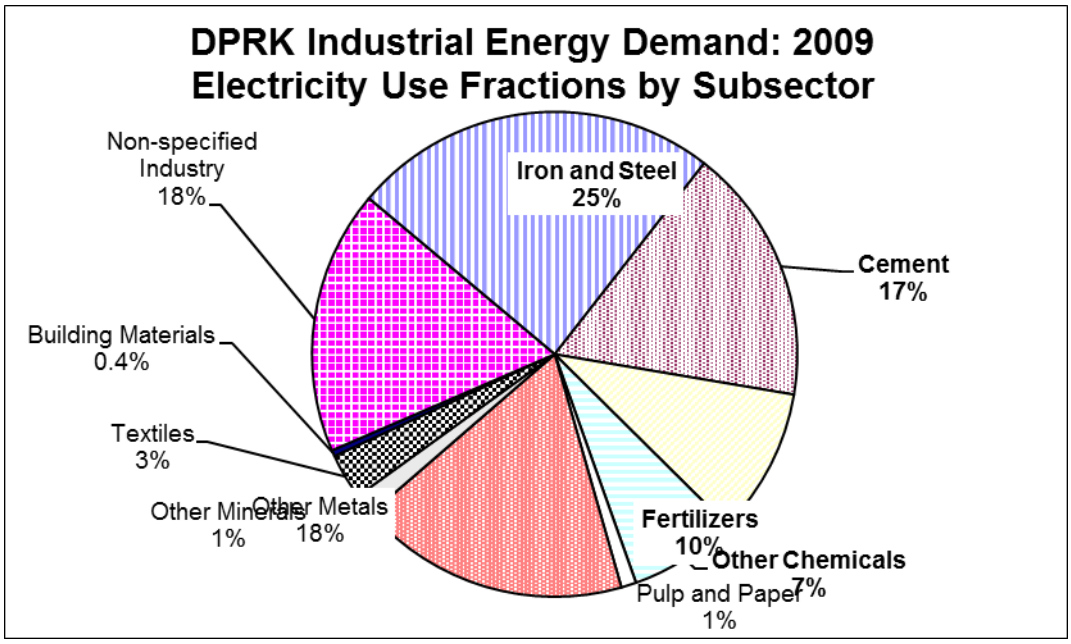

DPRK Industrial Energy Demand: 2005
Coal Use Fractions by Subsector
Fertilizers 2%
Other Chemicals 1%
Cement 16%
Pulp and Paper 1%
Iron and Steel 35%
Other Metals 11%
Other Minerals 2%
Textiles 4%
Non-specified Industry 14%
Building Materials 14%

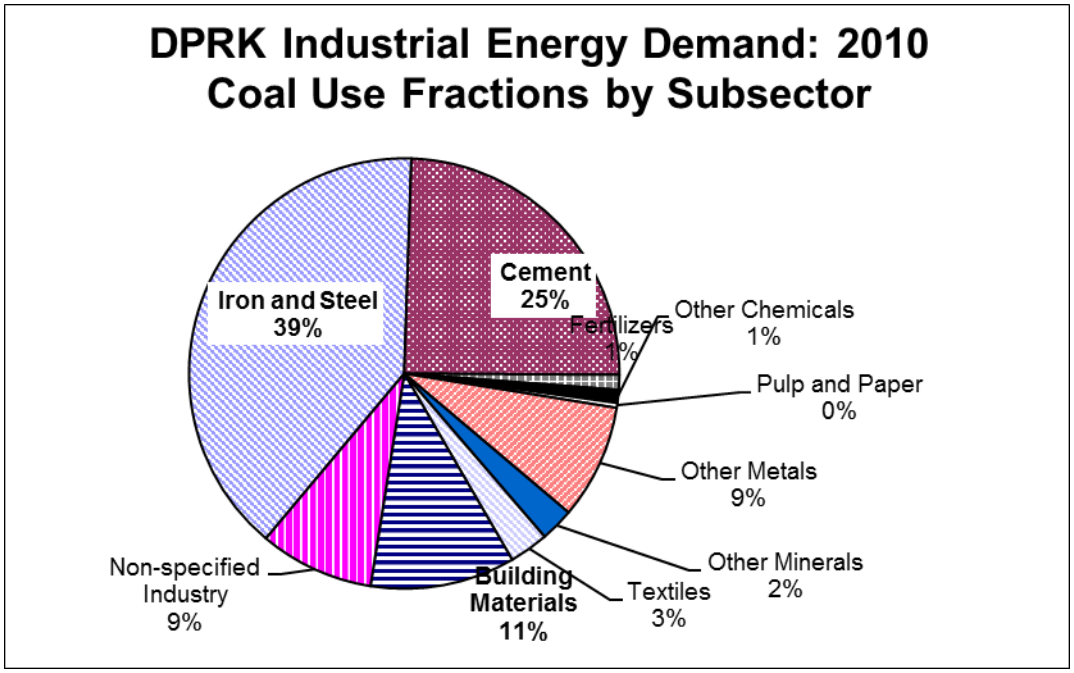

DPRK Industrial Energy Demand: 2005
Electricity Use Fractions by Subsector
Cement 11%
Iron and Steel 19%
Fertilizers 16%
Non-specified Industry 19%
Building Materials 0.4%
Other Chemicals 9%
Other Metals 19%
Textiles 4%
Pulp and Paper 1%
Other Minerals 2%

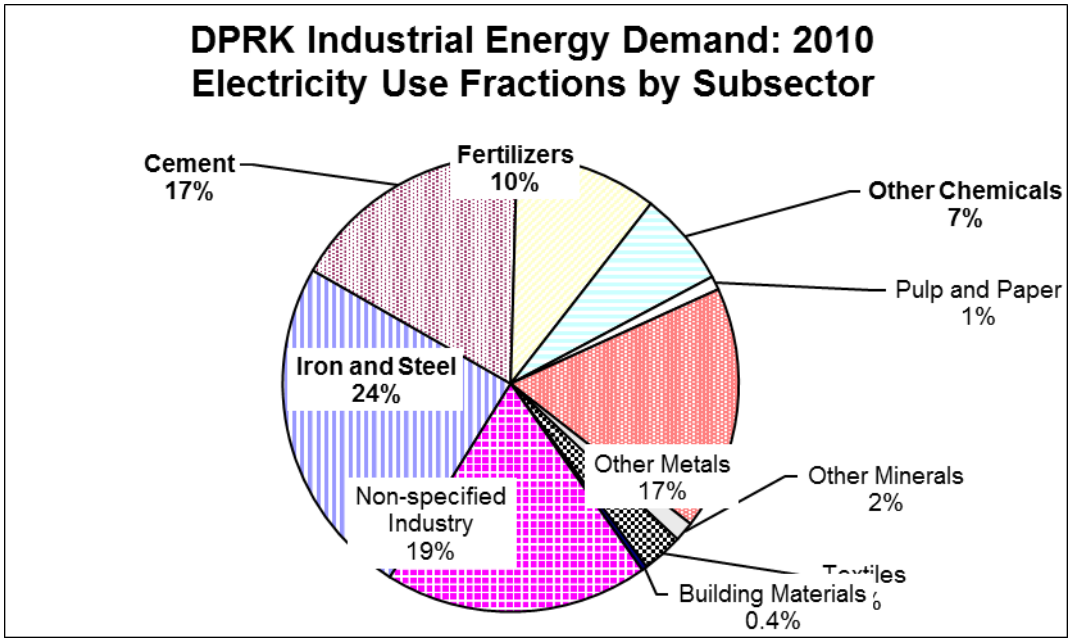

DPRK Industrial Energy Demand: 2008
Coal Use Fractions by Subsector
Fertilizers 2%
Other Chemicals 1%
Pulp and Paper 1%
Other Metals 10%
Other Minerals 3%
Textiles 4%
Building Materials 13%
Non-specified Industry 13%
Iron and Steel 33%
Cement 20%

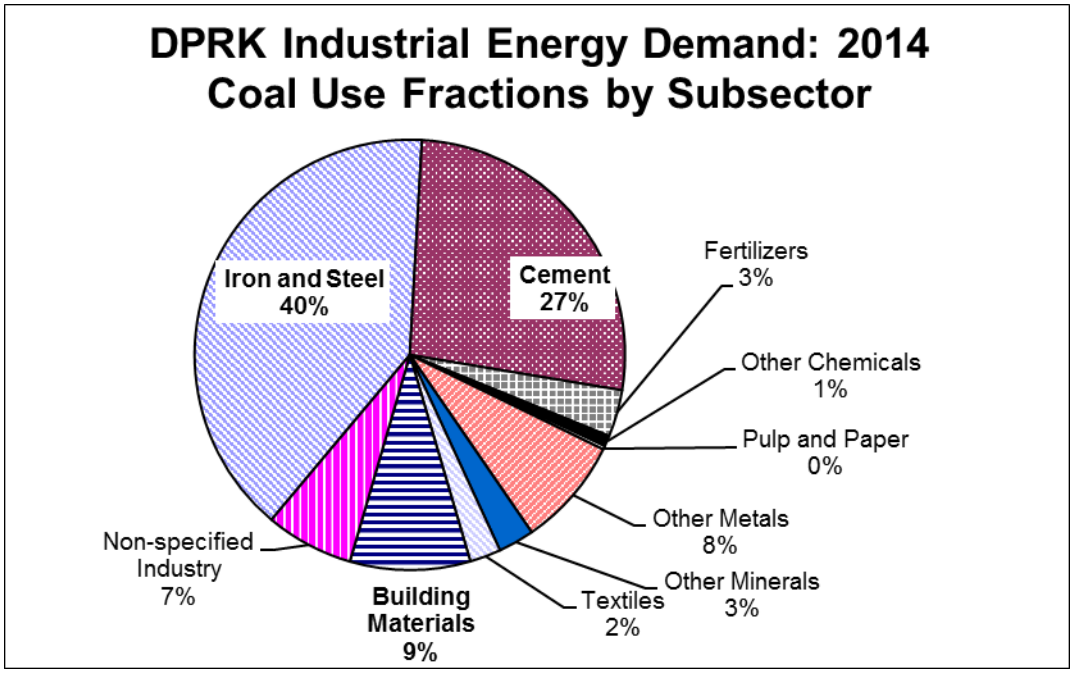

DPRK Industrial Energy Demand: 2008
Electricity Use Fractions by Subsector
Building Materials 0.4%
Textiles 4%
Other Minerals 2%
Other Metals 18%
Pulp and Paper 1%
Other Chemicals 8%
Fertilizers 15%
Cement 13%
Iron and Steel 18%
Non-specified Industry 21%

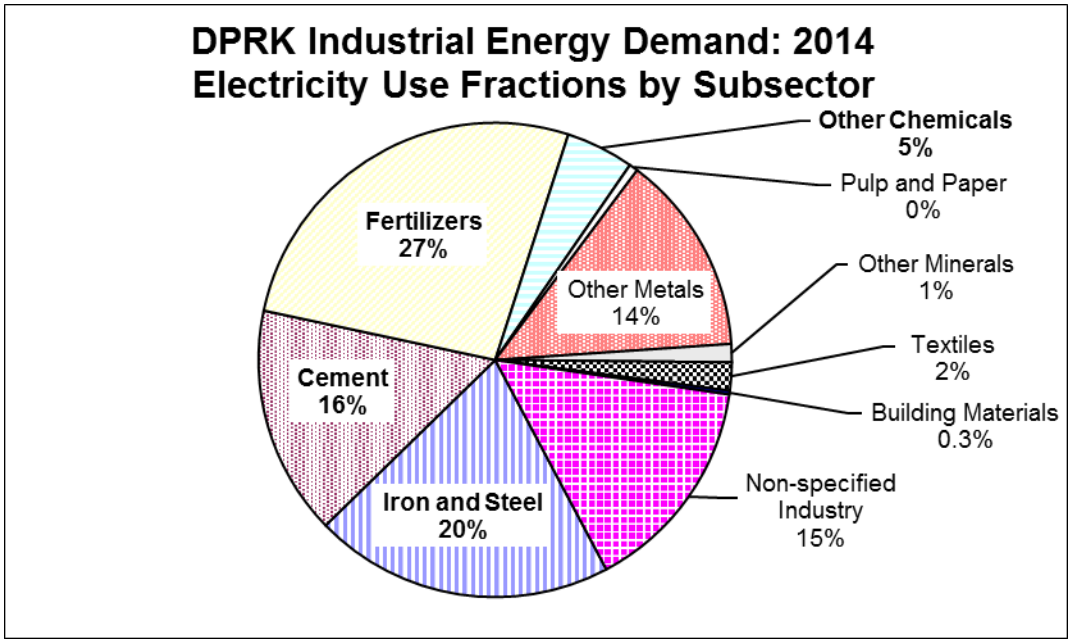

DPRK Industrial Energy Demand: 2009
Coal Use Fractions by Subsector
Cement 24%
Other Chemicals 1%
Fertilizers 1%
Pulp and Paper 0%
Other Metals 9%
Other Minerals 3%
Textiles 3%
Building Materials 11%
Non-specified Industry 9%
Iron and Steel 39%

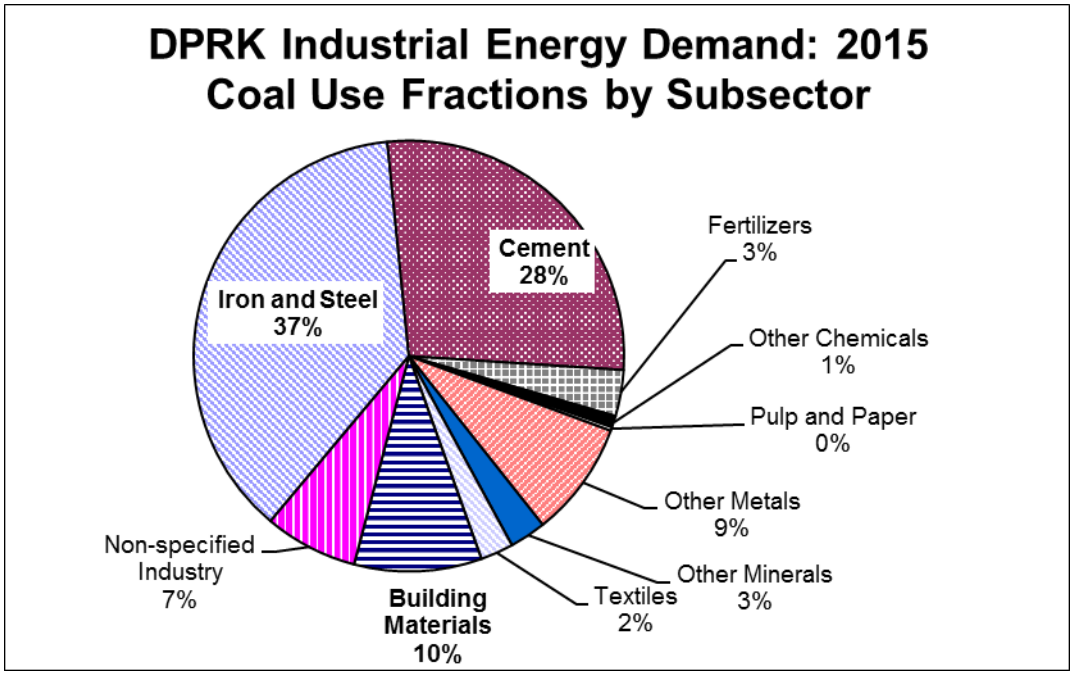

DPRK Industrial Energy Demand: 2009
Electricity Use Fractions by Subsector
Iron and Steel 25%
Cement 17%
Fertilizers 10%
Other Chemicals 7%
Pulp and Paper 1%
Other Metals 18%
Other Minerals 1%
Textiles 3%
Building Materials 0.4%
Non-specified Industry 18%

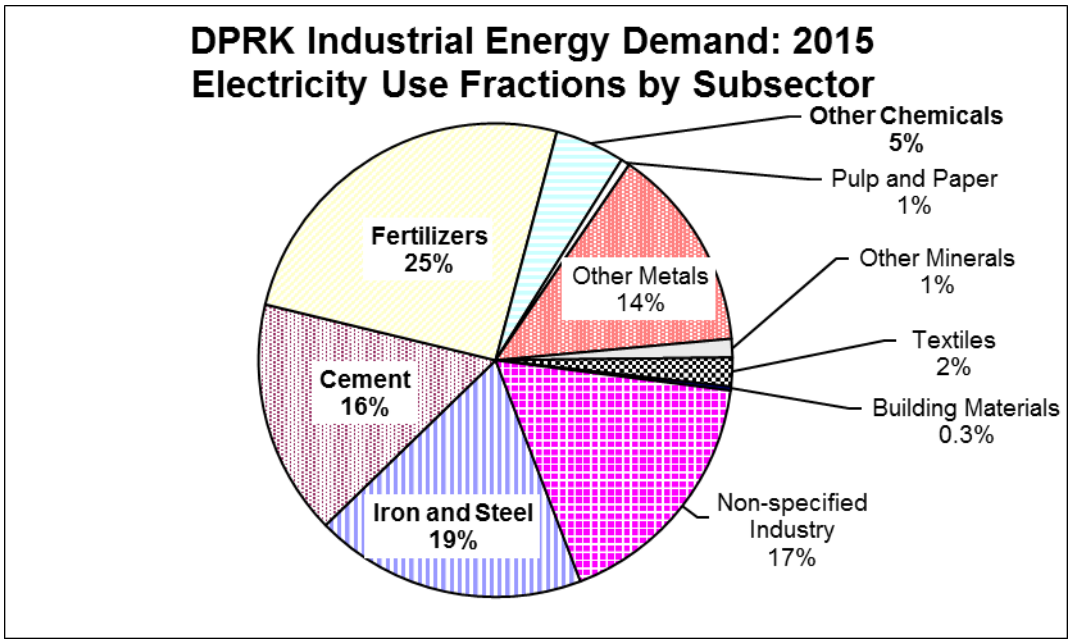

DPRK Industrial Energy Demand: 2010
Coal Use Fractions by Subsector
Cement 25%
Other Chemicals 1%
Fertilizers 1%
Pulp and Paper 0%
Other Metals 9%
Other Minerals 2%
Textiles 3%
Building Materials 11%
Non-specified Industry 9%
Iron and Steel 39%

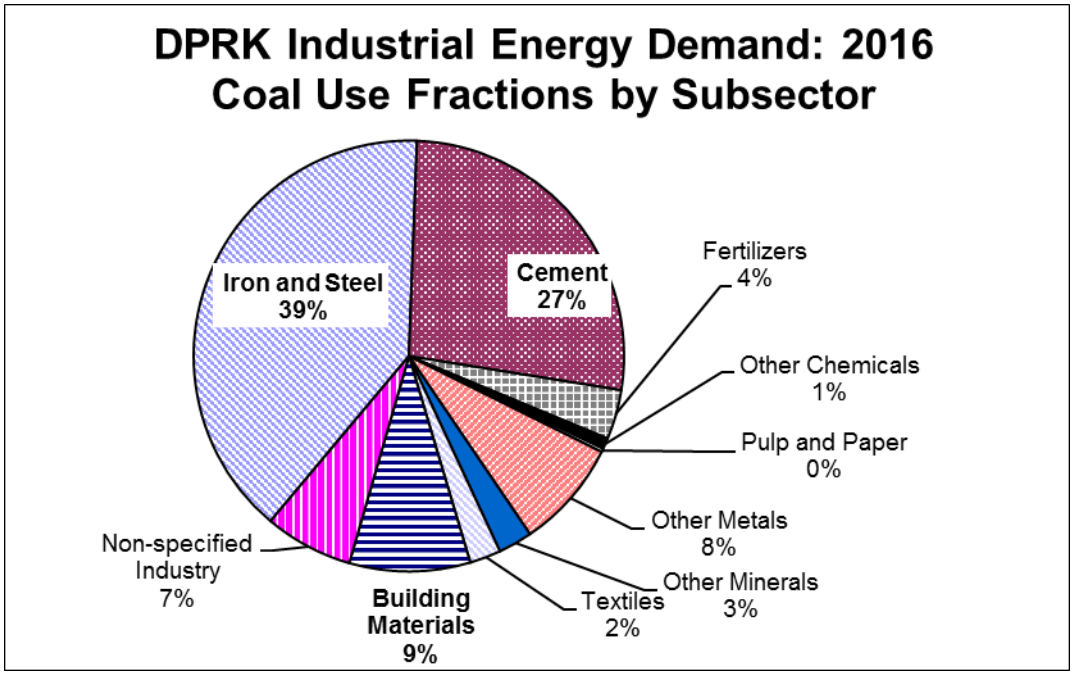

DPRK Industrial Energy Demand: 2010
Electricity Use Fractions by Subsector
Cement 17%
Fertilizers 10%
Other Chemicals 7%
Pulp and Paper 1%
Iron and Steel 24%
Other Metals 17%
Other Minerals 2%
Non-specified Industry 19%
Building Materials 0.4%

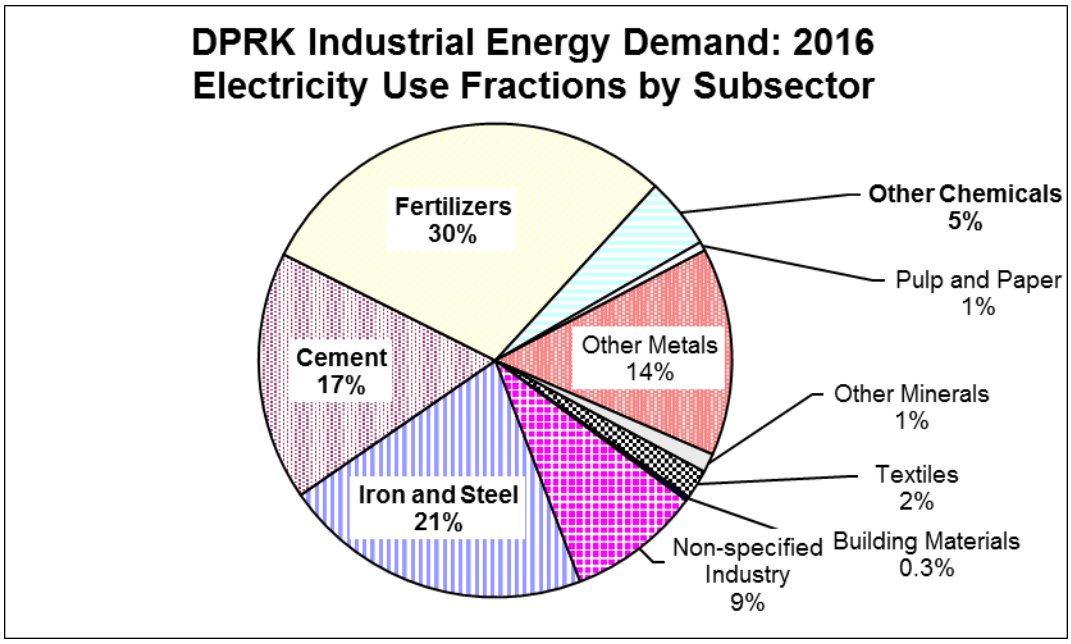

DPRK Industrial Energy Demand: 2014
Coal Use Fractions by Subsector
Iron and Steel 40%
Cement 27%
Fertilizers 3%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 9%
Non-specified Industry 7%

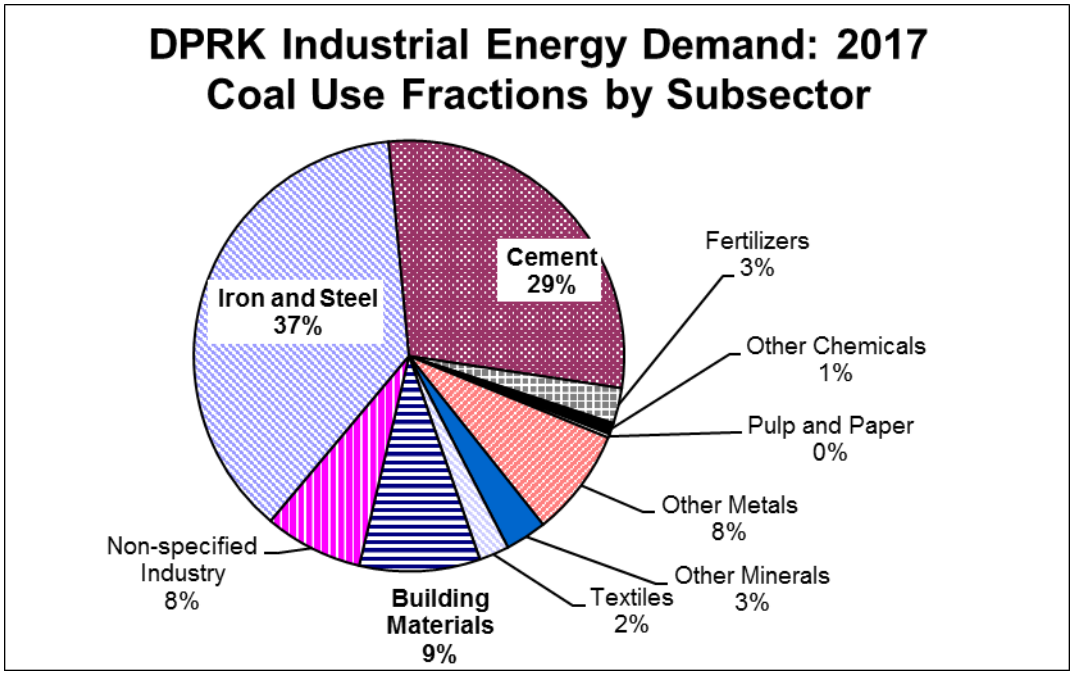

DPRK Industrial Energy Demand: 2014
Electricity Use Fractions by Subsector
Other Chemicals 5%
Pulp and Paper 0%
Other Minerals 1%
Textiles 2%
Building Materials 0.3%
Non-specified Industry 15%
Iron and Steel 20%
Cement 16%
Fertilizers 27%
Other Metals 14%

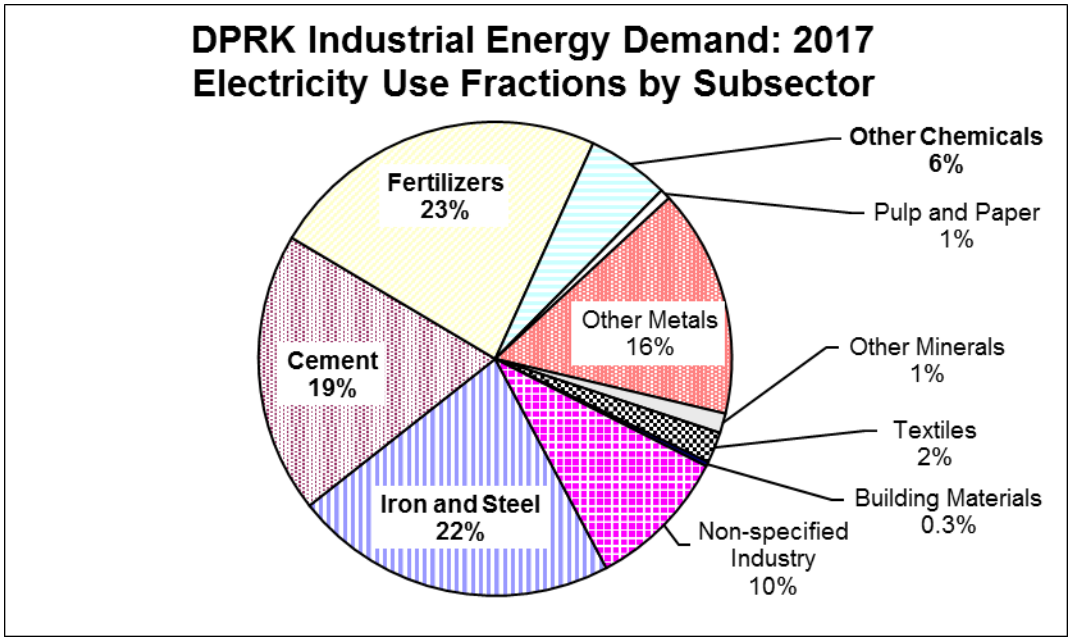

DPRK Industrial Energy Demand: 2015
Coal Use Fractions by Subsector
Cement 28%
Fertilizers 3%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 9%
Other Minerals 3%
Textiles 2%
Building Materials 10%
Non-specified Industry 7%
Iron and Steel 37%

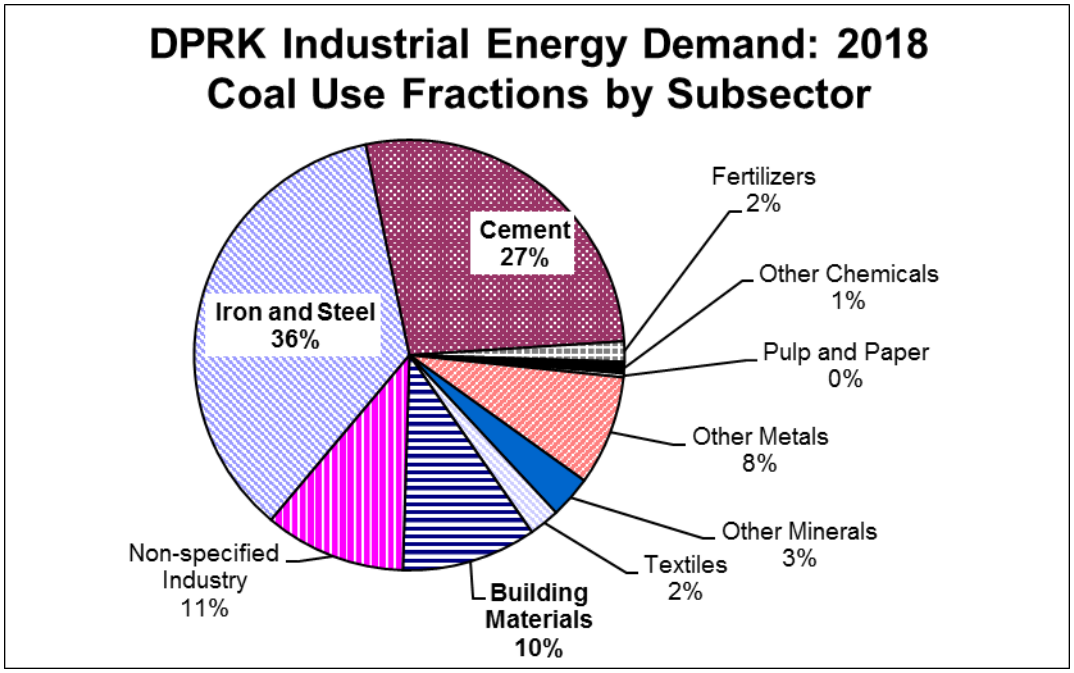

DPRK Industrial Energy Demand: 2015
Electricity Use Fractions by Subsector
Other Chemicals 5%
Pulp and Paper 1%
Other Minerals 1%
Textiles 2%
Building Materials 0.3%
Non-specified Industry 17%
Iron and Steel 19%
Cement 16%
Fertilizers 25%
Other Metals 14%

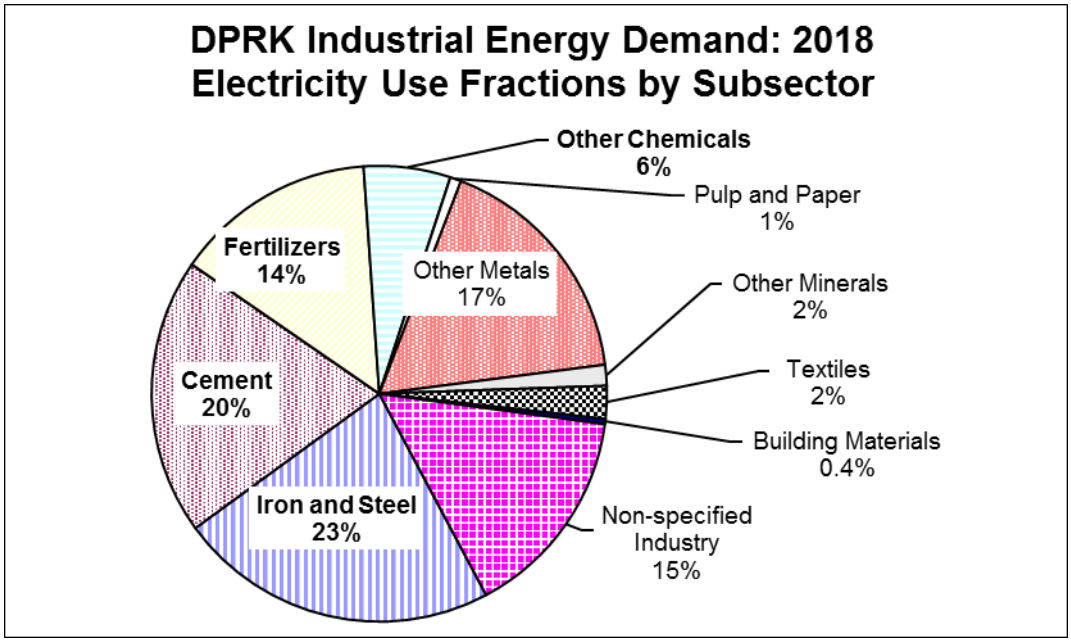

DPRK Industrial Energy Demand: 2016
Coal Use Fractions by Subsector
Iron and Steel 39%
Cement 27%
Fertilizers 4%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 9%
Non-specified Industry 7%

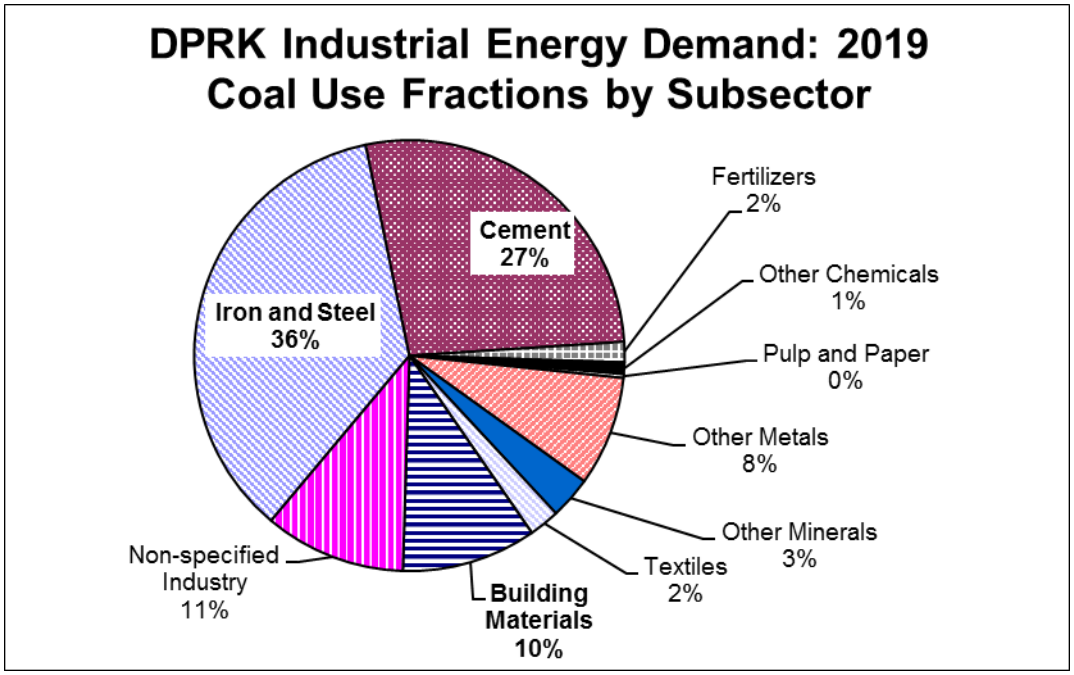

DPRK Industrial Energy Demand: 2016
Electricity Use Fractions by Subsector
Fertilizers 30%
Other Chemicals 5%
Pulp and Paper 1%
Other Metals 14%
Other Minerals 1%
Cement 17%
Textiles 2%
Iron and Steel 21%
Non-specified Industry 9%
Building Materials 0.3%

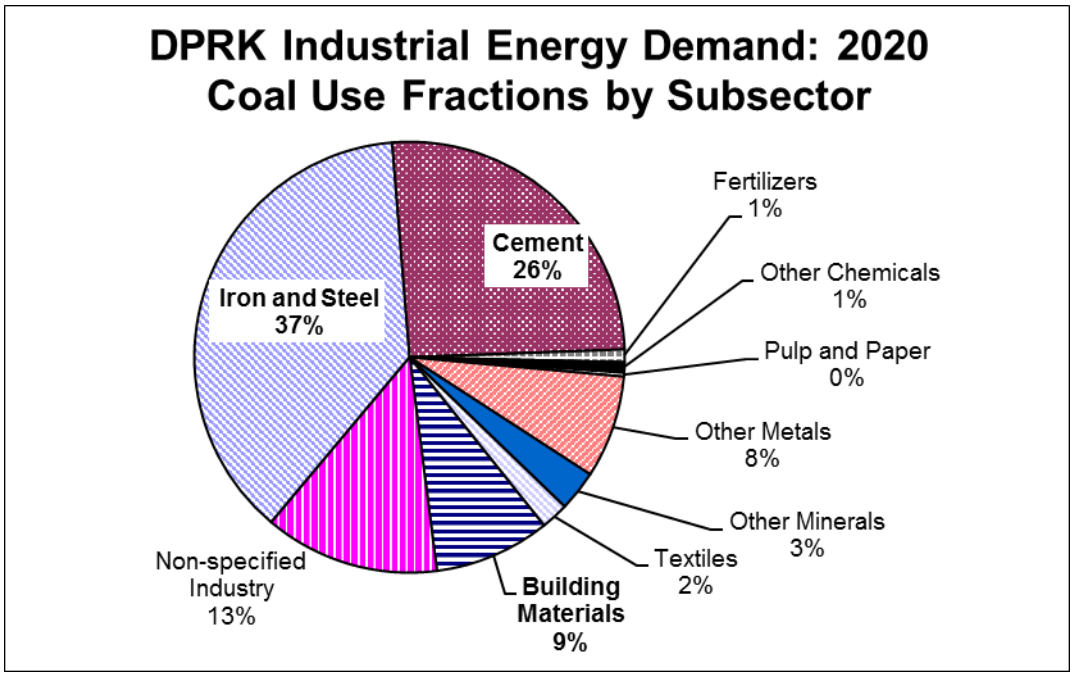

DPRK Industrial Energy Demand: 2017
Coal Use Fractions by Subsector
Cement 29%
Fertilizers 3%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 9%
Non-specified Industry 8%
Iron and Steel 37%

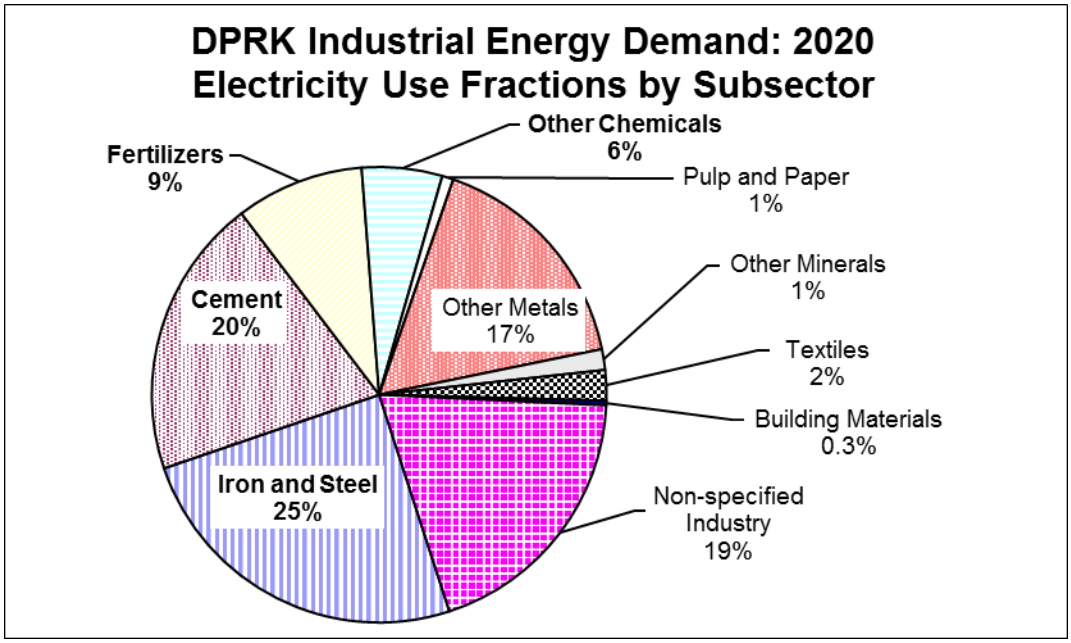

DPRK Industrial Energy Demand: 2017
Electricity Use Fractions by Subsector
Other Chemicals 6%
Pulp and Paper 1%
Other Metals 16%
Other Minerals 1%
Textiles 2%
Building Materials 0.3%
Non-specified Industry 10%
Iron and Steel 22%
Cement 19%
Fertilizers 23%


DPRK Industrial Energy Demand: 2018
Coal Use Fractions by Subsector
Cement 27%
Fertilizers 2%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 10%
Non-specified Industry 11%
Iron and Steel 36%


DPRK Industrial Energy Demand: 2018
Electricity Use Fractions by Subsector
Other Chemicals 6%
Pulp and Paper 1%
Other Minerals 2%
Textiles 2%
Building Materials 0.4%
Non-specified Industry 15%
Iron and Steel 23%
Cement 20%
Fertilizers 14%
Other Metals 17%


DPRK Industrial Energy Demand: 2019
Coal Use Fractions by Subsector
Cement 27%
Fertilizers 2%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 10%
Non-specified Industry 11%
Iron and Steel 36%


DPRK Industrial Energy Demand: 2020
Coal Use Fractions by Subsector
Cement 26%
Fertilizers 1%
Other Chemicals 1%
Pulp and Paper 0%
Other Metals 8%
Other Minerals 3%
Textiles 2%
Building Materials 9%
Non-specified Industry 13%
Iron and Steel 37%


DPRK Industrial Energy Demand: 2020
Electricity Use Fractions by Subsector
Other Chemicals
6%
Fertilizers
9%
Pulp and Paper
1%
Other Minerals
1%
Cement
20%
Other Metals
17%
Textiles
2%
Building Materials
0.3%
Iron and Steel
25%
Non-specified
Industry
19%

DPRK Transport Energy Demand By Subsector: 1990, 1996, 2000, annd 2005

Units: Terajoules (TJ)	**1990**			**1996**			**2000**			**2005**		
Subsector	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity
Road	32,571	1,672	-	14,528	884	-	6,548	504	-	8,958	816	-
Rail	1,949	-	10,870	779	-	4,815	585	-	3,237	935	-	3,532
Water	1,253	-	-	501	-	-	476	-	-	526	-	-
Air	1,123	-	-	899	-	-	786	-	-	797	-	-
Non-Specified	1,000	-	600	-	-	-	-	-	-	-	-	-

DPRK Transport Energy Demand By Subsector: 2008 through 2010 and 2014

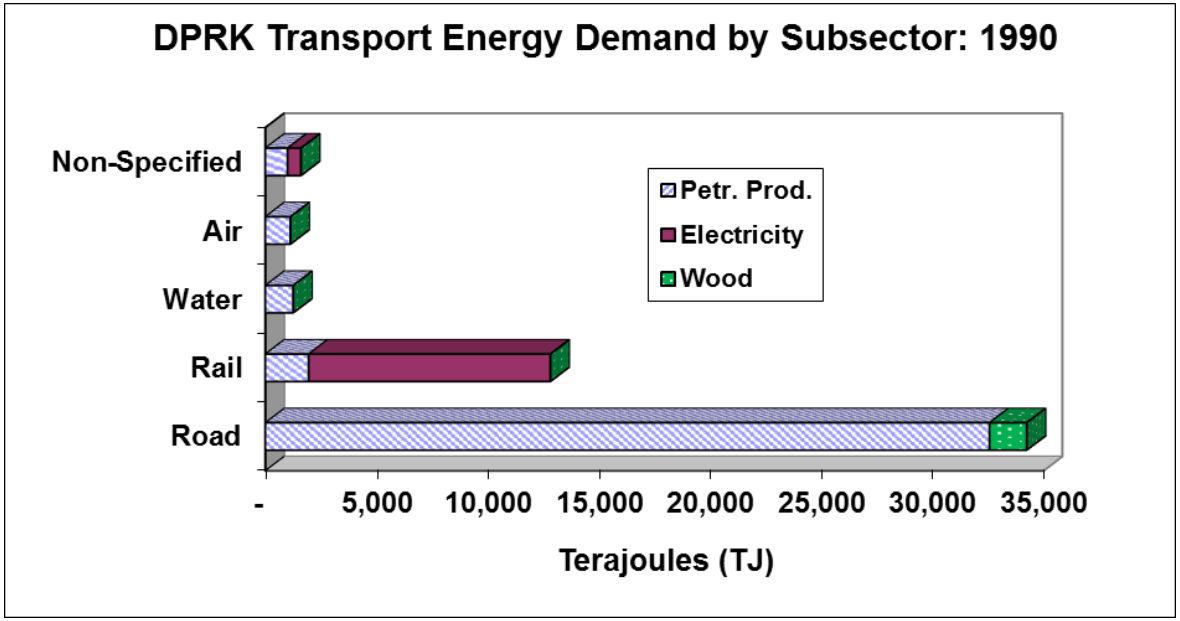
Units: Terajoules (TJ)	**2008**			**2009**			**2010**			**2014**		
Subsector	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity
Road	10,384	843	-	7,871	641	-	8,720	712	0	8,610	794	4
Rail	604	-	4,185	448	-	3,913	526	-	3,913	525	-	3,442
Water	414	-	-	351	-	-	376	-	-	338	-	-
Air	873	-	-	793	-	-	863	-	-	846	-	-
Non-Specified	-	-	-	-	-	-	-	-	-	-	-	-

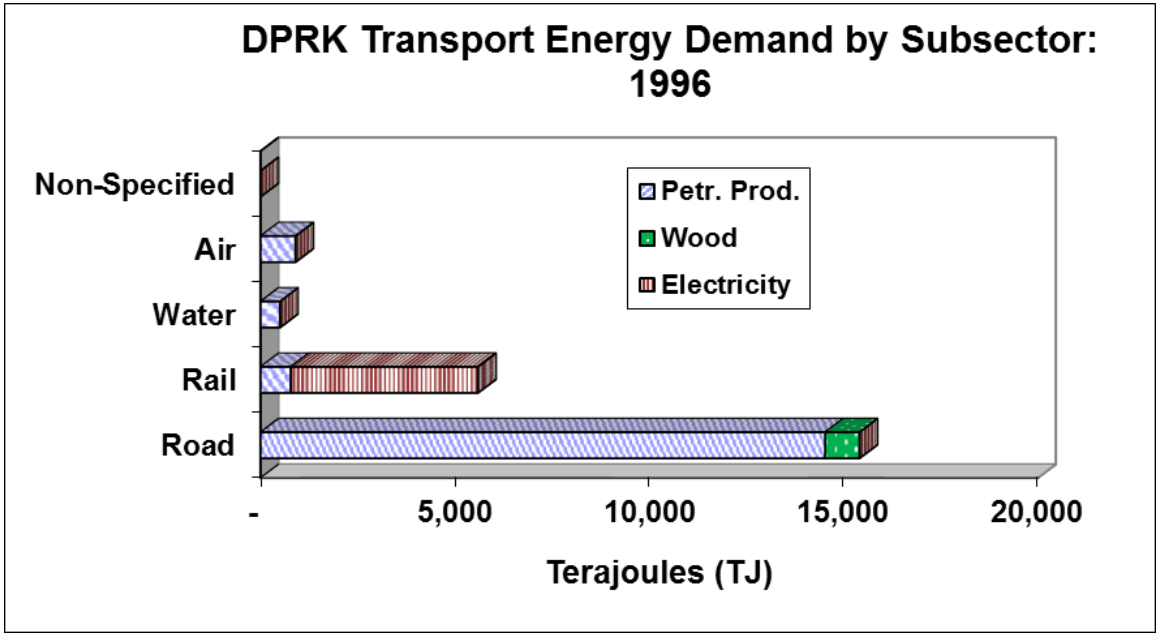
DPRK Transport Energy Demand By Subsector: 2015 through 2018

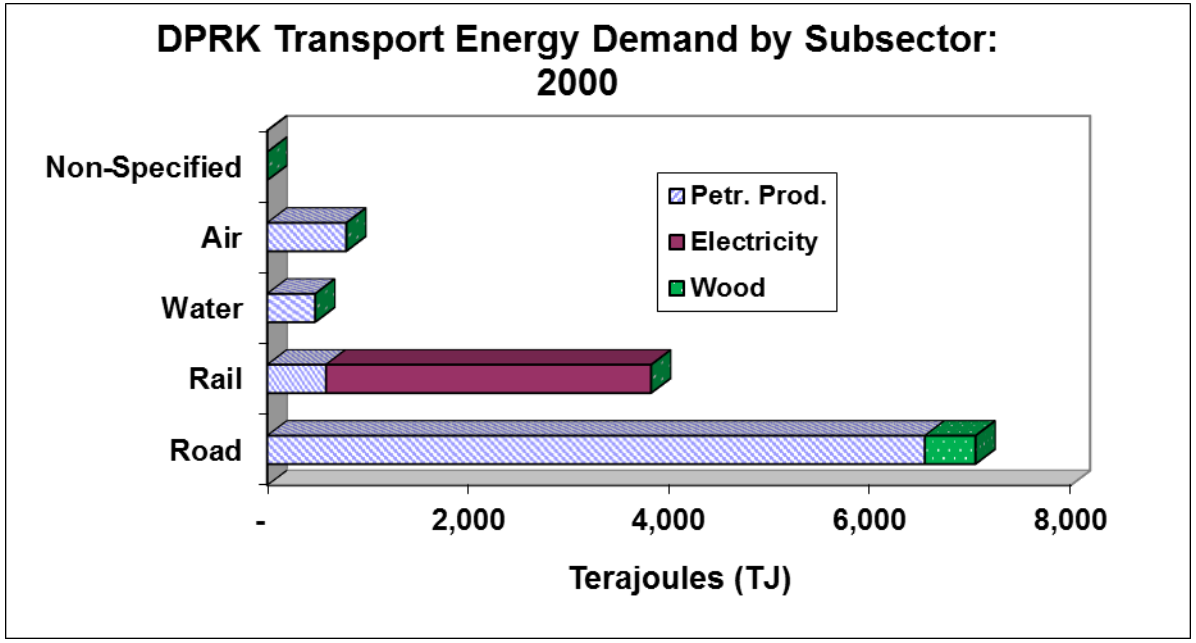
Units: Terajoules (TJ)	**2015**			**2016**			**2017**			**2018**		
Subsector	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity
Road	8,755	812	6	9,115	881	17	8,317	836	41	7,984	792	50
Rail	535	-	4,196	554	-	4,358	516	-	3,767	491	-	3,606
Water	351	-	-	363	-	-	338	-	-	320	-	-
Air	932	-	-	988	-	-	873	-	-	873	-	-
Non-Specified	-	-	-	-	-	-	-	-	-	-	-	-

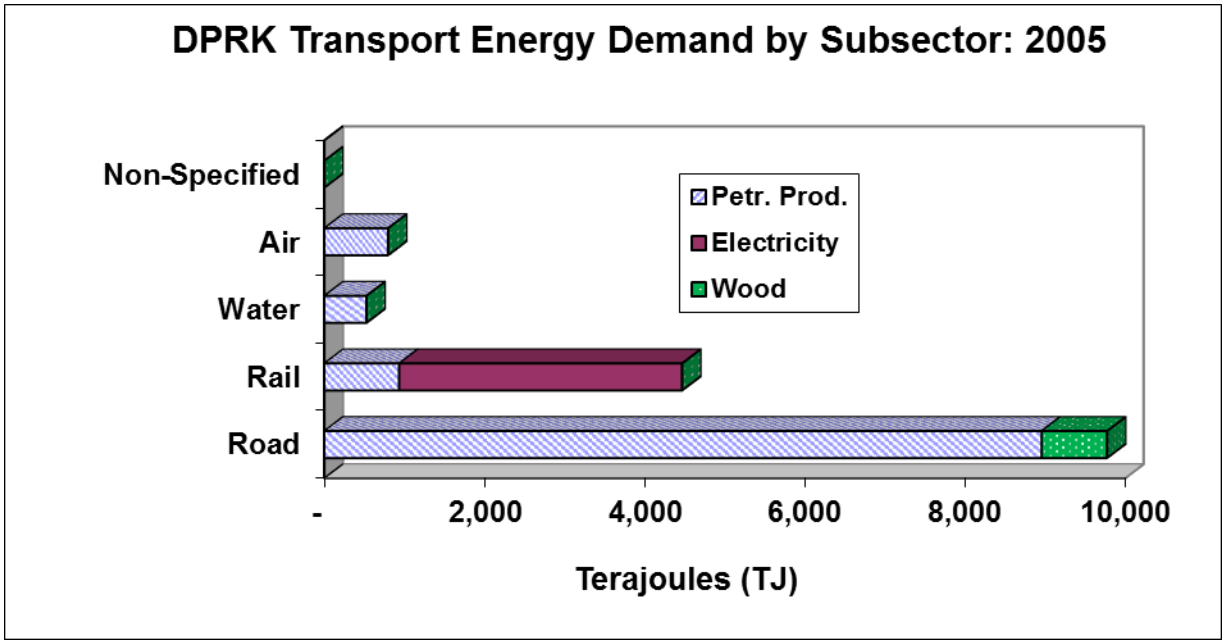
DPRK Transport Energy Demand By Subsector: 2019 through 2020

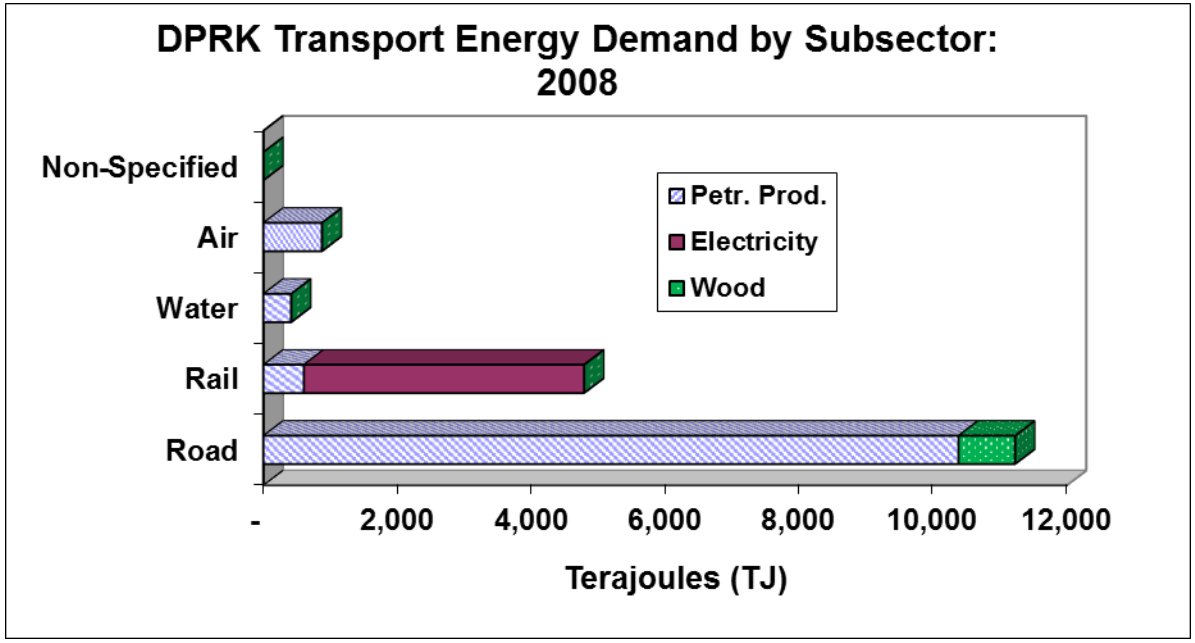
Units: Terajoules (TJ)	**2019**			**2020**		
Subsector	Petr. Prod.	Wood	Electricity	Petr. Prod.	Wood	Electricity
Road	7,988	785	55	6,111	582	57
Rail	496	-	3,606	374	-	3,606
Water	320	-	-	200	-	-
Air	858	-	-	547	-	-
Non-Specified	-	-	-	-	-	-

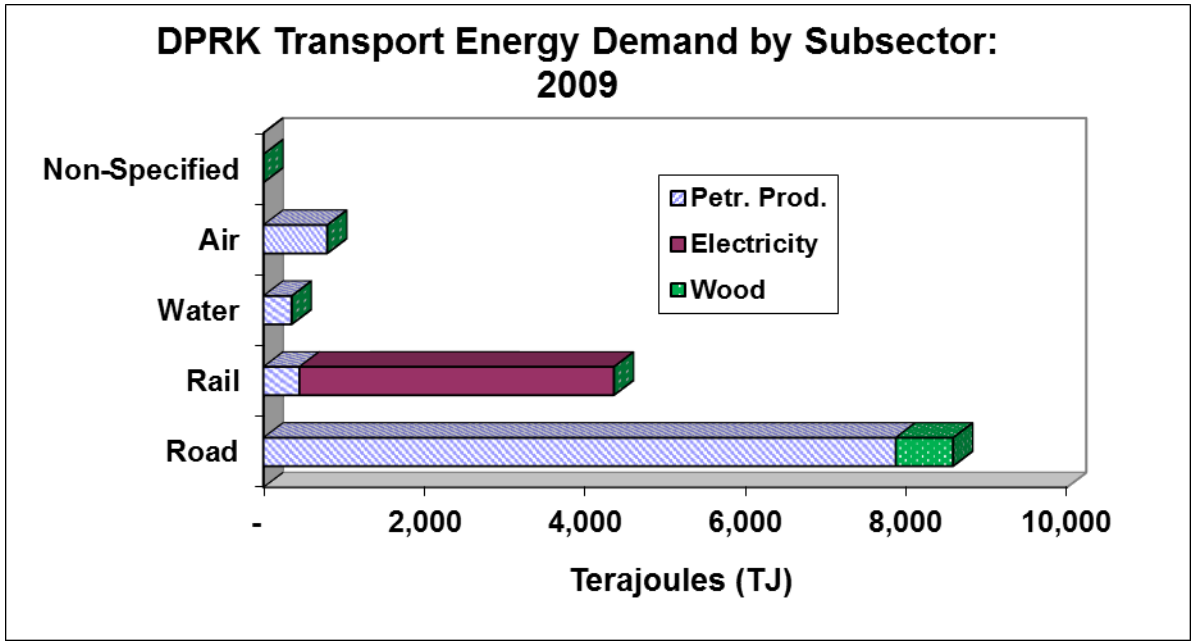

DPRK Transport Energy Demand by Subsector: 1990
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)

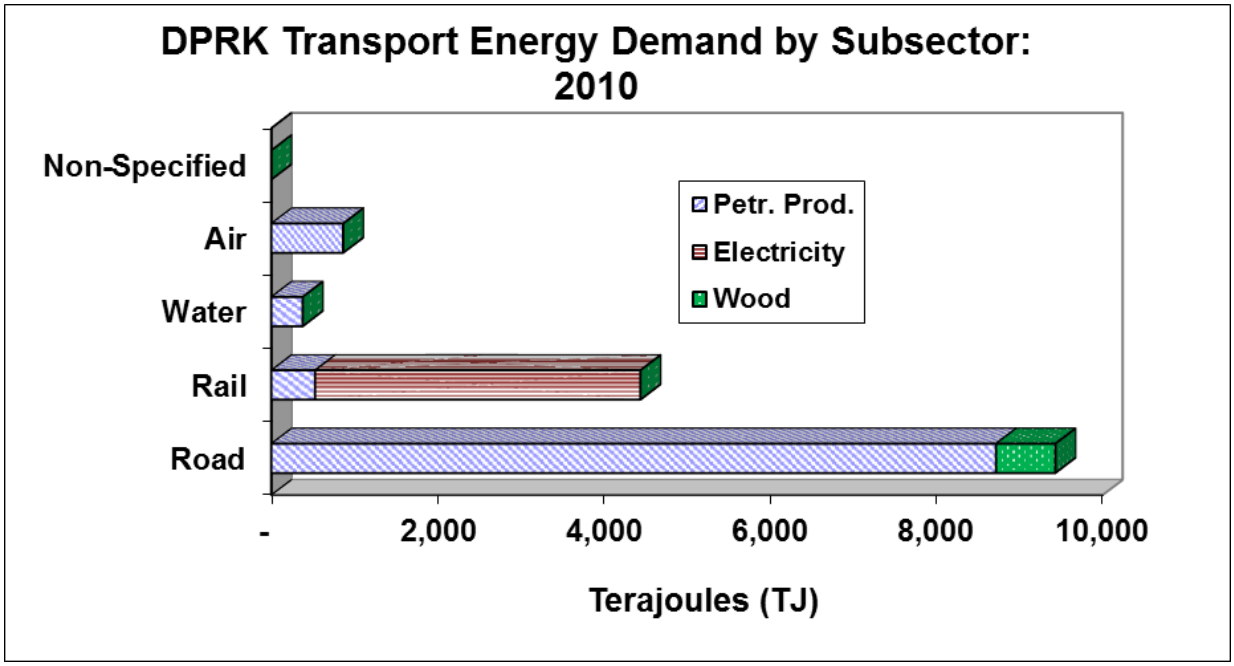

DPRK Transport Energy Demand by Subsector: 1996
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
Terajoules (TJ)

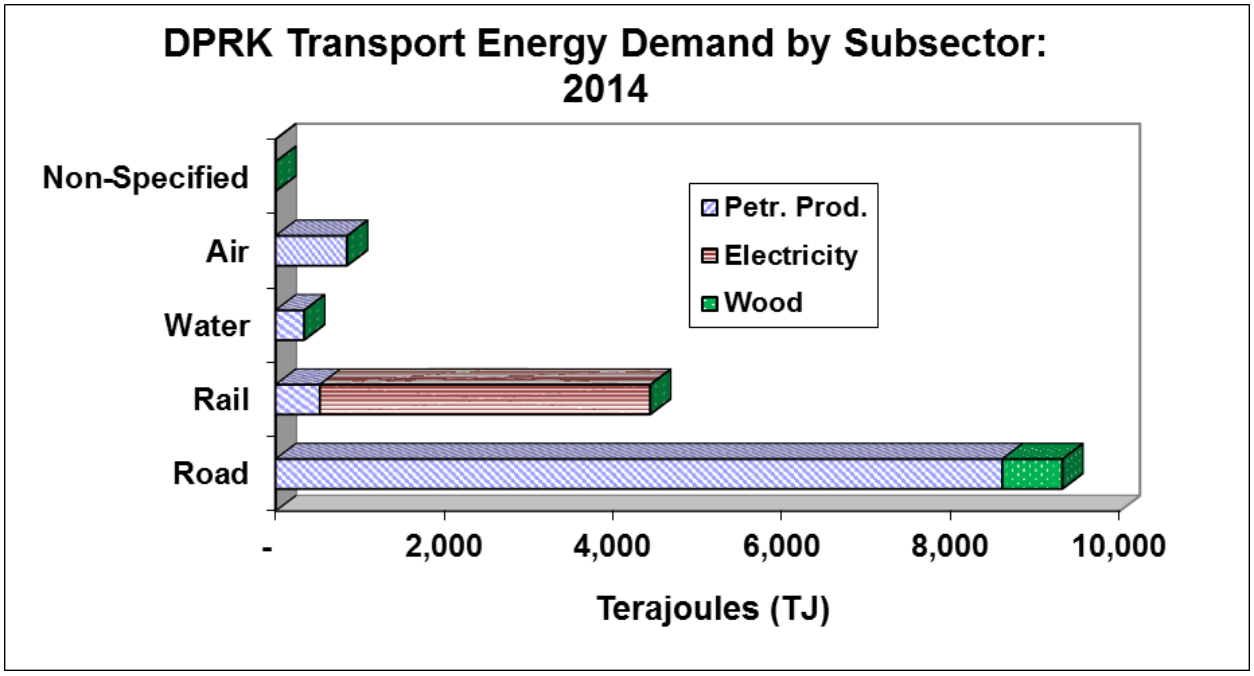

DPRK Transport Energy Demand by Subsector: 2000
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
Terajoules (TJ)

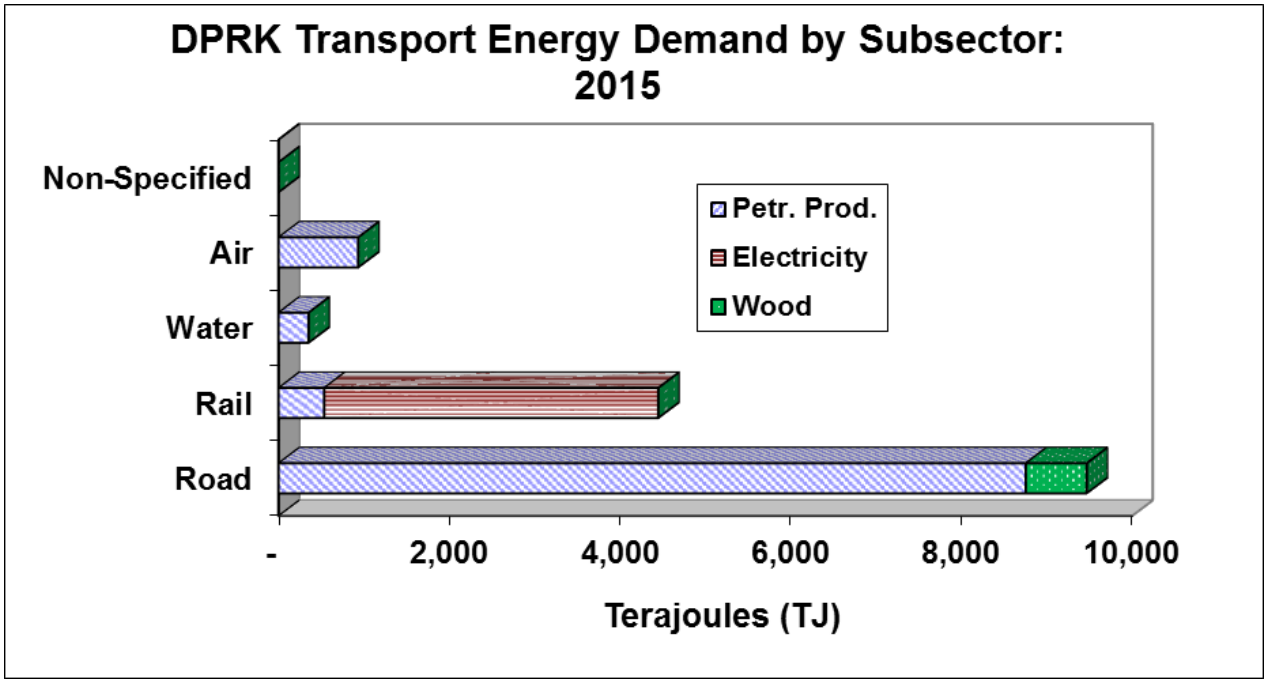

DPRK Transport Energy Demand by Subsector: 2005
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)

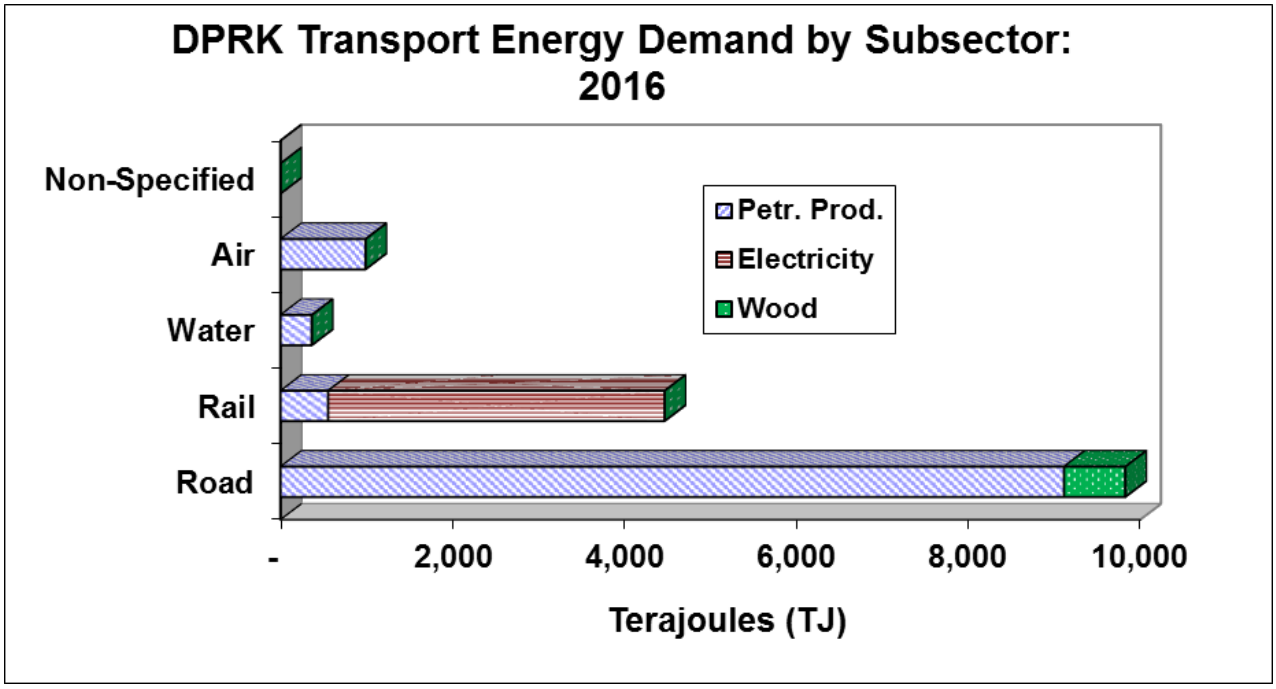

DPRK Transport Energy Demand by Subsector: 2008
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
12,000
Terajoules (TJ)

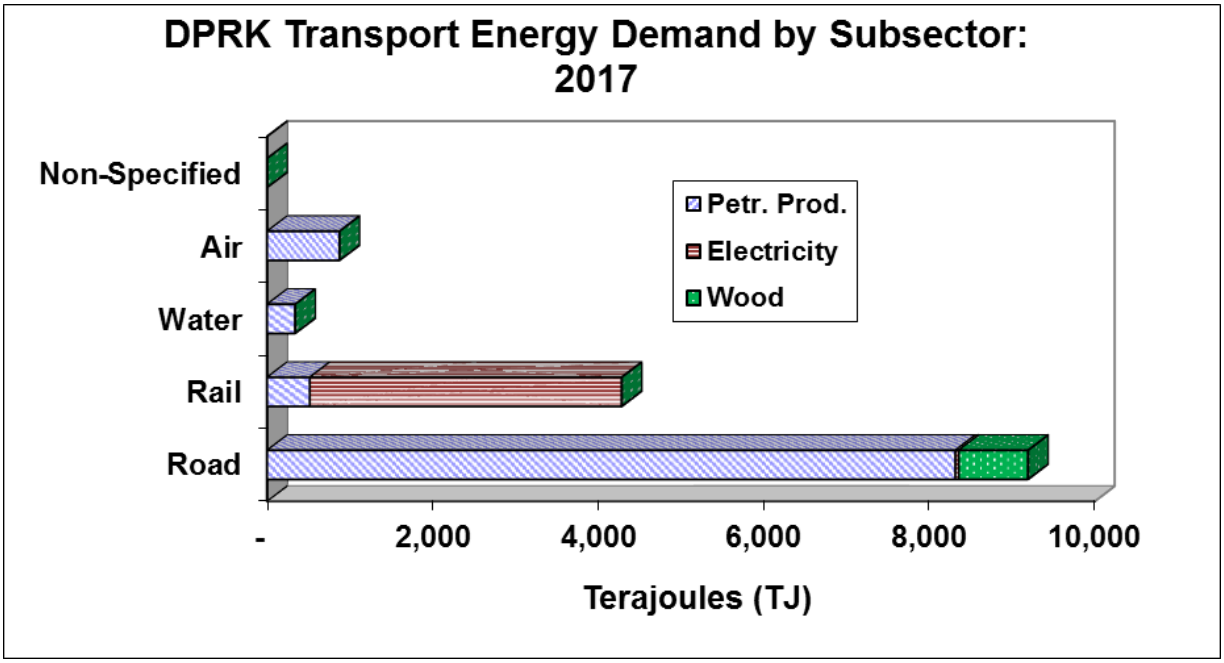

DPRK Transport Energy Demand by Subsector: 2009
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)

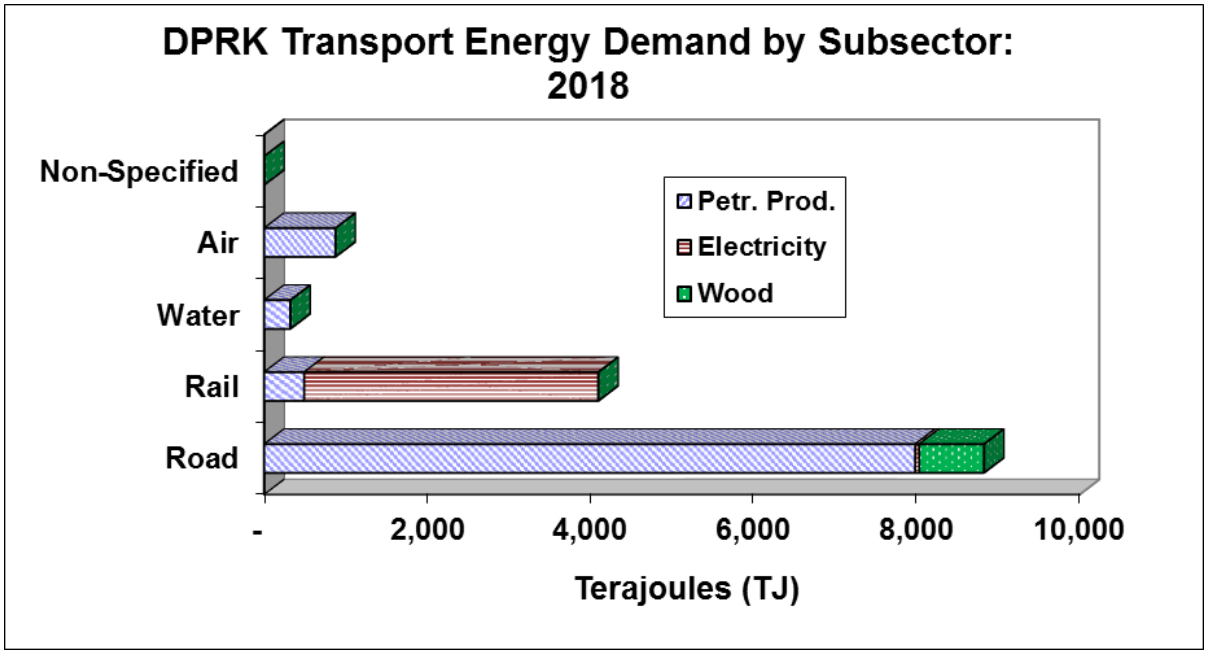

DPRK Transport Energy Demand by Subsector: 2010
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)

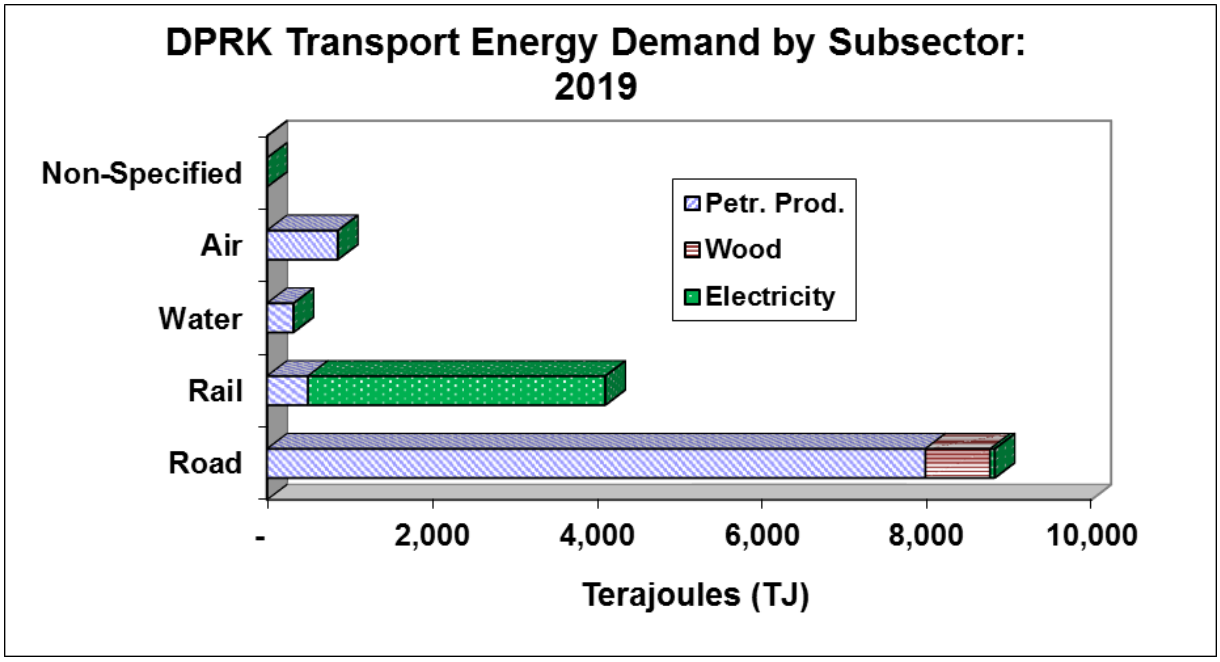

DPRK Transport Energy Demand by Subsector: 2014
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2015
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2016
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2017
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2018
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
Wood
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2019
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Wood
Electricity
-
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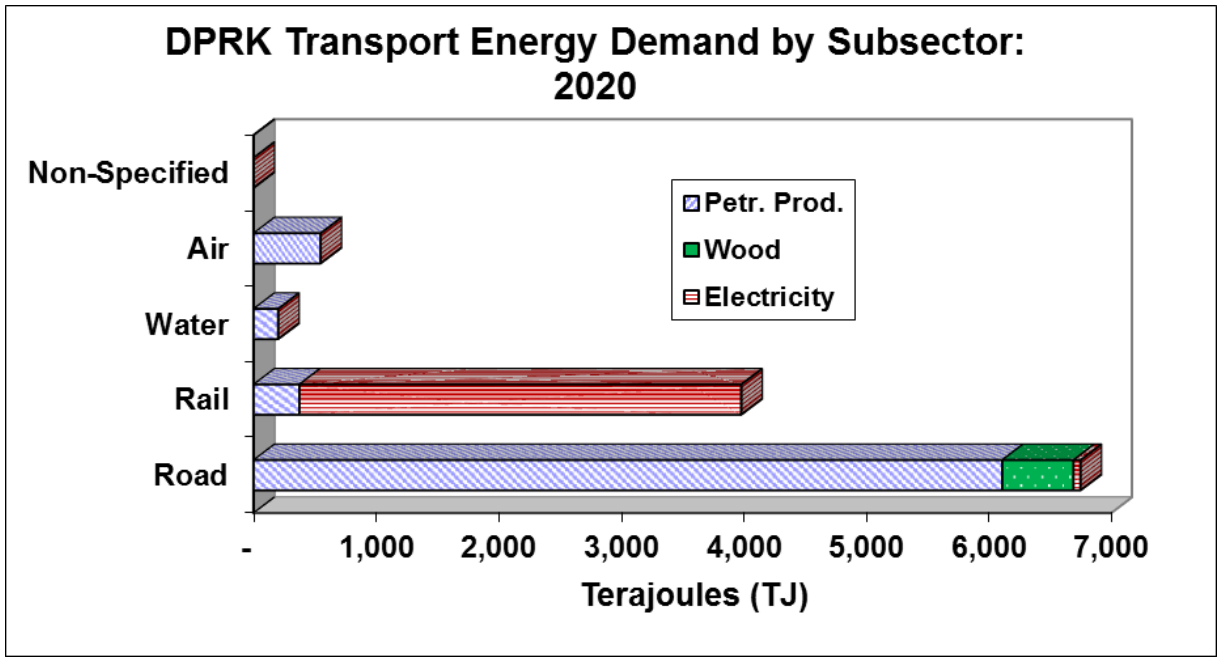
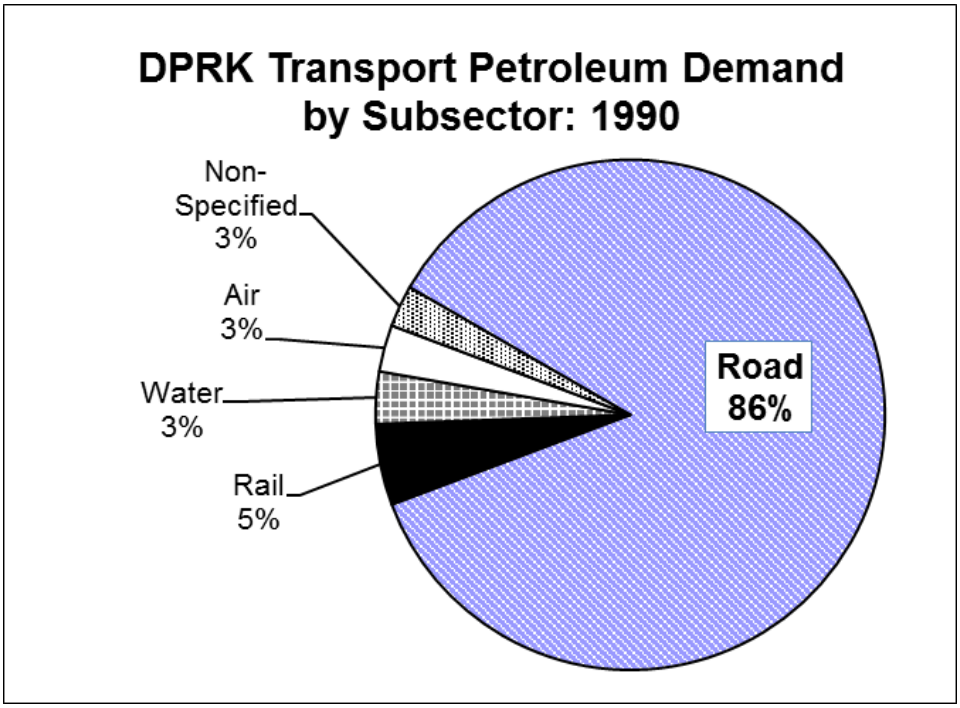
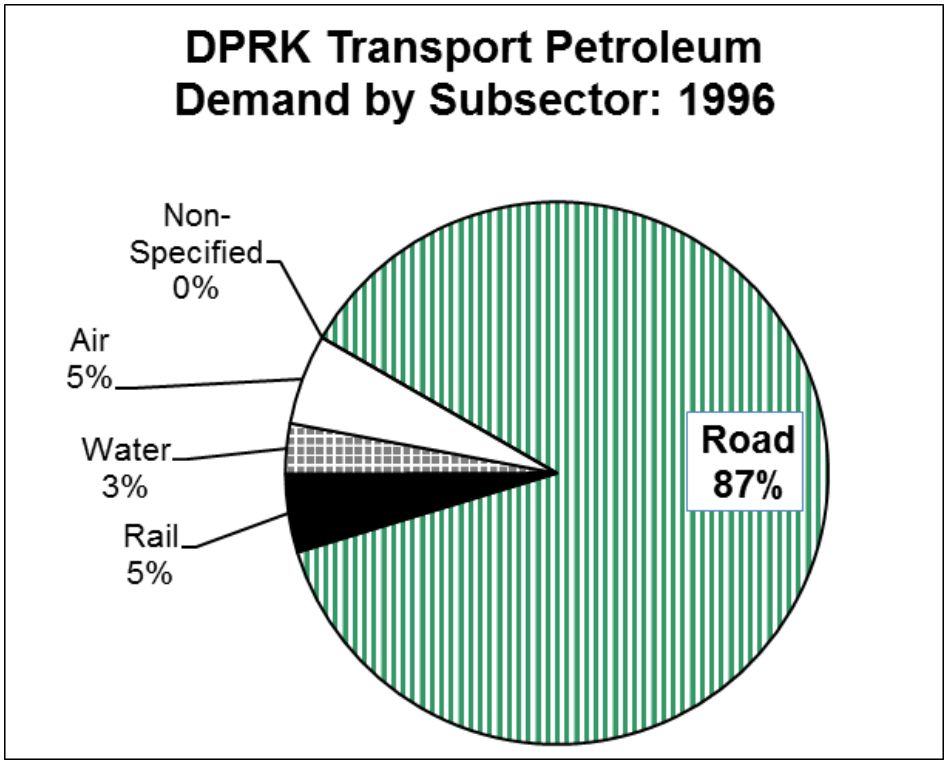
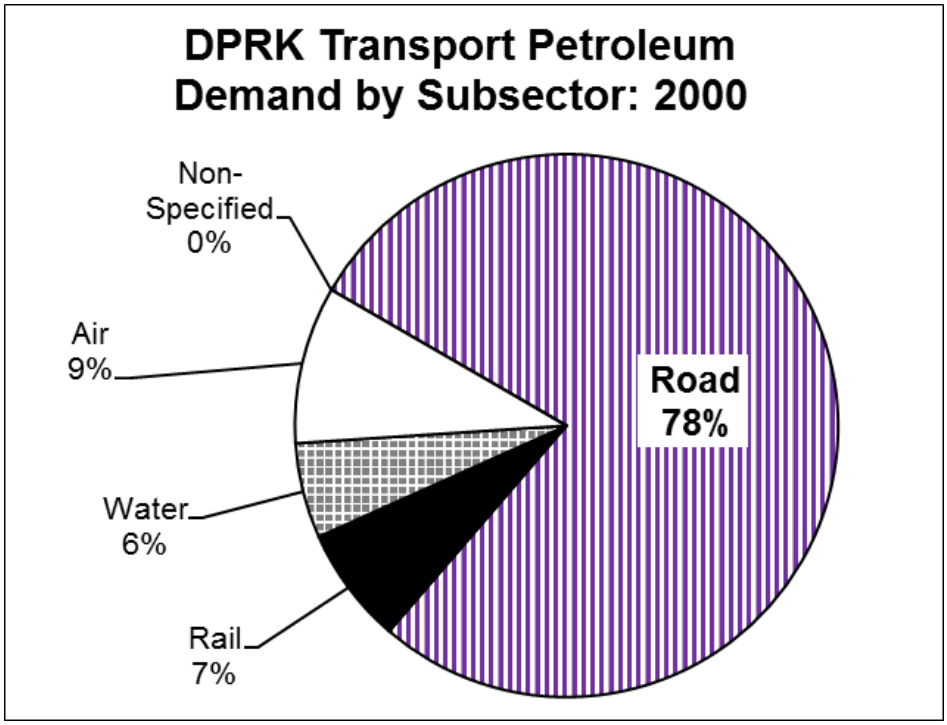
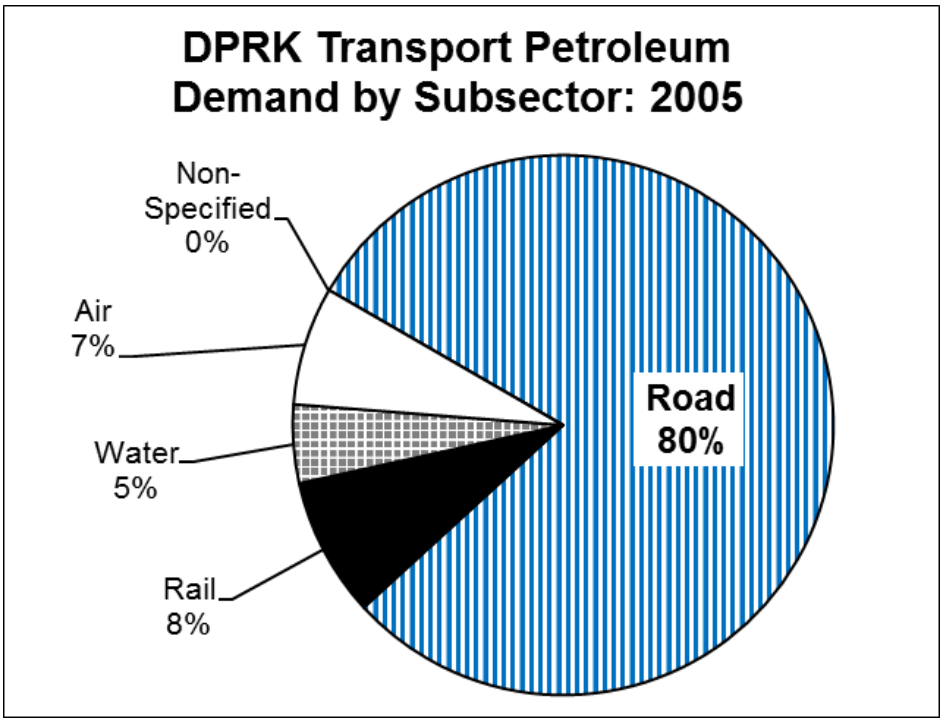
4,000
6,000
8,000
10,000
Terajoules (TJ)

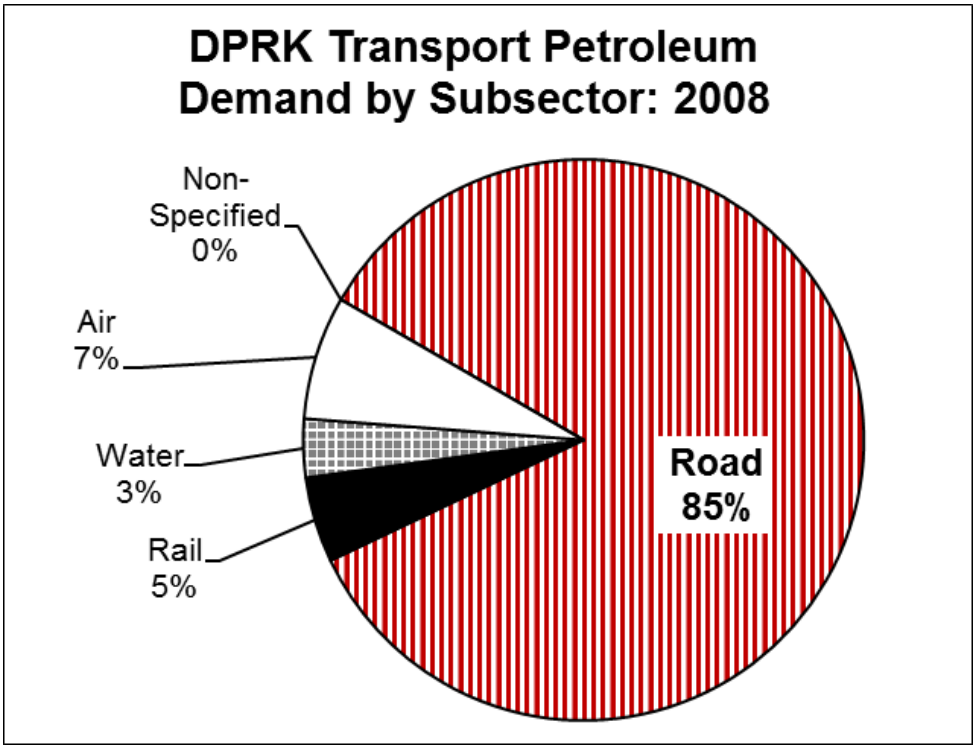

DPRK Transport Energy Demand by Subsector: 2020
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Wood
Electricity
-
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Terajoules (TJ)

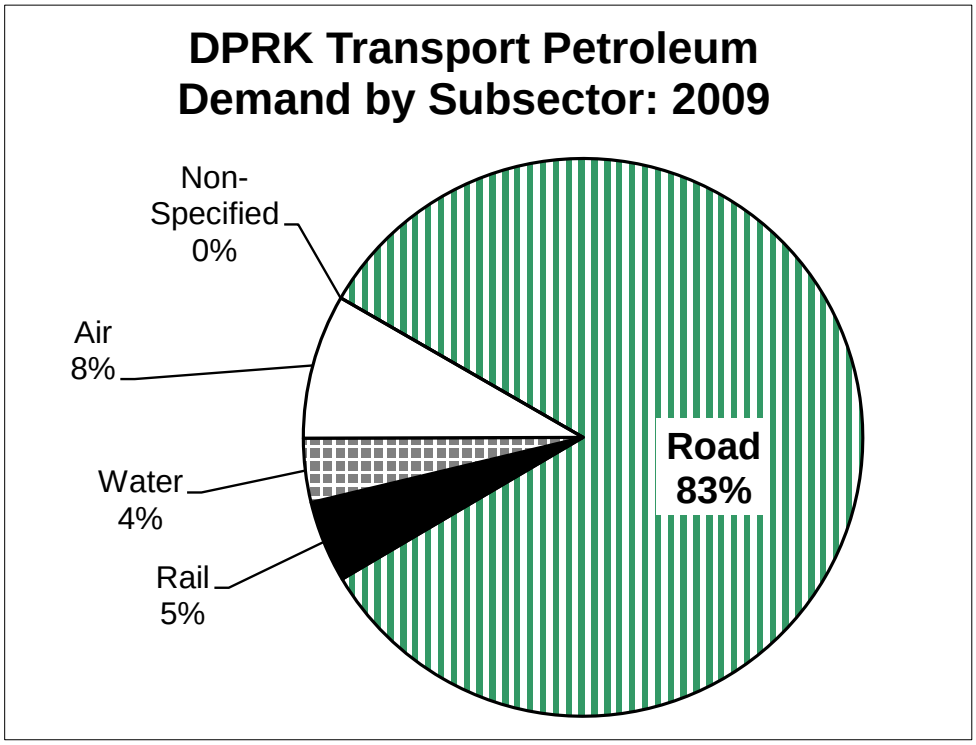

DPRK Transport Petroleum Demand by Subsector: 1990
Non-Specified 3%
Air 3%
Water 3%
Rail 5%
Road 86%

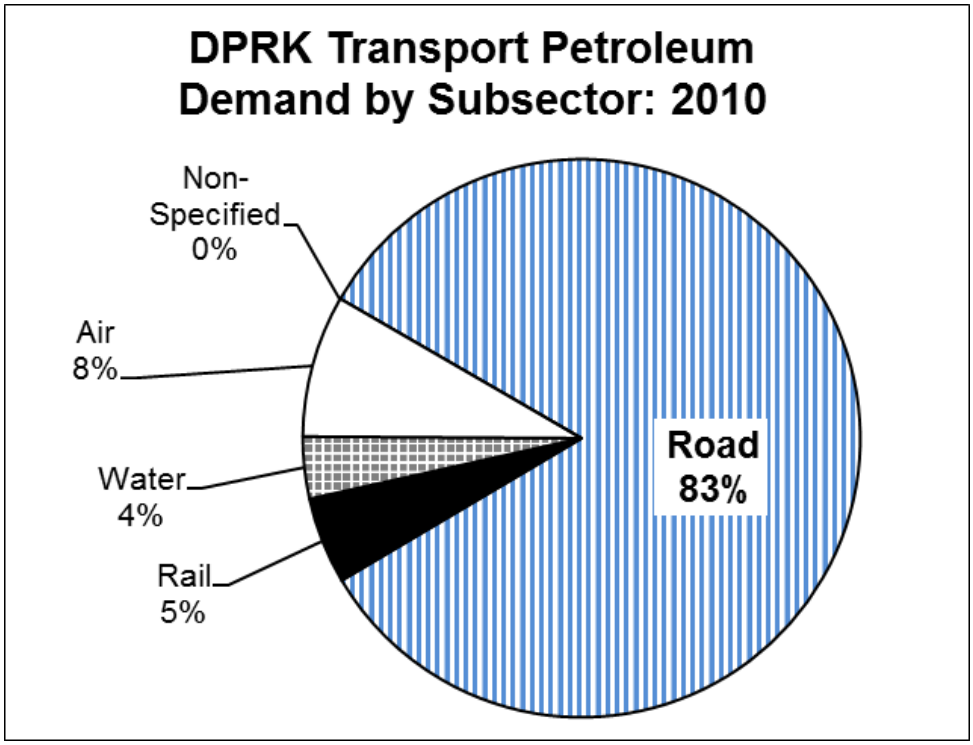

DPRK Transport Petroleum Demand by Subsector: 1996
Non-Specified 0%
Air 5%
Water 3%
Rail 5%
Road 87%

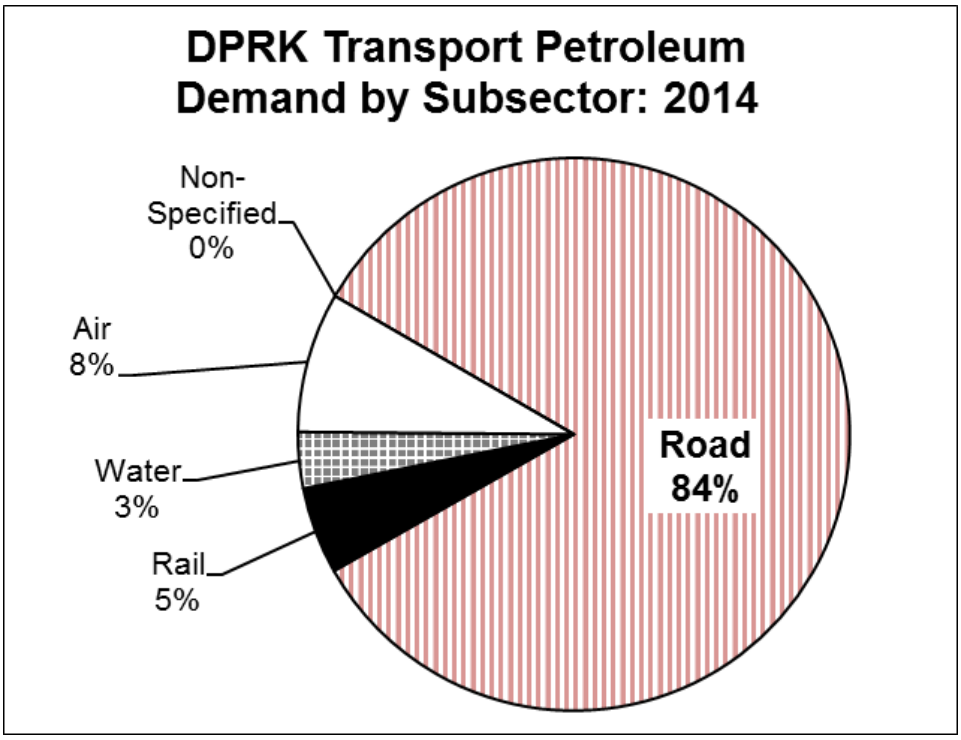

DPRK Transport Petroleum Demand by Subsector: 2000
Non-Specified 0%
Air 9%
Water 6%
Rail 7%
Road 78%

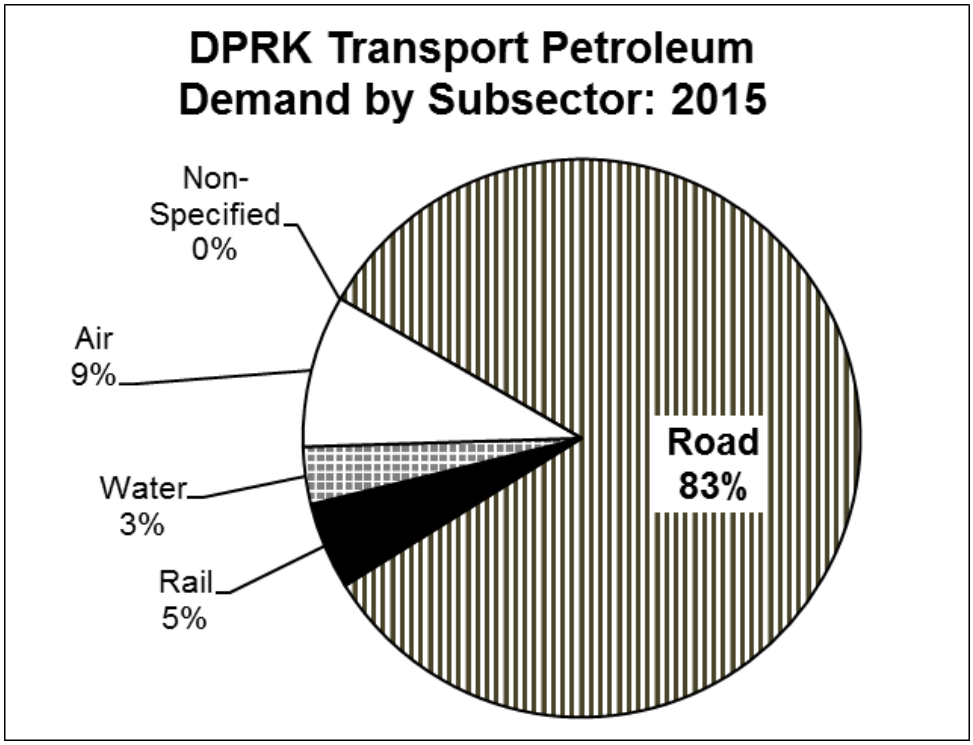

DPRK Transport Petroleum Demand by Subsector: 2005
Non-Specified 0%
Air 7%
Water 5%
Rail 8%
Road 80%

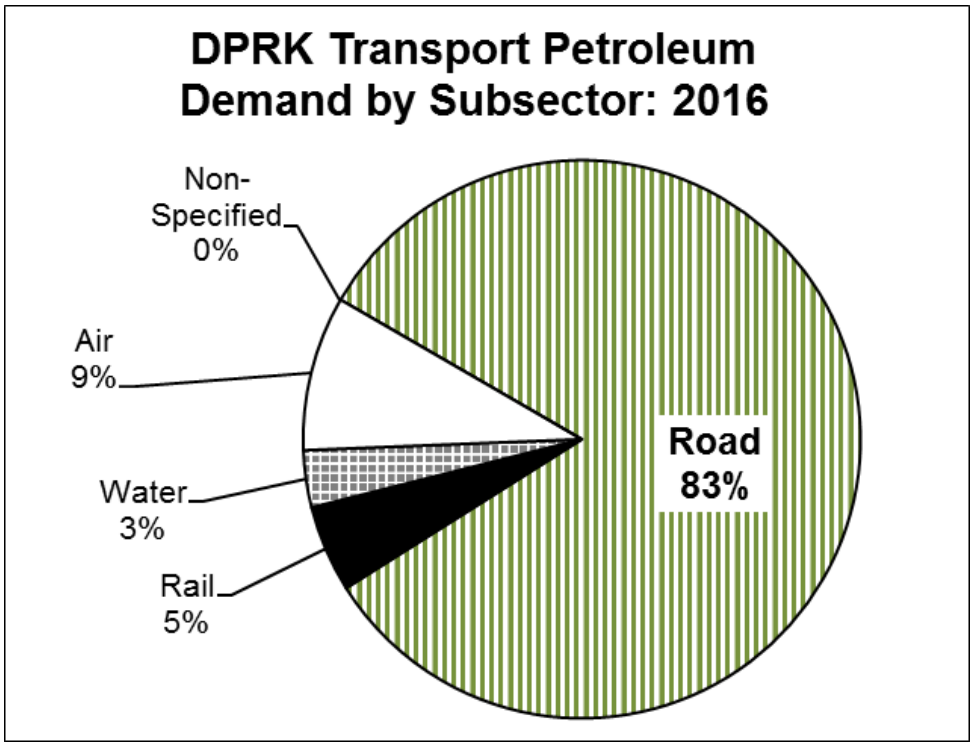

DPRK Transport Petroleum Demand by Subsector: 2008
Non-Specified 0%
Air 7%
Water 3%
Rail 5%
Road 85%

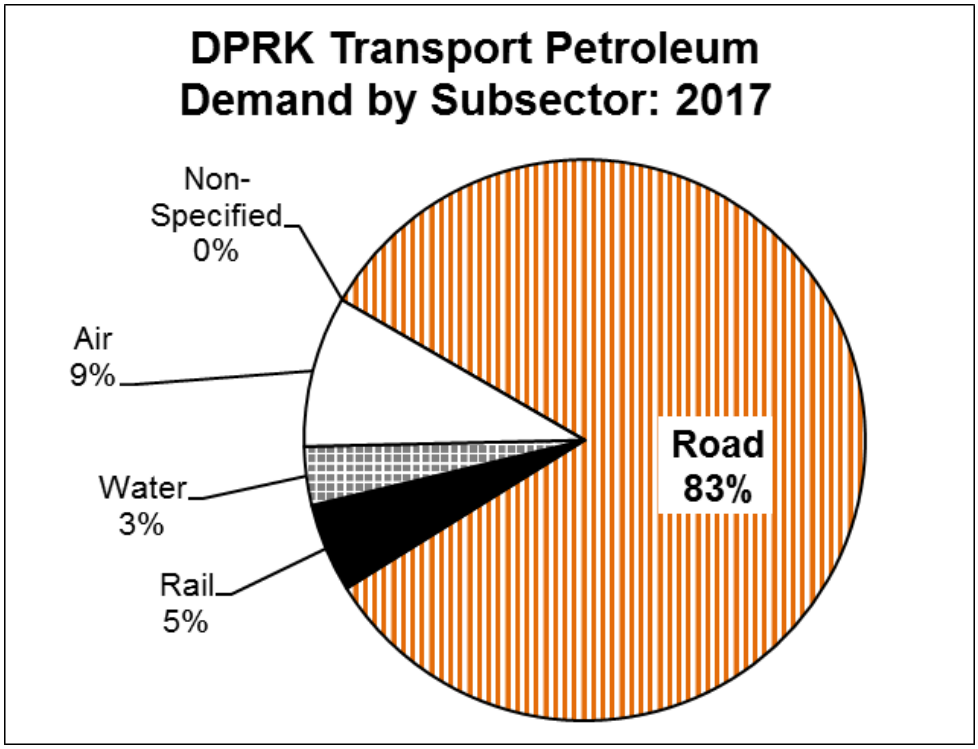

DPRK Transport Petroleum Demand by Subsector: 2009
Non-Specified 0%
Air 8%
Water 4%
Rail 5%
Road 83%

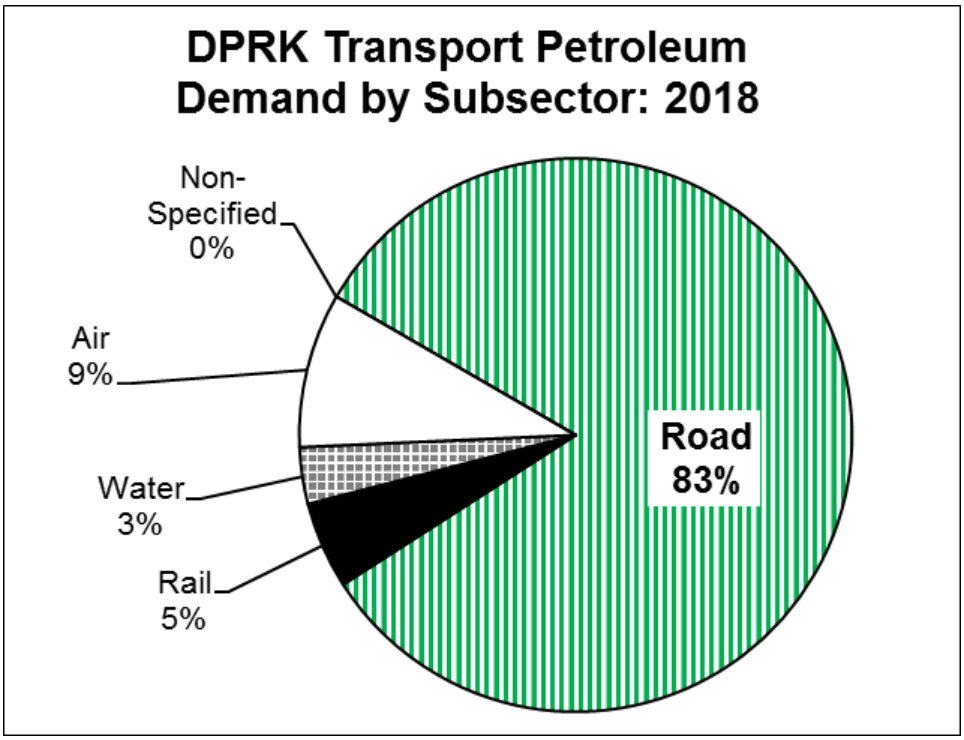

DPRK Transport Petroleum Demand by Subsector: 2010
Non-Specified 0%
Air 8%
Water 4%
Rail 5%
Road 83%

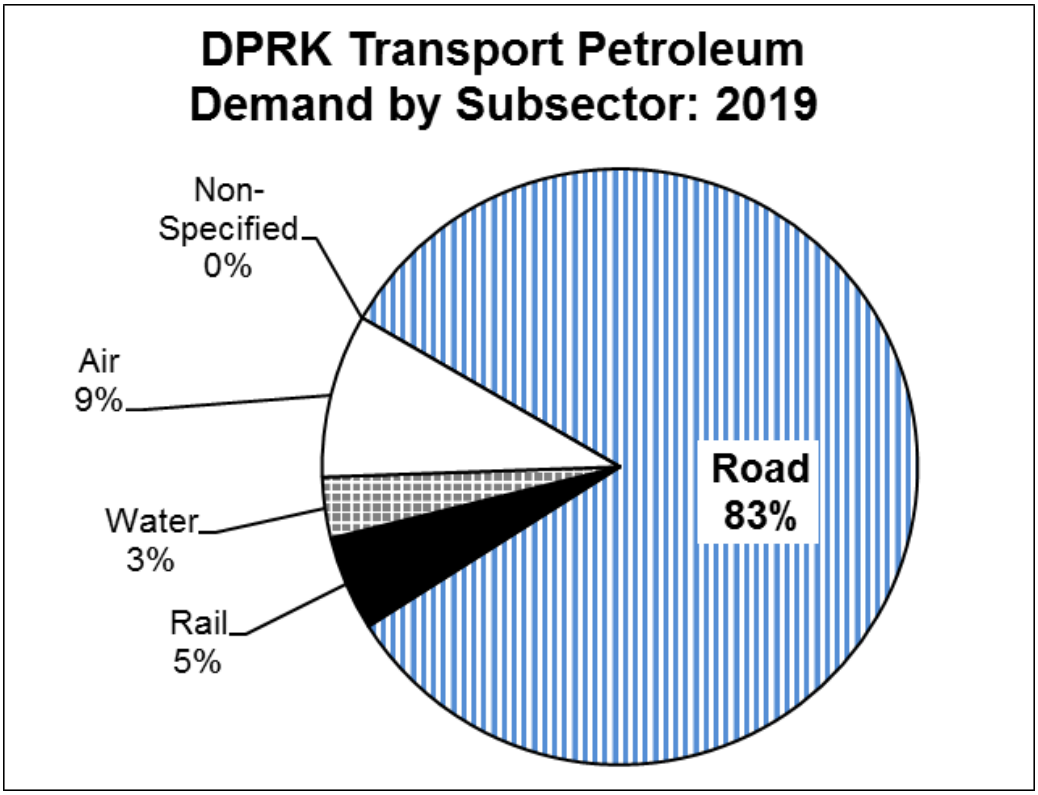

DPRK Transport Petroleum Demand by Subsector: 2014
Non-Specified 0%
Air 8%
Water 3%
Rail 5%
Road 84%

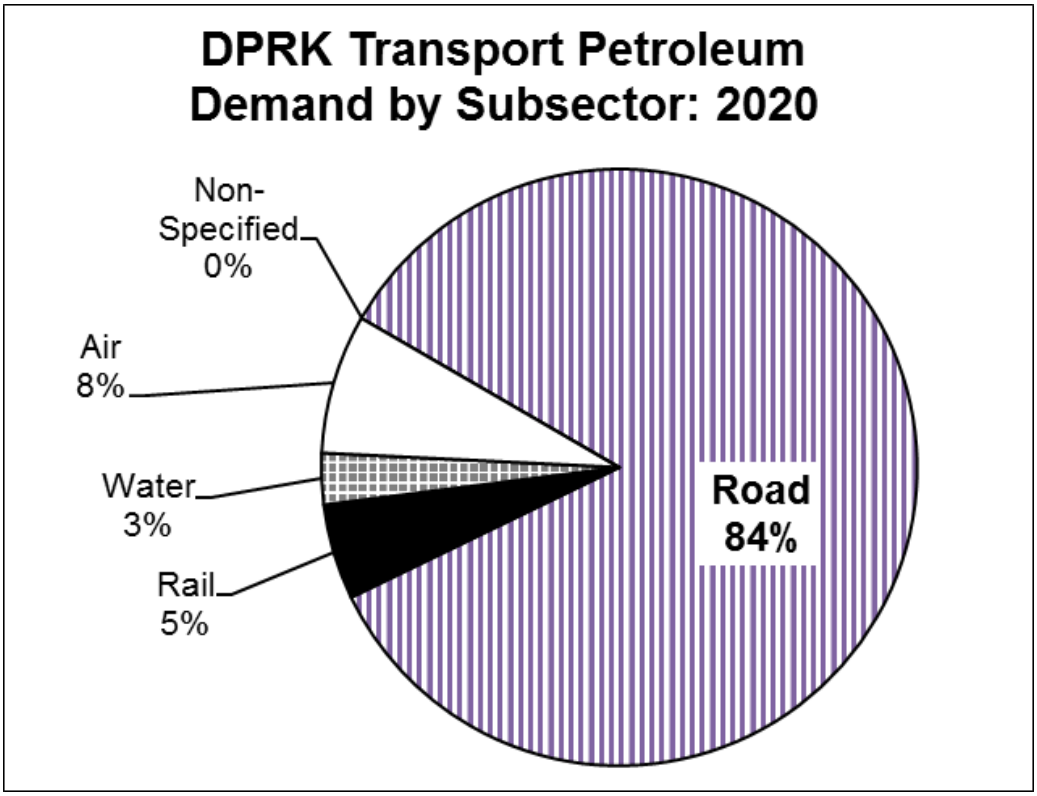

DPRK Transport Petroleum Demand by Subsector: 2015
Non-Specified 0%
Air 9%
Water 3%
Rail 5%
Road 83%


DPRK Transport Petroleum Demand by Subsector: 2016
Non-Specified 0%
Air 9%
Water 3%
Rail 5%
Road 83%


DPRK Transport Petroleum
Demand by Subsector: 2017
Non-
Specified
0%
Air
9%
Water
3%
Rail
5%
Road
83%


DPRK Transport Petroleum
Demand by Subsector: 2018
Non-
Specified
0%
Air
9%
Water
3%
Rail
5%
Road
83%


DPRK Transport Petroleum Demand by Subsector: 2019
Non-Specified 0%
Air 9%
Water 3%
Rail 5%
Road 83%


DPRK Transport Petroleum Demand by Subsector: 2020
Non-Specified 0%
Air 8%
Water 3%
Rail 5%
Road 84%

DPRK Military Energy Demand By Subsector: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020

Units: Terajoules (TJ)	**1990**			**1996**				**2000**			
Subsector	Coal	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	-	6,585	-	-	-	5,734	-	-	-	4,064	-
Armaments	-	263	-	-	-	211	-	-	-	148	-
Air Force	-	2,648	-	-	-	1,886	-	-	-	1,367	-
Naval Forces	-	6,937	-	-	-	5,261	-	-	-	5,430	-
Military Manufacturing	890	-	48	623	-	-	33	401	-	-	21
Buildings and Other	28,938	100	13,960	24,742	5,498	95	7,678	20,908	7,379	85	7,399

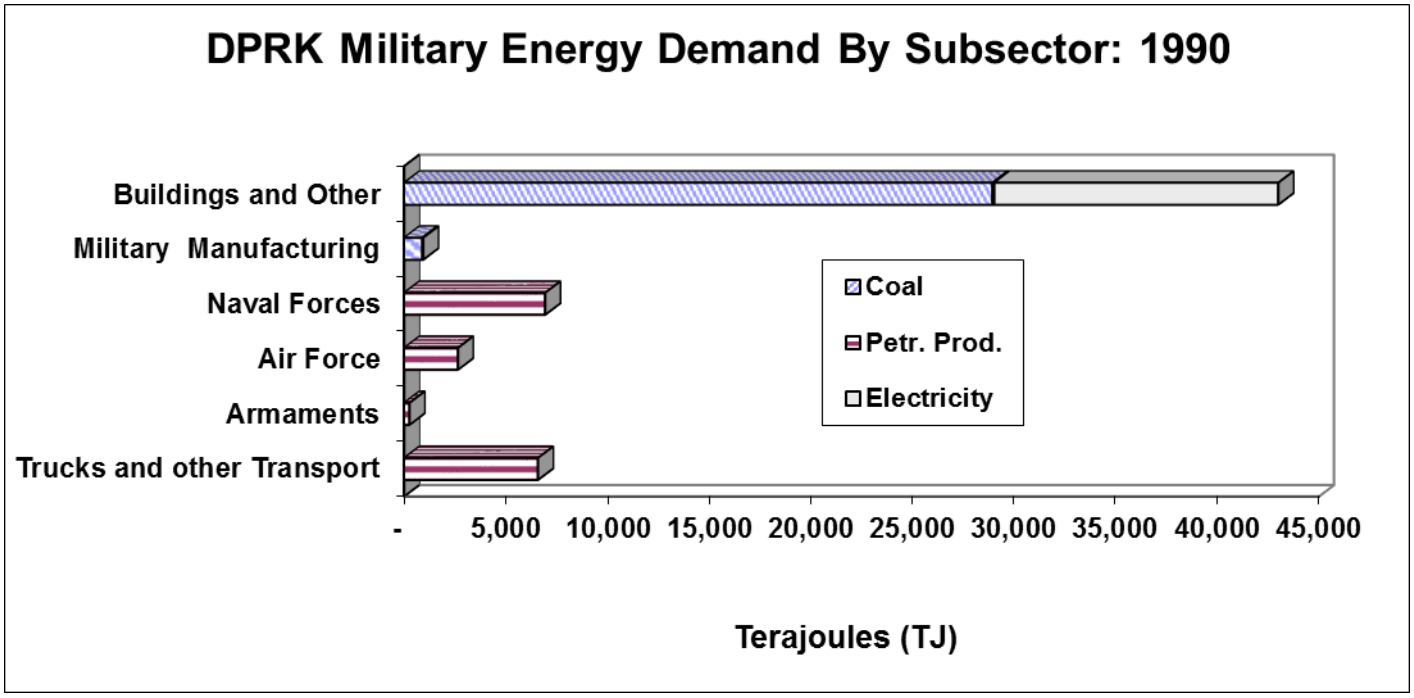
	2005				**2008**				**2009**			
Subsector	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	-	-	3,524	-	-	-	3,186	-	-	-	2,984	-
Armaments	-	-	129	-	-	-	101	-	-	-	101	-
Air Force	-	-	2,002	-	-	-	2,234	-	-	-	1,792	-
Naval Forces	-	-	5,513	-	-	-	4,227	-	-	-	3,901	-
Military Manufacturing	401	-	-	21	401	-	-	21	401	-	-	21
Buildings and Other	19,215	7,871	85	8,725	18,014	7,379	82	9,074	18,014	7,379	78	8,121

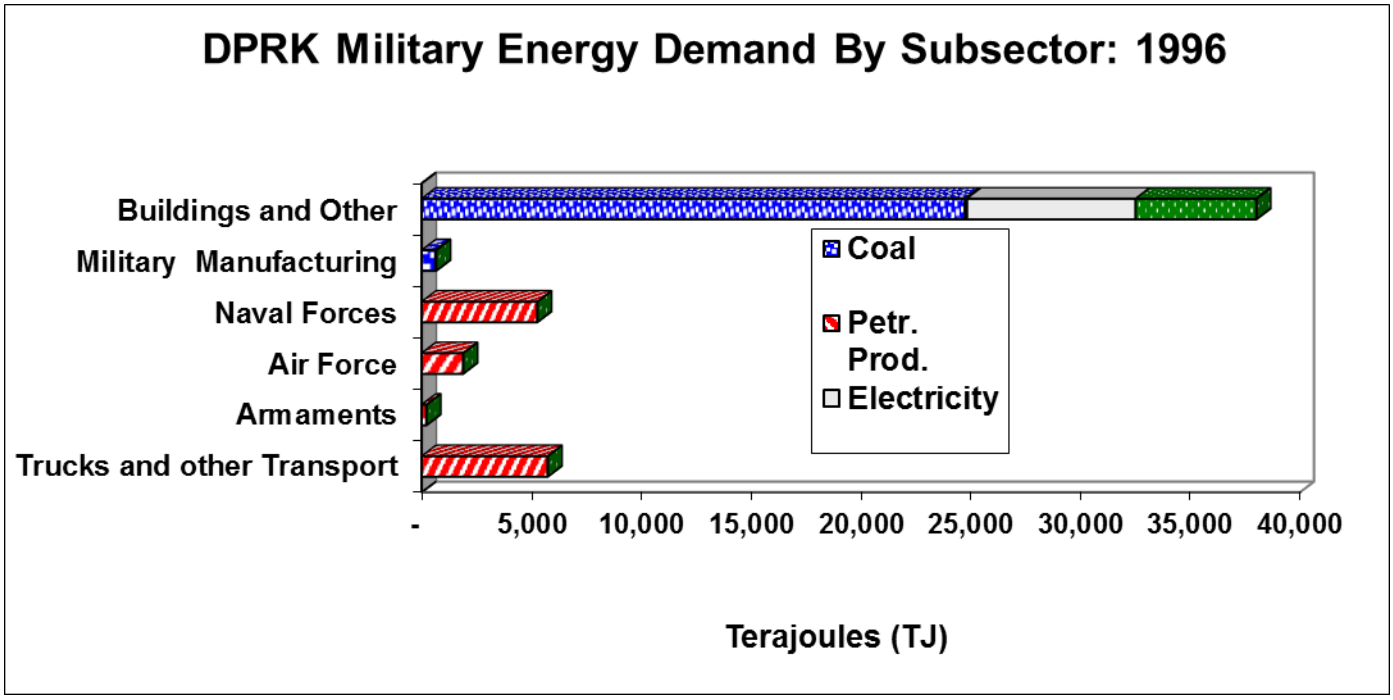
	2010				**2014**				**2015**			
Subsector	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	-	-	3,186	-	-	-	3,527	-	-	-	3,874	-
Armaments	-	-	103	-	-	-	96	-	-	-	102	-
Air Force	-	-	2,100	-	-	-	1,899	-	-	-	2,310	-
Naval Forces	-	-	4,553	-	-	-	3,923	-	-	-	3,944	-
Military Manufacturing	401	-	-	21	427	-	-	23	436	-	-	23
Buildings and Other	18,014	7,379	76	7,678	18,717	7,130	78	8,097	19,186	6,771	79	8,376
Total	18,415	7,379	10,018	7,699	19,144	7,130	9,522	8,120	19,622	6,771	10,310	8,399

	2010			
Subsector	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	0.0%	0.0%	31.8%	0.0%
Armaments	0.0%	0.0%	1.0%	0.0%
Air Force	0.0%	0.0%	21.0%	0.0%
Naval Forces	0.0%	0.0%	45.4%	0.0%
Military Manufacturing	2.2%	0.0%	0.0%	0.3%
Buildings and Other	97.8%	100.0%	0.8%	99.7%
Total	100.0%	100.0%	100.0%	100.0%

	2016				2017				2018			
Subsector	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Armaments	-	-	3,999	-	-	-	4,035	-	-	-	4,035	-
Air Force	-	-	111	-	-	-	85	-	-	-	85	-
Naval Forces	-	-	2,567	-	-	-	2,119	-	-	-	2,015	-
Military Manufacturing	-	-	4,049	-	-	-	3,072	-	-	-	2,867	-
Buildings and Other	445	-	-	24	445	-	-	24	445	-	-	24
Total	19,660	6,401	80	8,585	19,909	6,482	80	8,655	20,407	6,644	76	8,795
Total	20,106	6,401	10,805	8,609	20,355	6,482	9,391	8,679	20,852	6,644	9,078	8,819

	2019				2020			
Subsector	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Air Force	-	-	4,035	-	-	-	2,409	-
Naval Forces	-	-	85	-	-	-	47	-
Military Manufacturing	-	-	2,209	-	-	-	1,653	-
Buildings and Other	-	-	2,867	-	-	-	1,556	-
Total	445	-	-	24	223	-	-	12
Total	20,407	6,644	76	8,795	17,085	6,644	65	7,564
Total	20,852	6,644	9,272	8,819	17,308	6,644	5,731	7,575


DPRK Military Energy Demand By Subsector: 1990
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 1996
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
-
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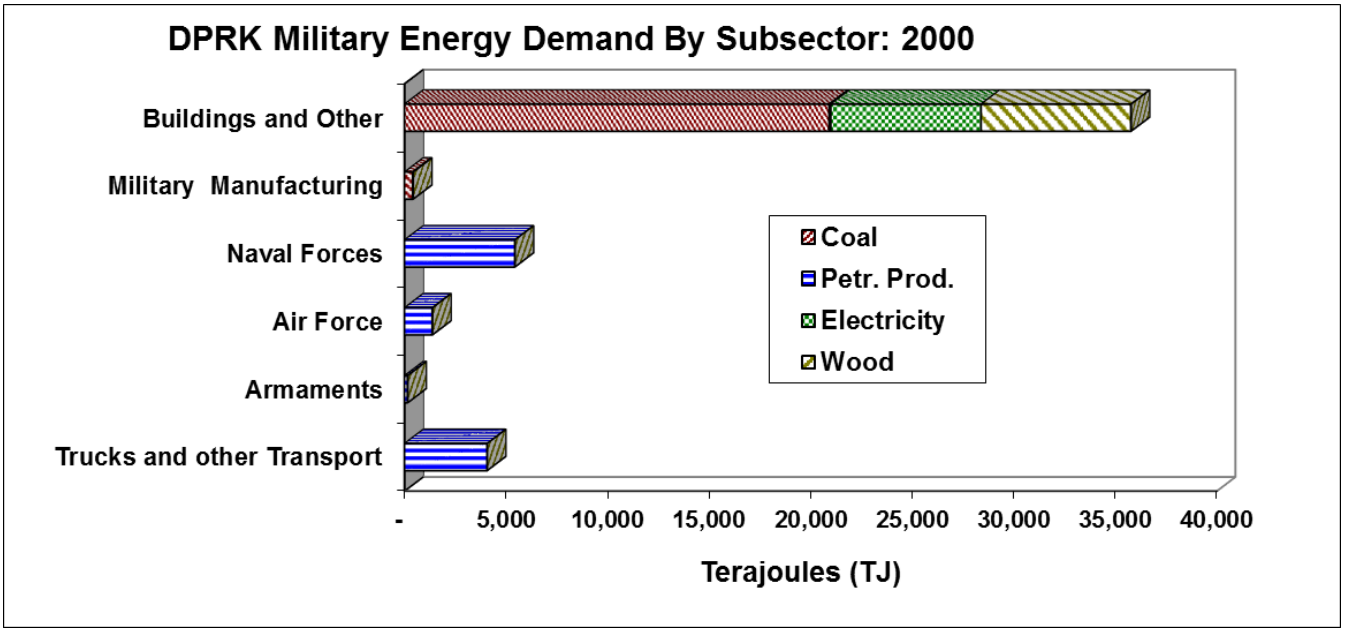
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2000
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
Wood
-
5,000
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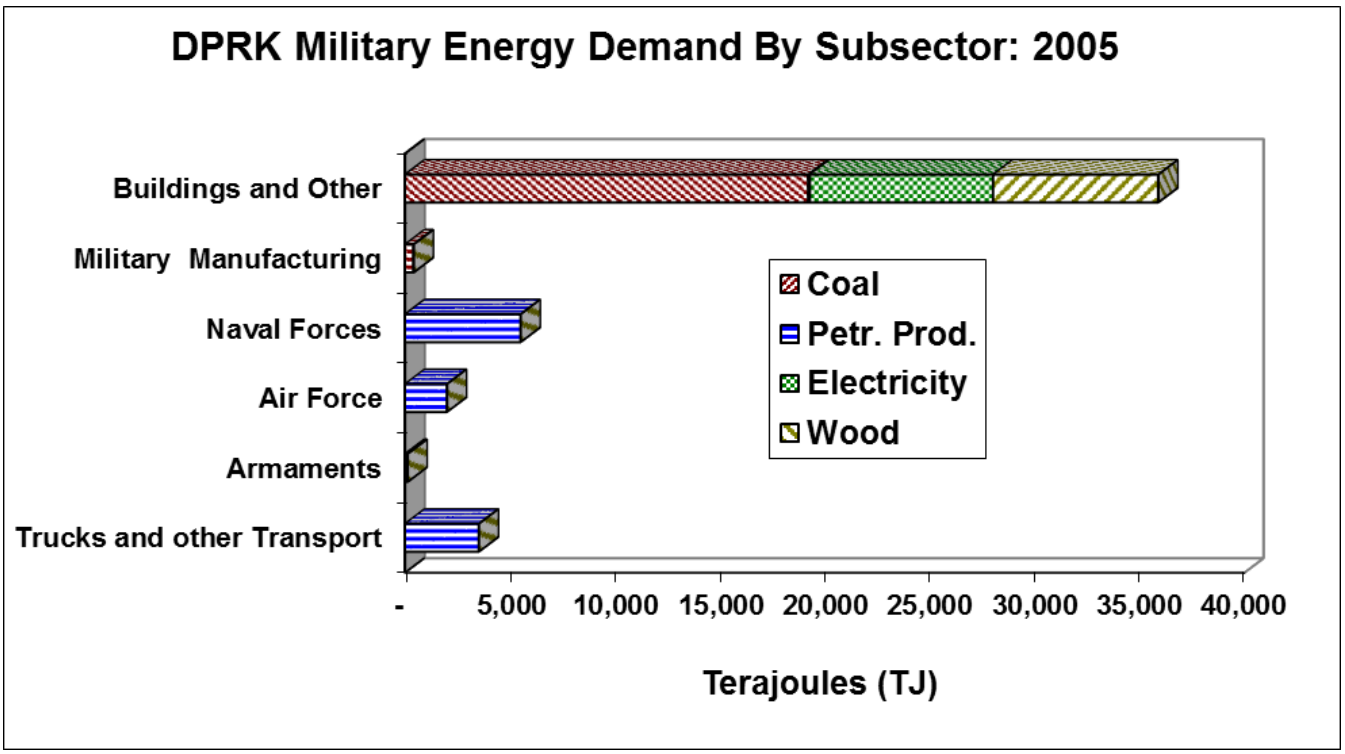
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2005
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
Wood
-
5,000
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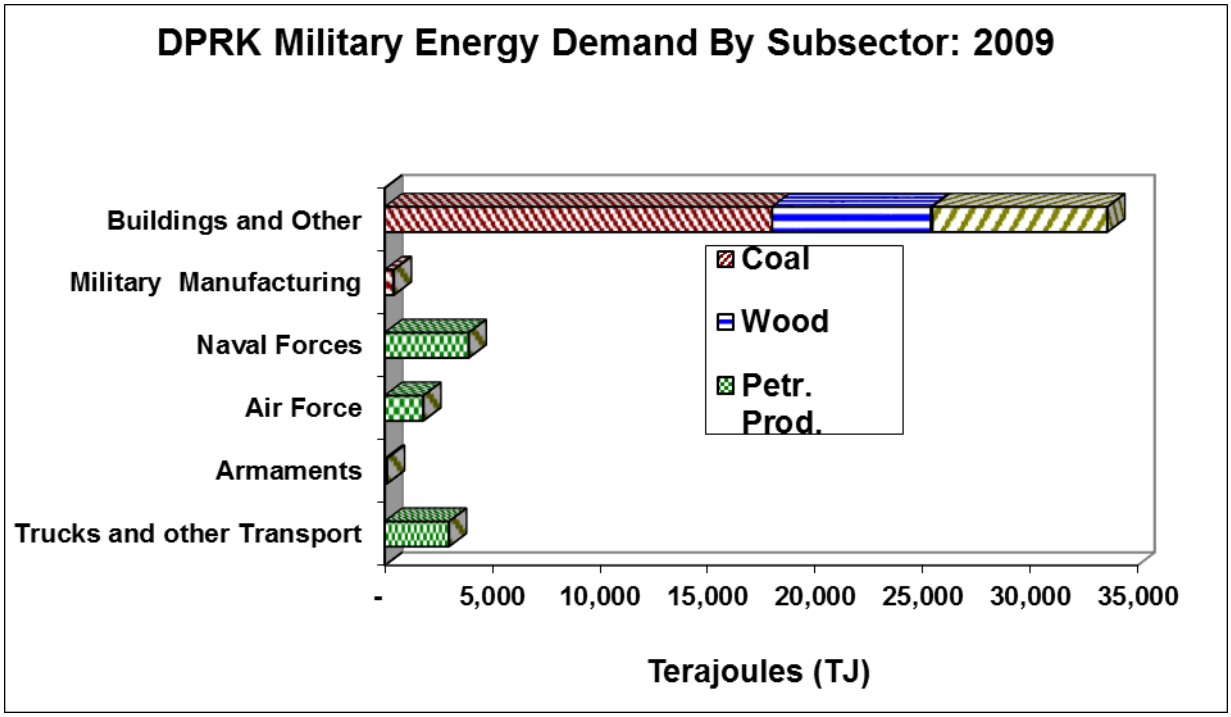
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2009
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
Petr. Prod.
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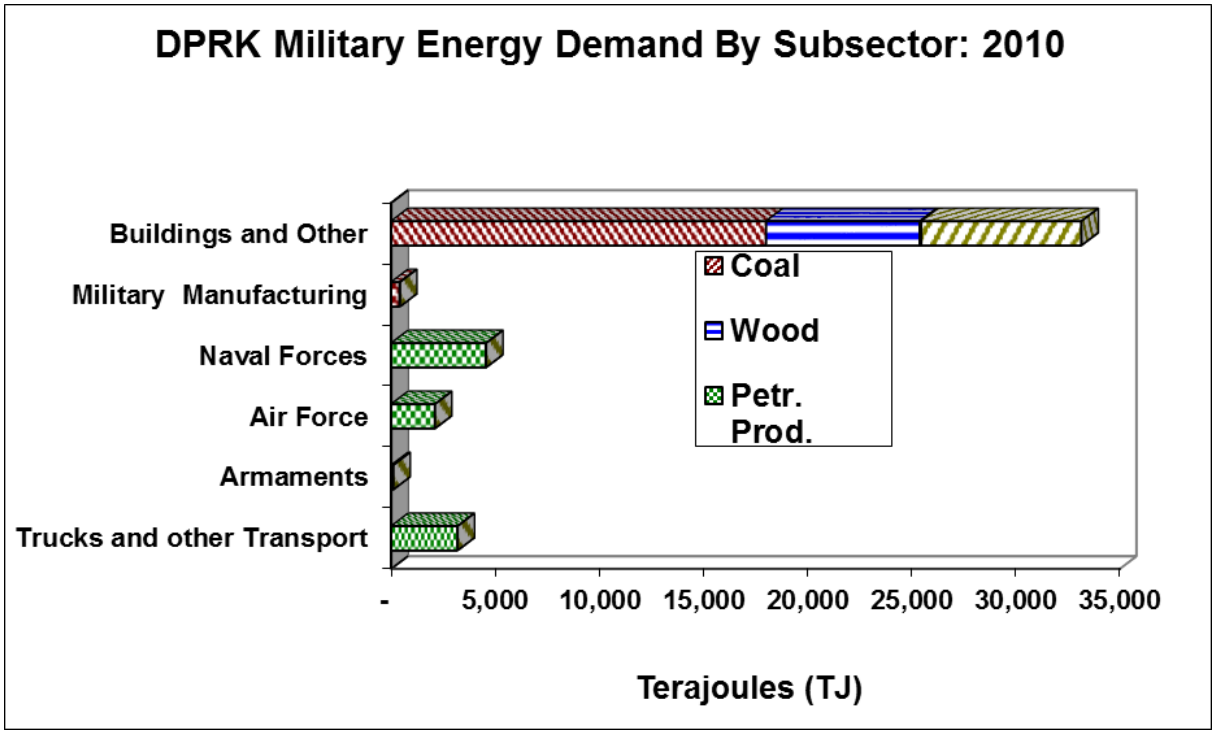
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2010
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
Petr. Prod.
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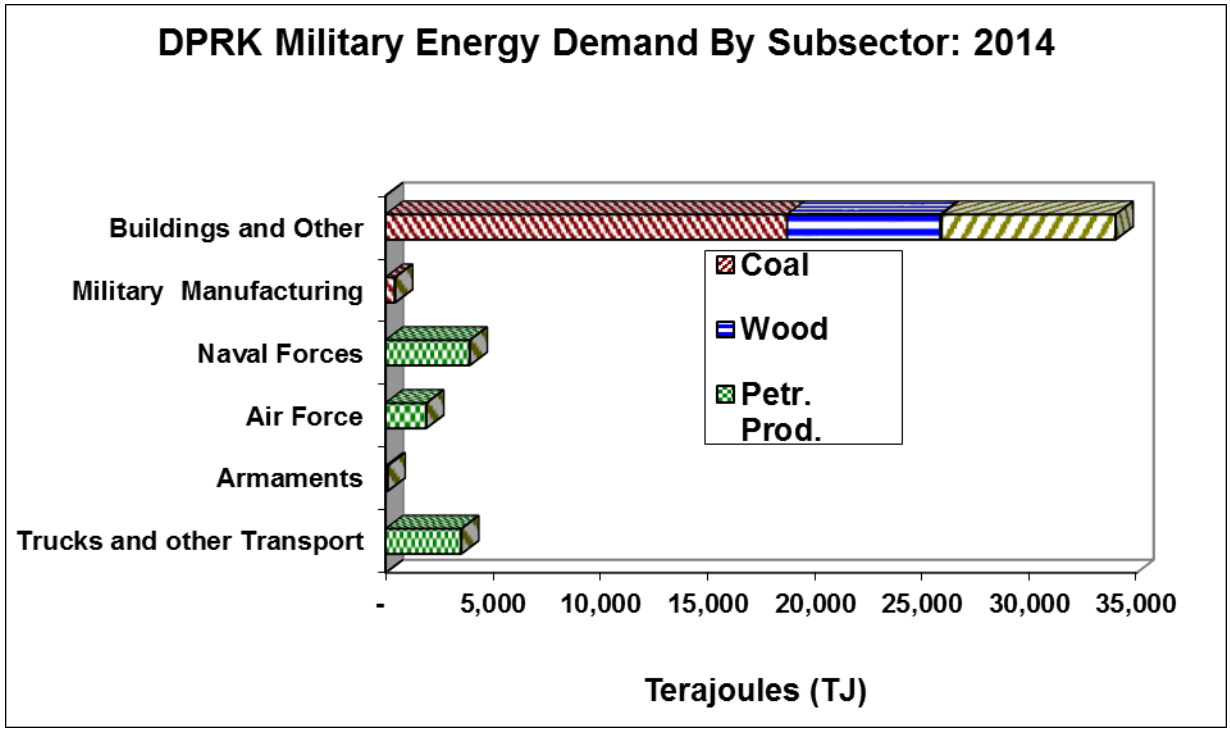
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2014
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
Petr. Prod.
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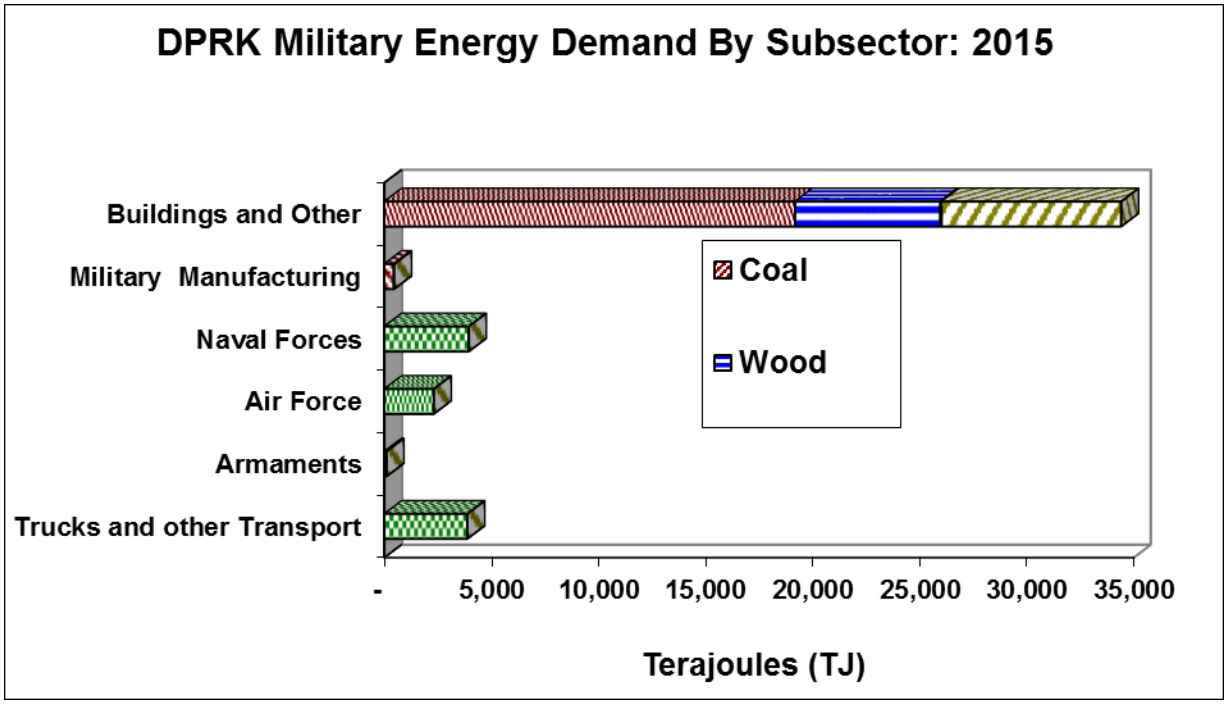
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2015
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
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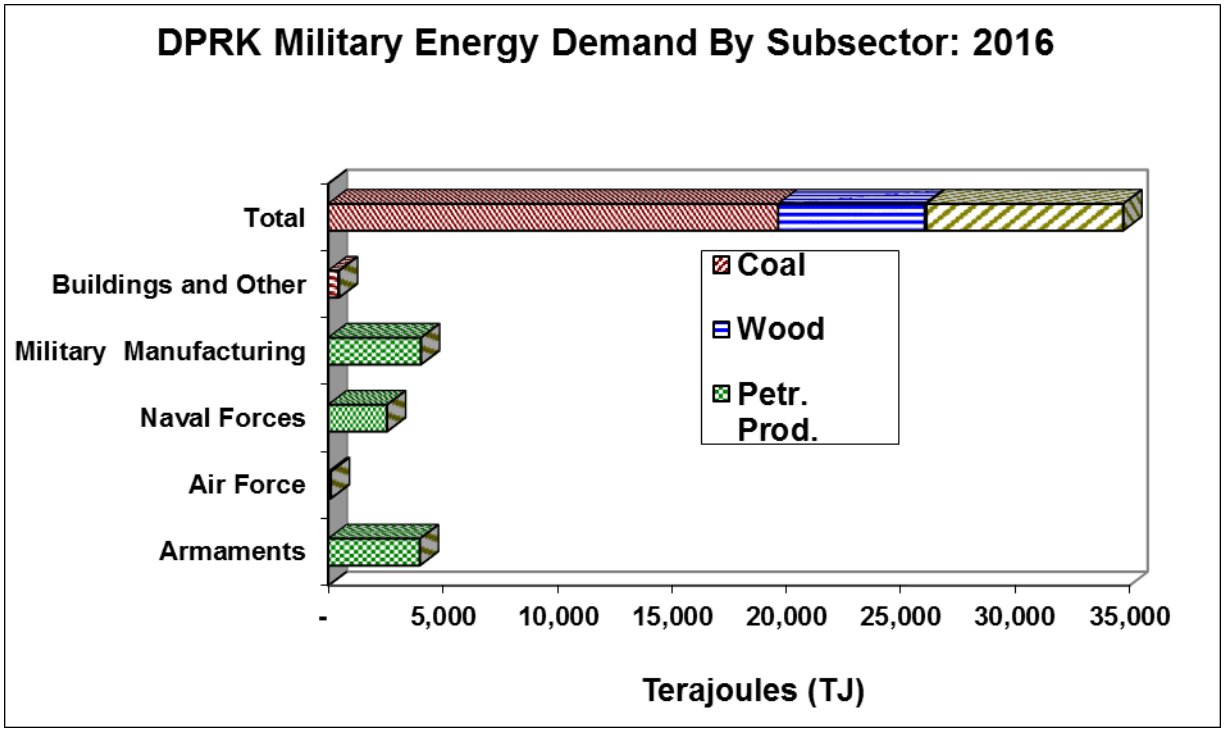
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2016
Total
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Coal
Wood
Petr. Prod.
-
5,000
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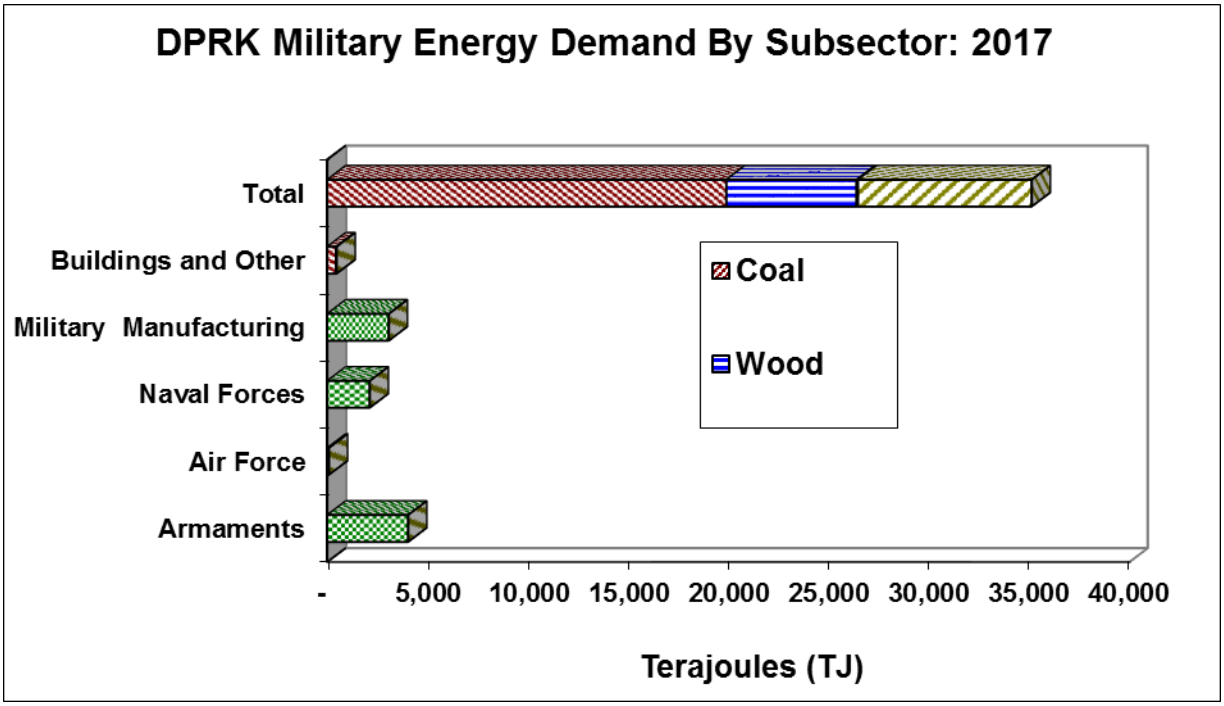
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2017
Total
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Coal
Wood
-
5,000
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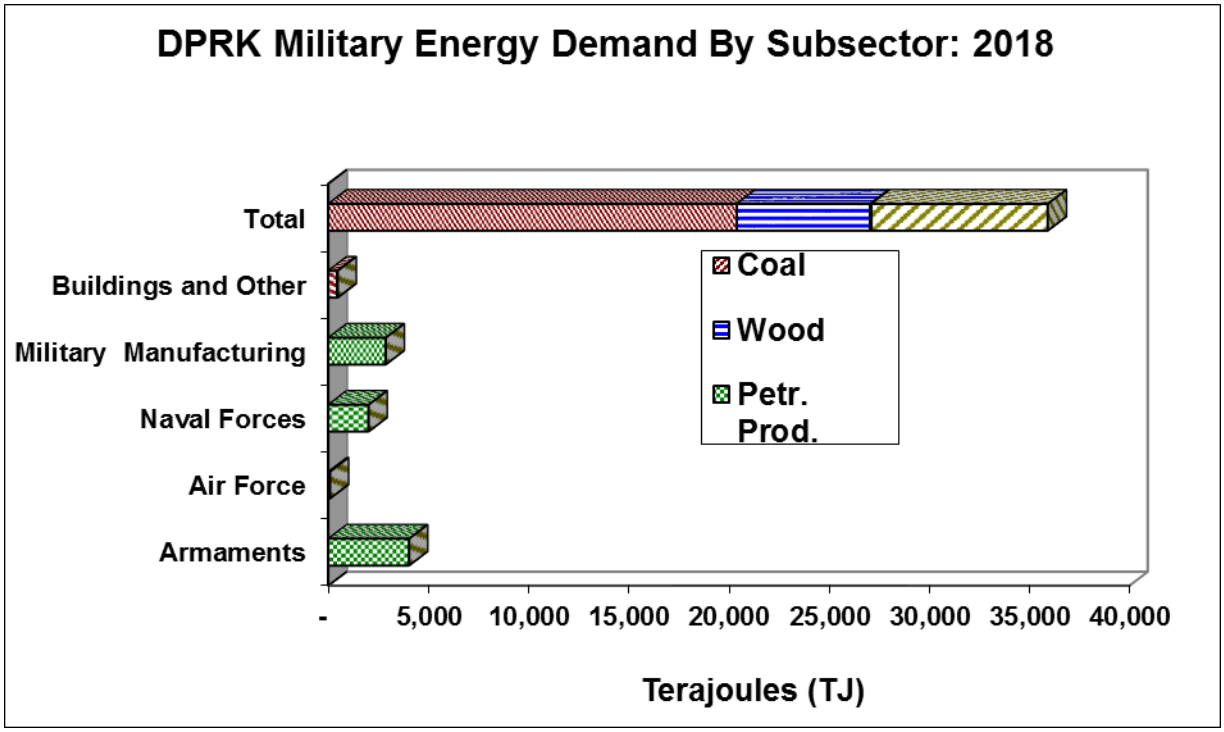
40,000
Terajoules (TJ)


DPRK Military Energy Demand By Subsector: 2018
Total
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Coal
Wood
Petr. Prod.
-
5,000
10,000
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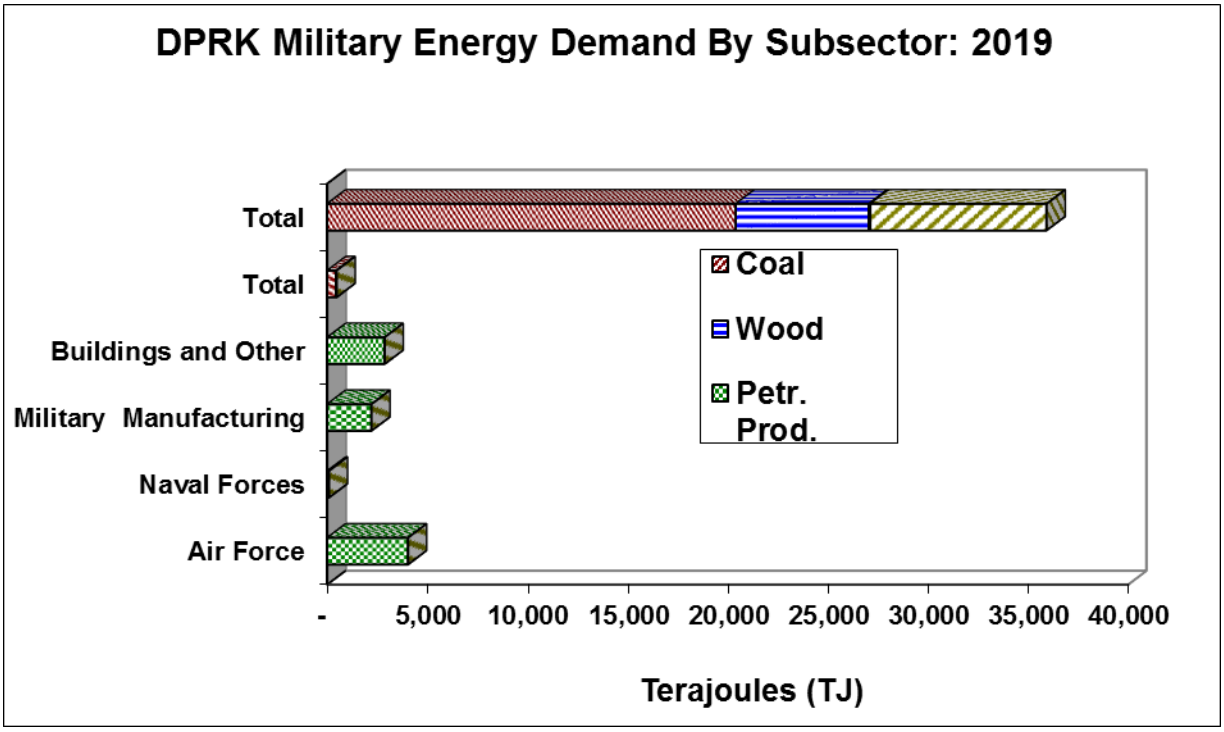
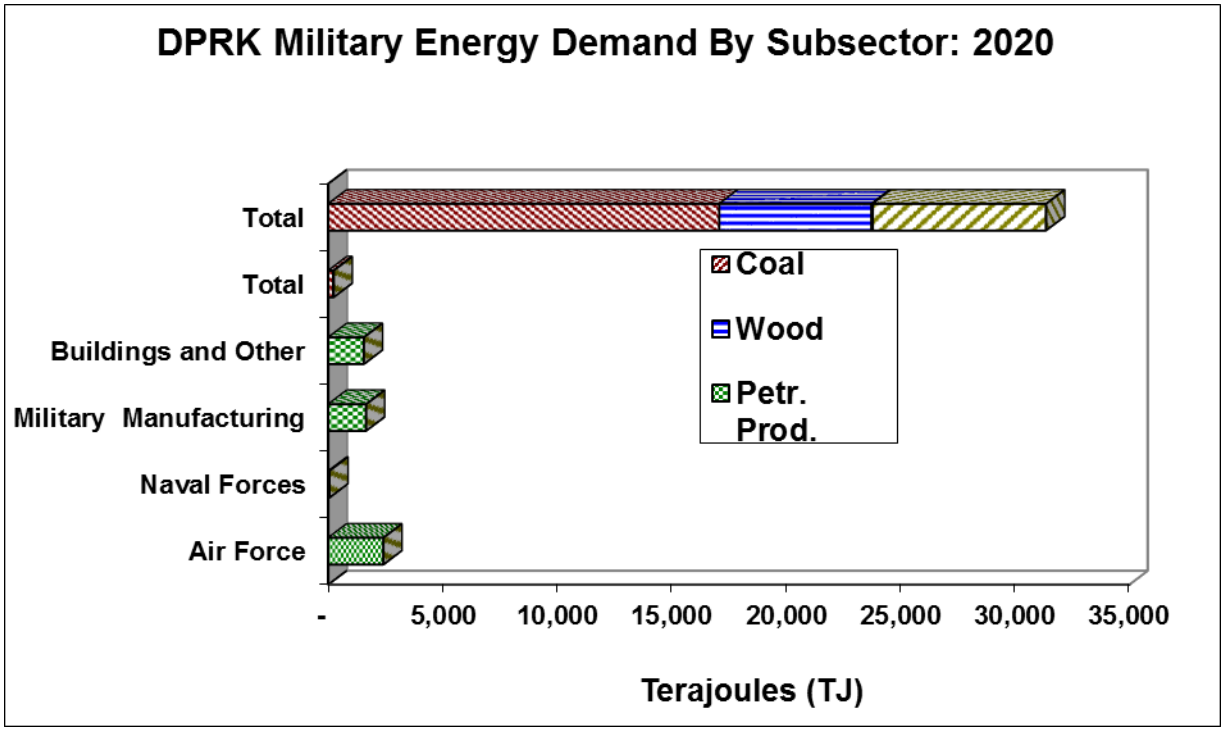
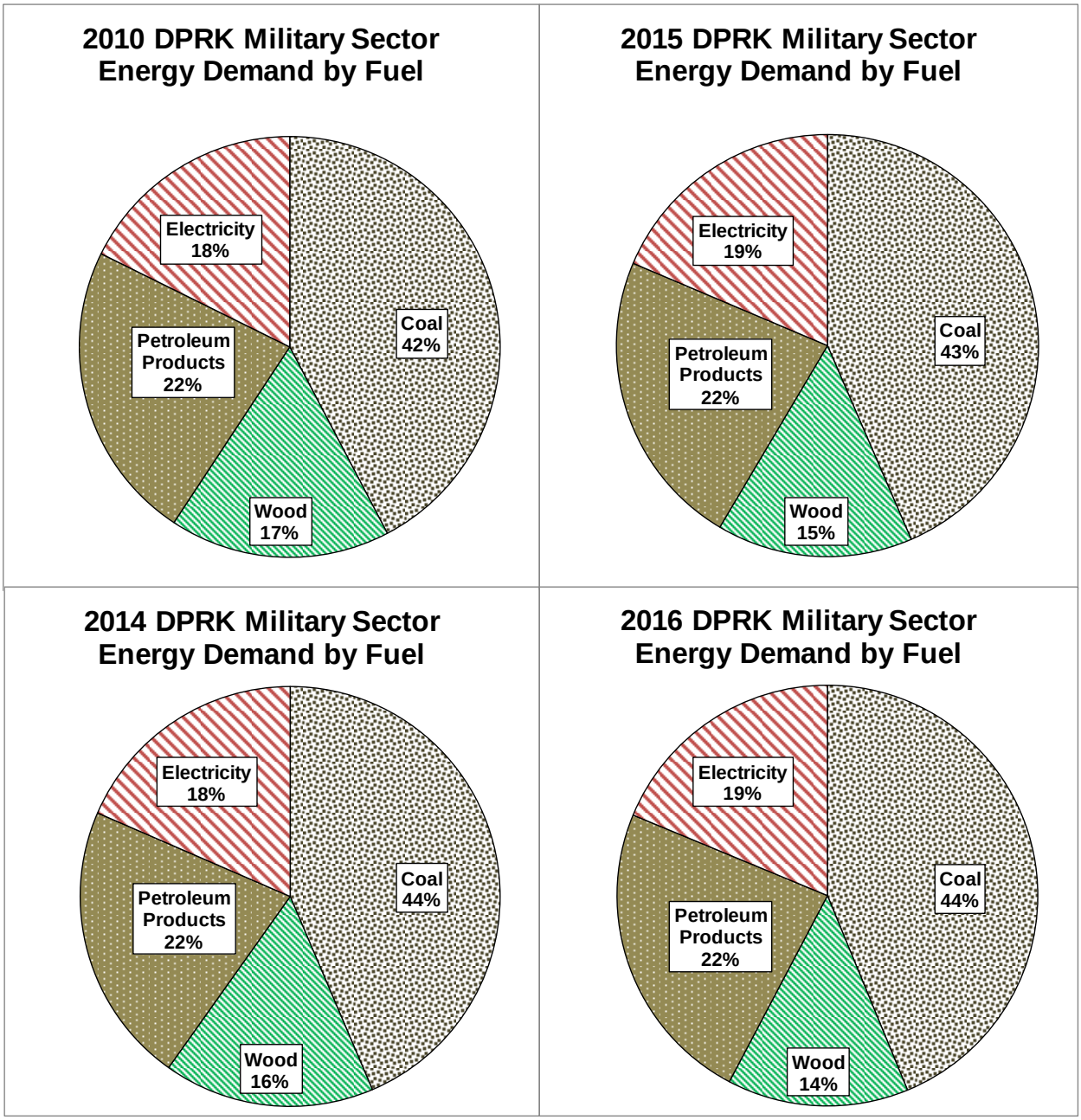
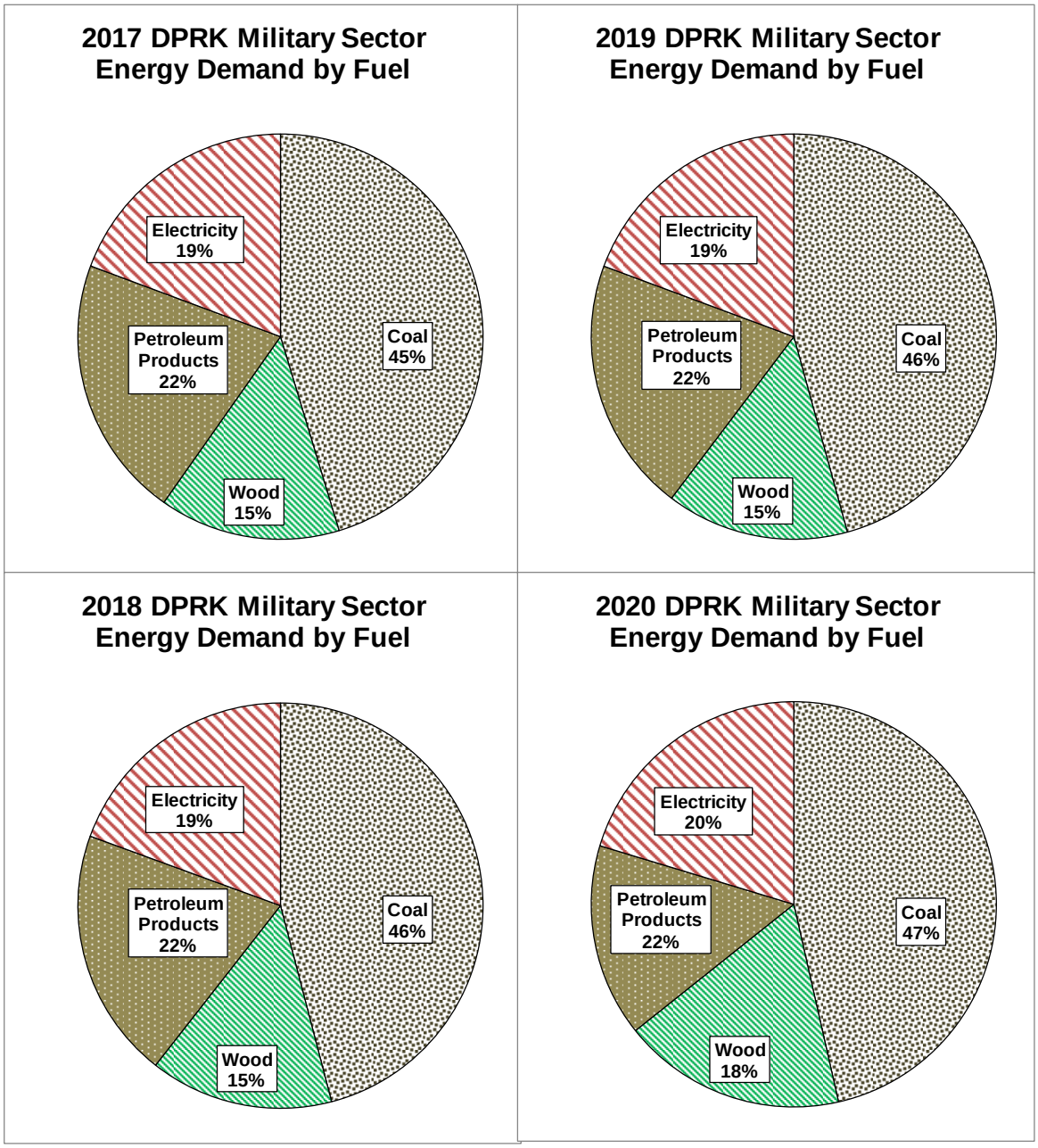
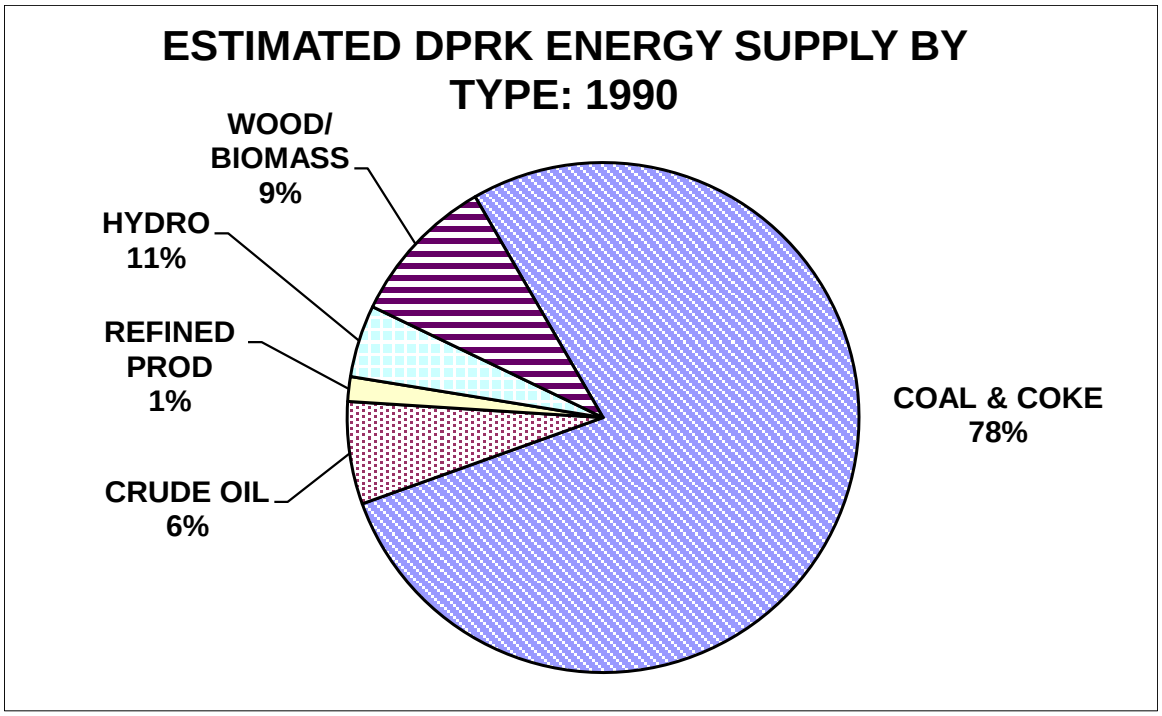
Terajoules (TJ)

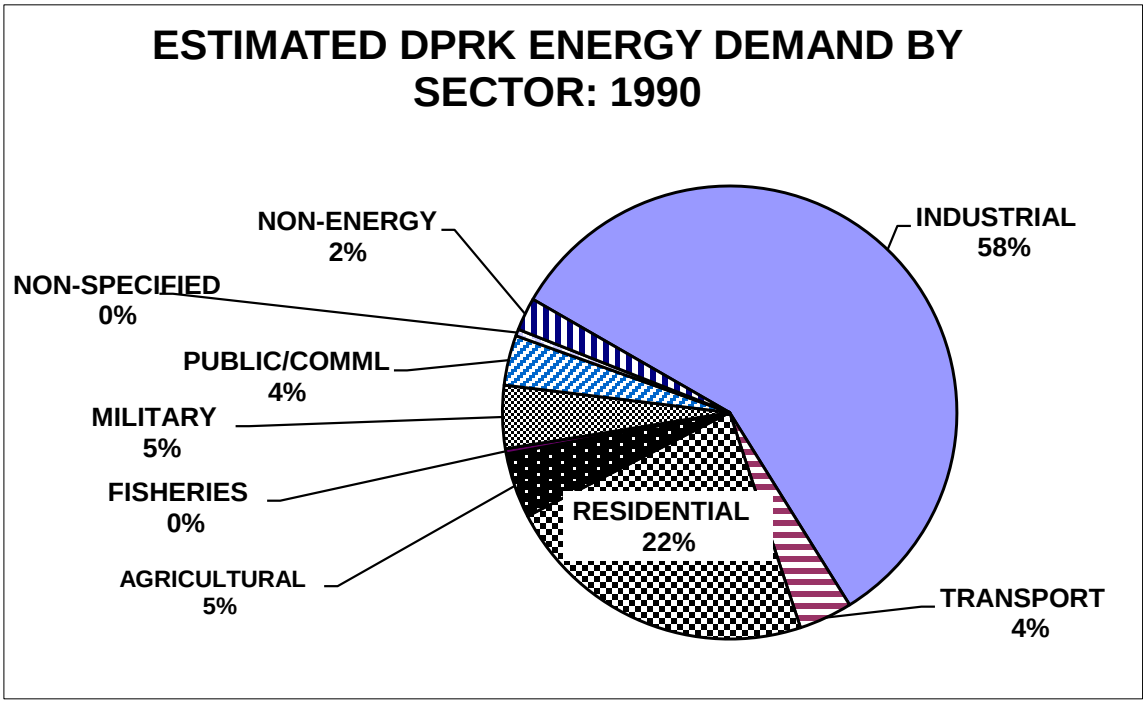

DPRK Military Energy Demand By Subsector: 2019
Total
Total
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Coal
Wood
Petr. Prod.
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

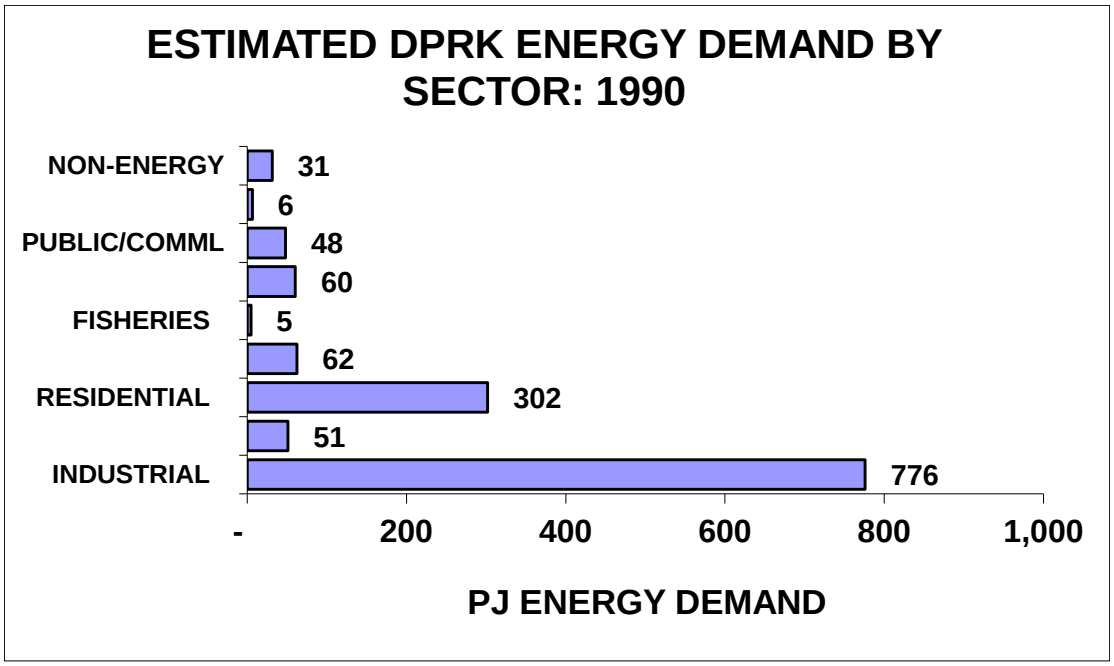

DPRK Military Energy Demand By Subsector: 2020
Total
Total
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Coal
Wood
Petr. Prod.
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)

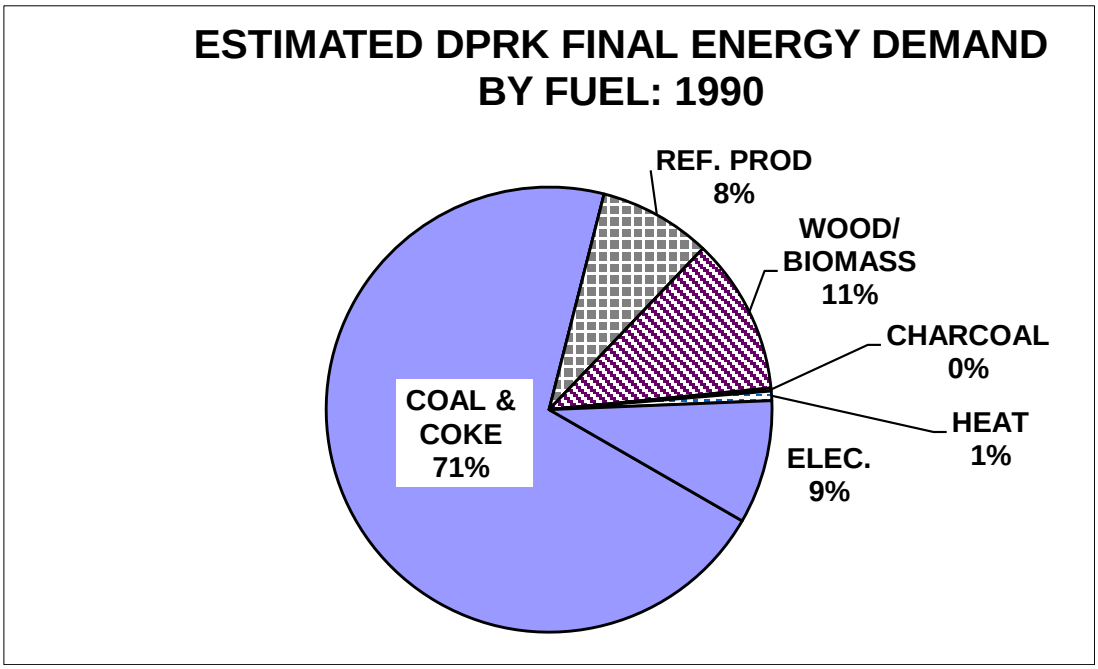

2010 DPRK Military Sector Energy Demand by Fuel
Electricity 18%
Coal 42%
Petroleum Products 22%
Wood 17%
2015 DPRK Military Sector Energy Demand by Fuel
Electricity 19%
Coal 43%
Petroleum Products 22%
Wood 15%
2014 DPRK Military Sector Energy Demand by Fuel
Electricity 18%
Coal 44%
Petroleum Products 22%
Wood 16%
2016 DPRK Military Sector Energy Demand by Fuel
Electricity 19%
Coal 44%
Petroleum Products 22%
Wood 14%

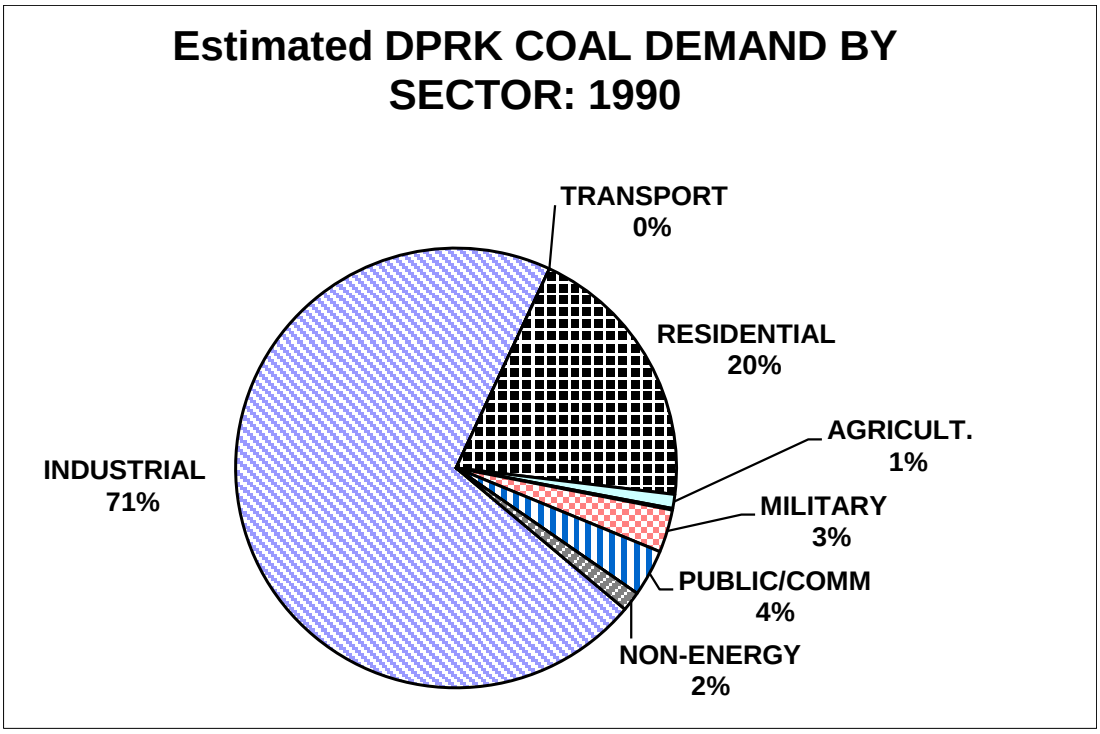

2017 DPRK Military Sector Energy Demand by Fuel
Electricity 19%
Petroleum Products 22%
Coal 45%
Wood 15%
2019 DPRK Military Sector Energy Demand by Fuel
Electricity 19%
Petroleum Products 22%
Coal 46%
Wood 15%
2018 DPRK Military Sector Energy Demand by Fuel
Electricity 19%
Petroleum Products 22%
Coal 46%
Wood 15%
2020 DPRK Military Sector Energy Demand by Fuel
Electricity 20%
Petroleum Products 22%
Coal 47%
Wood 18%

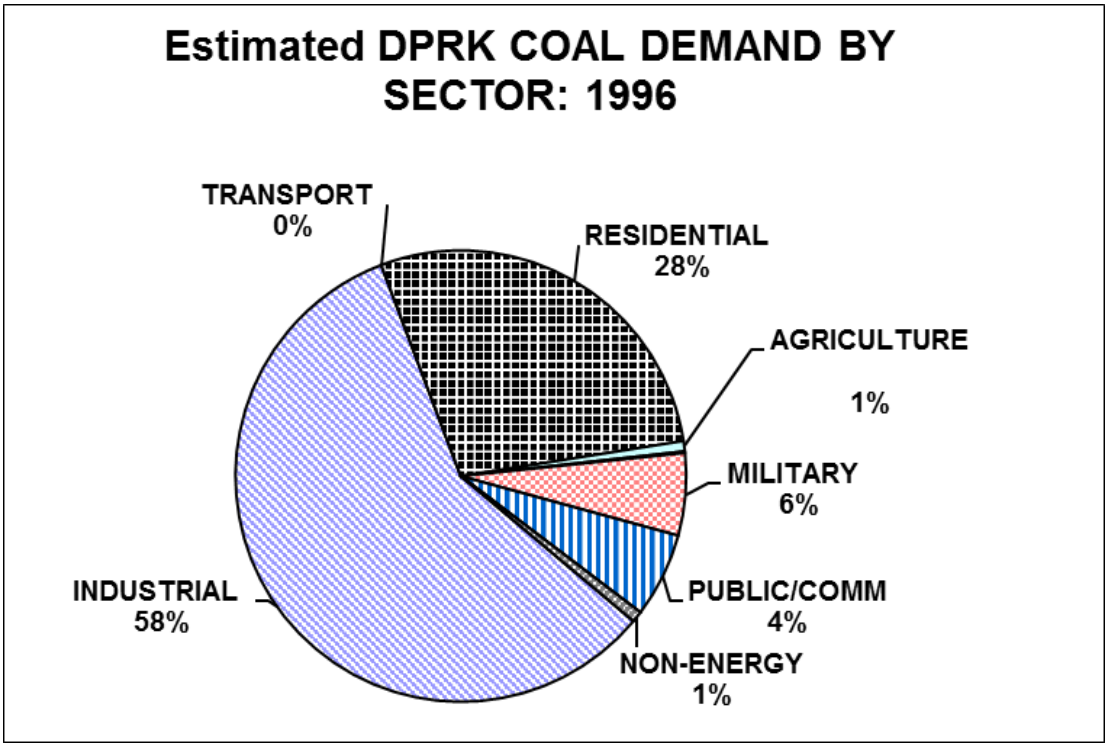

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1990
WOOD/ BIOMASS 9%
HYDRO 11%
REFINED PROD 1%
CRUDE OIL 6%
COAL & COKE 78%

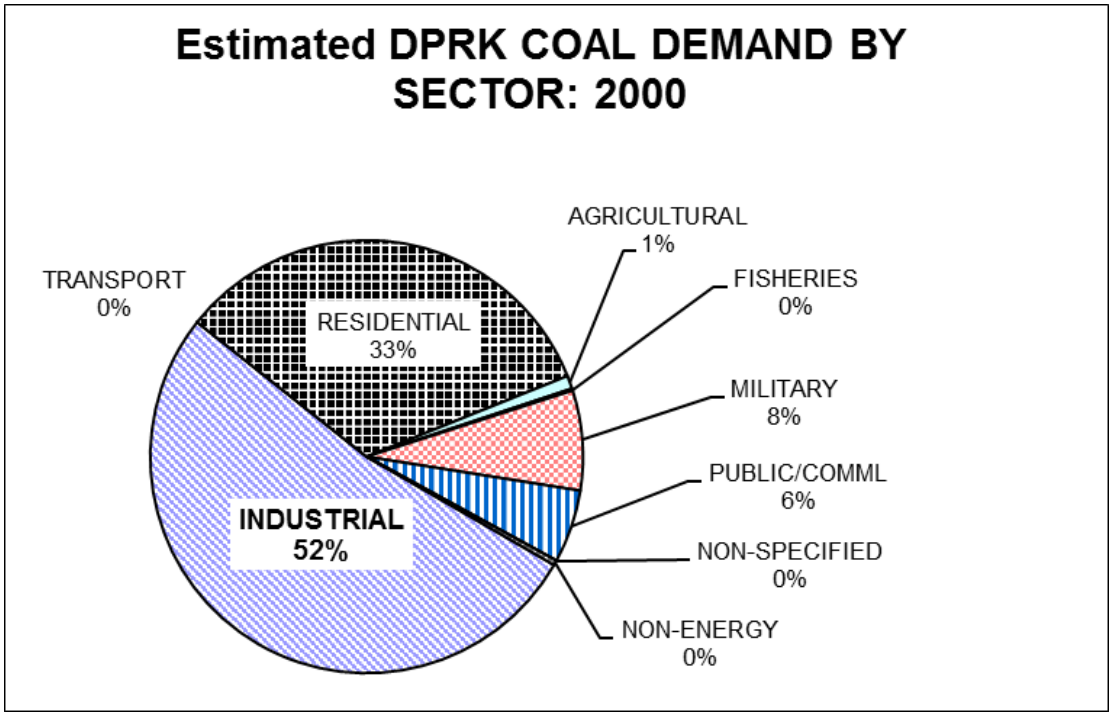

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY 2%
NON-SPECIFIED 0%
PUBLIC/COMML 4%
MILITARY 5%
FISHERIES 0%
AGRICULTURAL 5%
RESIDENTIAL 22%
INDUSTRIAL 58%
TRANSPORT 4%

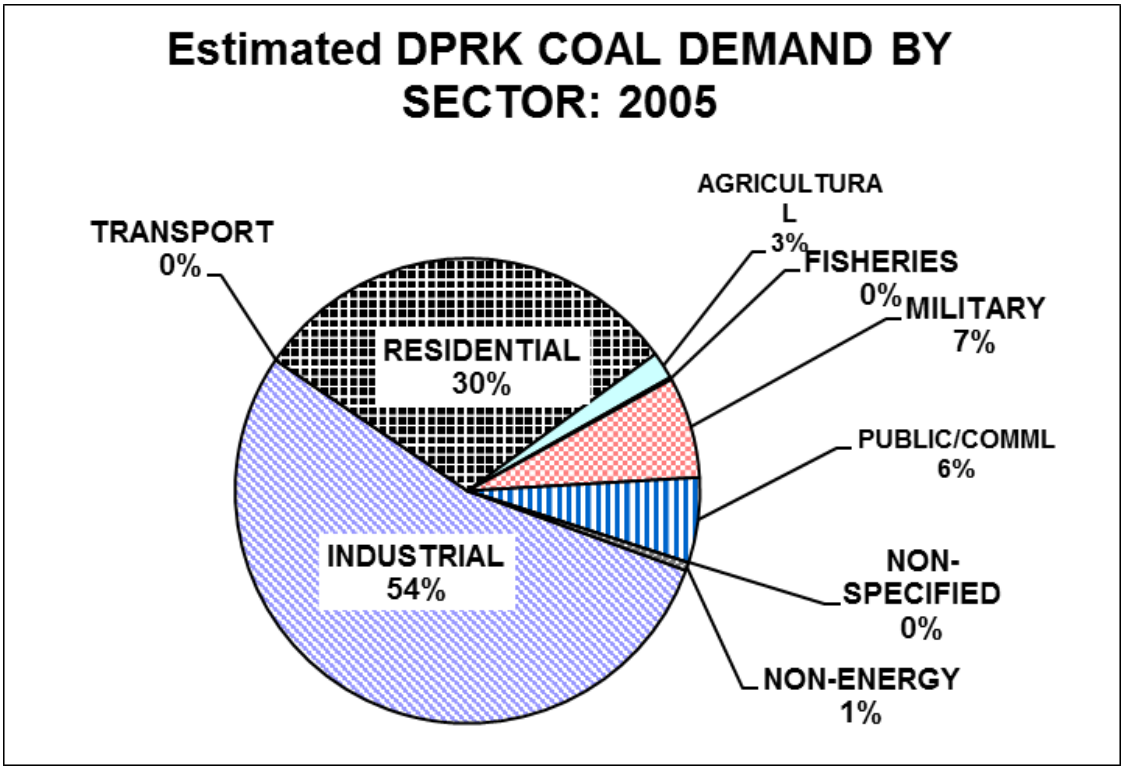

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY
31
6
PUBLIC/COMML
48
60
FISHERIES
5
62
RESIDENTIAL
302
51
INDUSTRIAL
776
-
200
400
600
800
1,000
PJ ENERGY DEMAND

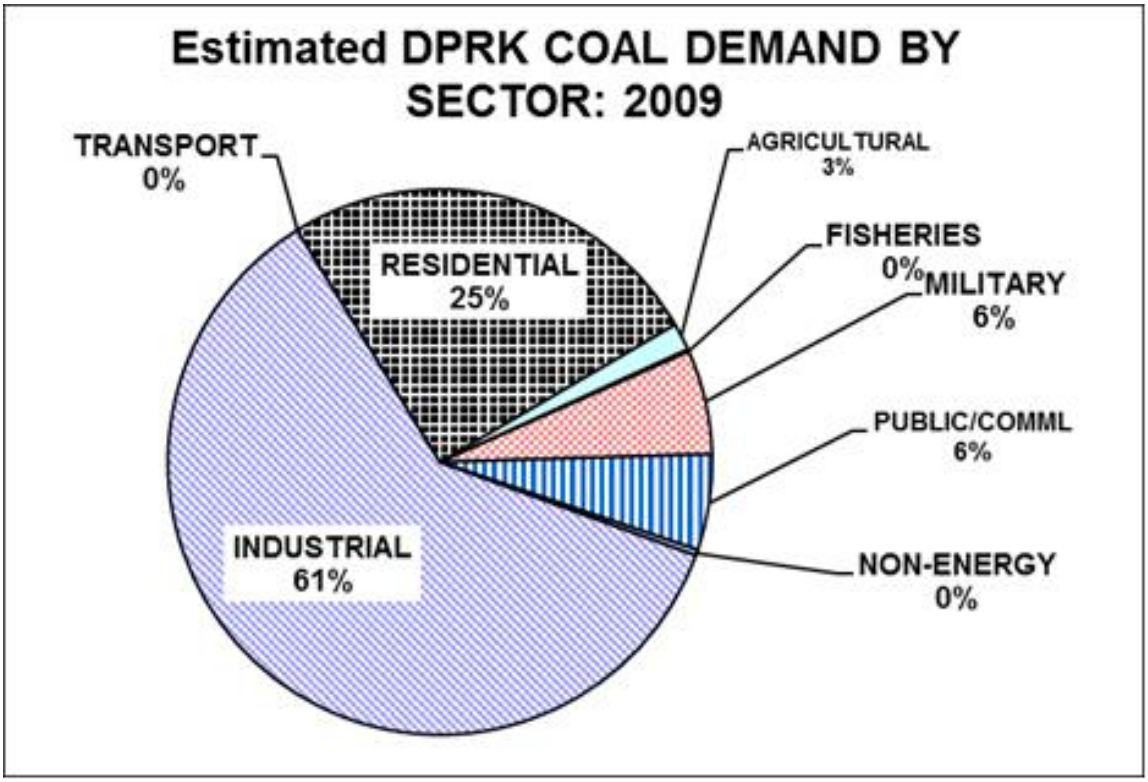

ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL: 1990
REF. PROD 8%
WOOD/ BIOMASS 11%
CHARCOAL 0%
HEAT 1%
ELEC. 9%
COAL & COKE 71%

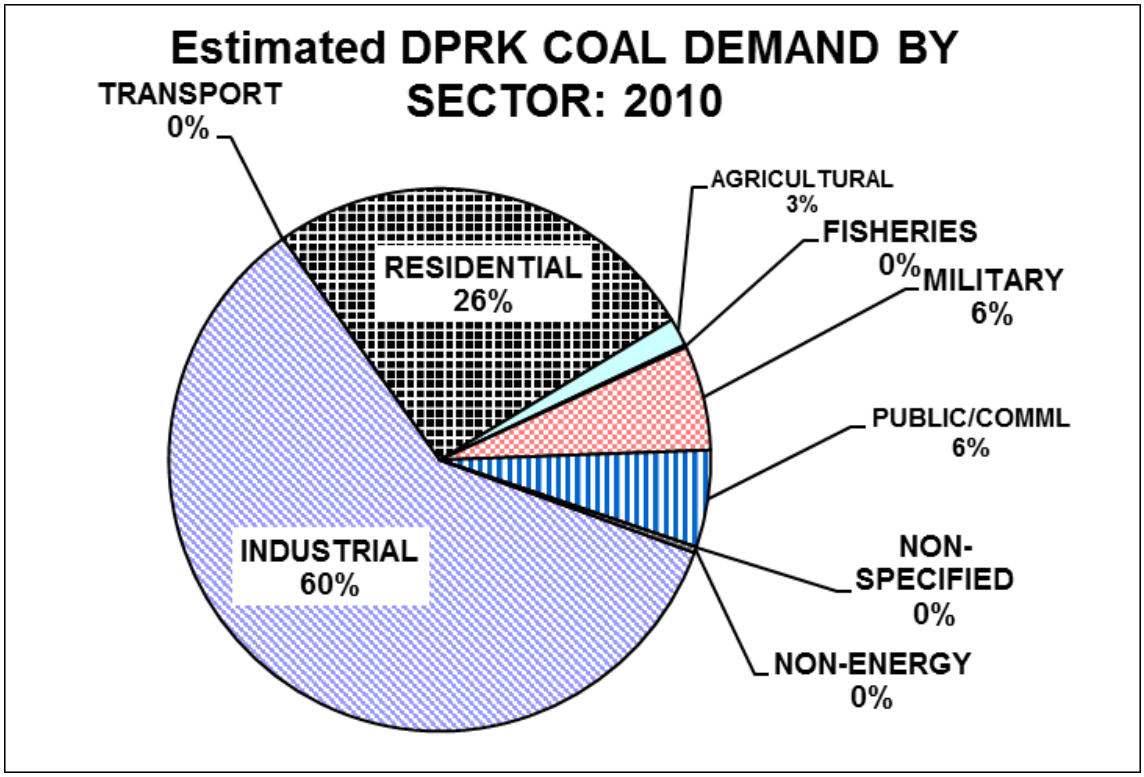

Estimated DPRK COAL DEMAND BY SECTOR: 1990
TRANSPORT 0%
RESIDENTIAL 20%
AGRICULT. 1%
MILITARY 3%
PUBLIC/COMM 4%
NON-ENERGY 2%
INDUSTRIAL 71%

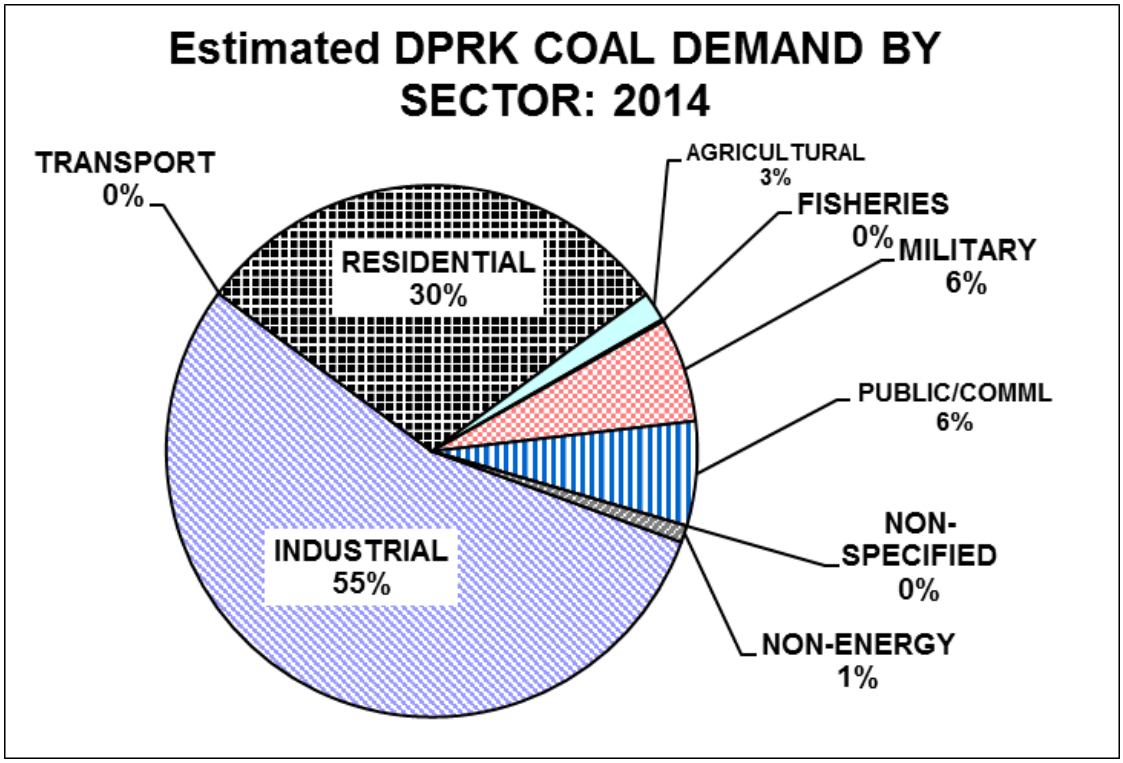

Estimated DPRK COAL DEMAND BY SECTOR: 1996
TRANSPORT 0%
RESIDENTIAL 28%
AGRICULTURE 1%
MILITARY 6%
PUBLIC/COMM 4%
NON-ENERGY 1%
INDUSTRIAL 58%

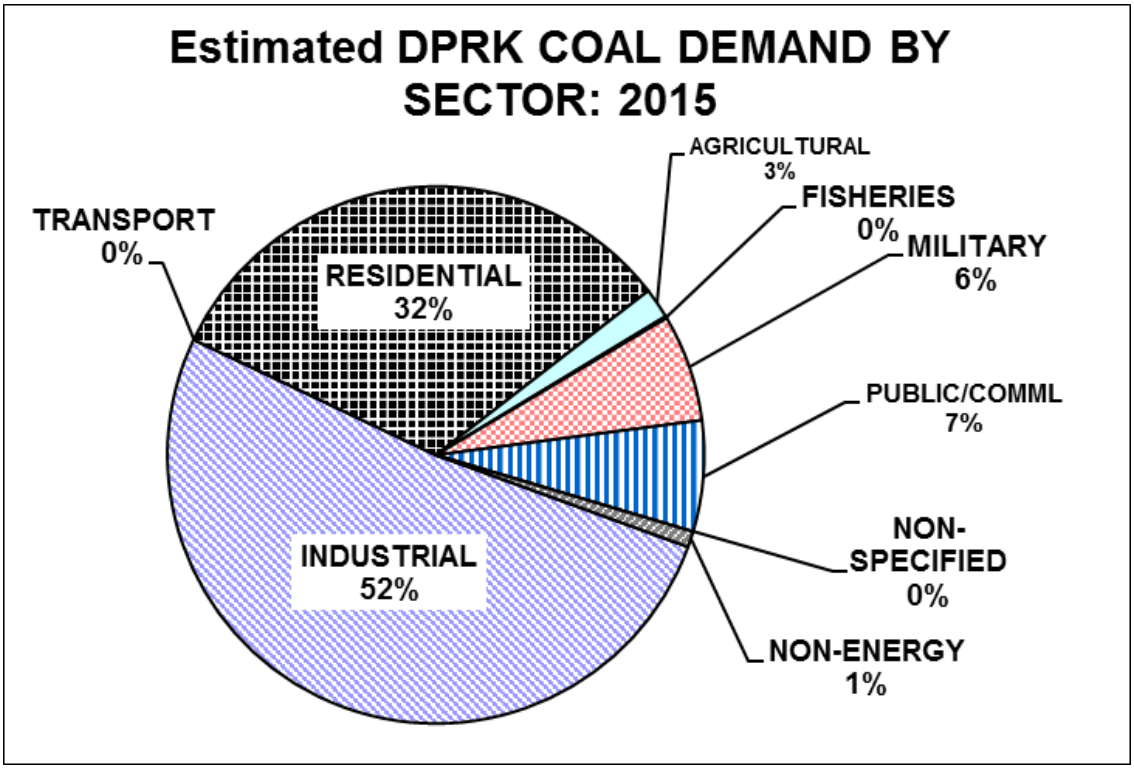

Estimated DPRK COAL DEMAND BY SECTOR: 2000
AGRICULTURAL 1%
FISHERIES 0%
MILITARY 8%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
NON-ENERGY 0%
TRANSPORT 0%
RESIDENTIAL 33%
INDUSTRIAL 52%

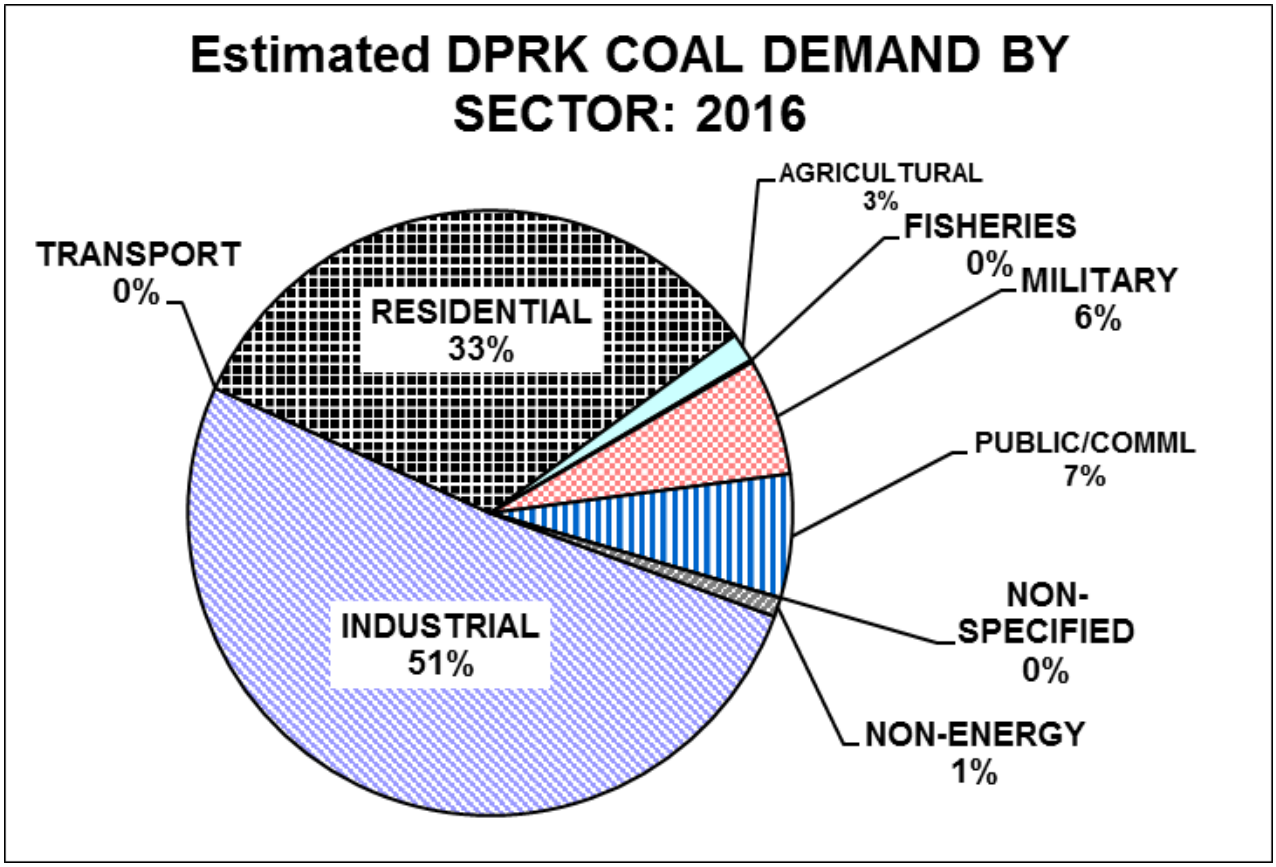

Estimated DPRK COAL DEMAND BY SECTOR: 2005
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 7%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
NON-ENERGY 1%
TRANSPORT 0%
RESIDENTIAL 30%
INDUSTRIAL 54%

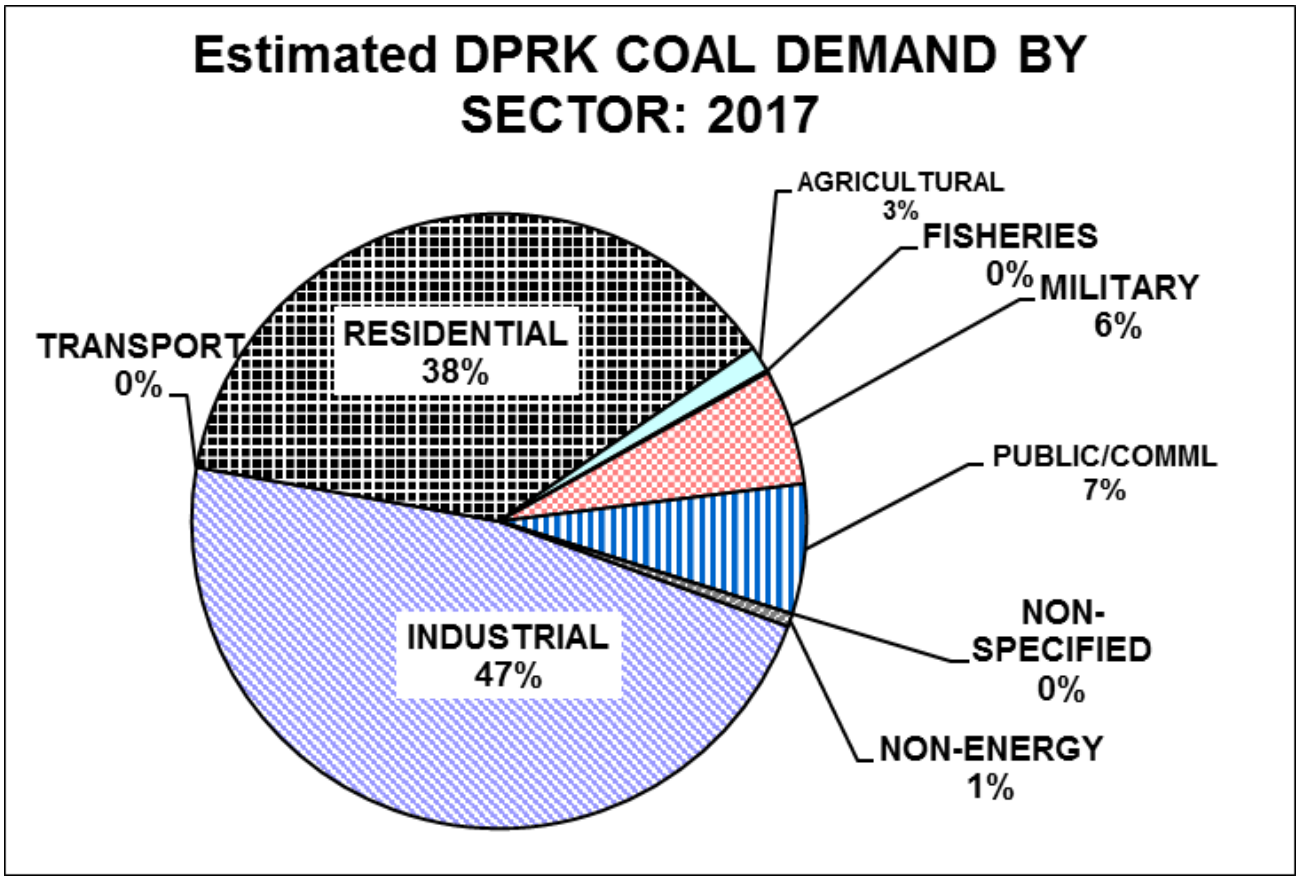

Estimated DPRK COAL DEMAND BY SECTOR: 2009
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
RESIDENTIAL 25%
PUBLIC/COMML 6%
INDUSTRIAL 61%
NON-ENERGY 0%

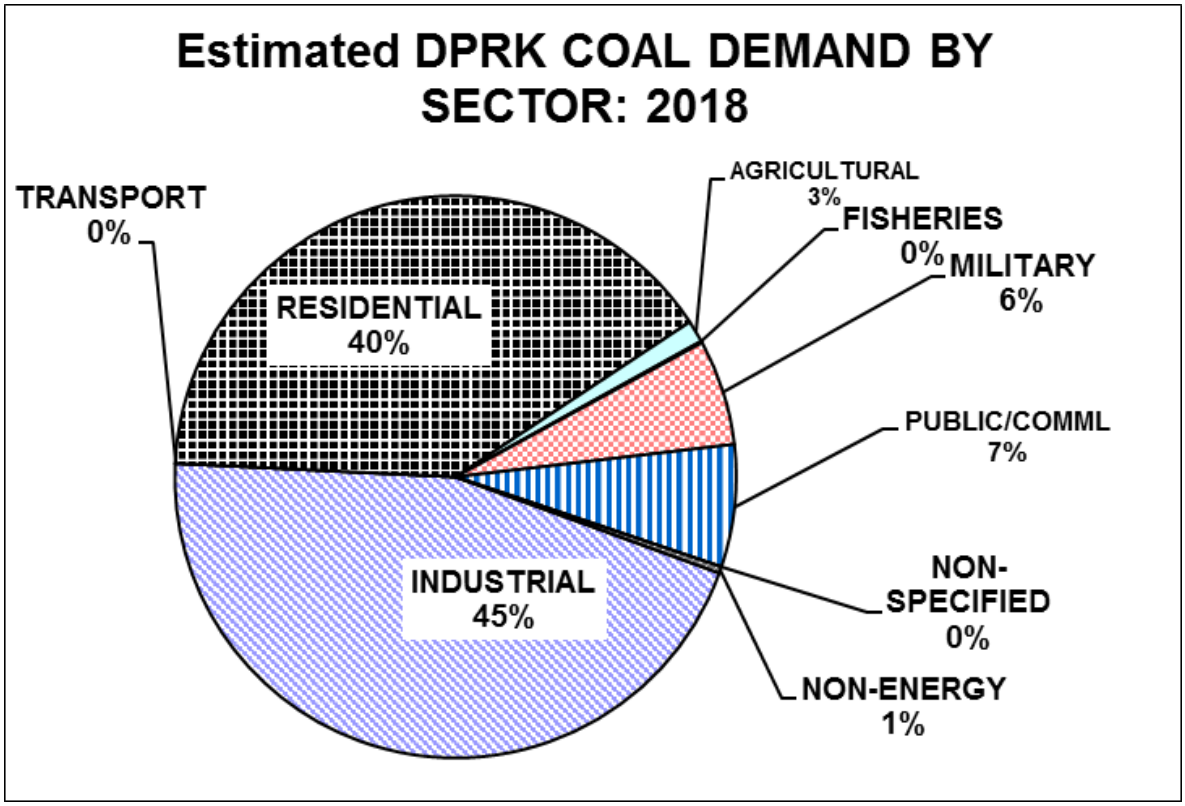

Estimated DPRK COAL DEMAND BY SECTOR: 2010
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
RESIDENTIAL 26%
PUBLIC/COMML 6%
INDUSTRIAL 60%
NON-SPECIFIED 0%
NON-ENERGY 0%

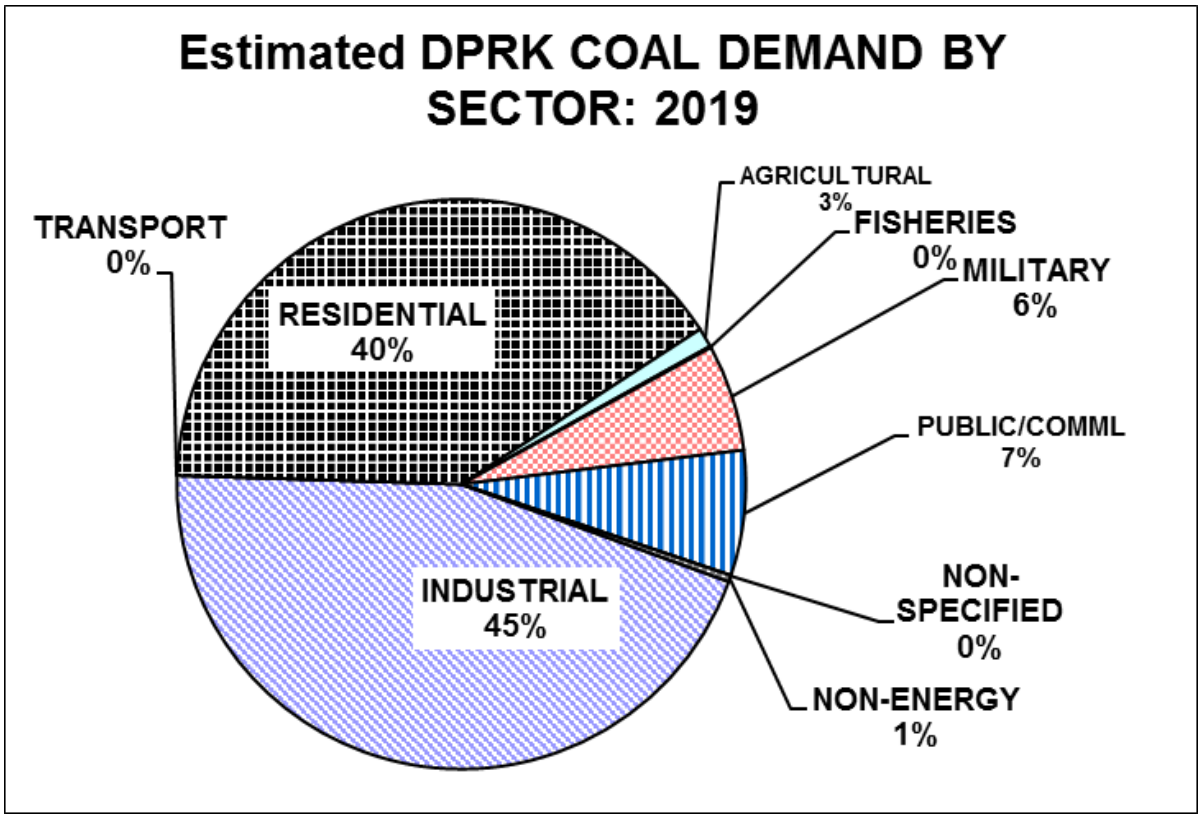

Estimated DPRK COAL DEMAND BY SECTOR: 2014
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
NON-ENERGY 1%
RESIDENTIAL 30%
INDUSTRIAL 55%

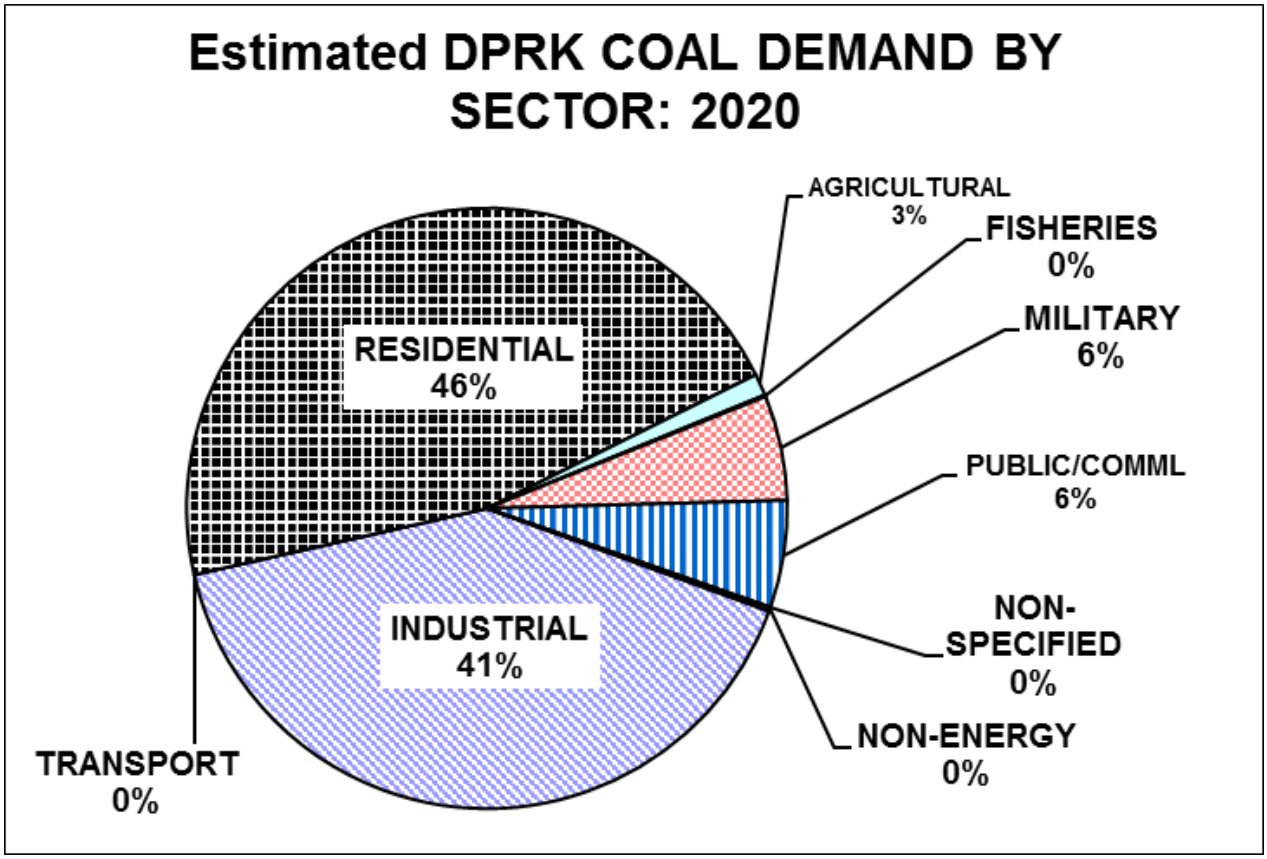

Estimated DPRK COAL DEMAND BY SECTOR: 2015
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
NON-ENERGY 1%
RESIDENTIAL 32%
INDUSTRIAL 52%

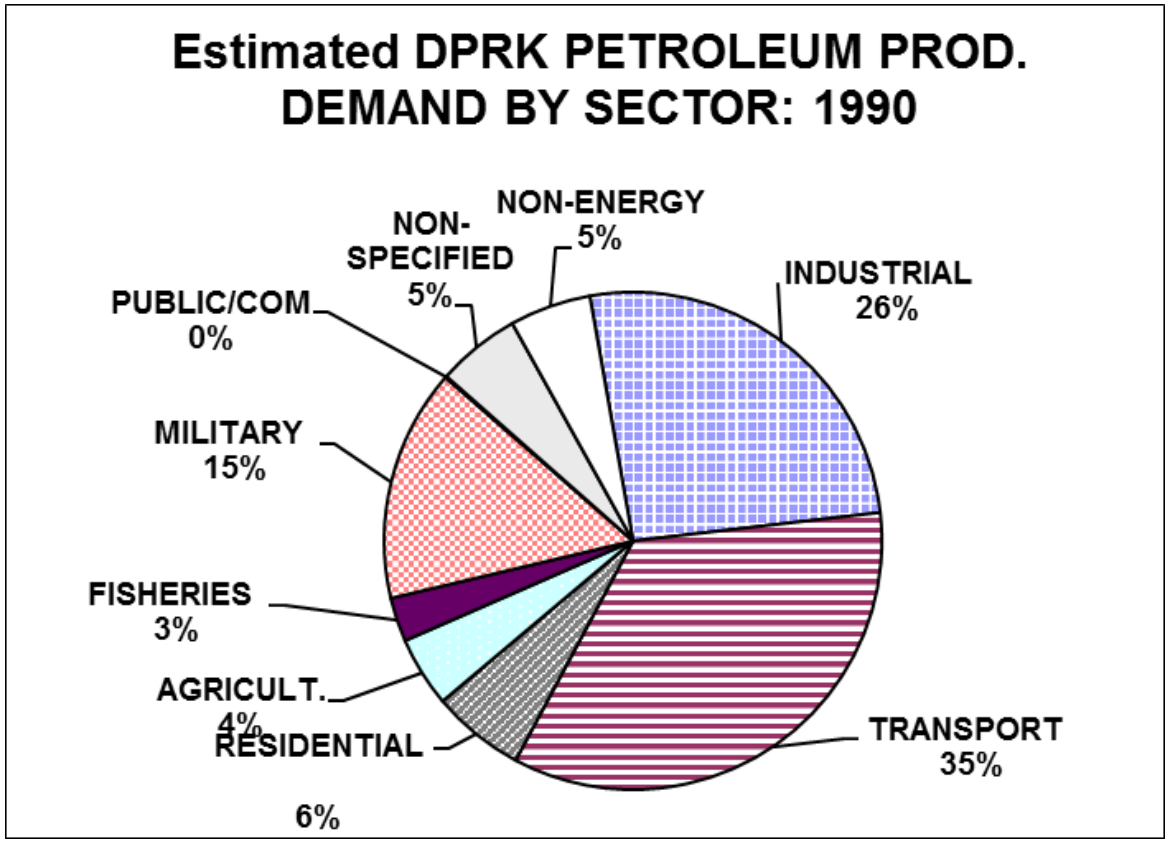

Estimated DPRK COAL DEMAND BY SECTOR: 2016
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
NON-ENERGY 1%
TRANSPORT 0%
RESIDENTIAL 33%
INDUSTRIAL 51%

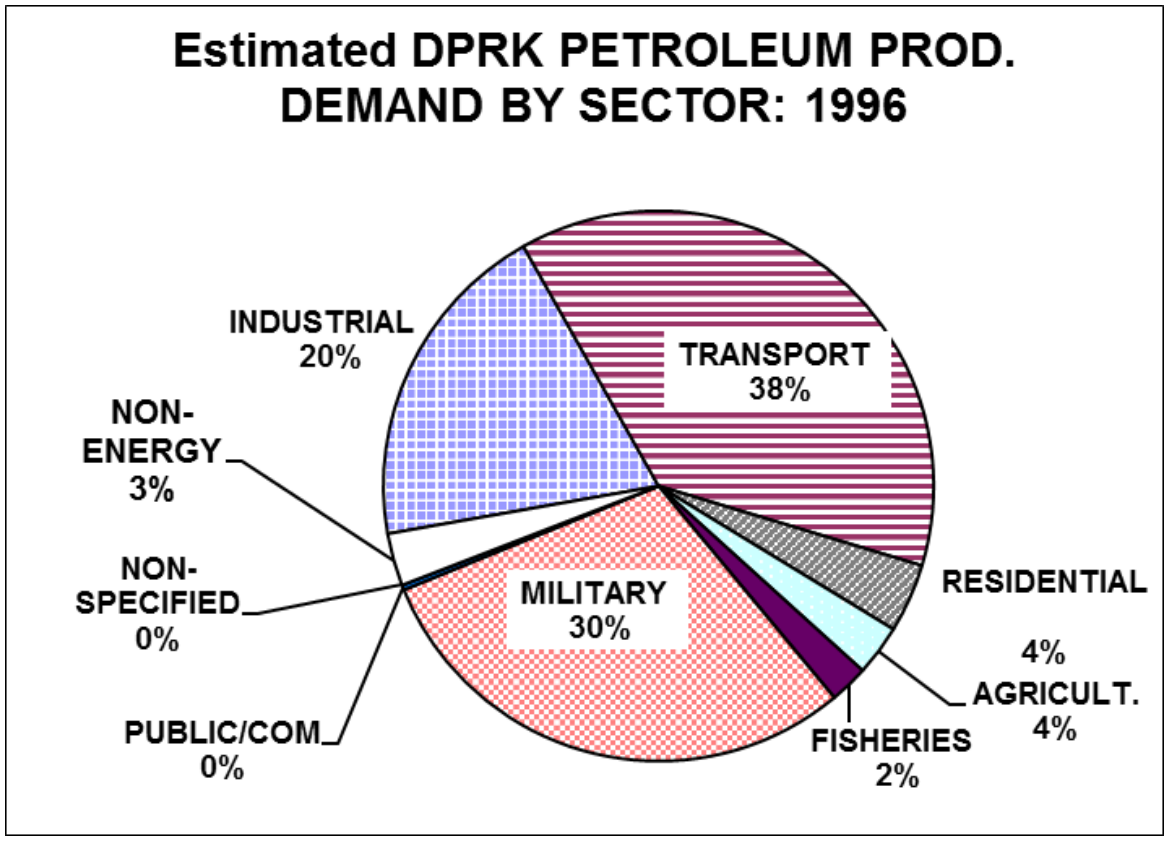

Estimated DPRK COAL DEMAND BY SECTOR: 2017
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
NON-ENERGY 1%
TRANSPORT 0%
RESIDENTIAL 38%
INDUSTRIAL 47%

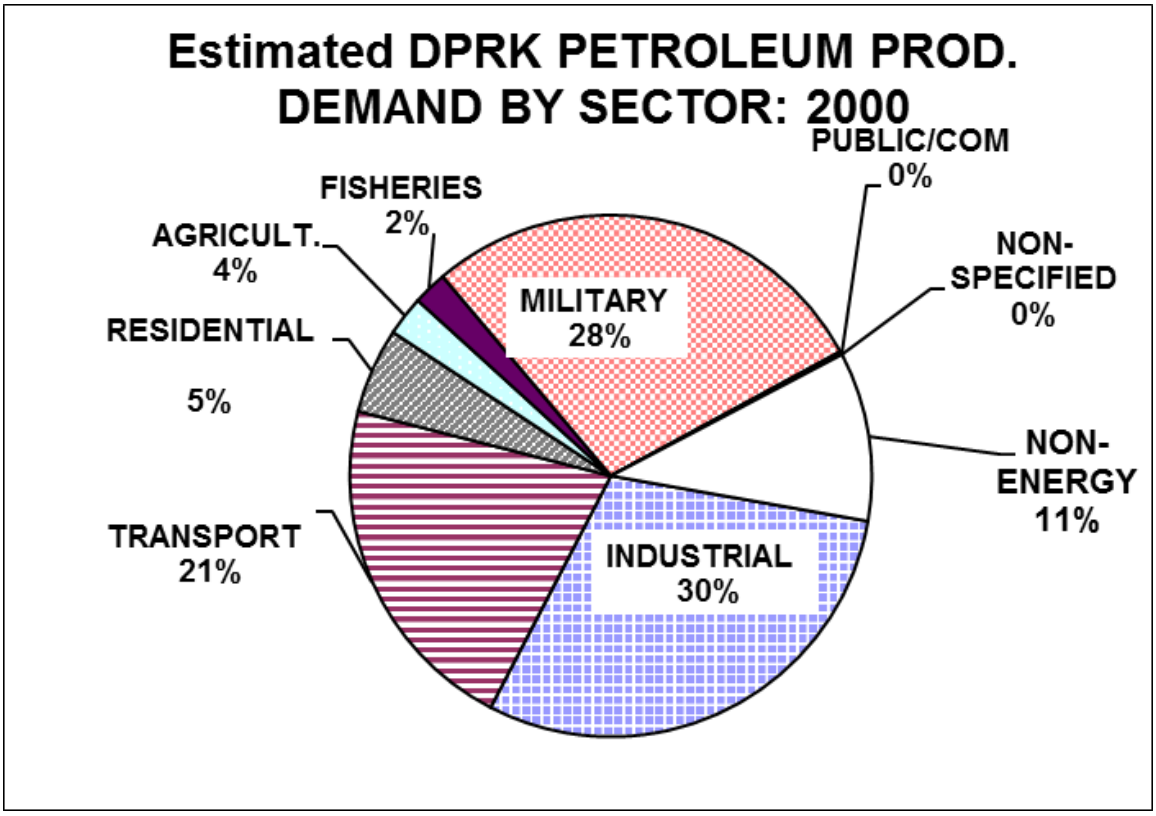

Estimated DPRK COAL DEMAND BY SECTOR: 2018
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
RESIDENTIAL 40%
PUBLIC/COMML 7%
INDUSTRIAL 45%
NON-SPECIFIED 0%
NON-ENERGY 1%

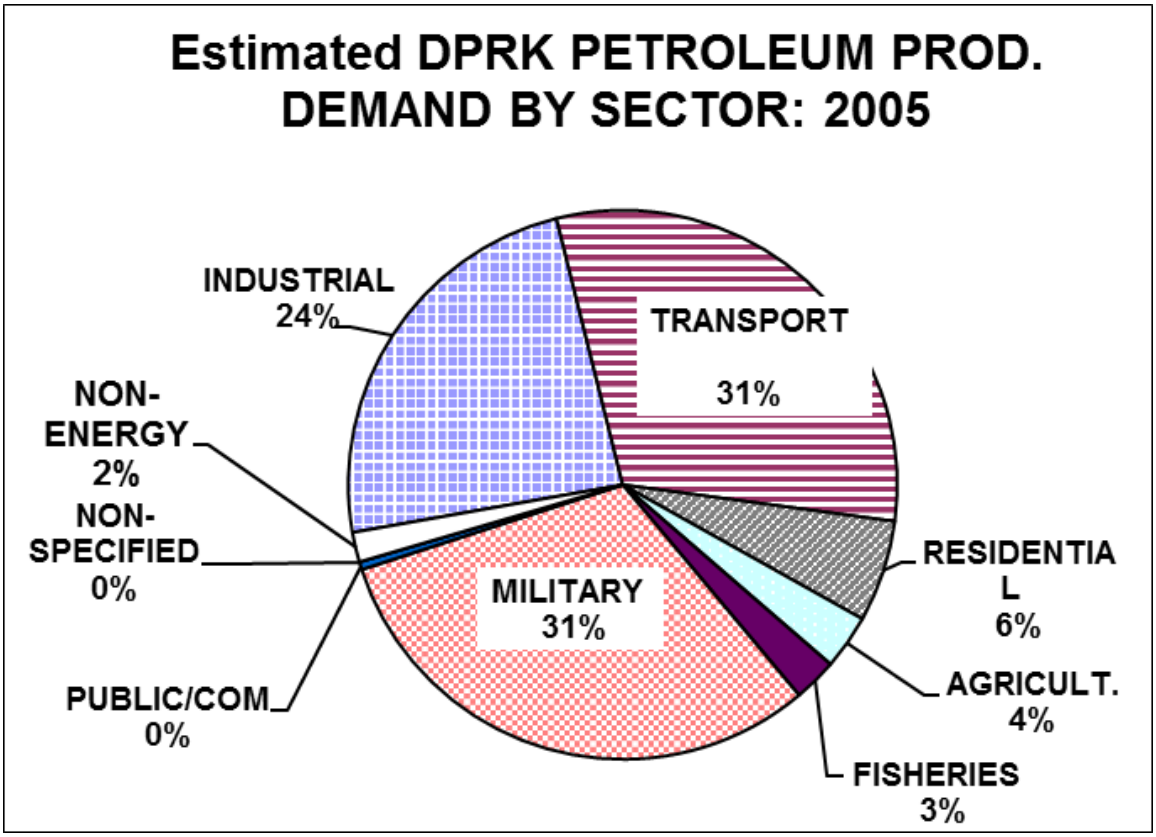

Estimated DPRK COAL DEMAND BY SECTOR: 2019
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
RESIDENTIAL 40%
PUBLIC/COMML 7%
INDUSTRIAL 45%
NON-SPECIFIED 0%
NON-ENERGY 1%

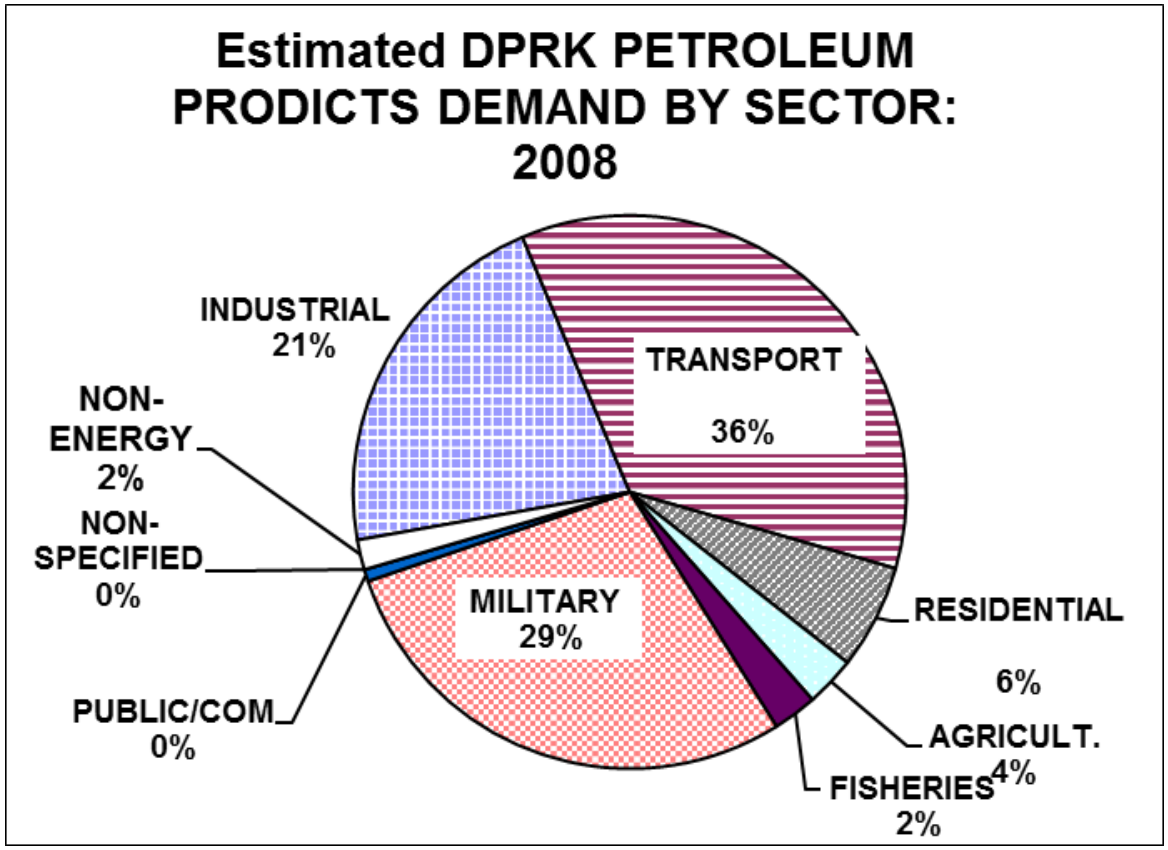

Estimated DPRK COAL DEMAND BY SECTOR: 2020
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 6%
PUBLIC/COMML 6%
NON-SPECIFIED 0%
NON-ENERGY 0%
TRANSPORT 0%
INDUSTRIAL 41%
RESIDENTIAL 46%

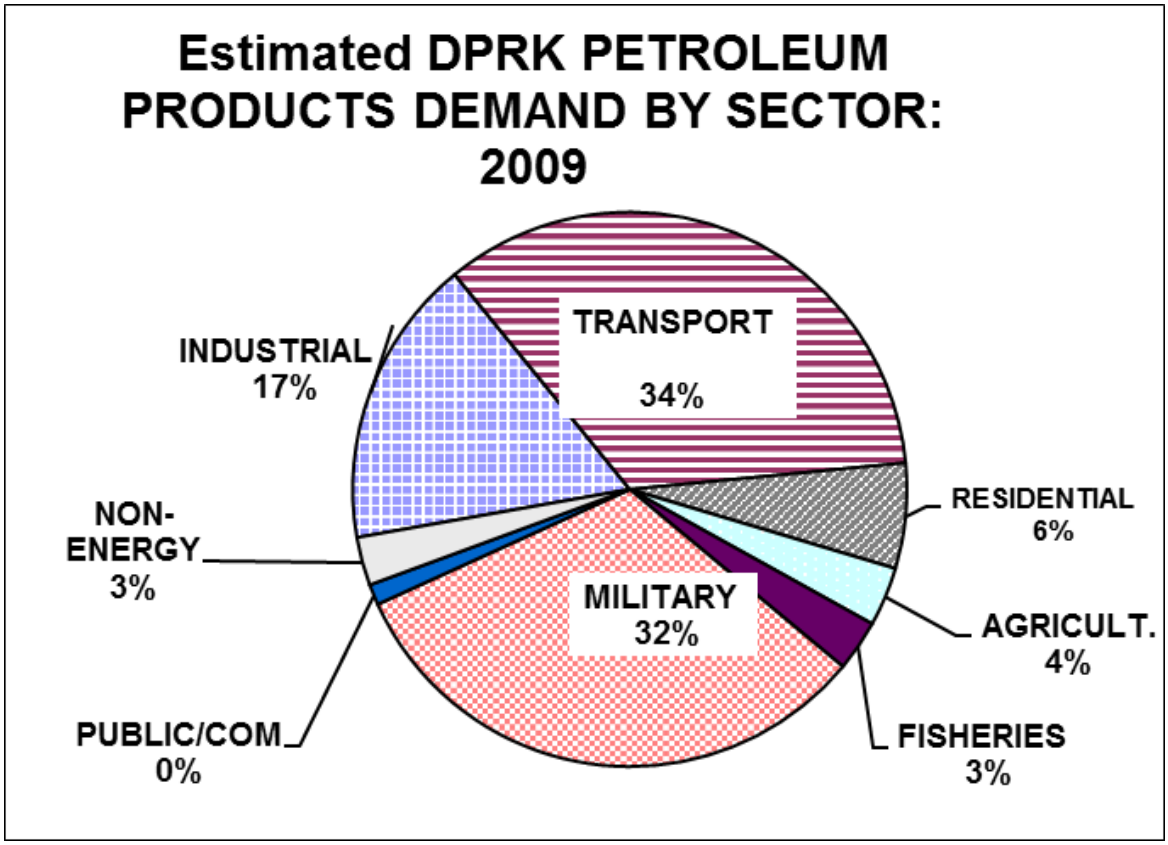

Estimated DPRK PETROLEUM PROD.
DEMAND BY SECTOR: 1990
NON-ENERGY
5%
NON-
SPECIFIED
5%
INDUSTRIAL
26%
PUBLIC/COM
0%
MILITARY
15%
FISHERIES
3%
AGRICULT.
4%
RESIDENTIAL
6%
TRANSPORT
35%

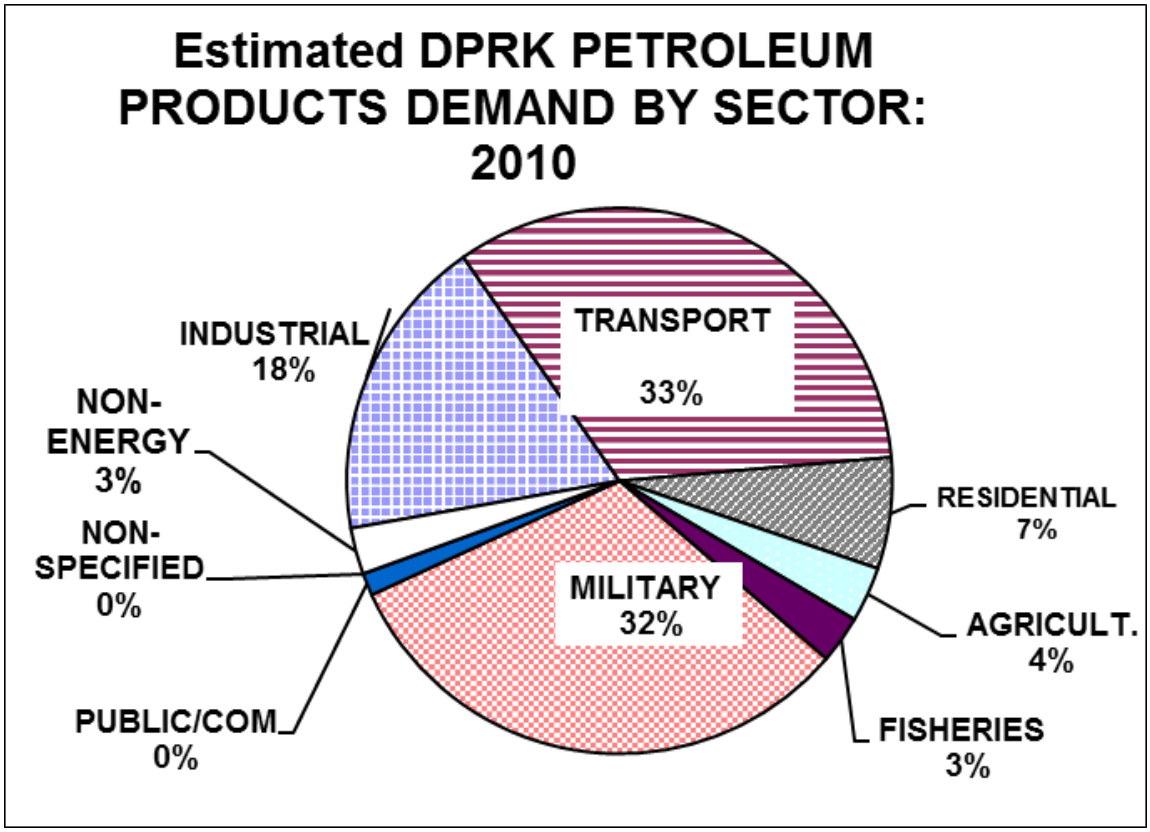

Estimated DPRK PETROLEUM PROD.
DEMAND BY SECTOR: 1996
INDUSTRIAL
20%
TRANSPORT
38%
NON-
ENERGY
3%
NON-
SPECIFIED
0%
MILITARY
30%
RESIDENTIAL
4%
AGRICULT.
4%
PUBLIC/COM
0%
FISHERIES
2%

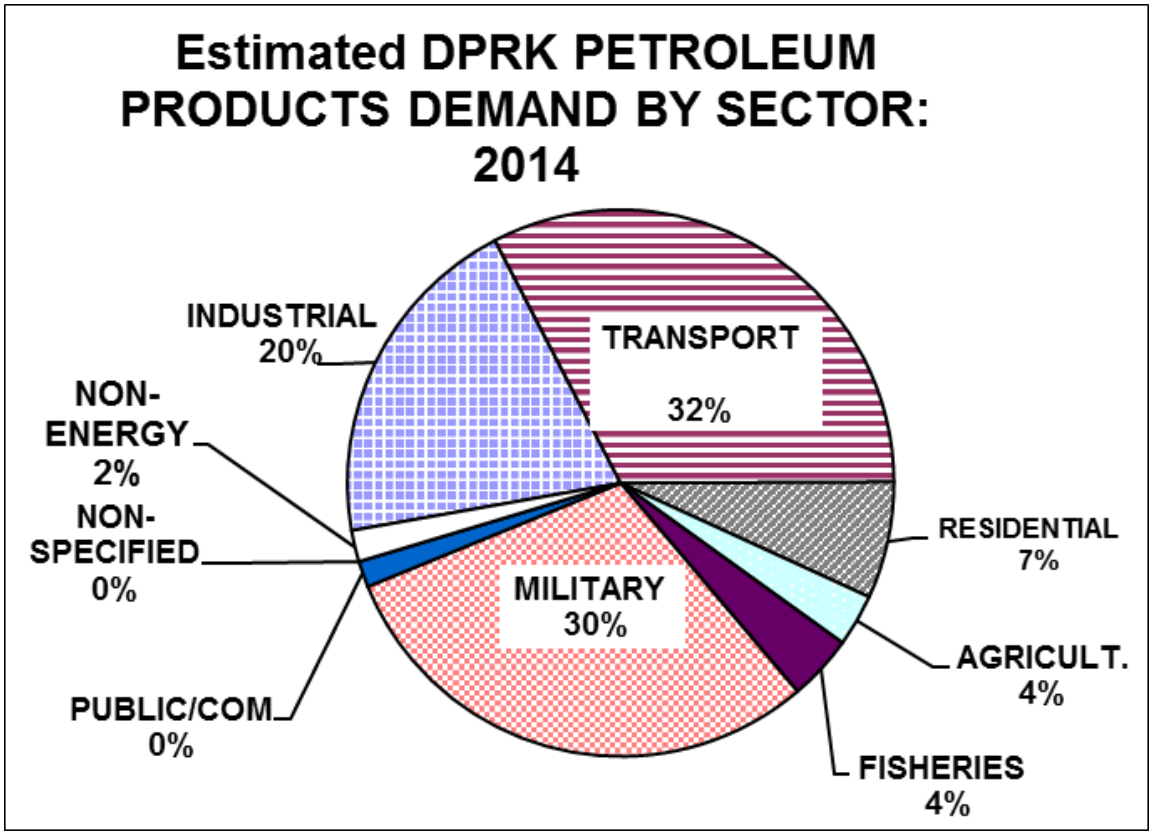

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2000
PUBLIC/COM 0%
FISHERIES 2%
AGRICULT. 4%
NON-SPECIFIED 0%
MILITARY 28%
RESIDENTIAL 5%
NON-ENERGY 11%
TRANSPORT 21%
INDUSTRIAL 30%

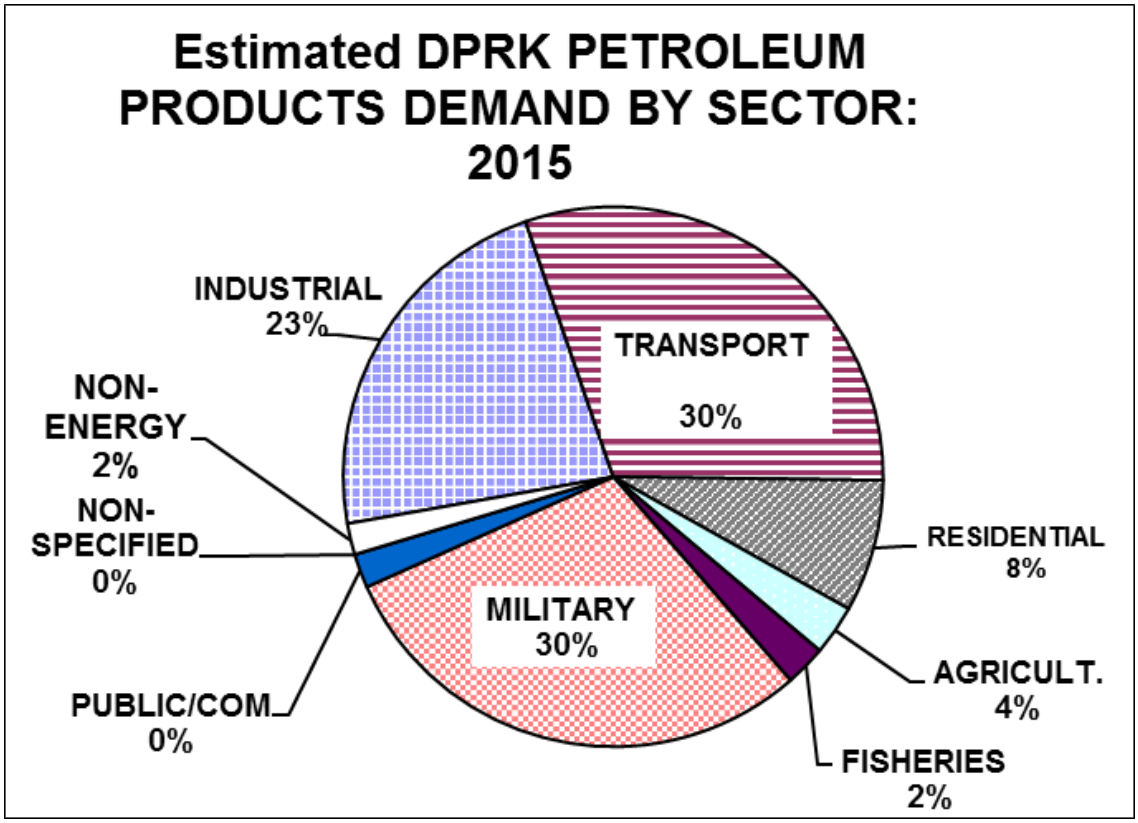

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2005
INDUSTRIAL 24%
TRANSPORT 31%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 31%
RESIDENTIAL 6%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 3%

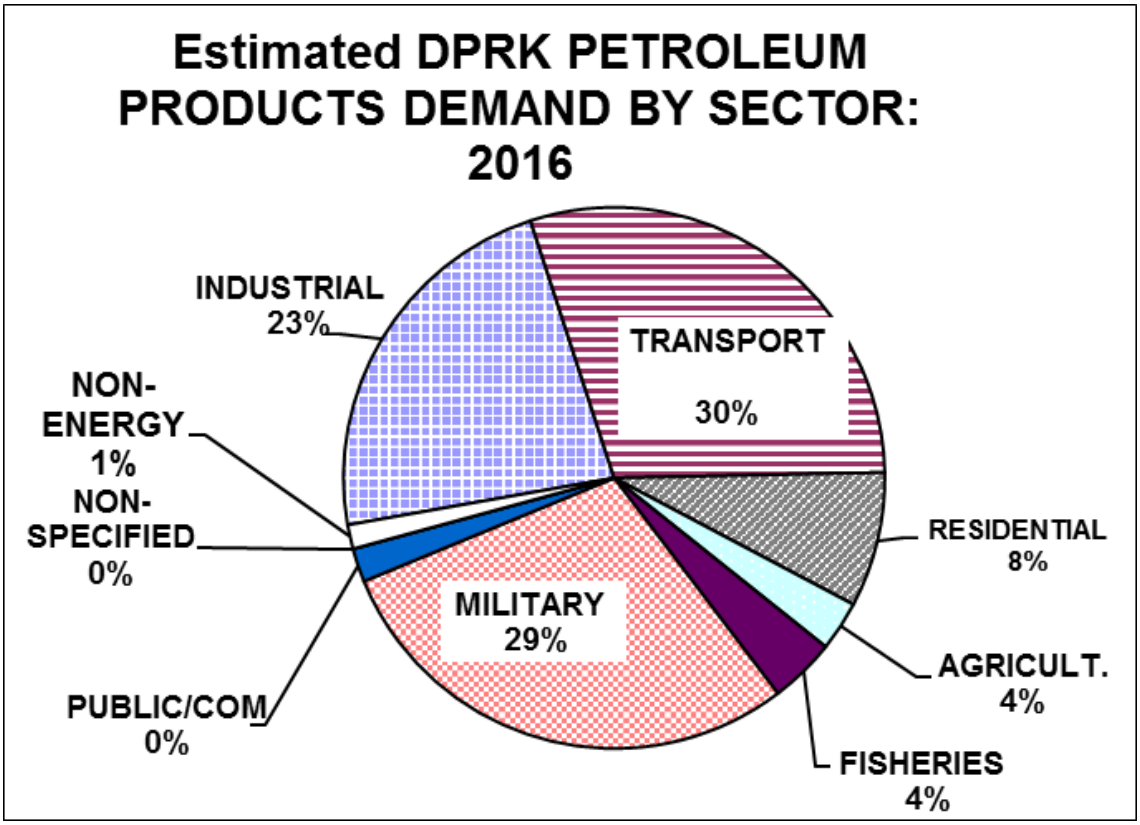

Estimated DPRK PETROLEUM PRODICTS DEMAND BY SECTOR: 2008
INDUSTRIAL 21%
TRANSPORT 36%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 29%
RESIDENTIAL 6%
PUBLIC/COM 0%
AGRICULT. 4%
FISHERIES 2%

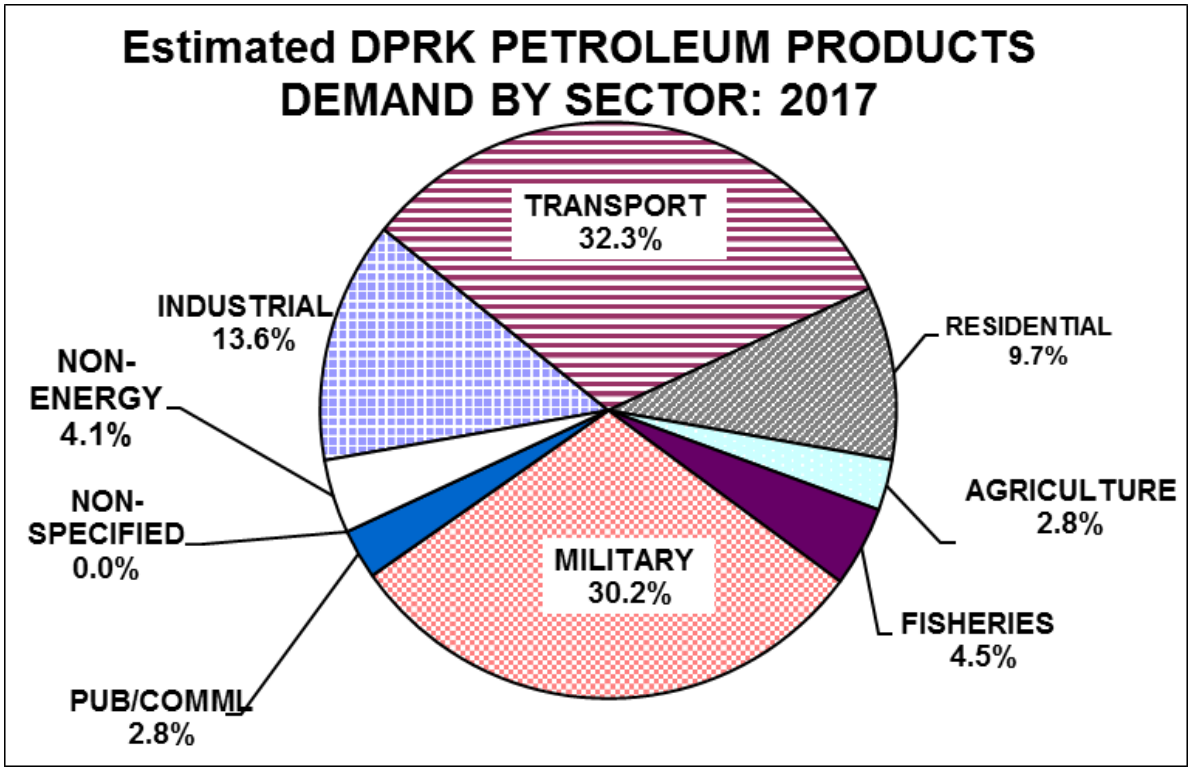

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2009
TRANSPORT 34%
INDUSTRIAL 17%
RESIDENTIAL 6%
NON-ENERGY 3%
MILITARY 32%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 3%

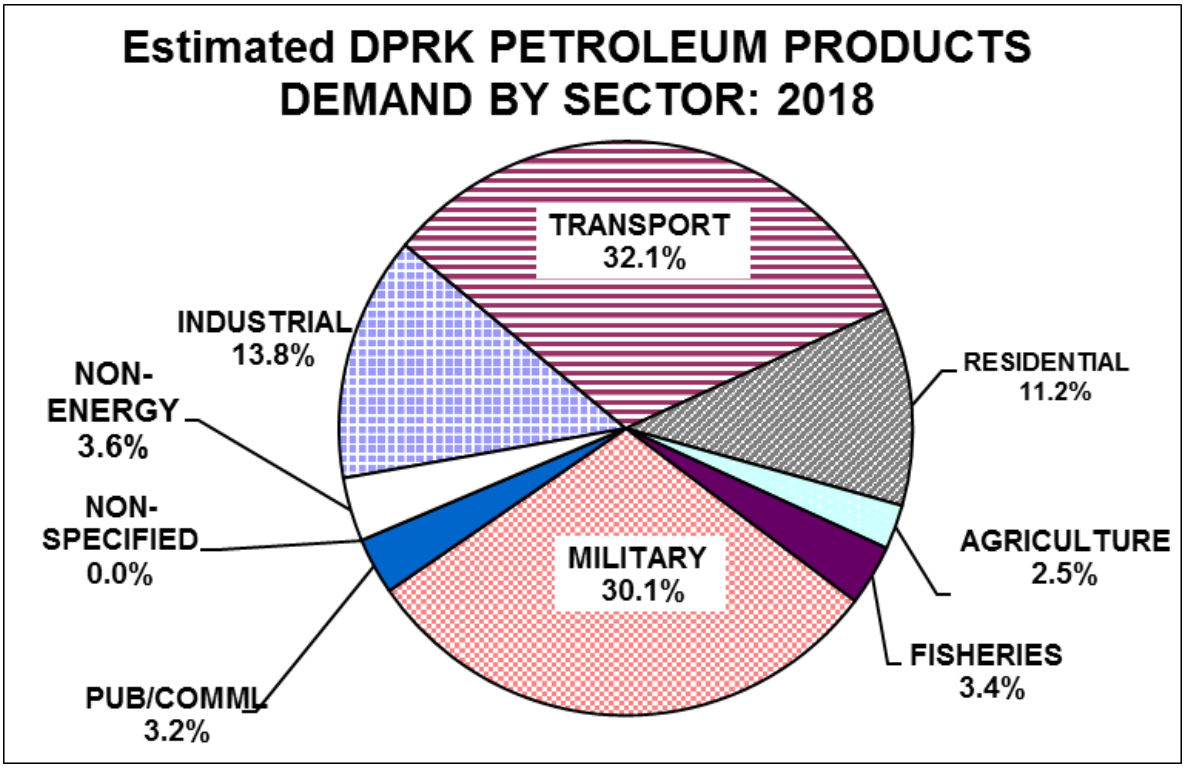

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2010
TRANSPORT 33%
INDUSTRIAL 18%
NON-ENERGY 3%
NON-SPECIFIED 0%
PUBLIC/COM 0%
MILITARY 32%
RESIDENTIAL 7%
AGRICULT. 4%
FISHERIES 3%

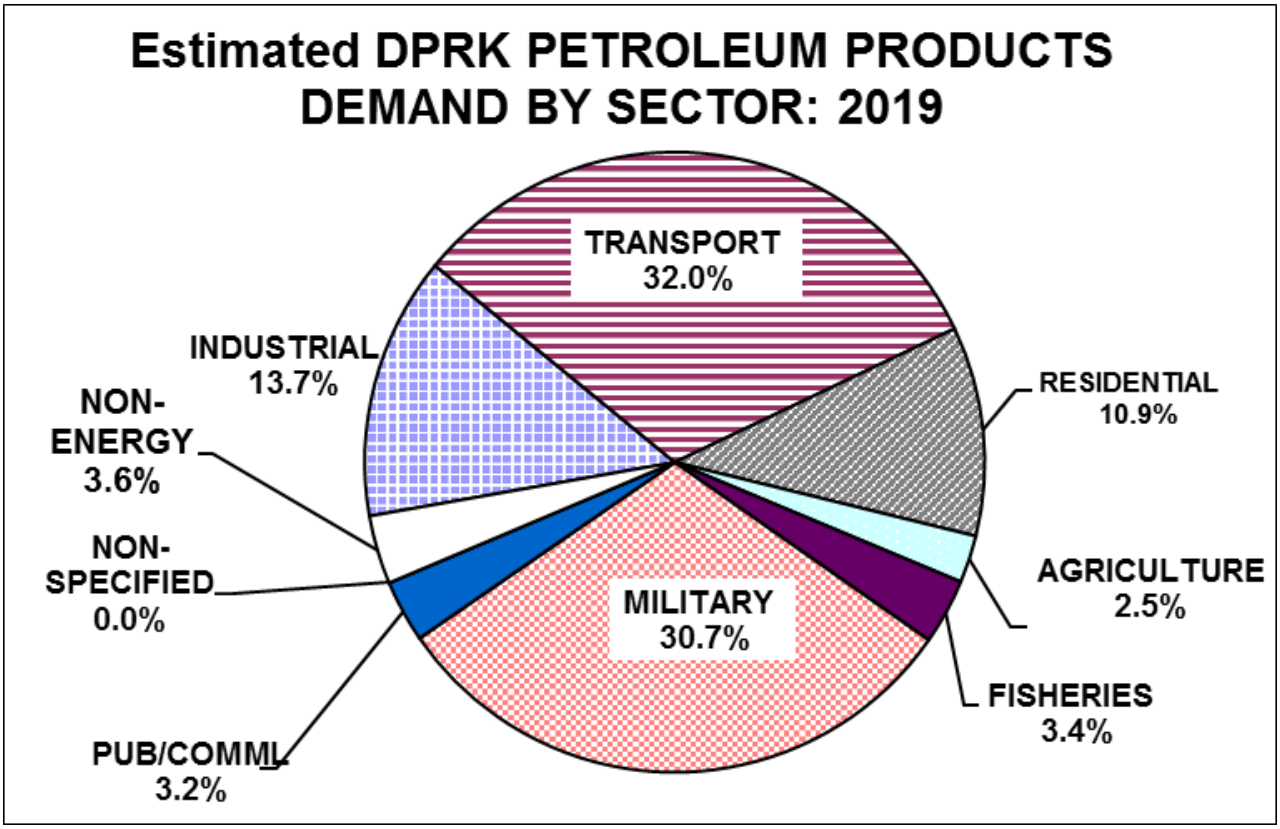

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2014
TRANSPORT 32%
INDUSTRIAL 20%
NON-ENERGY 2%
NON-SPECIFIED 0%
PUBLIC/COM 0%
MILITARY 30%
RESIDENTIAL 7%
AGRICULT. 4%
FISHERIES 4%

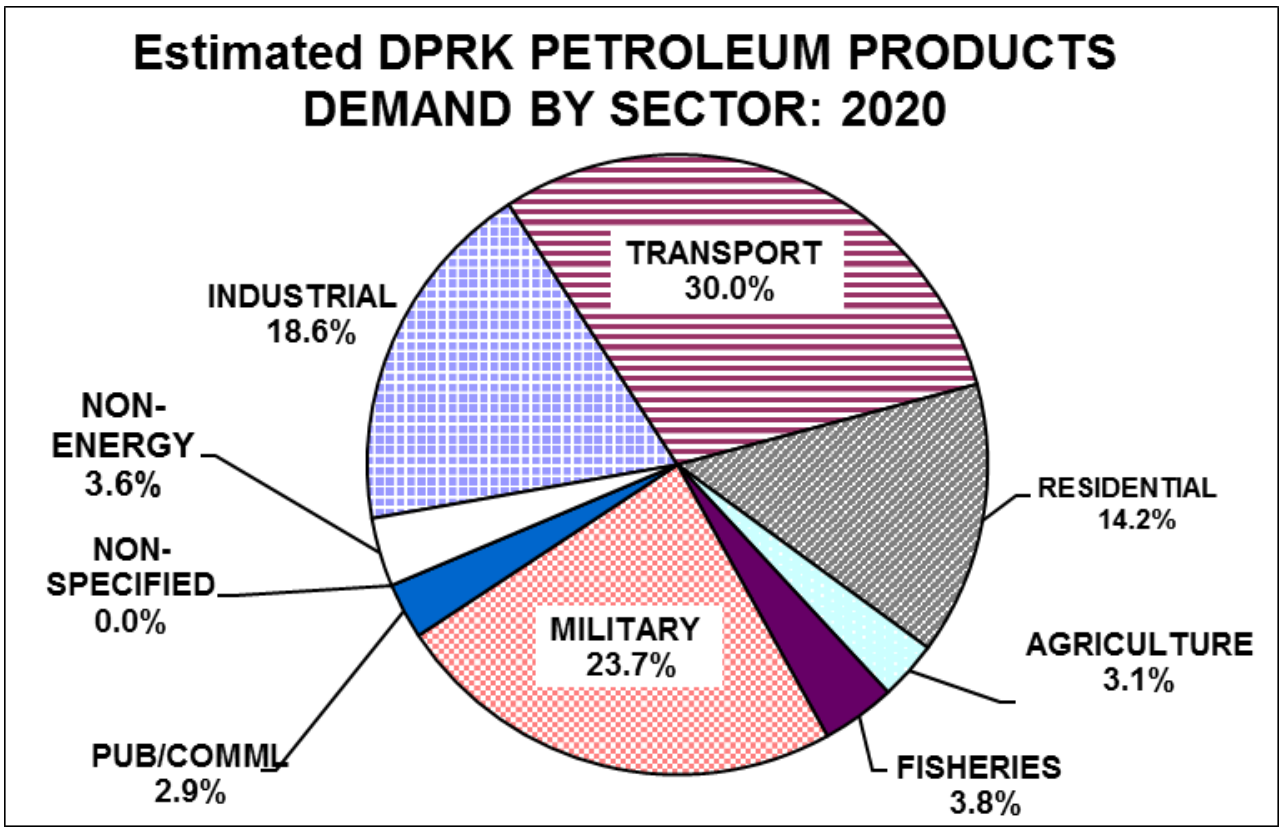

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2015
INDUSTRIAL 23%
TRANSPORT 30%
NON-ENERGY 2%
NON-SPECIFIED 0%
RESIDENTIAL 8%
MILITARY 30%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 2%

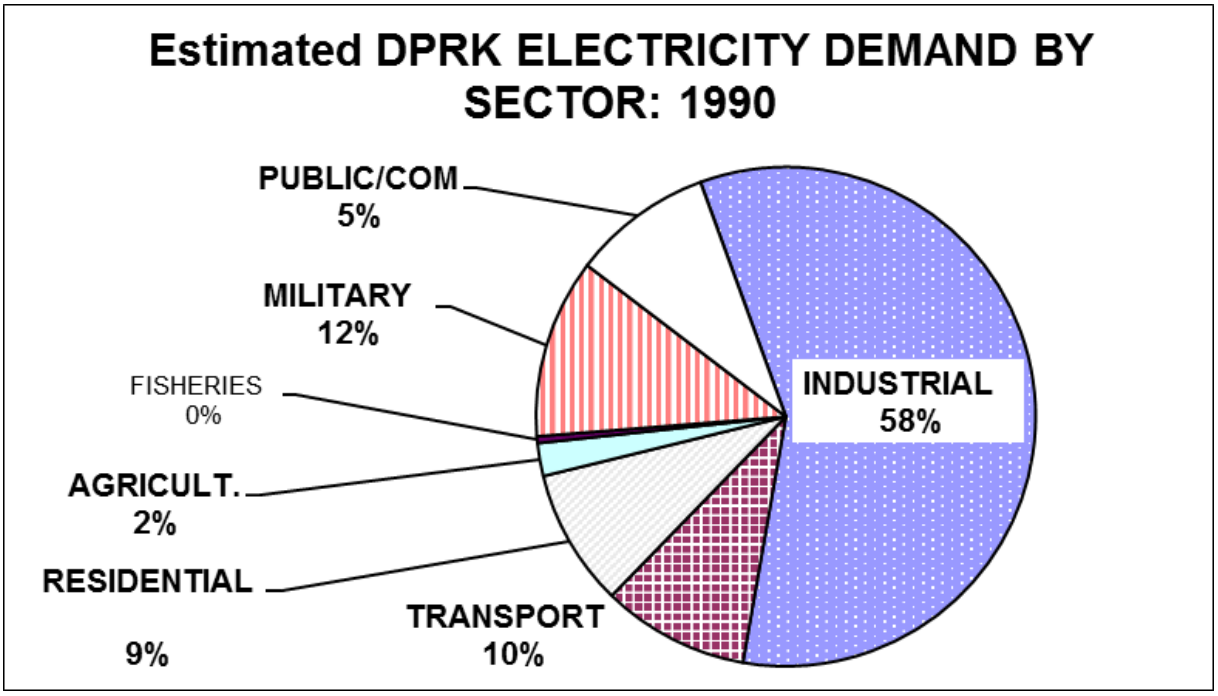

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2016
INDUSTRIAL 23%
TRANSPORT 30%
NON-ENERGY 1%
NON-SPECIFIED 0%
RESIDENTIAL 8%
MILITARY 29%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 4%

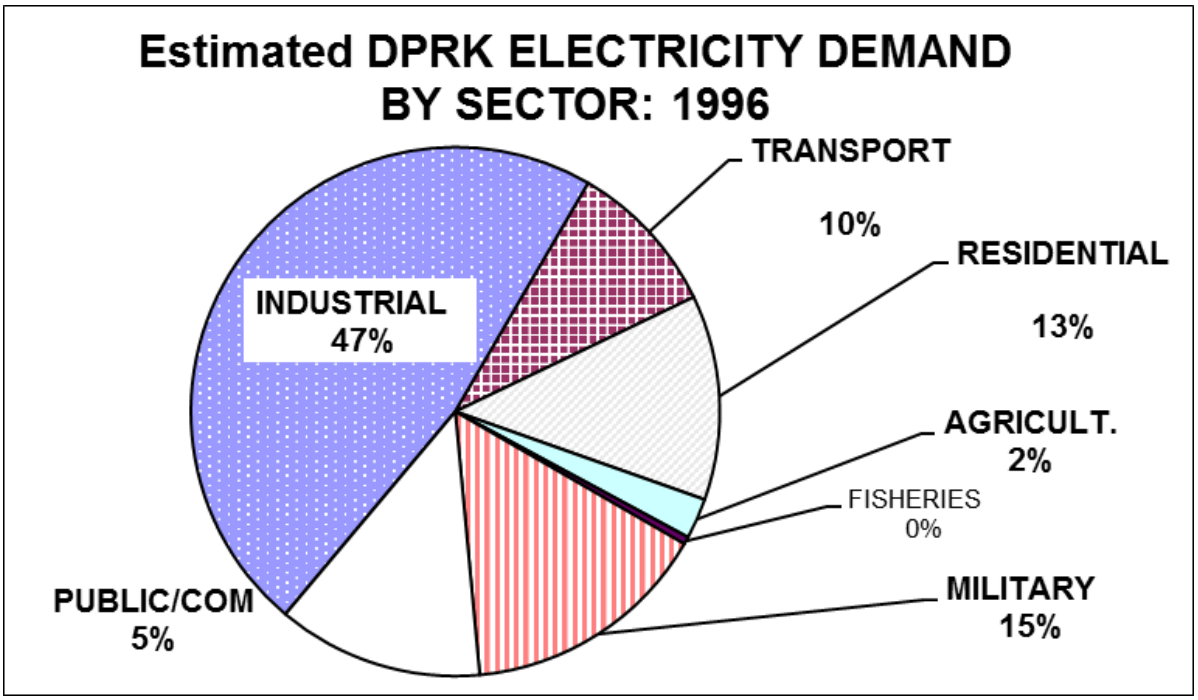

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2017
TRANSPORT 32.3%
RESIDENTIAL 9.7%
AGRICULTURE 2.8%
FISHERIES 4.5%
MILITARY 30.2%
PUB/COMML 2.8%
NON-SPECIFIED 0.0%
NON-ENERGY 4.1%
INDUSTRIAL 13.6%

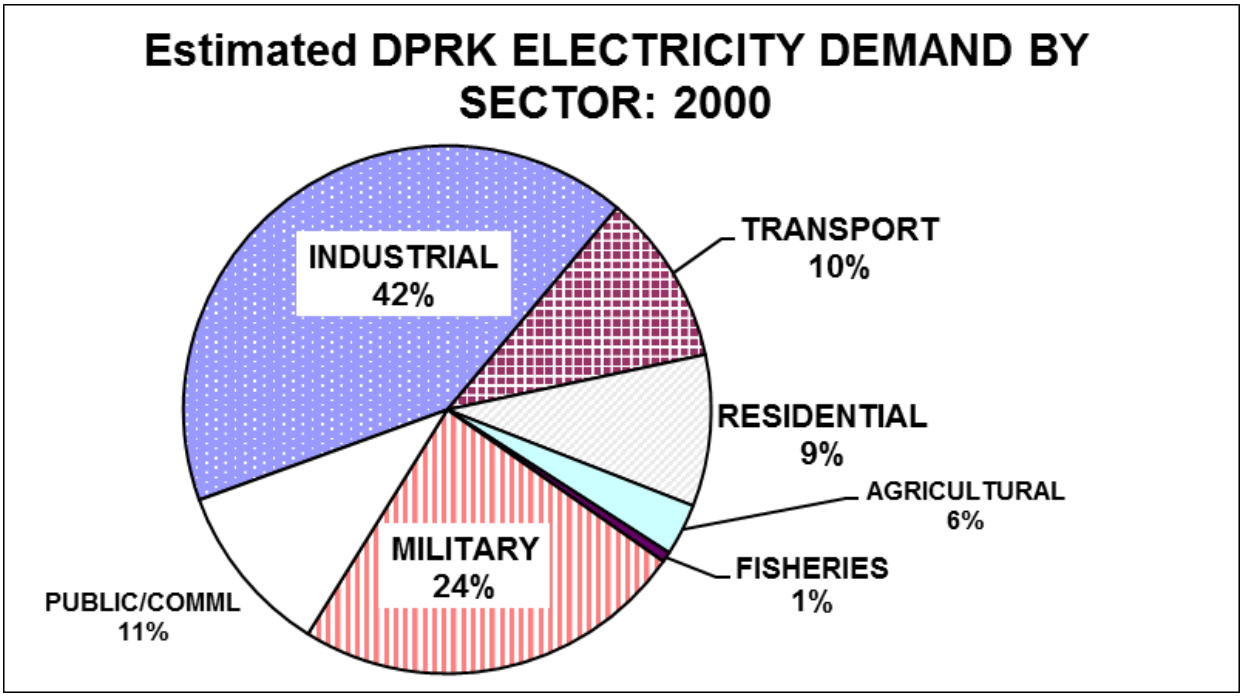

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2018
TRANSPORT 32.1%
RESIDENTIAL 11.2%
AGRICULTURE 2.5%
FISHERIES 3.4%
MILITARY 30.1%
PUB/COMML 3.2%
NON-SPECIFIED 0.0%
NON-ENERGY 3.6%
INDUSTRIAL 13.8%

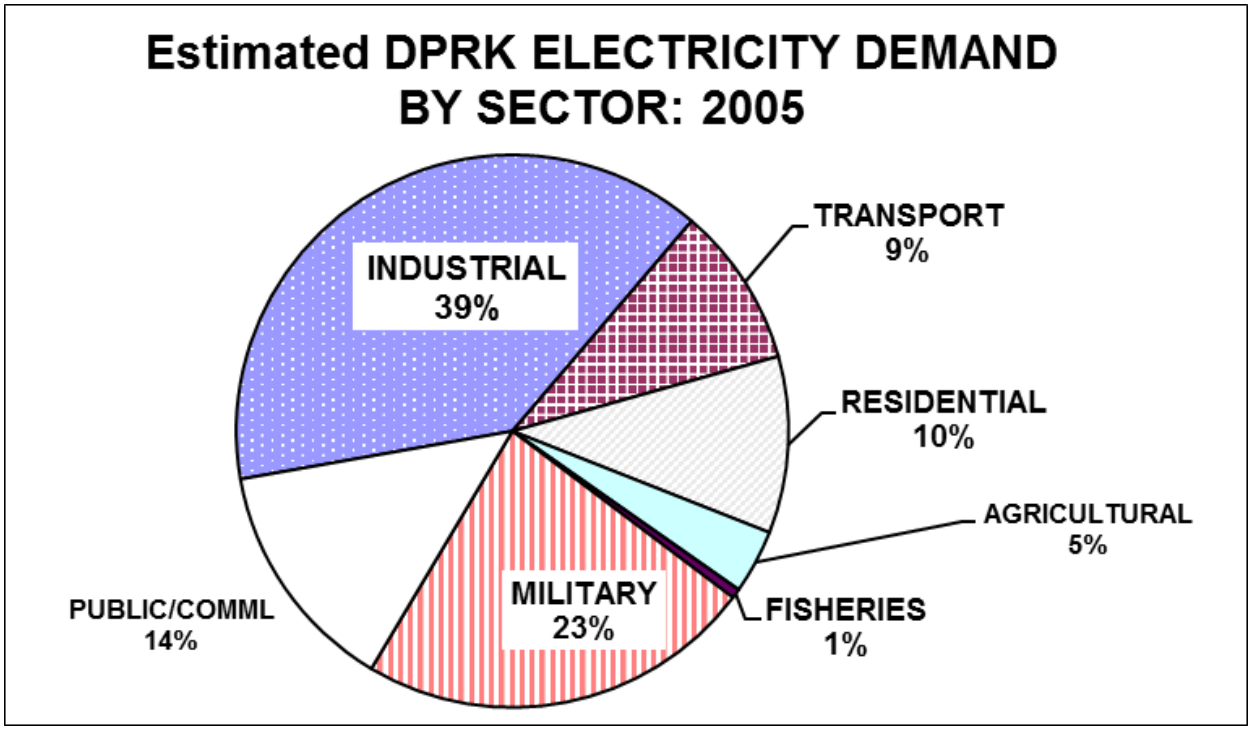

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2019
TRANSPORT 32.0%
INDUSTRIAL 13.7%
NON-ENERGY 3.6%
NON-SPECIFIED 0.0%
PUB/COMML 3.2%
MILITARY 30.7%
RESIDENTIAL 10.9%
AGRICULTURE 2.5%
FISHERIES 3.4%

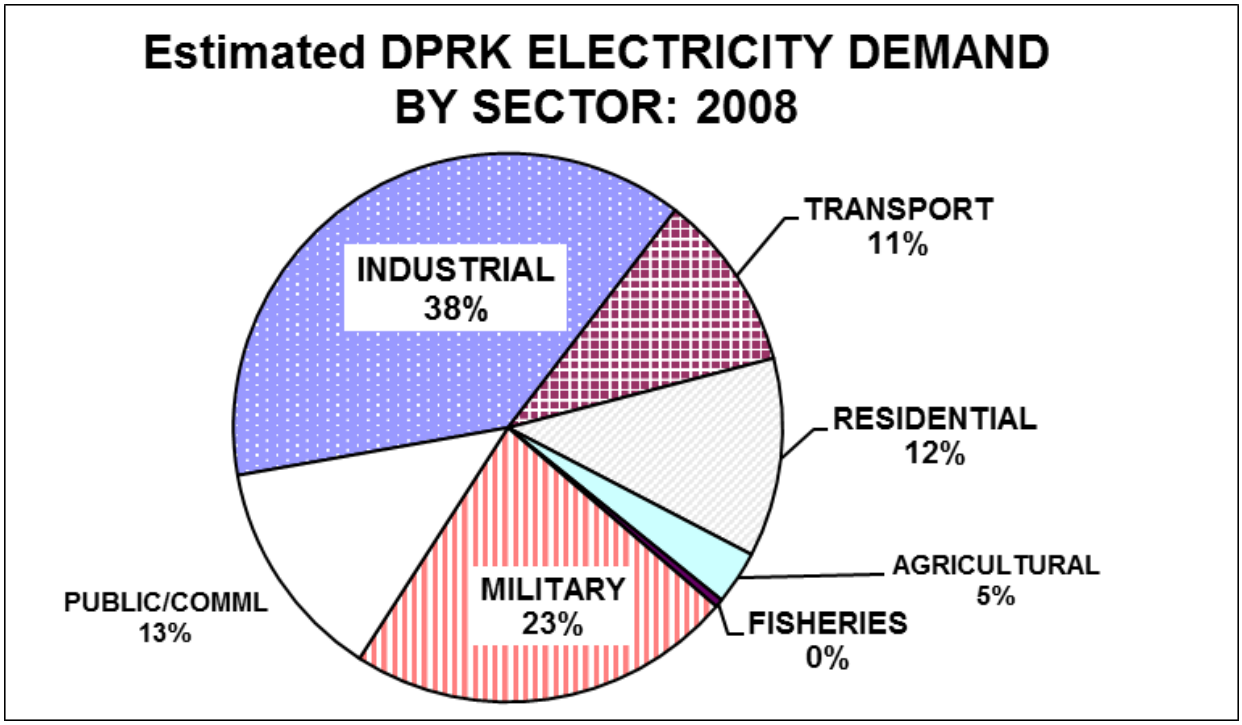

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2020
TRANSPORT 30.0%
INDUSTRIAL 18.6%
NON-ENERGY 3.6%
NON-SPECIFIED 0.0%
PUB/COMML 2.9%
MILITARY 23.7%
RESIDENTIAL 14.2%
AGRICULTURE 3.1%
FISHERIES 3.8%

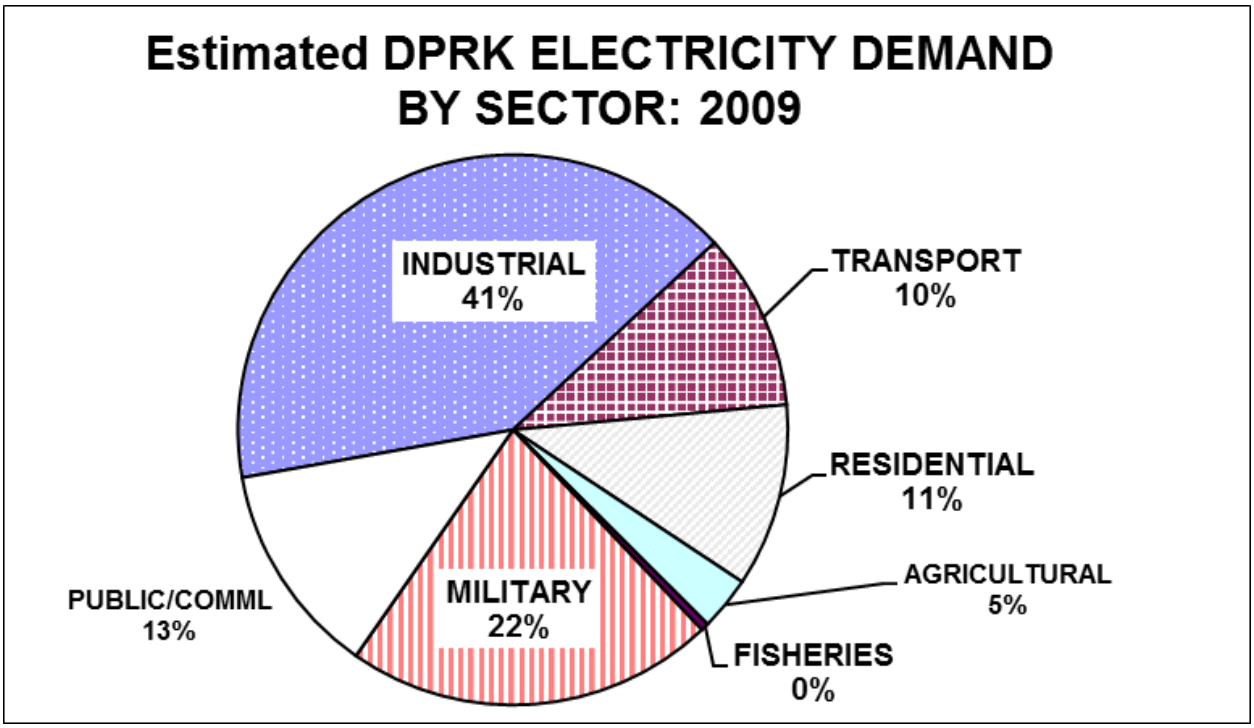

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1990
PUBLIC/COM 5%
MILITARY 12%
FISHERIES 0%
AGRICULT. 2%
RESIDENTIAL 9%
TRANSPORT 10%
INDUSTRIAL 58%

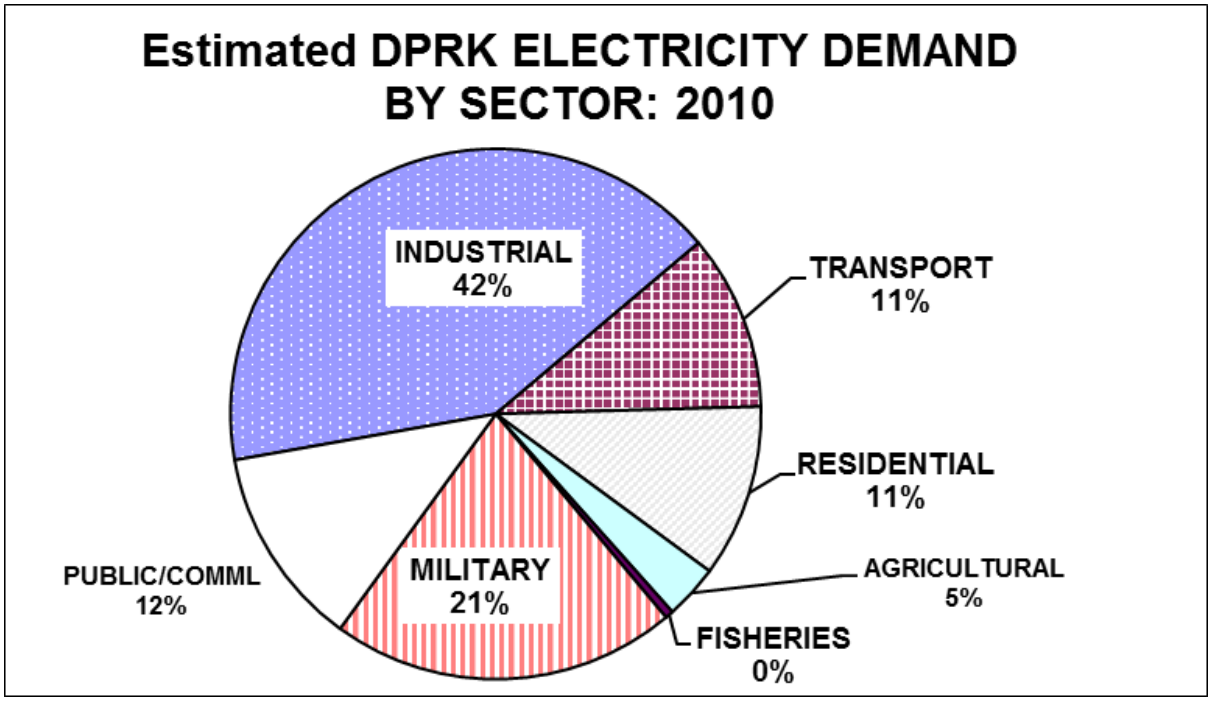

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1996
TRANSPORT 10%
RESIDENTIAL 13%
AGRICULT. 2%
FISHERIES 0%
MILITARY 15%
PUBLIC/COM 5%
INDUSTRIAL 47%

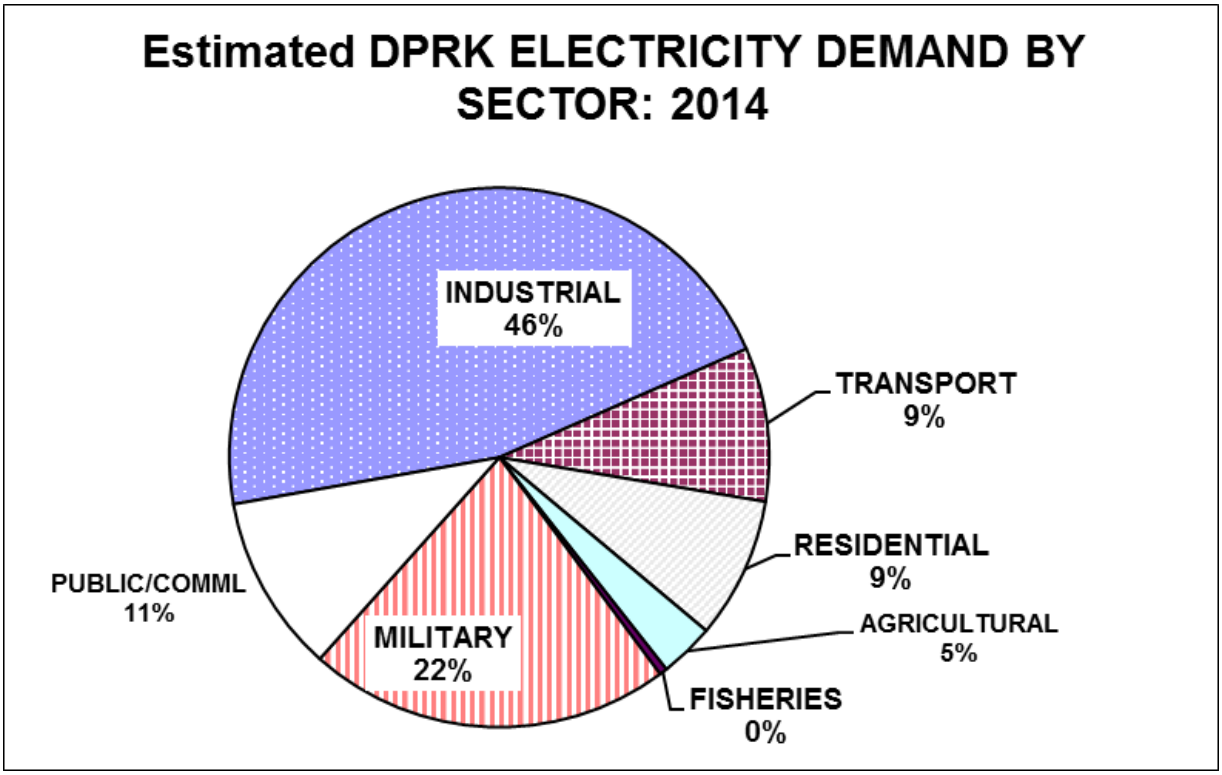

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2000
INDUSTRIAL 42%
TRANSPORT 10%
RESIDENTIAL 9%
AGRICULTURAL 6%
FISHERIES 1%
MILITARY 24%
PUBLIC/COMML 11%

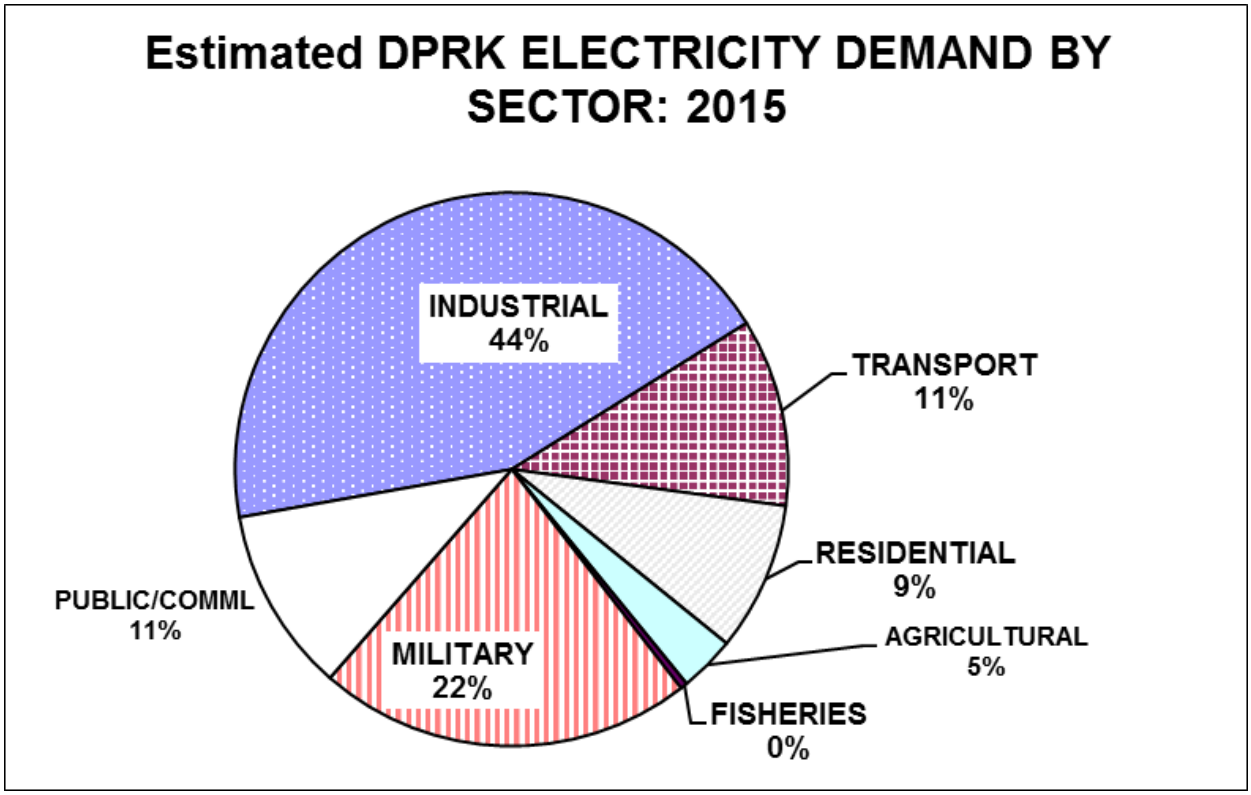

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2005
INDUSTRIAL 39%
TRANSPORT 9%
RESIDENTIAL 10%
AGRICULTURAL 5%
FISHERIES 1%
MILITARY 23%
PUBLIC/COMML 14%


Estimated DPRK ELECTRICITY DEMAND
BY SECTOR: 2008
INDUSTRIAL
38%
TRANSPORT
11%
RESIDENTIAL
12%
AGRICULTURAL
5%
FISHERIES
0%
MILITARY
23%
PUBLIC/COMML
13%


Estimated DPRK ELECTRICITY DEMAND
BY SECTOR: 2009
INDUSTRIAL
41%
TRANSPORT
10%
RESIDENTIAL
11%
AGRICULTURAL
5%
FISHERIES
0%
MILITARY
22%
PUBLIC/COMML
13%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2010
INDUSTRIAL 42%
TRANSPORT 11%
RESIDENTIAL 11%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 21%
PUBLIC/COMML 12%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2014
INDUSTRIAL 46%
TRANSPORT 9%
RESIDENTIAL 9%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 22%
PUBLIC/COMML 11%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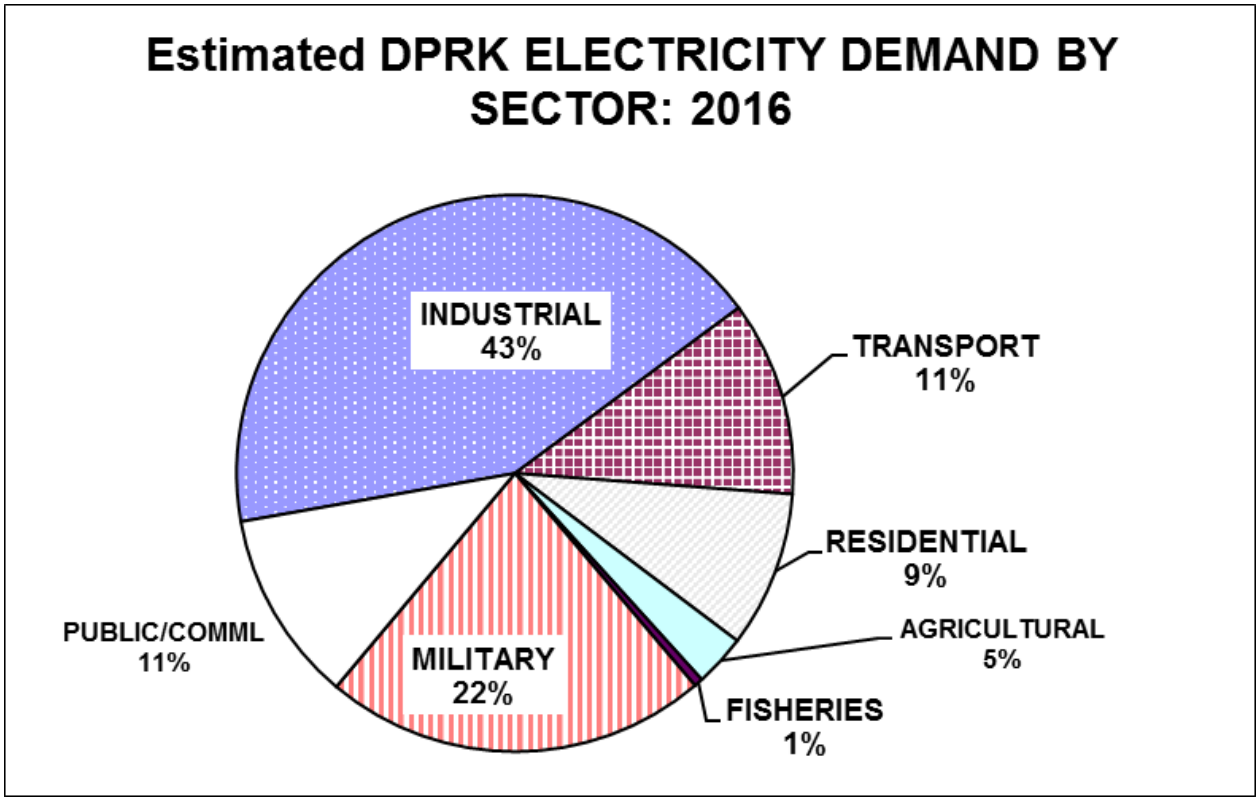
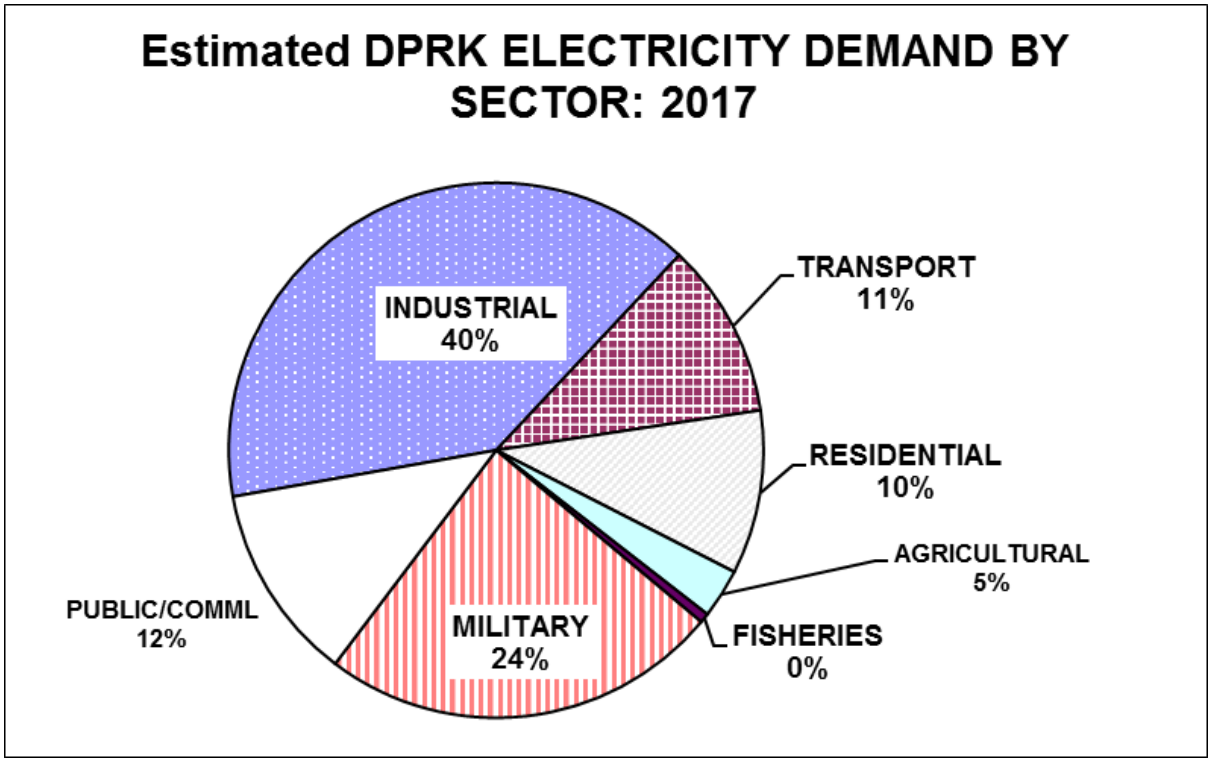
INDUSTRIAL 44%
TRANSPORT 11%
RESIDENTIAL 9%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 22%
PUBLIC/COMML 11%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2016
INDUSTRIAL 43%
TRANSPORT 11%
RESIDENTIAL 9%
AGRICULTURAL 5%
FISHERIES 1%
MILITARY 22%
PUBLIC/COMML 11%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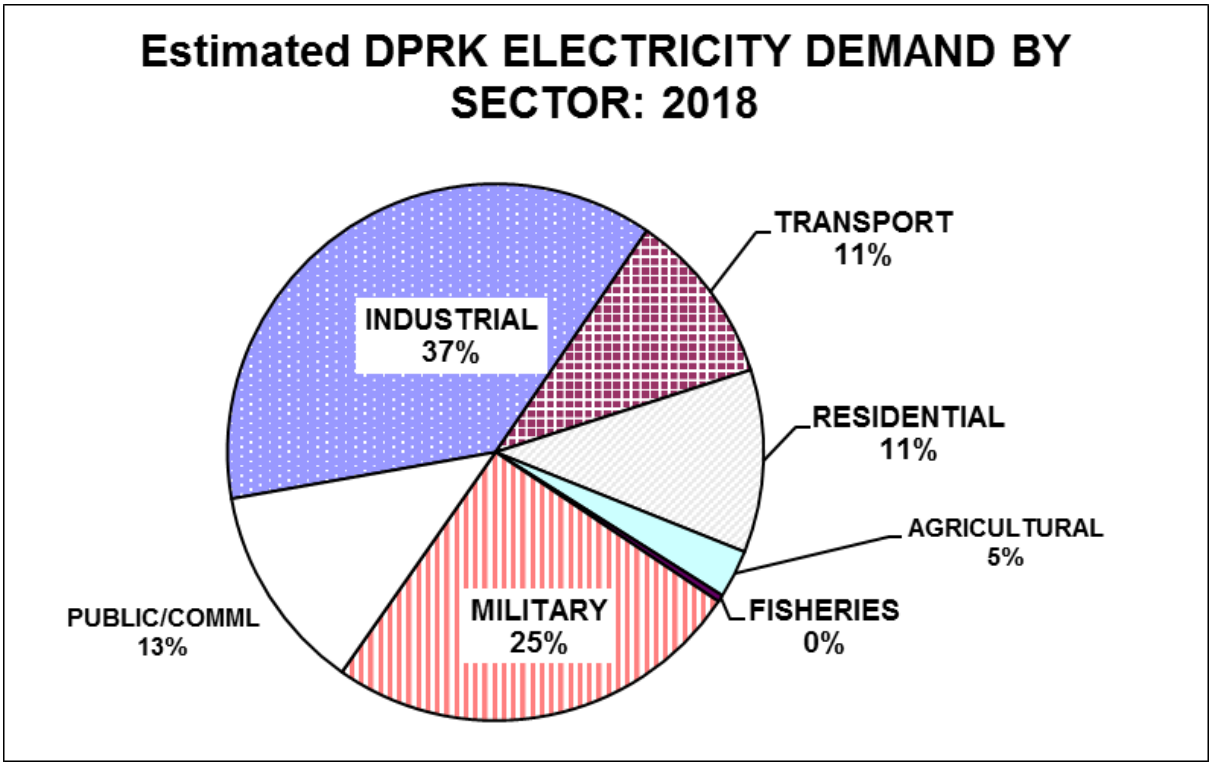
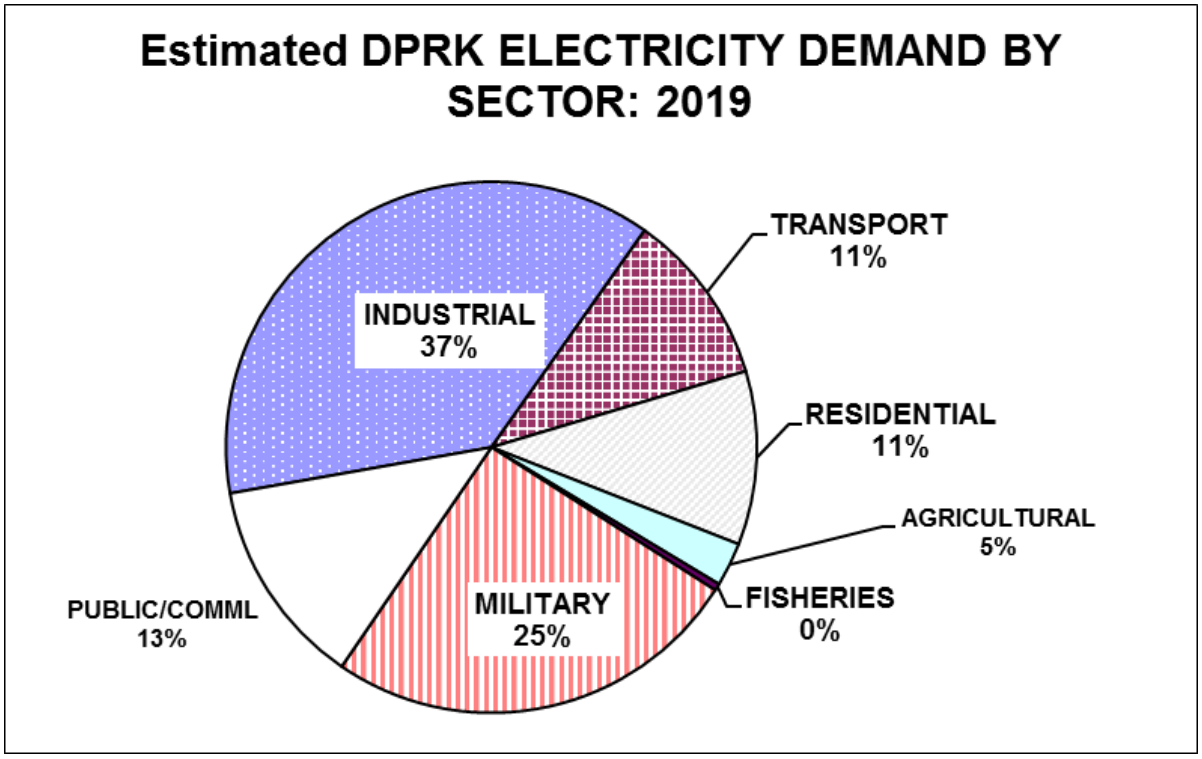
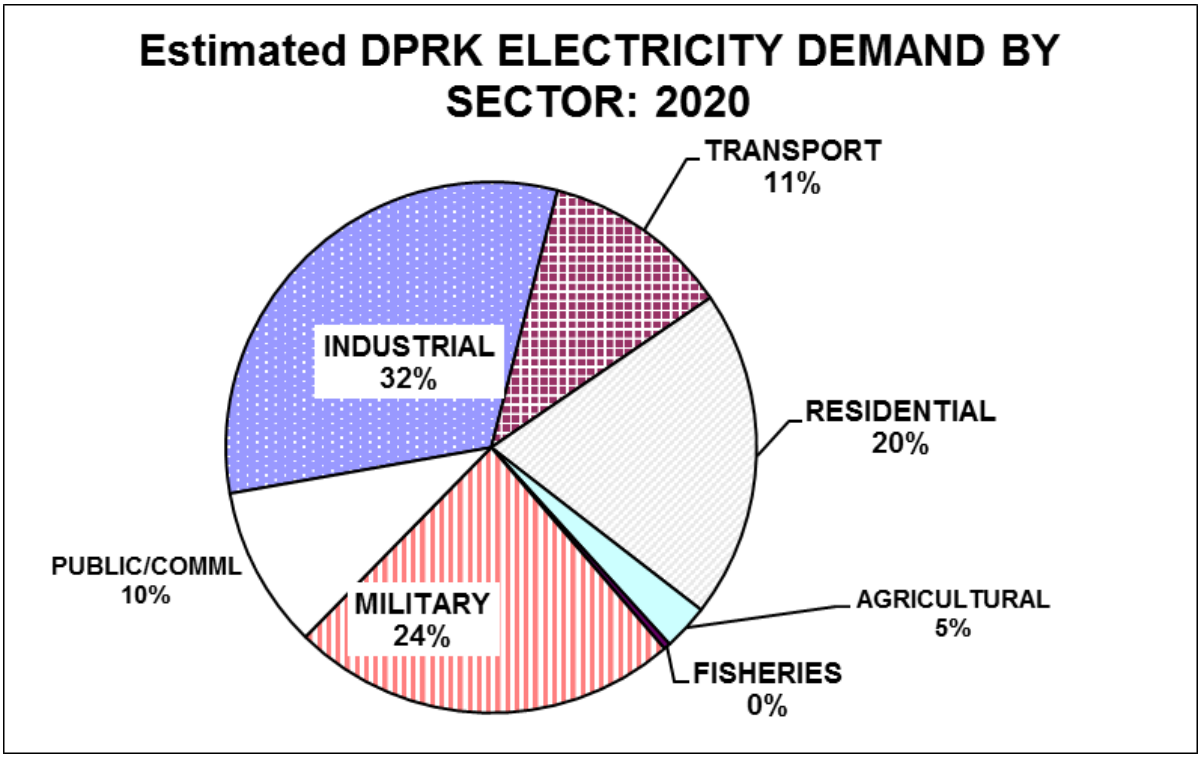
INDUSTRIAL 40%
TRANSPORT 11%
RESIDENTIAL 10%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 24%
PUBLIC/COMML 12%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2018
INDUSTRIAL 37%
TRANSPORT 11%
RESIDENTIAL 11%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 25%
PUBLIC/COMML 13%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2019
TRANSPORT 11%
INDUSTRIAL 37%
RESIDENTIAL 11%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 25%
PUBLIC/COMML 13%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2020
TRANSPORT 11%
INDUSTRIAL 32%
RESIDENTIAL 20%
AGRICULTURAL 5%
FISHERIES 0%
MILITARY 24%
PUBLIC/COMML 10%

DPRK Energy Supply By Fuel and Source: 1990

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	1,301	-	-	78	150
Imports	68	111	27	-	12
Exports	(44)	-	-	-	(0)

DPRK Energy Supply By Fuel and Source: 1996

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	683	-	-	19	148
Imports	12	40	39	-	14
Exports	(12)	-	(1)	-	(4)

DPRK Energy Supply By Fuel and Source: 2000

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	336	0	-	38	151
Imports	12	17	42	-	12
Exports	(9)	-	(3)	-	(3)

DPRK Energy Supply By Fuel and Source: 2005

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	434	0	-	44	182
Imports	36	22	23	-	7
Exports	(80)	-	(0)	-	(2)

DPRK Energy Supply By Fuel and Source: 2008

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	427	0	-	43	200
Imports	19	23	30	-	6
Exports	(67)	-	(4)	-	(1)

DPRK Energy Supply By Fuel and Source: 2009

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	484	0	-	43	202
Imports	7	22	14	-	5
Exports	(94)	-	(0)	-	(1)

DPRK Energy Supply By Fuel and Source: 2010

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	492	0	-	43	205
Imports	13	25	16	-	4
Exports	(122)	-	(2)	-	(1)

DPRK Energy Supply By Fuel and Source: 2014

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	851	0	-	39	205
Imports	8	25	22	-	5
Exports	(402)	-	(1)	-	(2)

DPRK Energy Supply By Fuel and Source: 2015

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	950	0	-	40	202
Imports	30	27	25	-	5
Exports	(516)	-	(0)	-	(2)

DPRK Energy Supply By Fuel and Source: 2016

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	1,020	0	-	42	194
Imports	41	28	30	-	4
Exports	(584)	-	(0)	-	(2)

DPRK Energy Supply By Fuel and Source: 2017

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	567	0	-	38	169
Imports	29	27	17	-	4
Exports	(137)	-	(0)	-	(1)

DPRK Energy Supply By Fuel and Source: 2018

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	531	0	-	39	161
Imports	0	30	13	-	4
Exports	(82)	-	(0)	-	(0)

DPRK Energy Supply By Fuel and Source: 2019

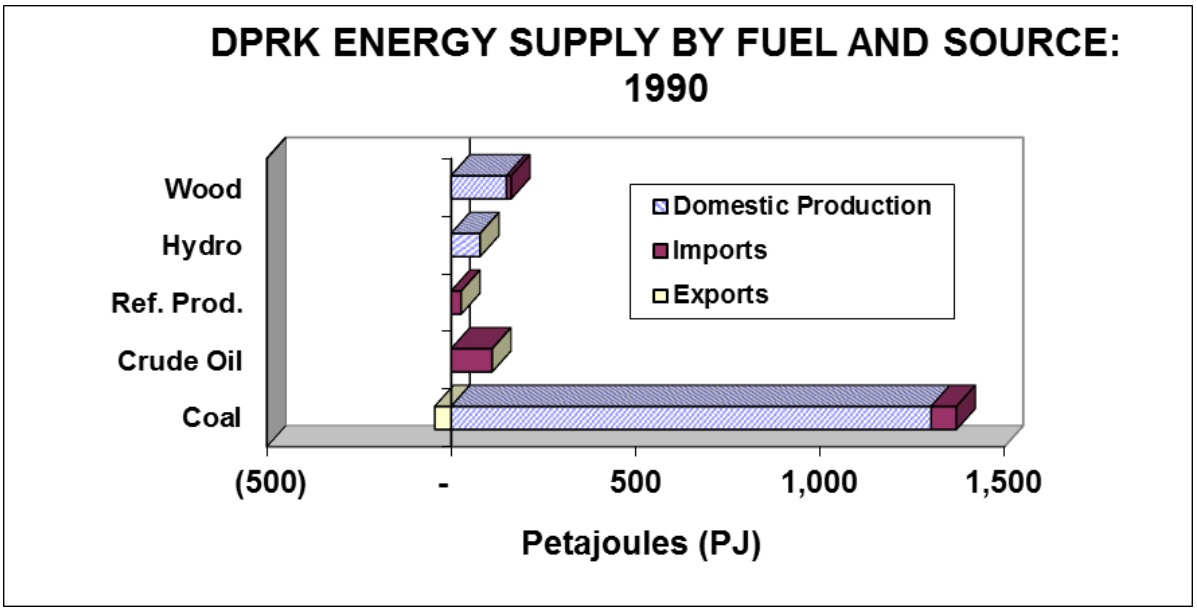
Units:Petajoules (PJ)

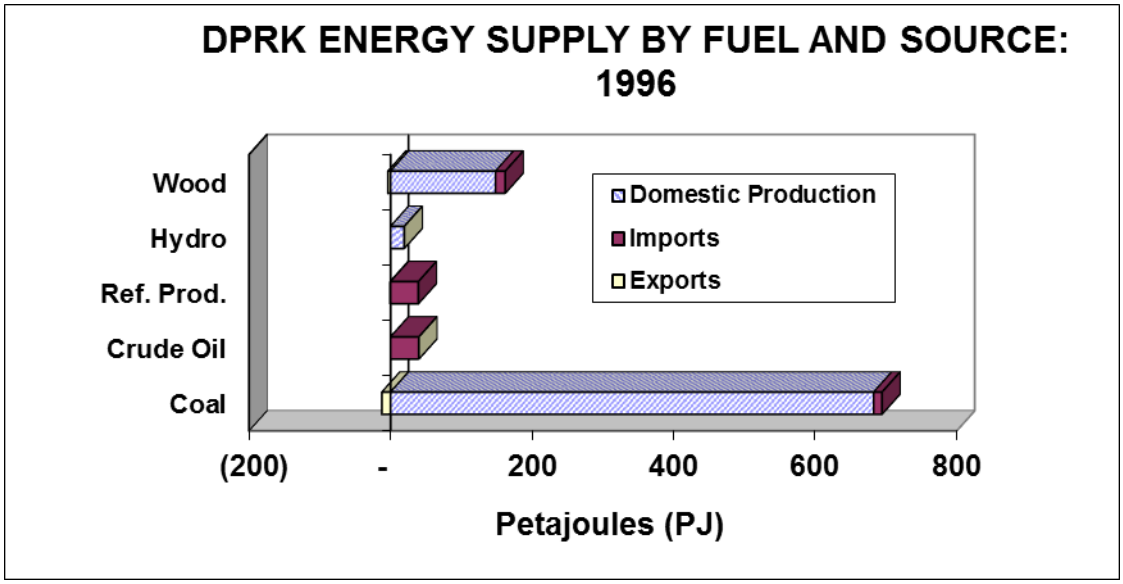
Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	619	0	-	38	161
Imports	0	30	14	-	4
Exports	(163)	-	(0)	-	-

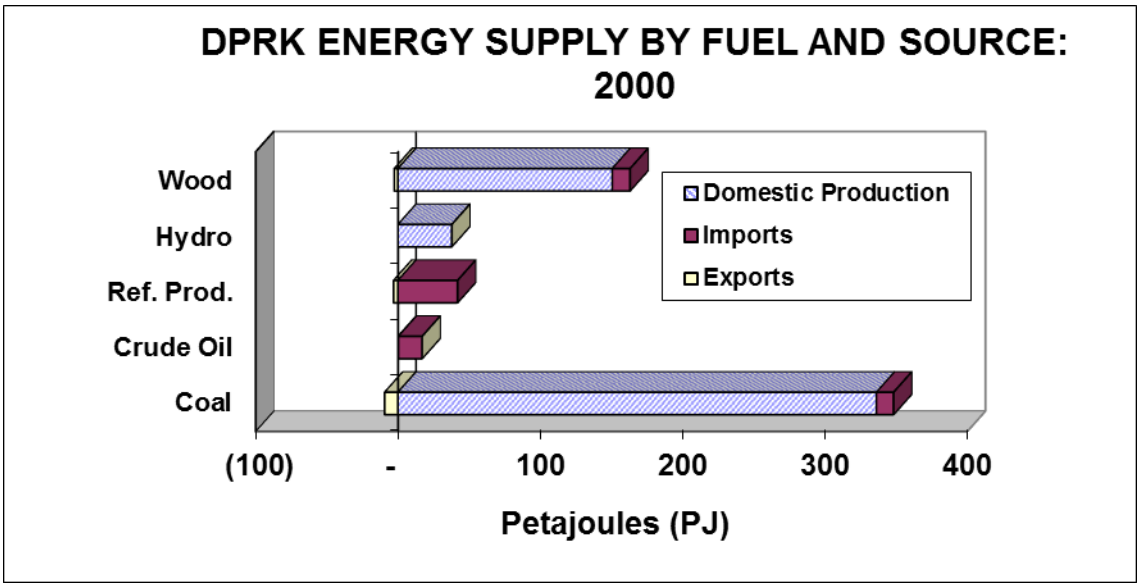
DPRK Energy Supply By Fuel and Source: 2020

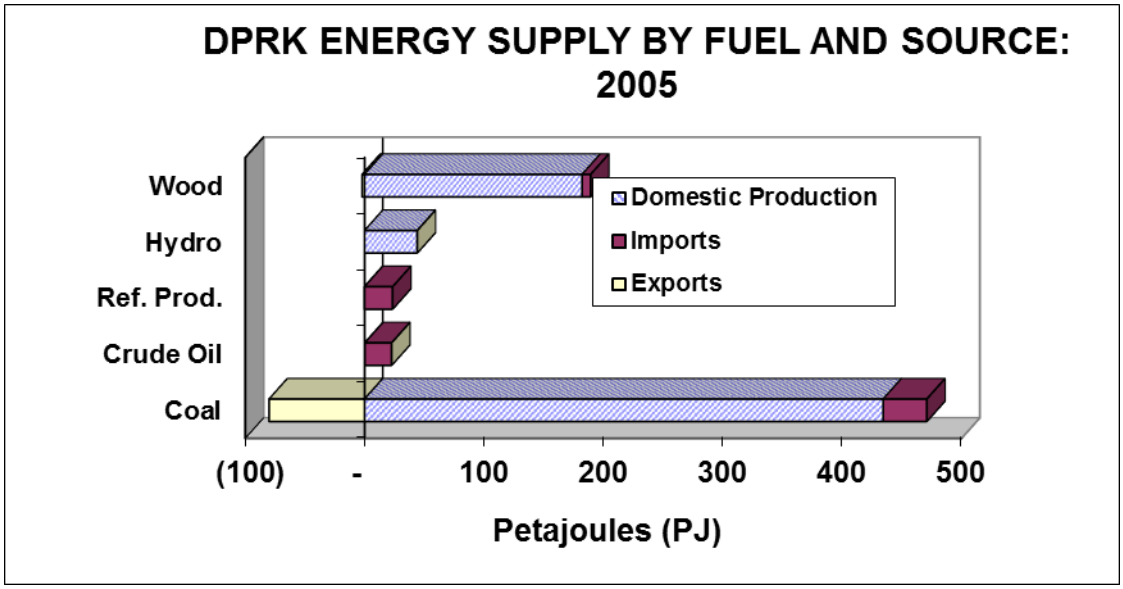
Units:Petajoules (PJ)

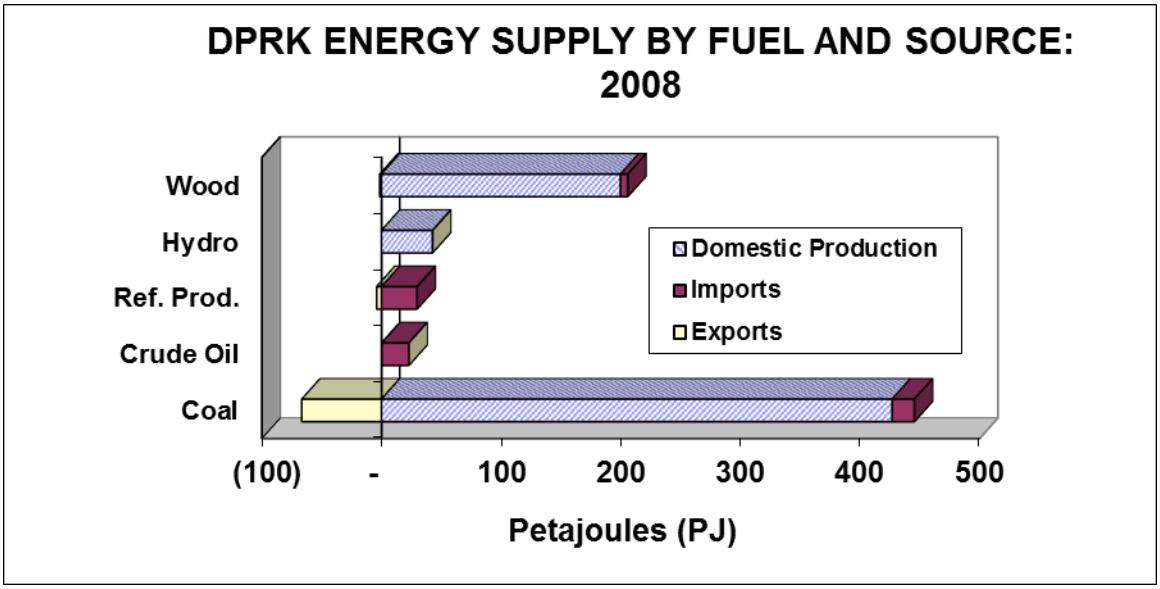
Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	461	0	-	39	162
Imports	0	32	7	-	2
Exports	(82)	-	-	-	-

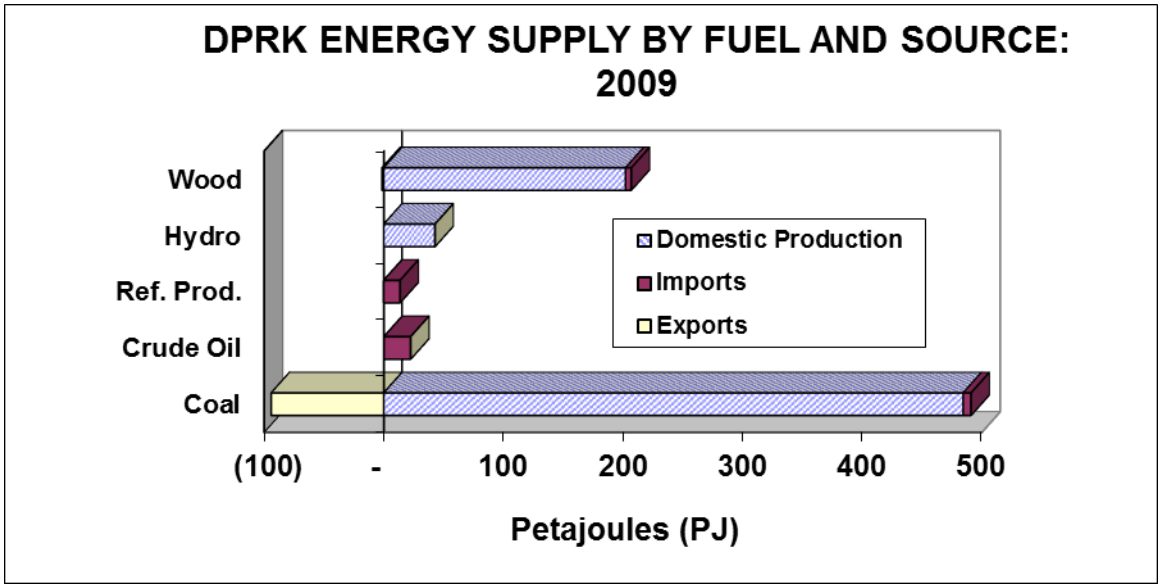


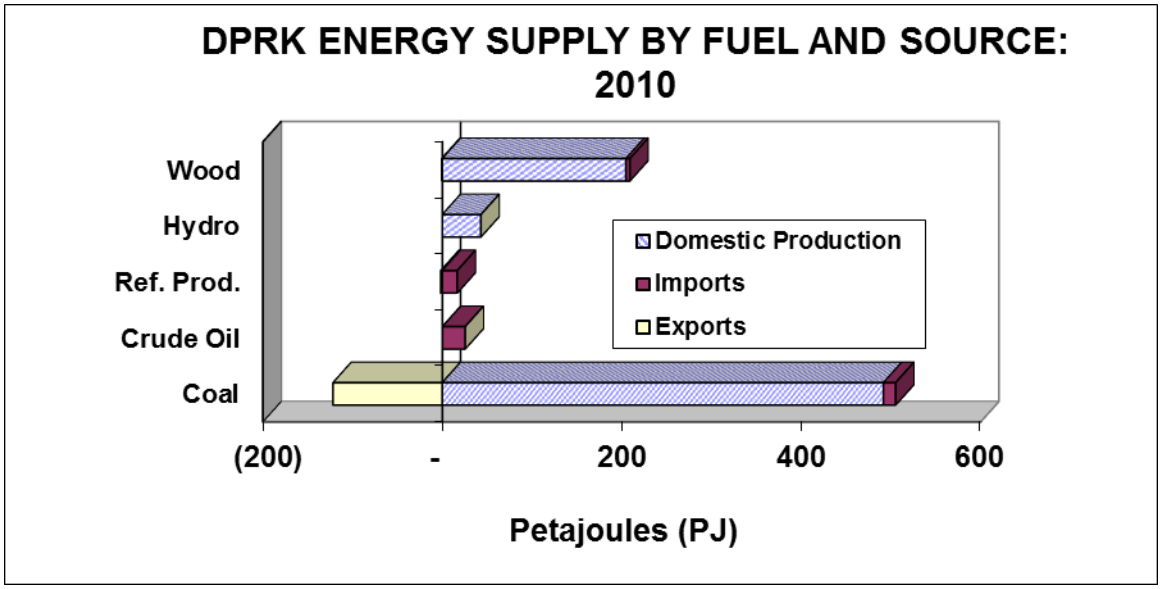

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 1996
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(200)
-
200
400
600
800
Petajoules (PJ)

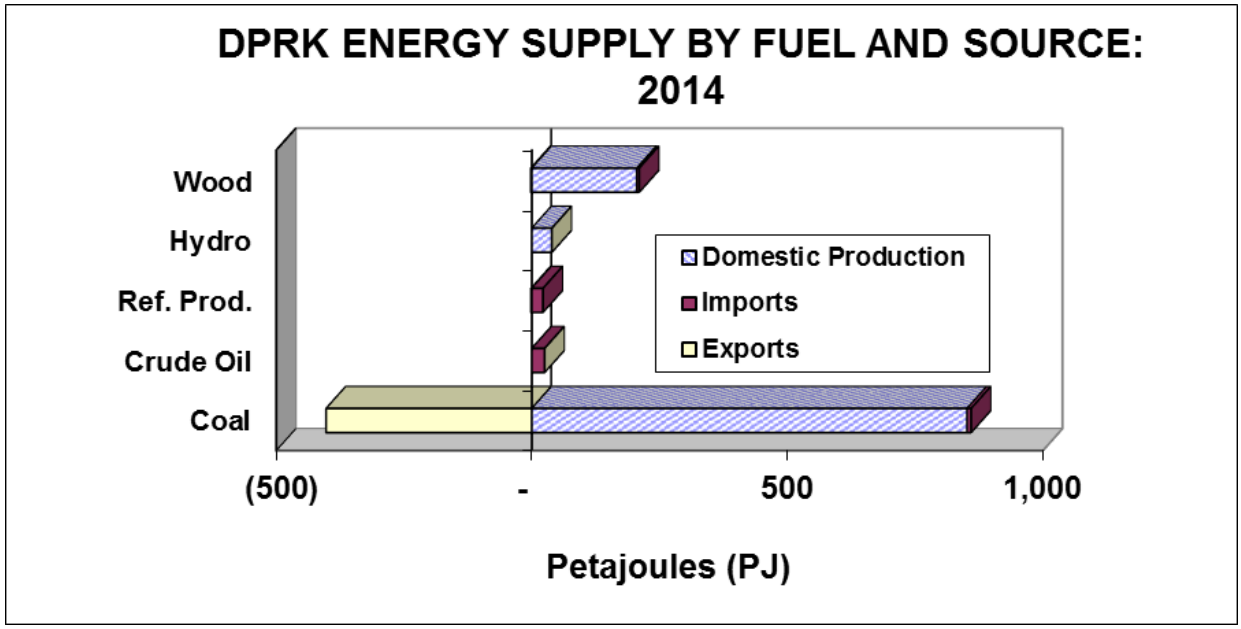

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2000
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(100)
-
100
200
300
400
Petajoules (PJ)

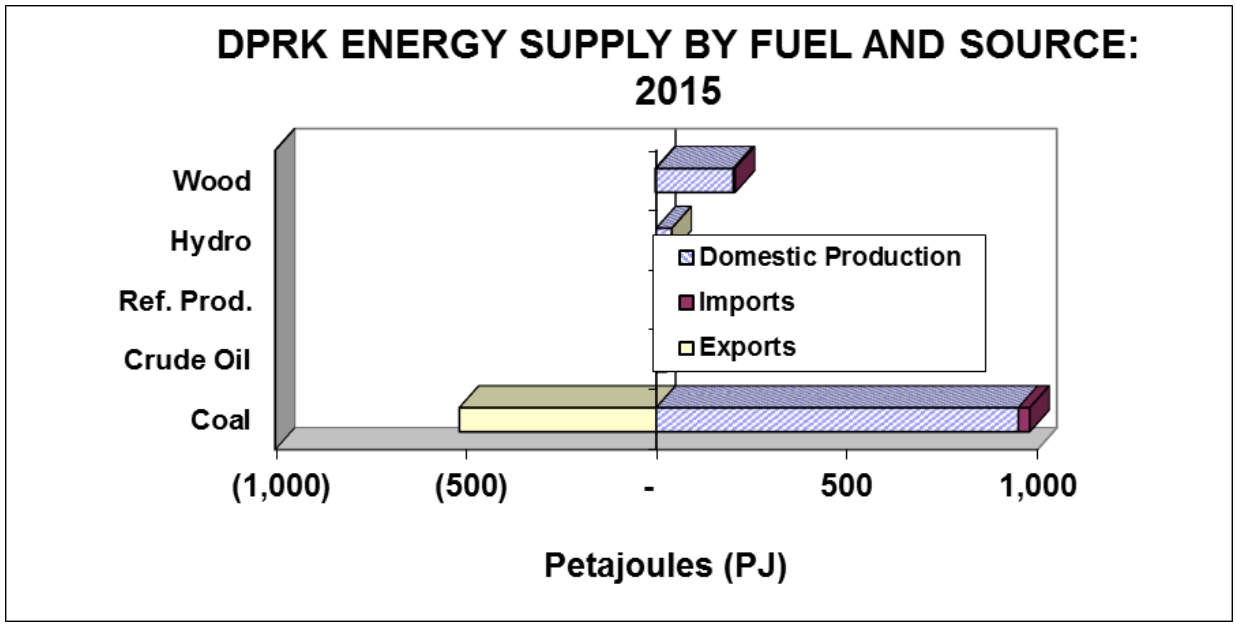

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2005
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(100)
-
100
200
300
400
500
Petajoules (PJ)

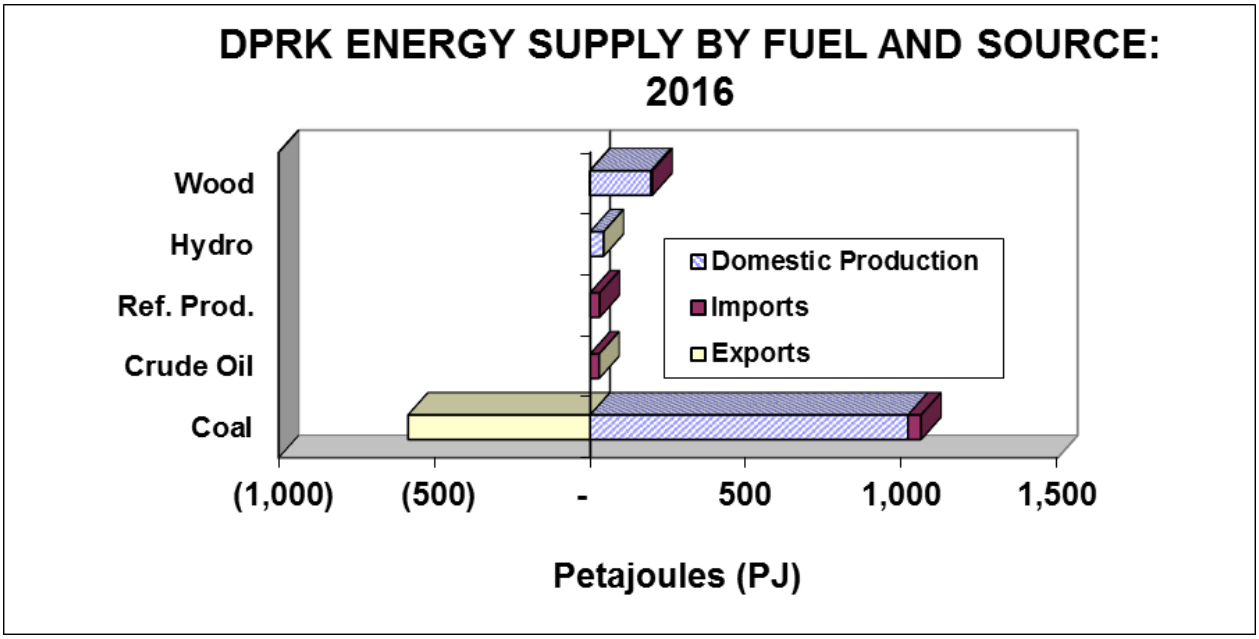

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2008
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(100)
-
100
200
300
400
500
Petajoules (PJ)

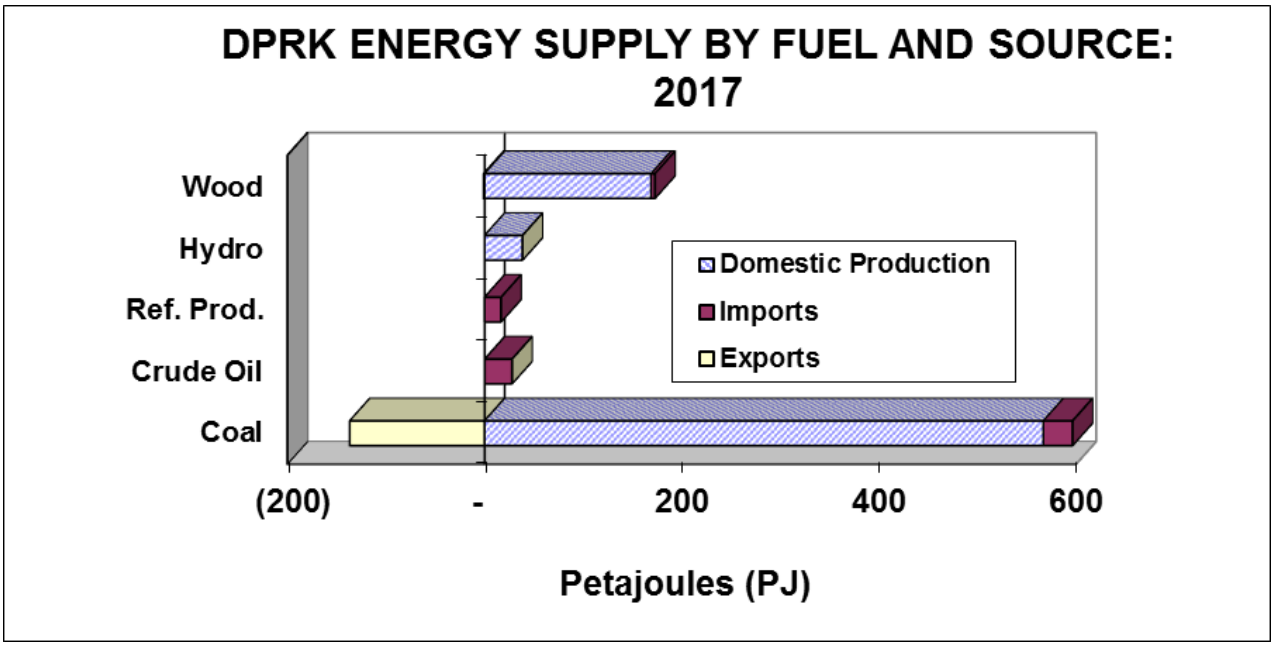

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2009
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(100)
-
100
200
300
400
500
Petajoules (PJ)

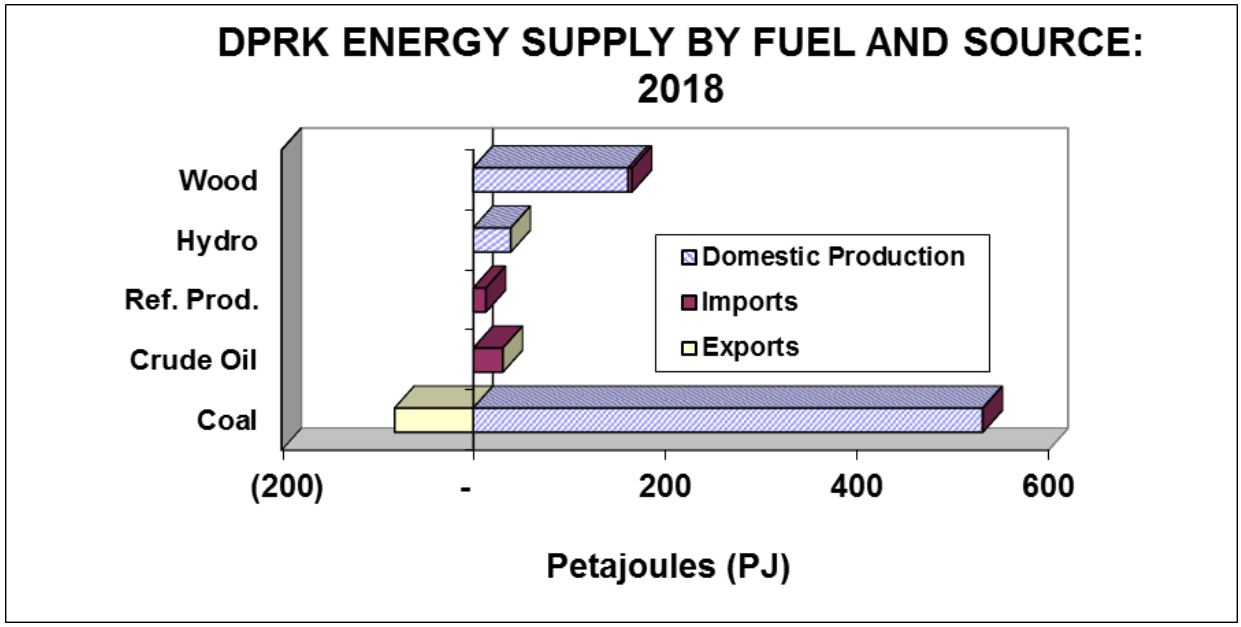

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2010
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(200)
-
200
400
600
Petajoules (PJ)

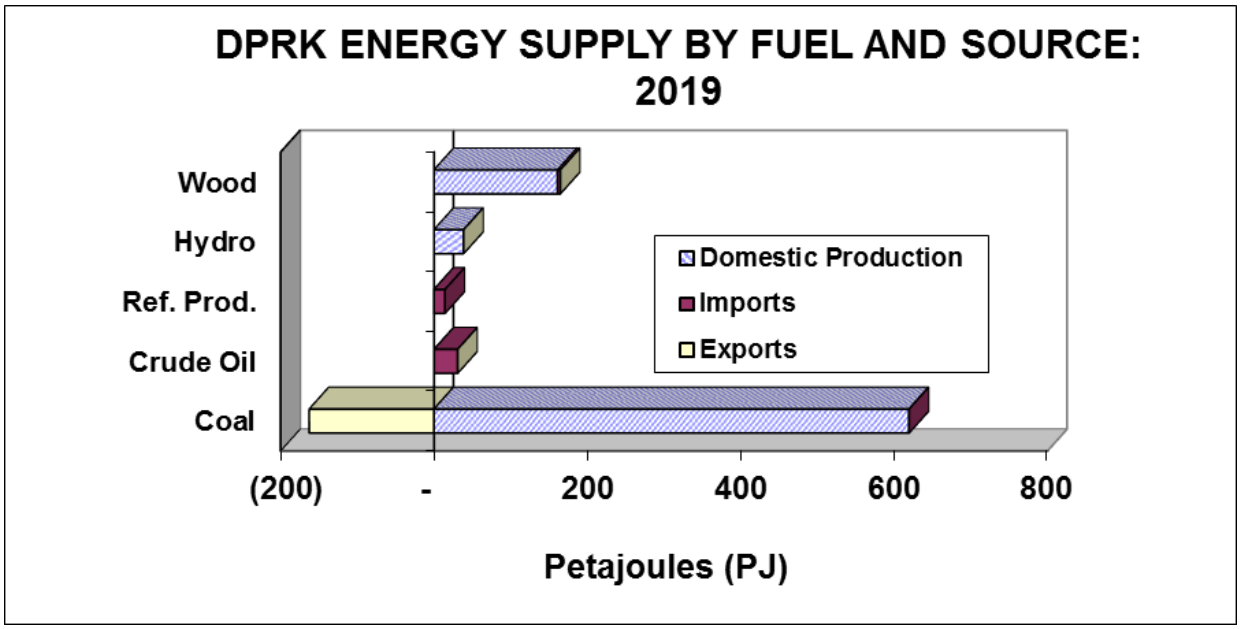

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2014
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(500)
-
500
1,000
Petajoules (PJ)

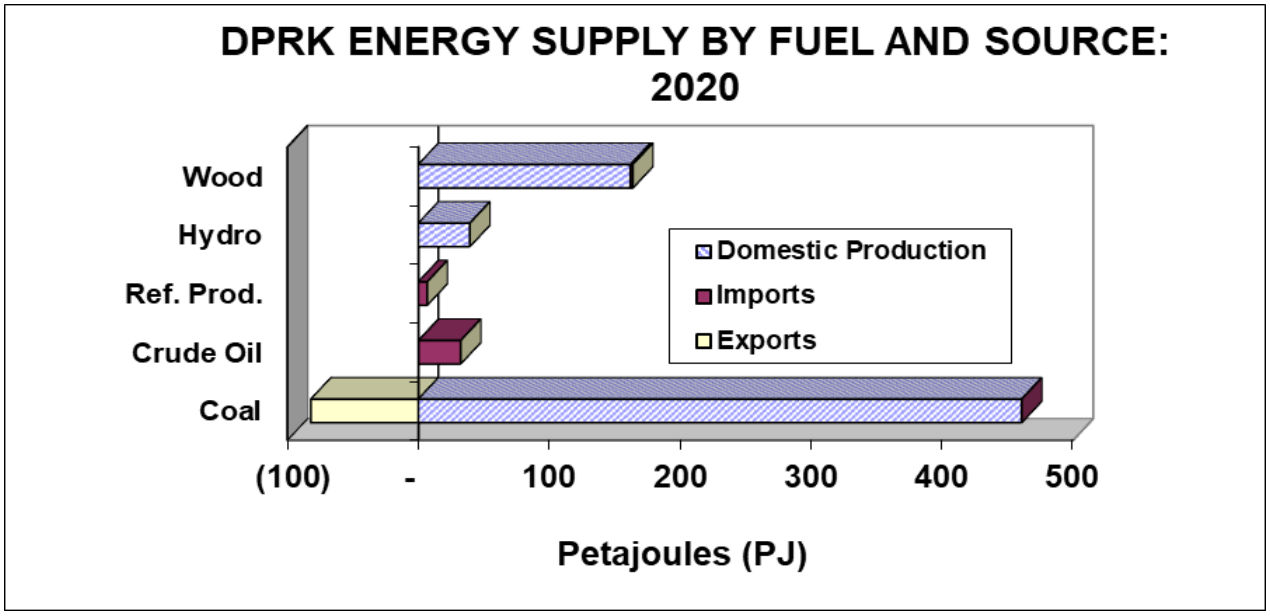

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2015
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(1,000)
(500)
-
500
1,000
Petajoules (PJ)


DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2016
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(1,000)
(500)
-
500
1,000
1,500
Petajoules (PJ)


DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2017
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(200)
-
200
400
600
Petajoules (PJ)


DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2018
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(200)
-
200
400
600
Petajoules (PJ)


DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2019
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(200)
-
200
400
600
800
Petajoules (PJ)

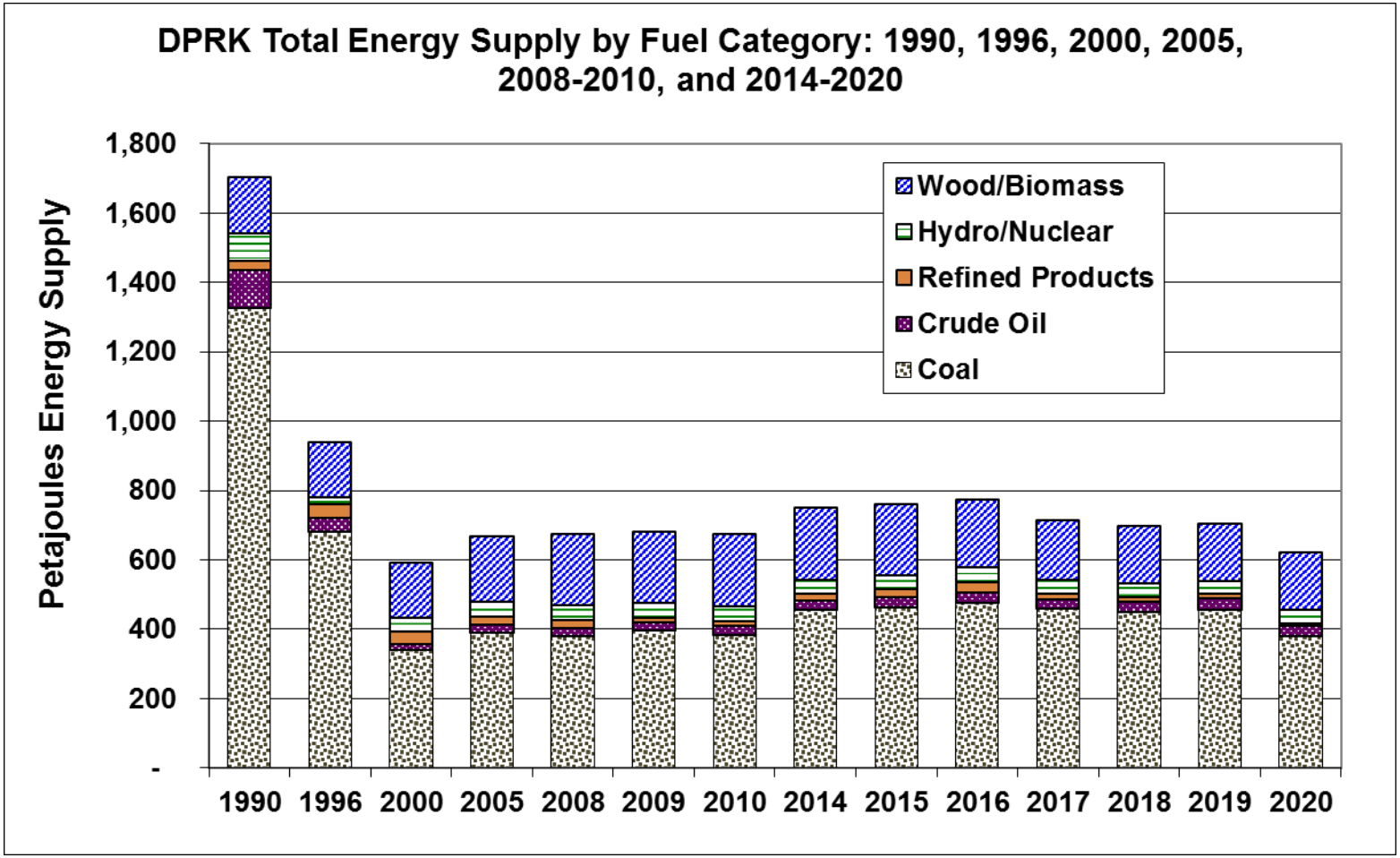

DPRK ENERGY SUPPLY BY FUEL AND SOURCE: 2020
Wood
Hydro
Ref. Prod.
Crude Oil
Coal
Domestic Production
Imports
Exports
(100)
-
100
200
300
400
500
Petajoules (PJ)

DPRK Energy Supply By Fuel Category: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020
Units: Petajoules (PJ)

SECTOR	1990	1996	2000	2005	2008	2009	2010	2014
Coal	1,326	682	339	391	379	397	383	457
Crude Oil	111	40	17	23	23	22	25	25
Refined Products	27	39	39	23	26	13	15	21
Hydro/Nuclear	78	19	38	44	43	43	43	39
Wood/Biomass	162	158	160	187	204	205	208	208
TOTAL	**1,703**	**938**	**593**	**668**	**674**	**681**	**675**	**750**

DPRK Energy Supply By Fuel Category: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020
Units: Petajoules (PJ)

SECTOR	2015	2016	2017	2018	2019	2020
Coal	463	477	460	449	457	379
Crude Oil	28	28	28	31	31	32
Refined Products	25	30	17	13	14	7
Hydro/Nuclear	40	42	38	39	38	39
Wood/Biomass	204	197	172	165	165	164
TOTAL	**761**	**774**	**714**	**697**	**705**	**620**


DPRK Total Energy Supply by Fuel Category: 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Petajoules Energy Supply
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Wood/Biomass
Hydro/Nuclear
Refined Products
Crude Oil
Coal
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

DPRK Residential Sector Energy Demand By Fuel and Subsector: 1990 and 1996

Units:Terajoules (TJ)	**1990**						**1996**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	129,155	6,256	-	1,814	6,134	7,420	92,747	1,649	15,135	1,455	3,669	4,685
Rural	60,119	344	86,140	1,159	-	3,298	28,988	136	102,471	919	-	1,674

DPRK Residential Sector Energy Demand By Fuel and Subsector: 2000 and 2005

Units:Terajoules (TJ)	**2000**						**2005**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	73,246	1,924	19,021	1,117	1,826	2,421	67,806	2,016	24,739	1,132	2,442	3,403
Rural	21,808	156	102,580	701	-	435	17,079	153	109,810	704	-	488

DPRK Residential Sector Energy Demand By Fuel and Subsector: 2008 and 2009

Units:Terajoules (TJ)	**2008**						**2009**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	61,212	1,916	34,093	1,089	2,818	4,050	62,349	1,549	34,685	1,108	2,427	3,524
Rural	13,090	184	119,228	673	-	625	13,292	142	121,072	683	-	518

DPRK Residential Sector Energy Demand By Fuel and Subsector: 2010

Units:Terajoules (TJ)

	2010						
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	**Implied 2010 Electricity use per Household (kWh)**
Urban	63,513	1,894	35,291	1,127	2,294	3,366	252
Rural	13,499	177	122,957	694	-	483	56

DPRK Residential Sector Energy Demand By Fuel and Subsector: 2014 and 2015
Units:Terajoules (TJ)

	2014						2015					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	73,032	2,004	34,289	1,234	1,852	2,839	78,328	2,528	32,981	1,282	1,943	3,012
Rural	17,583	183	121,521	754	-	326	20,289	224	118,141	782	-	331

DPRK Residential Sector Energy Demand By Fuel and Subsector: 2016 and 2017
Units:Terajoules (TJ)

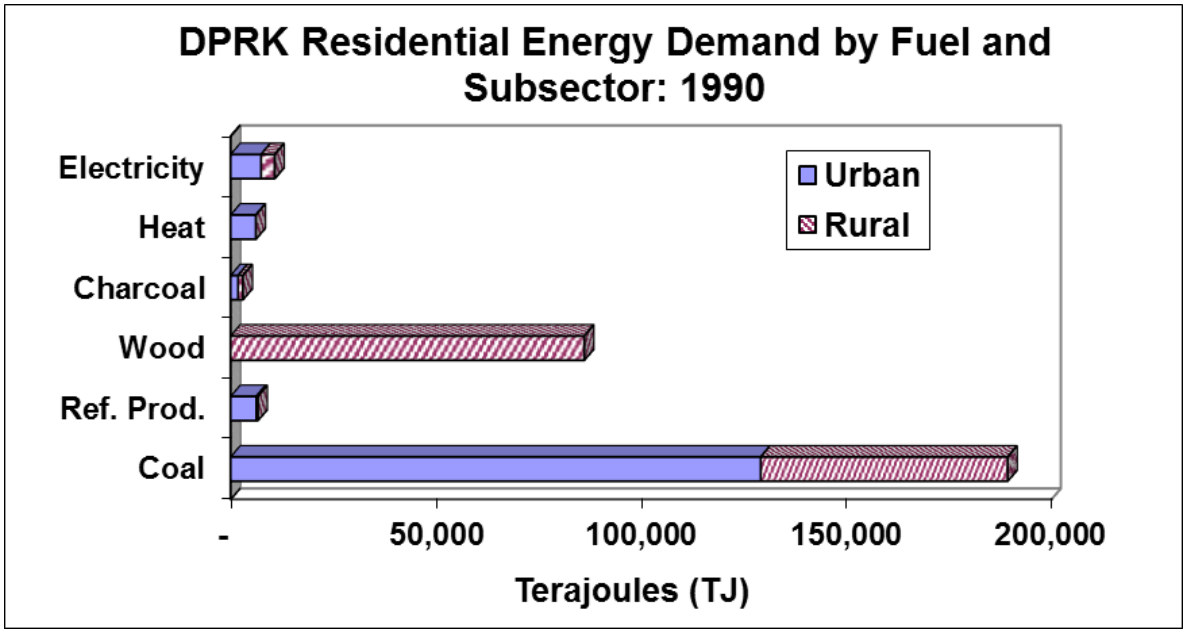
	2016						2017					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	83,880	2,728	31,668	1,331	2,023	3,172	95,433	2,748	25,401	1,325	2,025	3,212
Rural	23,213	266	114,754	810	-	336	30,289	275	97,706	805	-	341

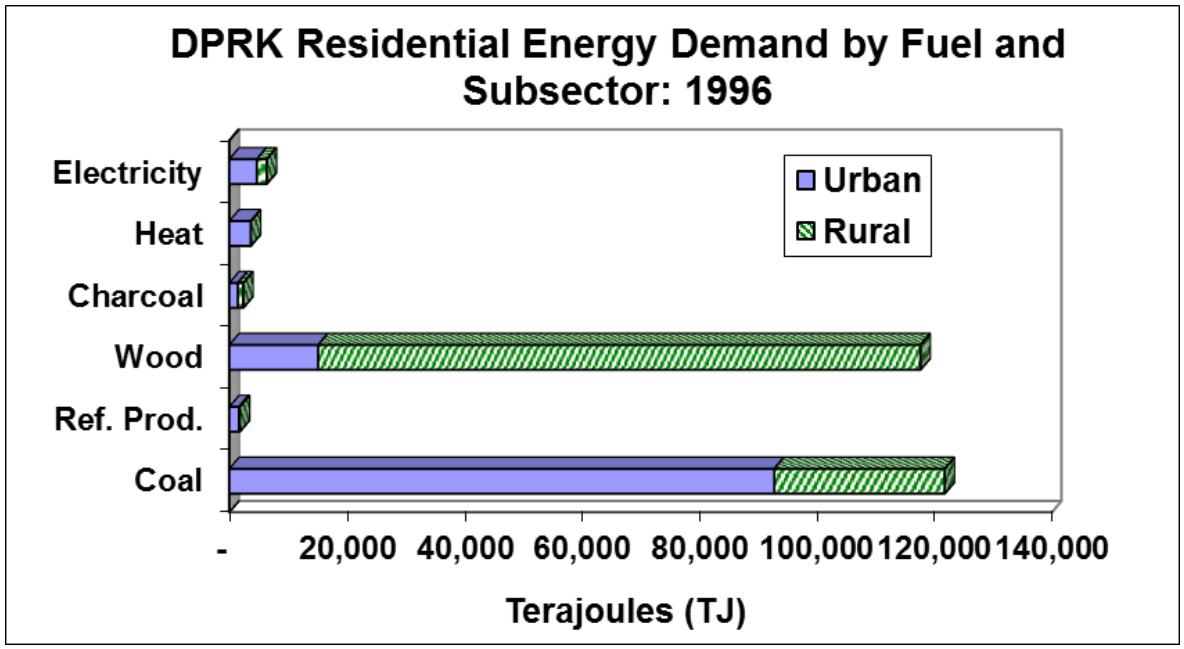
DPRK Residential Sector Energy Demand By Fuel and Subsector: 2018 and 2019
Units:Terajoules (TJ)

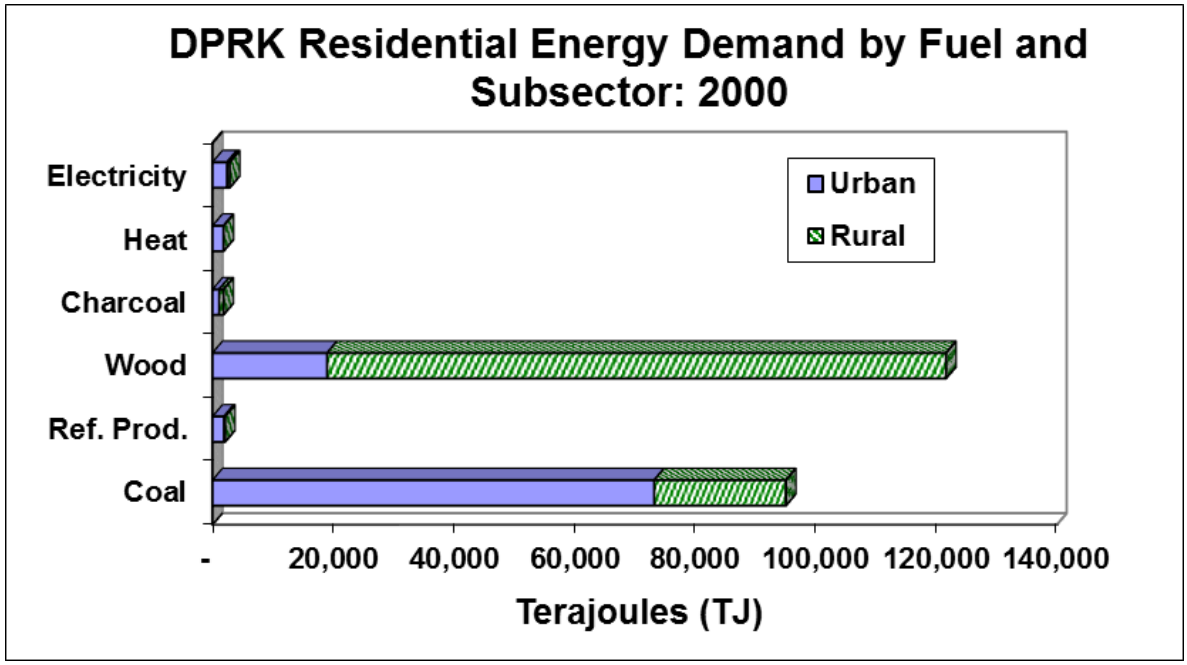
	2018						2019					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	103,341	3,060	23,242	1,346	2,169	3,481	105,137	2,998	23,621	1,368	2,037	3,308
Rural	33,442	311	94,072	817	-	356	33,924	301	95,427	828	-	351

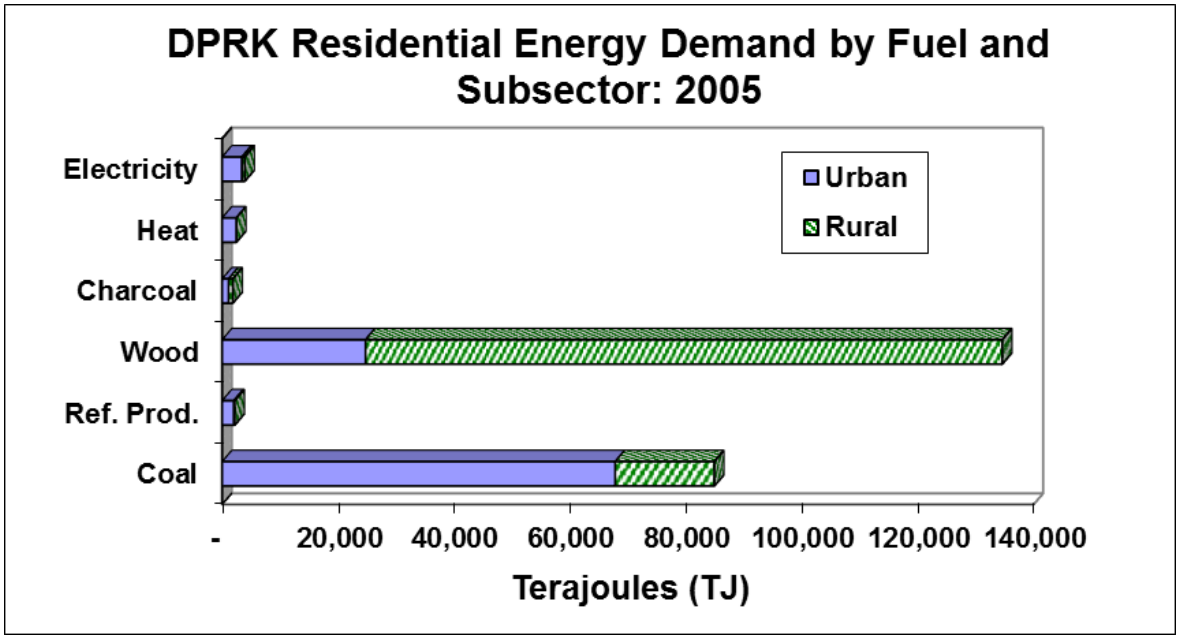
DPRK Residential Sector Energy Demand By Fuel and Subsector: 2020
Units:Terajoules (TJ)

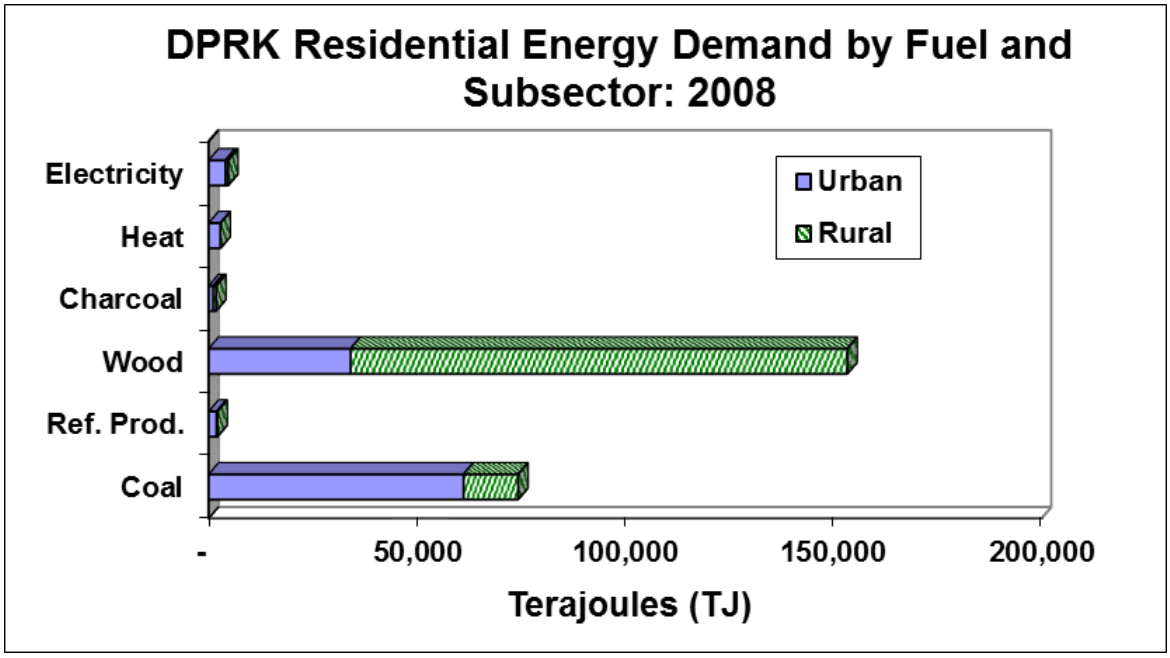
	2020					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	106,977	3,127	24,009	1,390	3,528	5,796
Rural	34,417	310	96,814	840	-	610

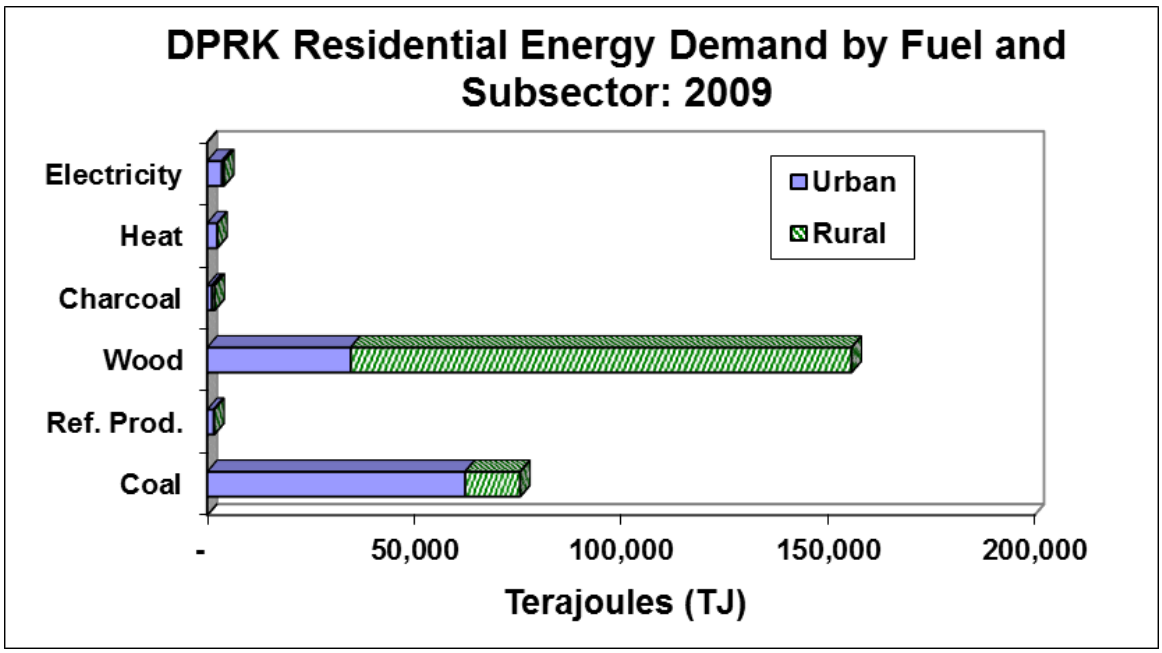

DPRK Residential Energy Demand by Fuel and Subsector: 1990
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
200,000
Terajoules (TJ)

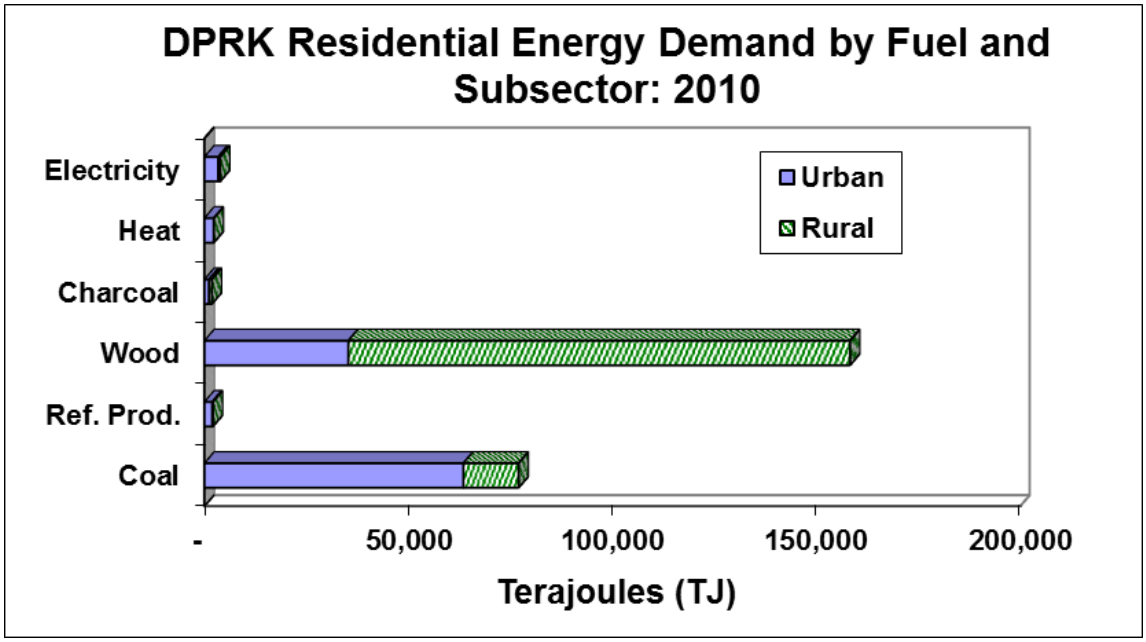

DPRK Residential Energy Demand by Fuel and Subsector: 1996
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)

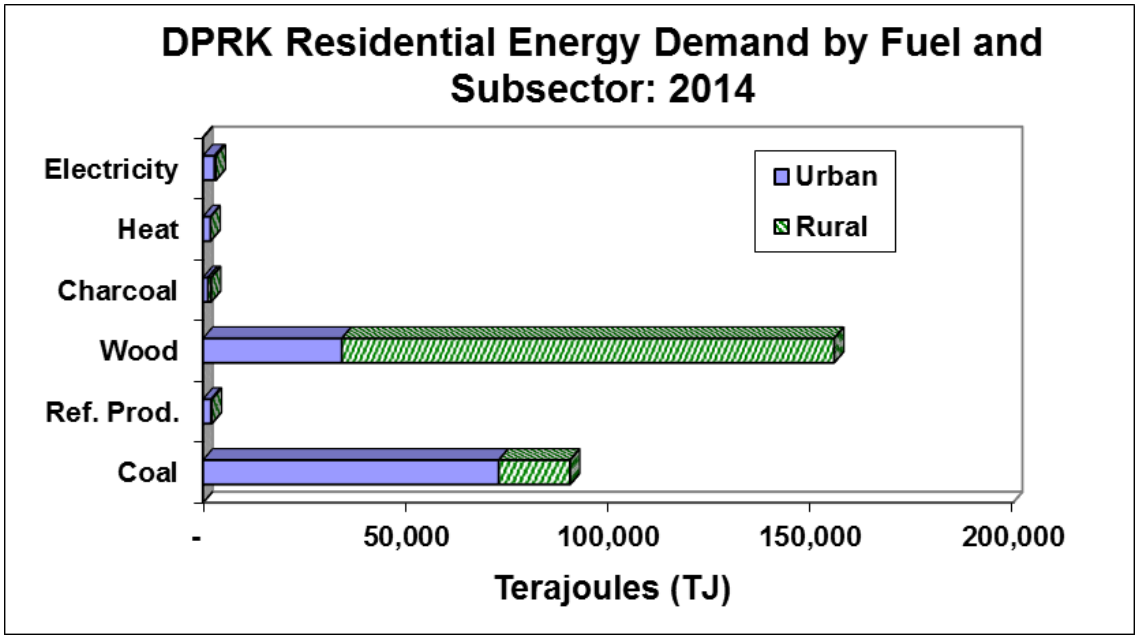

DPRK Residential Energy Demand by Fuel and Subsector: 2000
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)

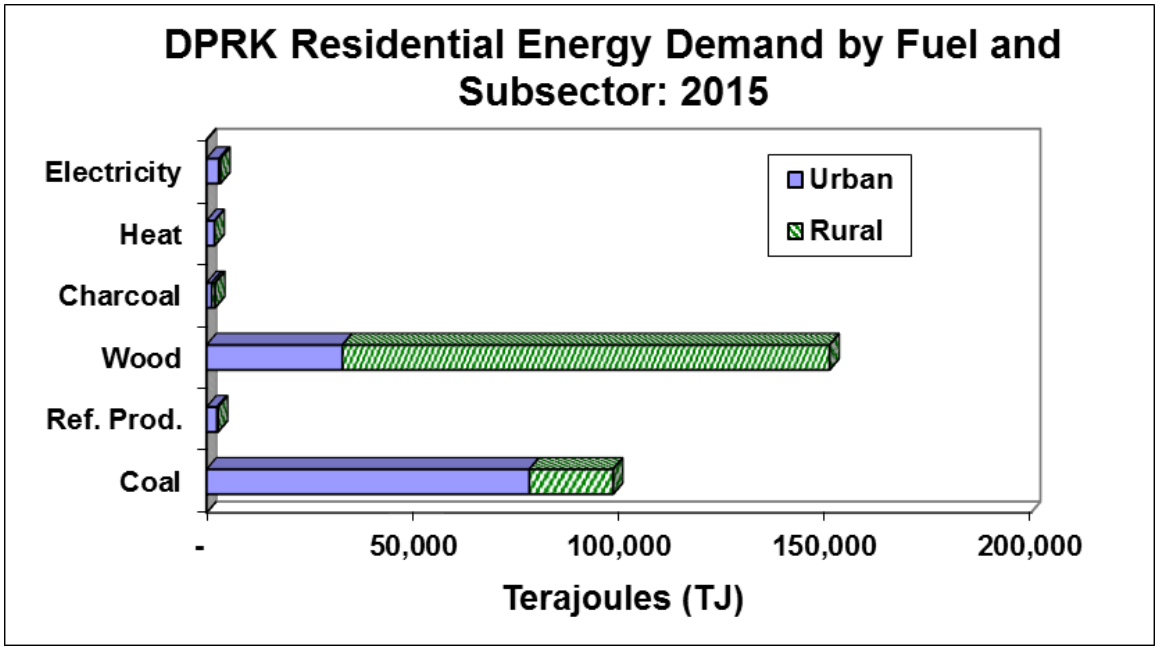

DPRK Residential Energy Demand by Fuel and Subsector: 2005
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2008
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
200,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2009
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
200,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2010
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
200,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2014
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
200,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2015
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
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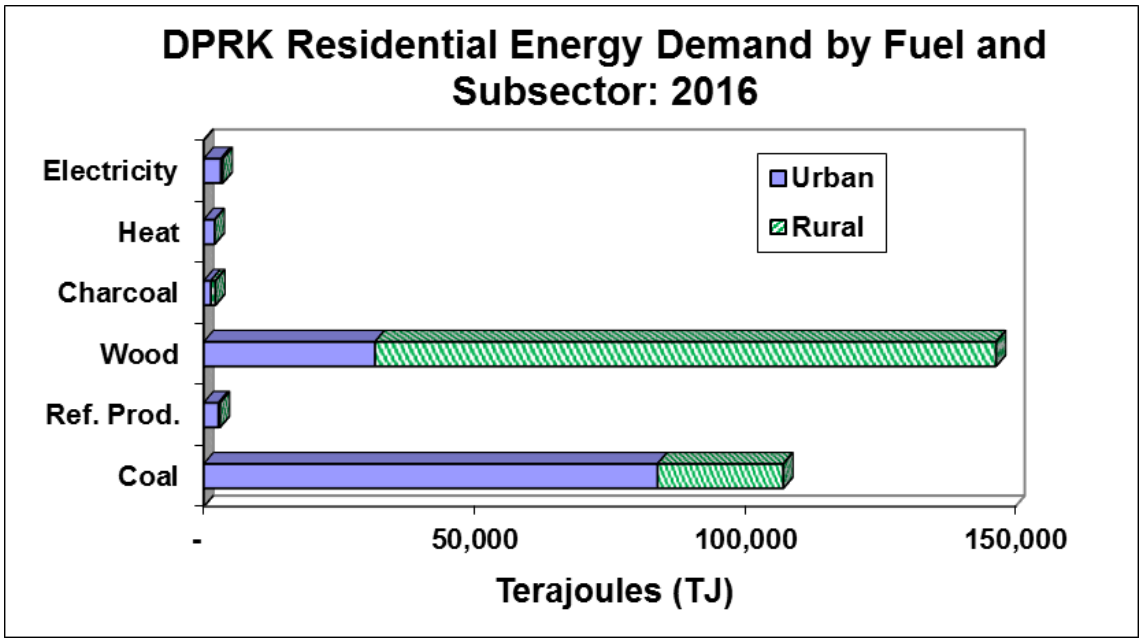
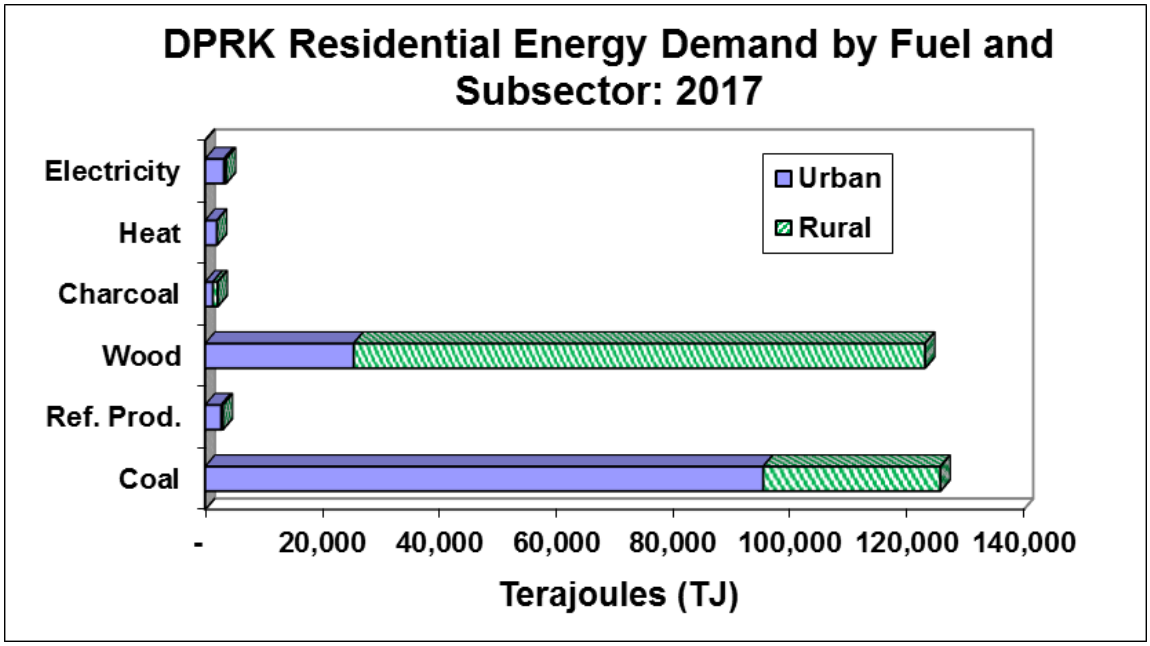
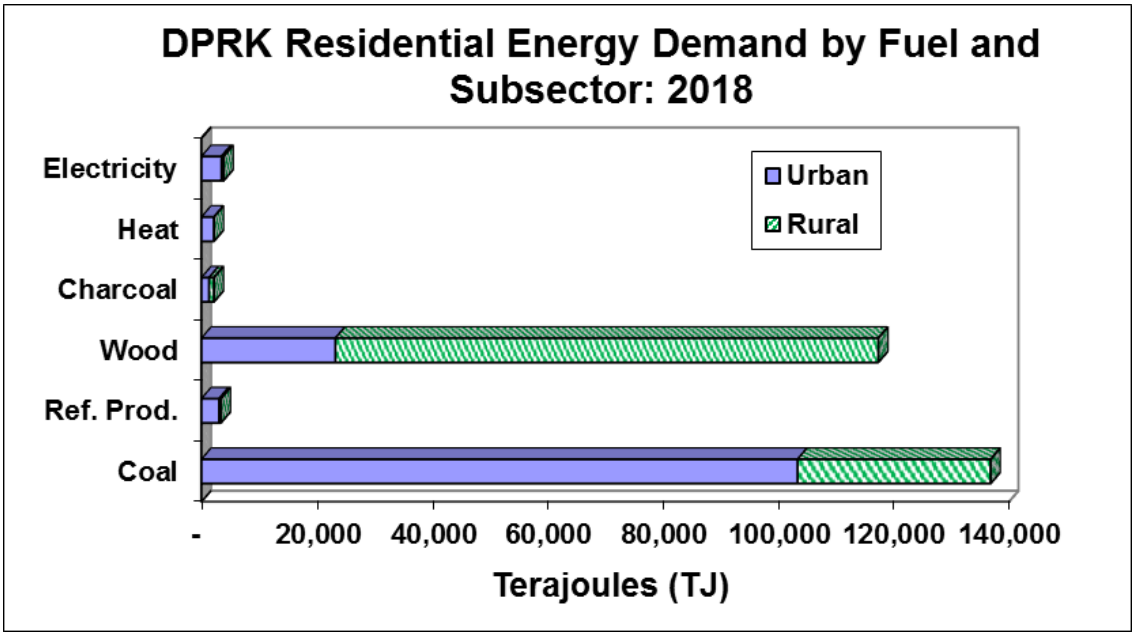
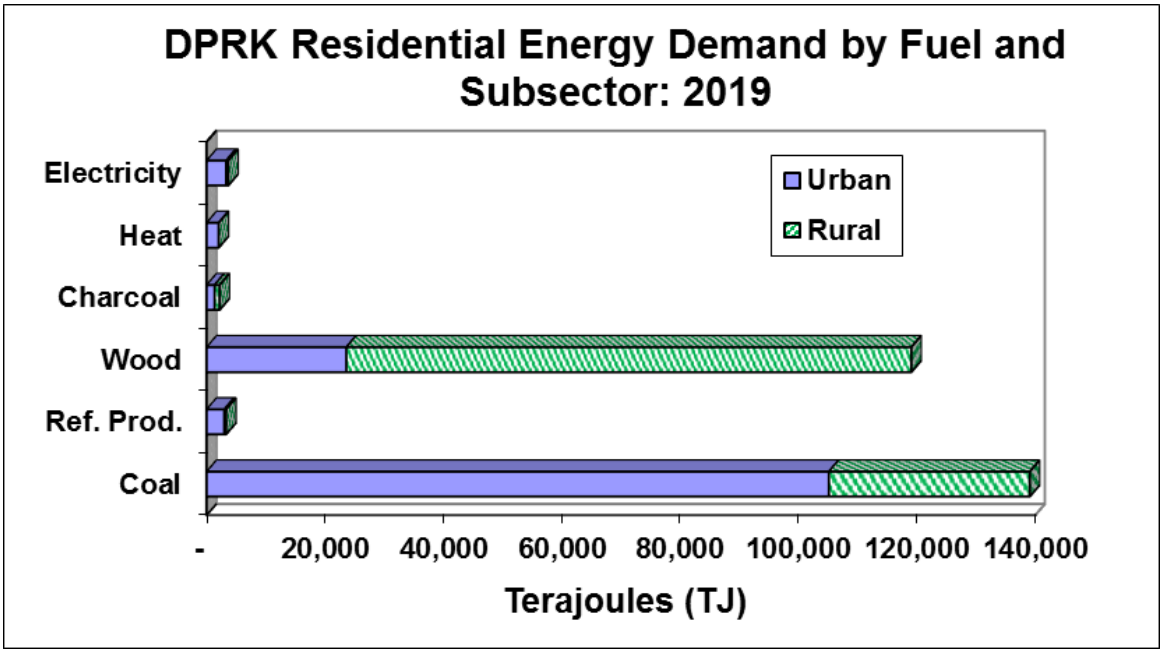
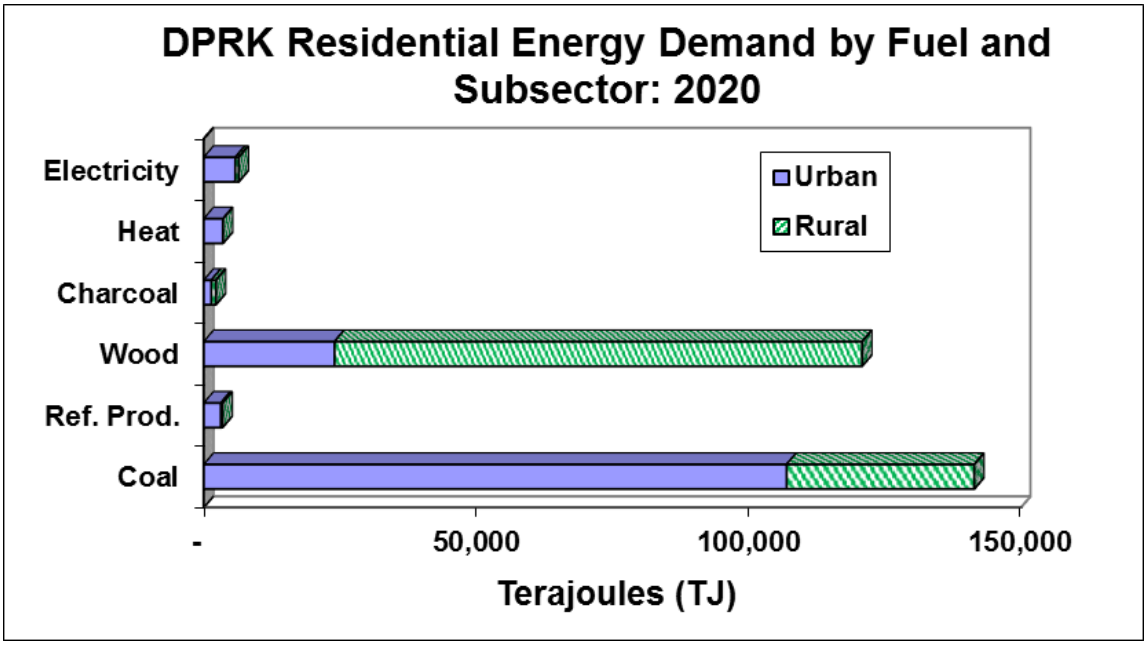
100,000
150,000
200,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2016
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2017
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2018
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2019
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Terajoules (TJ)


DPRK Residential Energy Demand by Fuel and Subsector: 2020
Electricity
Heat
Charcoal
Wood
Ref. Prod.
Coal
Urban
Rural
-
50,000
100,000
150,000
Terajoules (TJ)

DPRK Energy Demand By Sector: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020

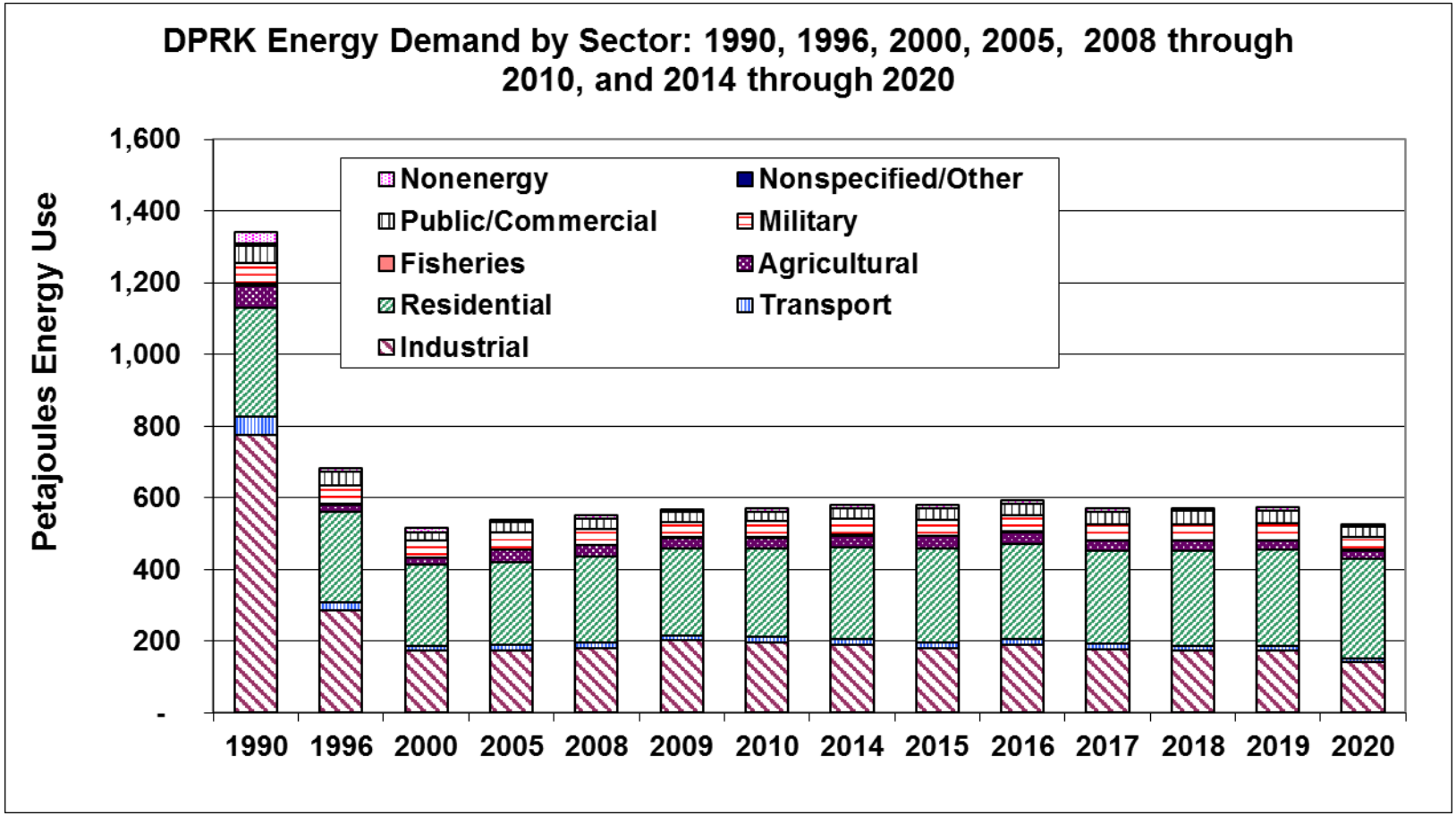
Units: Petajoules (PJ)

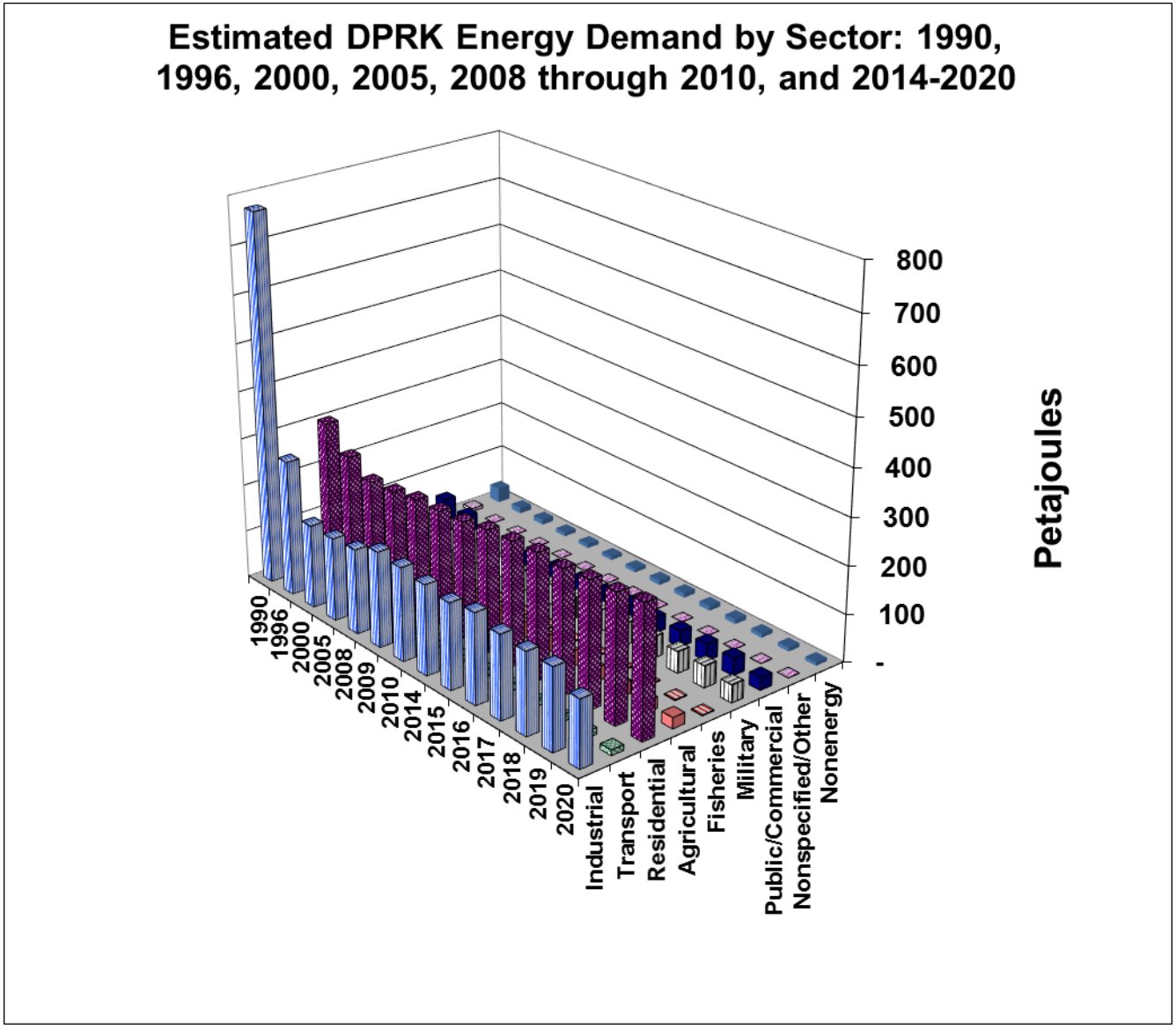
SECTOR	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Industrial	776	285	175	175	179	202	197	190	182	191	177	173	173	140
Transport	51	22	12	16	17	14	15	15	16	16	15	14	14	11
Residential	302	254	225	230	239	241	245	256	260	264	260	266	269	278
Agricultural	62	20	19	34	32	31	31	34	35	32	29	27	24	23
Fisheries	5	2	1	2	1	1	2	2	1	2	2	1	1	1
Military	60	52	47	47	45	43	44	44	45	46	45	45	46	37
Public/Commercial	48	37	23	28	29	28	28	30	31	33	34	36	37	26
Nonspecified/Other	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonenergy	31	12	11	8	8	8	8	10	10	10	10	8	8	7
TOTAL	**1,342**	**684**	**515**	**539**	**550**	**568**	**570**	**580**	**580**	**593**	**571**	**571**	**572**	**525**

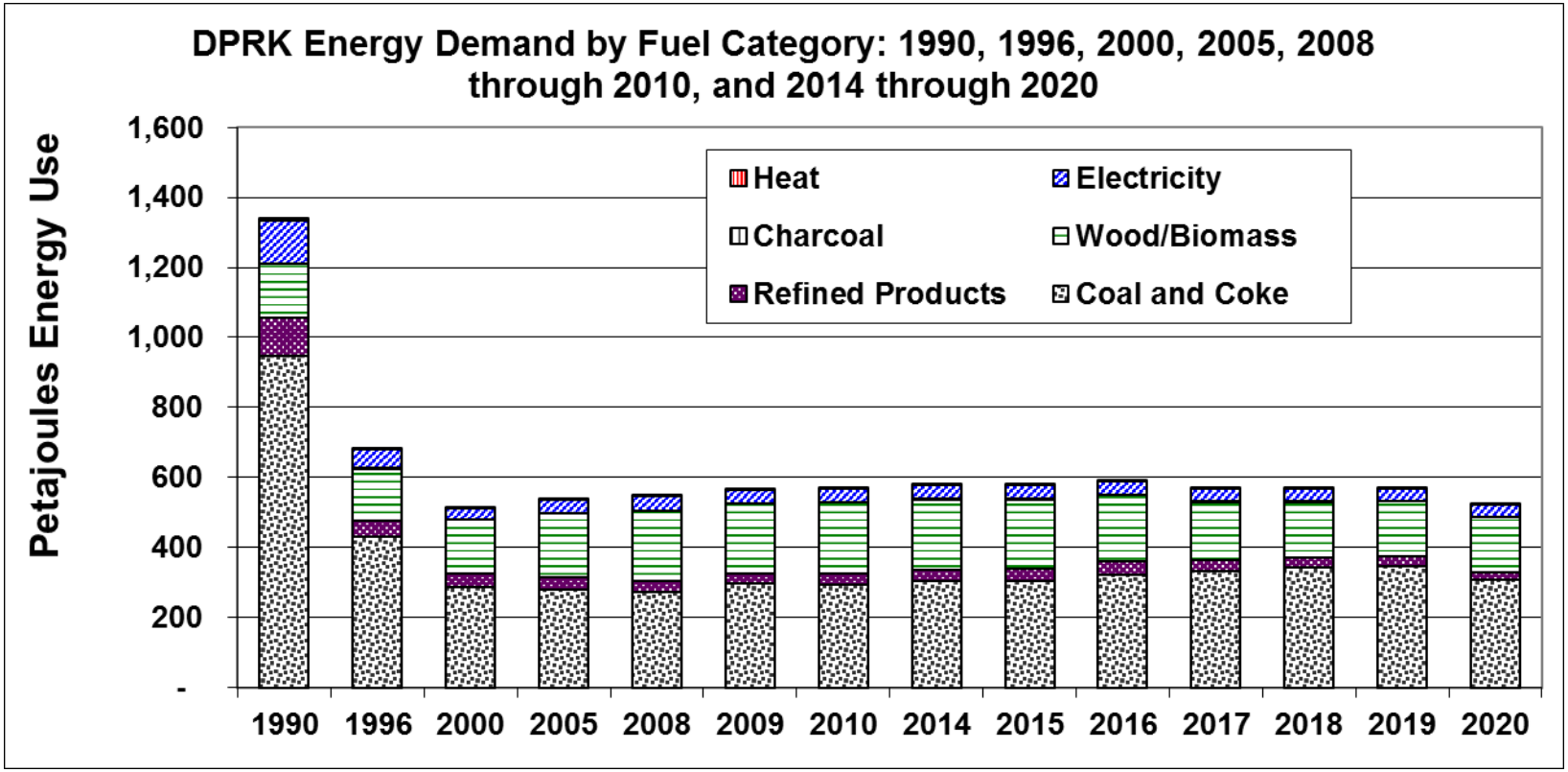
DPRK Energy Demand By Fuel Category: 1990, 1996, 2000, 2005, 2008 through 2010 and 2014 through 2017

Units: Petajoules (PJ)

SECTOR	1990	1996	2000	2005	2008	2009	2010	2014	2015	2016	2017	2018	2019	2020
Coal and Coke	948	431	286	279	272	298	294	304	304	322	334	343	345	306
Refined Products	109	44	39	36	34	28	31	32	35	37	31	30	30	24
Wood/Biomass	152	150	154	181	198	199	202	202	198	190	165	158	157	156
Charcoal	3	2	2	2	2	2	2	2	2	2	2	2	2	2
Heat	9	5	3	4	4	4	4	3	3	3	3	3	3	4
Electricity	120	51	31	38	40	37	37	37	38	39	36	35	35	32
TOTAL	**1,342**	**684**	**515**	**539**	**550**	**568**	**570**	**580**	**580**	**593**	**571**	**571**	**572**	**525**

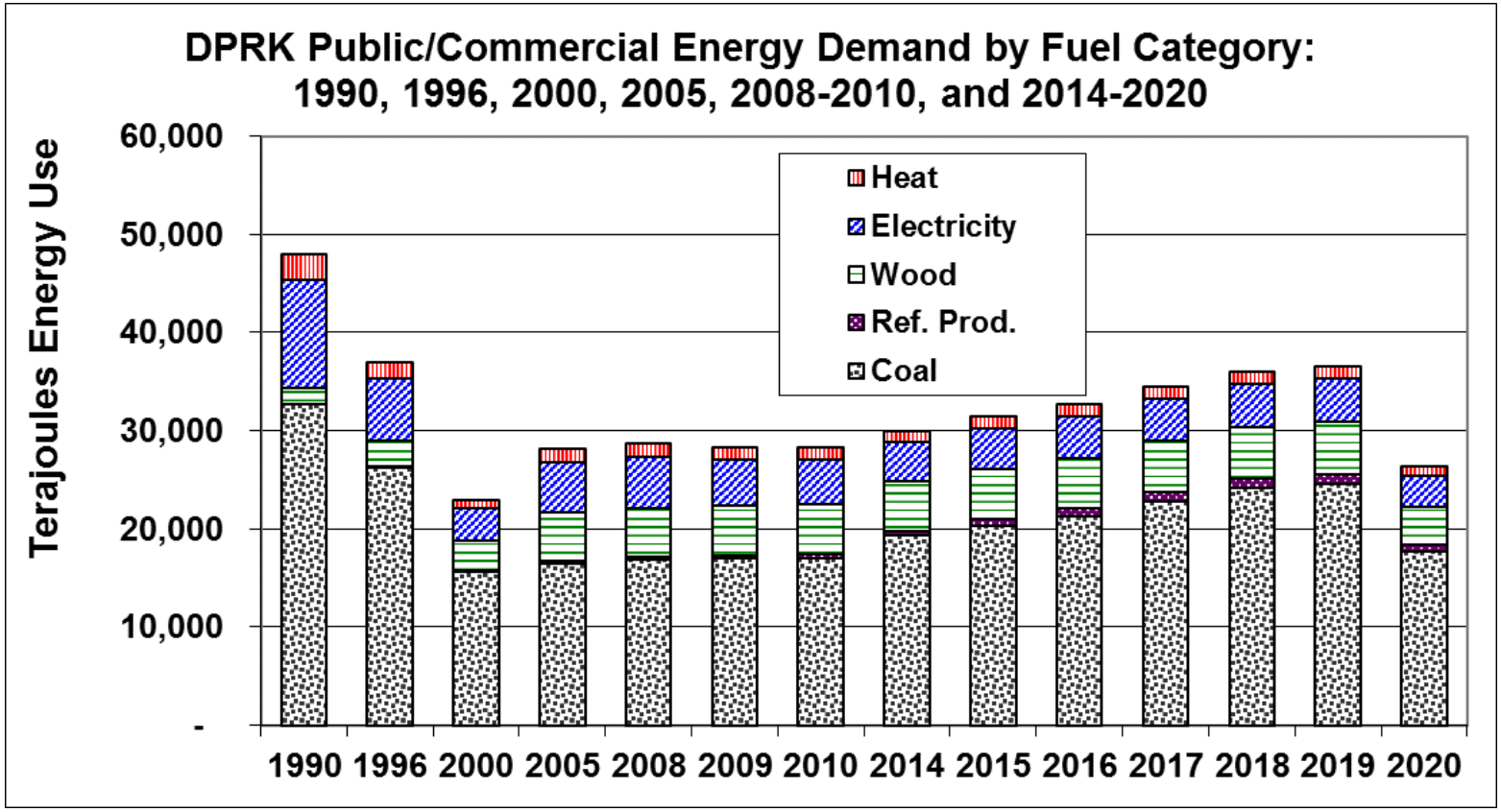

DPRK Energy Demand by Sector: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020
Petajoules Energy Use
1,600
1,400
1,200
1,000
800
600
400
200
-
Nonenergy
Nonspecified/Other
Public/Commercial
Military
Fisheries
Agricultural
Residential
Transport
Industrial
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020


Estimated DPRK Energy Demand by Sector: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014-2020
800
700
600
500
400
300
200
100
-
Petajoules
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020
Industrial
Transport
Residential
Agricultural
Fisheries
Military
Public/Commercial
Nonspecified/Other
Nonenergy


DPRK Energy Demand by Fuel Category: 1990, 1996, 2000, 2005, 2008 through 2010, and 2014 through 2020
Petajoules Energy Use
1,600
1,400
1,200
1,000
800
600
400
200
-
Heat
Electricity
Charcoal
Wood/Biomass
Refined Products
Coal and Coke
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

DPRK Public/Commercial Sector Energy Demand By Fuel 1990 through 2018

Units:Terajoules (TJ)	**Fuel Category**					
Year	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
1990	32,646	98	1,632	-	2,644	10,932
1996	26,180	131	2,618	-	1,612	6,387
2000	15,629	78	3,126	-	820	3,258
2005	16,506	165	4,952	-	1,396	5,150
2008	16,850	239	5,055	-	1,395	5,235
2009	16,944	330	5,083	-	1,281	4,705
2010	17,037	417	5,111	-	1,224	4,469
2014	19,322	491	5,024	-	1,119	3,975
2015	20,297	710	5,074	-	1,186	4,143
2016	21,312	746	5,115	-	1,254	4,300
2017	22,825	872	5,250	-	1,266	4,281
2018	24,122	965	5,307	-	1,300	4,355
2019	24,515	981	5,393	-	1,321	4,387
2020	17,682	707	3,890	-	953	3,161


DPRK Public/Commercial Energy Demand by Fuel Category:
1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules Energy Use
60,000
50,000
40,000
30,000
20,000
10,000
-
Heat
Electricity
Wood
Ref. Prod.
Coal
1990 1996 2000 2005 2008 2009 2010 2014 2015 2016 2017 2018 2019 2020

DPRK Agricuture and Fisheries Energy Demand By Subsector: 1990, 1996, 2000, 2005, 2008 - 2010, and 2014 - 2020

Units: Terajoules (TJ)

	1990				1996			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	2,619	-	907	-	690	-	717
Agriculture--Processing/Other	9,750	2,386	44,950	1,664	3,183	629	14,674	543
Fisheries--Large Ships	-	2,681	-	-	-	804	-	-
Fisheries--Collectives/Processing/Other	1,132	456	-	524	509	193	-	236

	2000				2005			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	507	-	526	-	609	-	508
Agriculture--Processing/Other	2,827	461	14,663	452	5,282	555	25,784	902
Fisheries--Large Ships	-	668	-	-	-	751	-	-
Fisheries--Collectives/Processing/Other	423	161	-	196	453	173	-	210

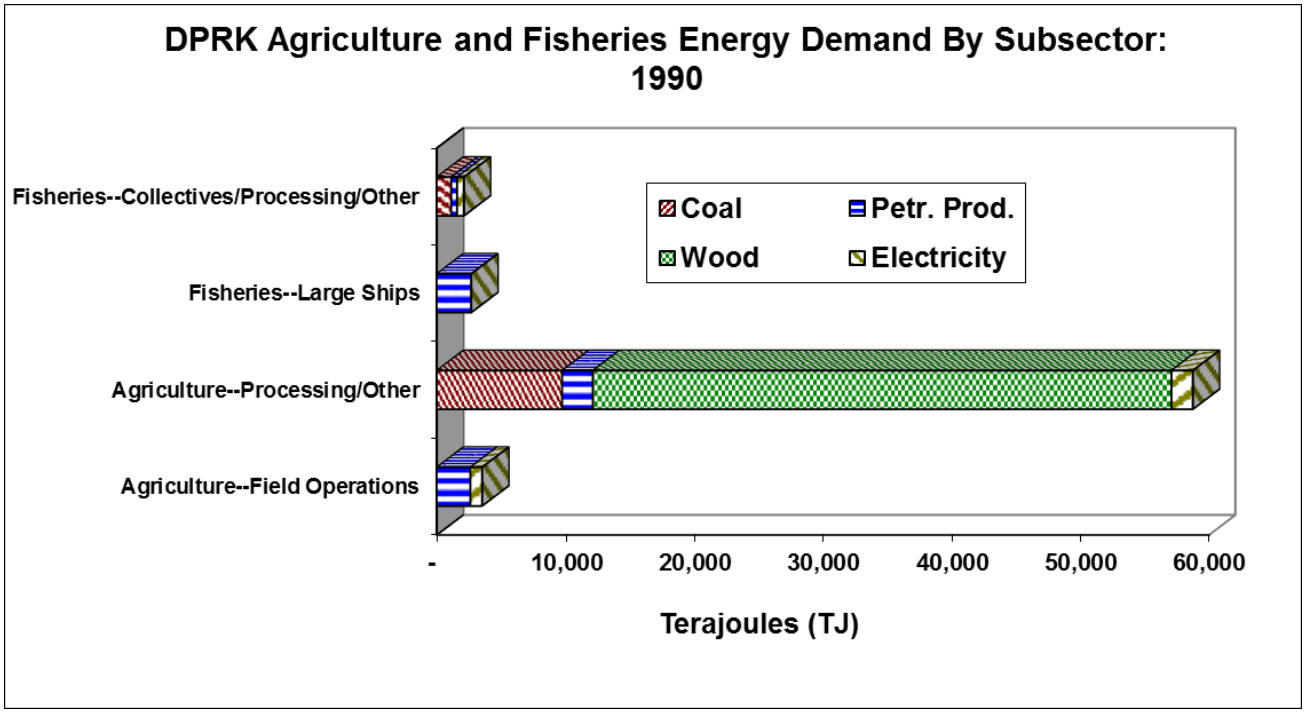
	2008				2009			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Wood	Petr. Prod.	Electricity
Agriculture--Field Operations	-	517	-	392	-	-	518	359
Agriculture--Processing/Other	5,094	491	24,864	870	4,839	23,623	432	826
Fisheries--Large Ships	-	724	-	-	-	-	670	-
Fisheries--Collectives/Processing/Other	419	160	-	194	396	-	150	178

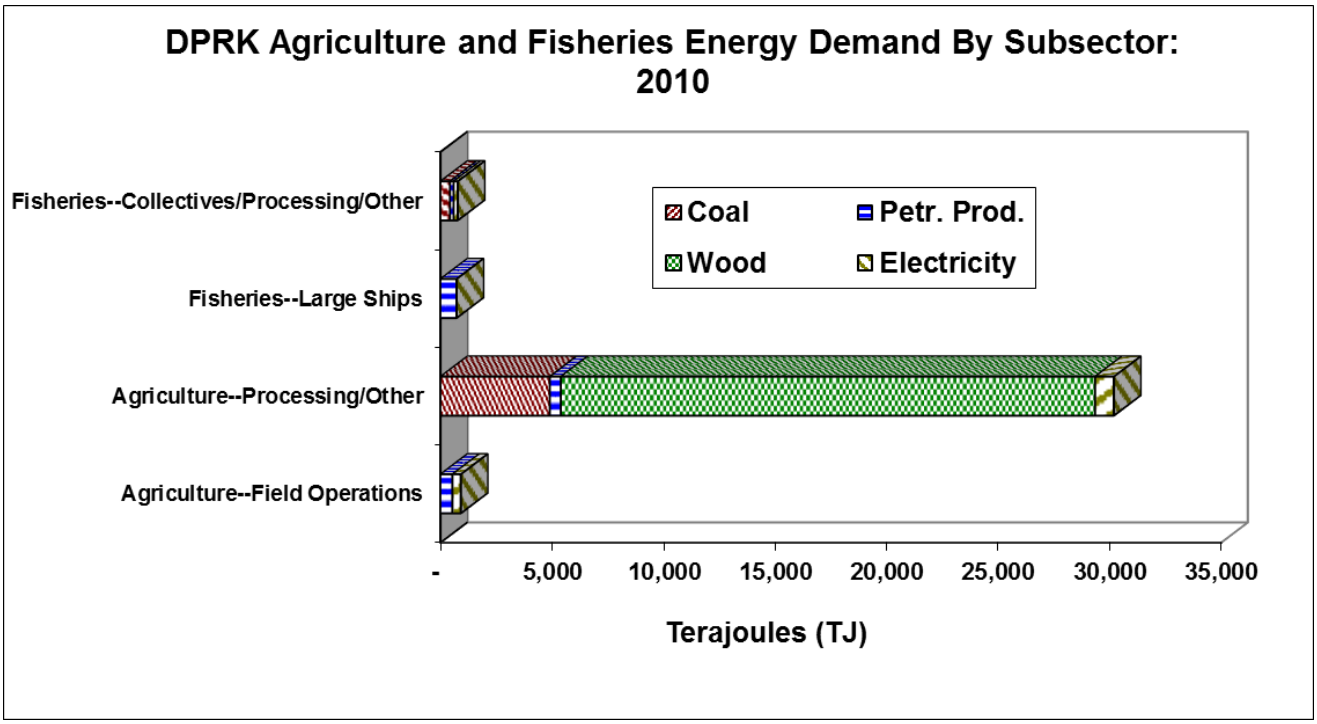
	2010				2014			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	539	-	374	-	515	-	357
Agriculture--Processing/Other	4,907	491	23,955	838	5,410	469	26,410	869
Fisheries--Large Ships	-	724	-	-	-	1,048	-	-
Fisheries--Collectives/Processing/Other	430	165	-	183	430	174	-	173

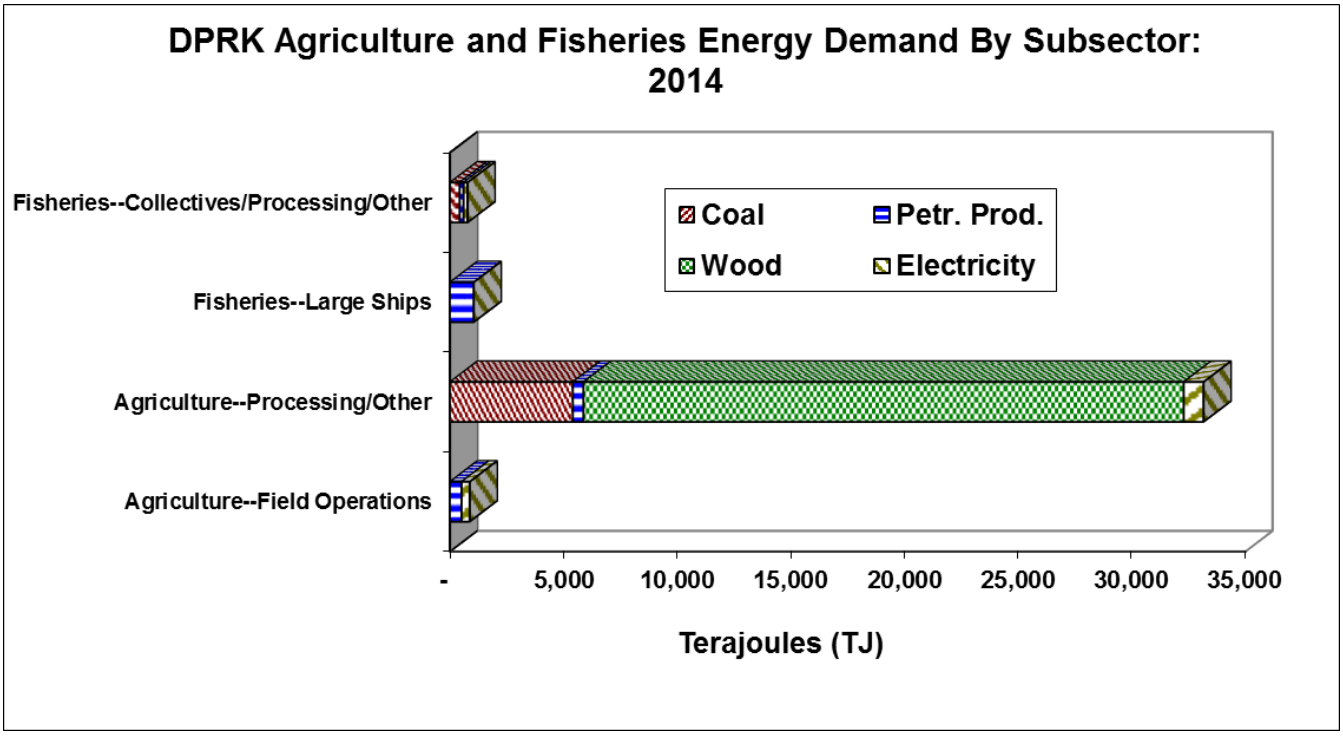
	2015				2016			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	546	-	357	-	579	-	359
Agriculture--Processing/Other	5,581	497	27,243	897	5,004	527	24,428	804
Fisheries--Large Ships	-	717	-	-	-	1,282	-	-
Fisheries--Collectives/Processing/Other	340	134	-	157	430	181	-	199

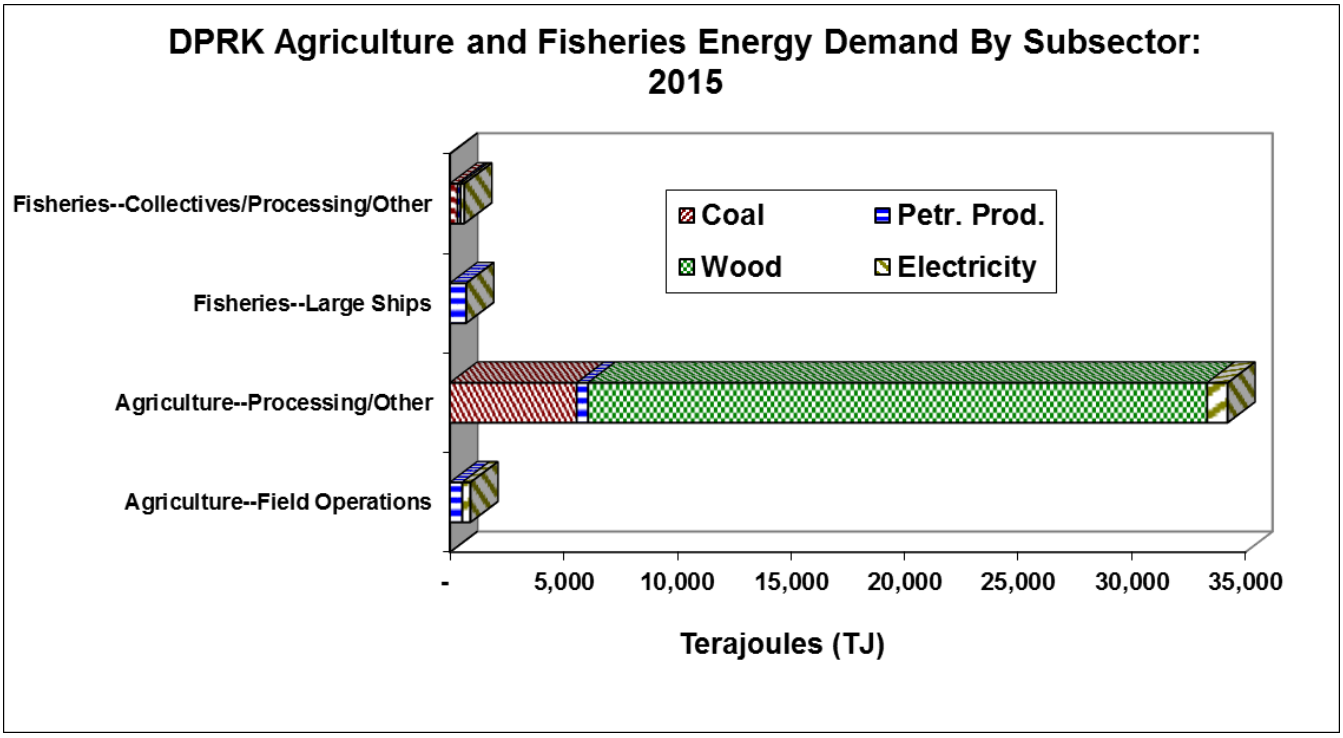
	2017				2018			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	464	-	338	-	396	-	312
Agriculture--Processing/Other	4,574	423	22,330	735	4,370	361	21,331	702
Fisheries--Large Ships	-	1,232	-	-	-	910	-	-
Fisheries--Collectives/Processing/Other	408	172	-	210	285	122	-	147

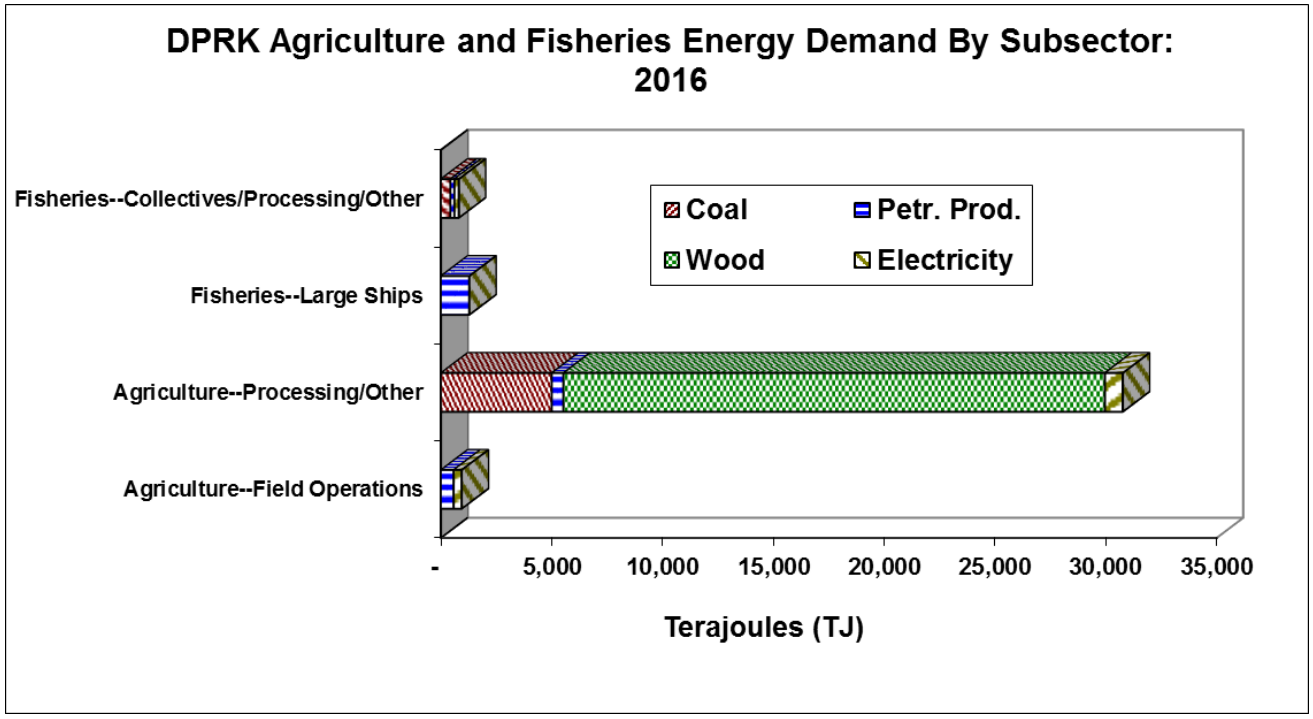
	2019				2020			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Agriculture--Field Operations	-	396	-	312	-	396	-	312
Agriculture--Processing/Other	3,826	353	18,678	615	3,629	344	17,713	583
Fisheries--Large Ships	-	910	-	-	-	819	-	-
Fisheries--Collectives/Processing/Other	285	122	-	147	257	110	-	132

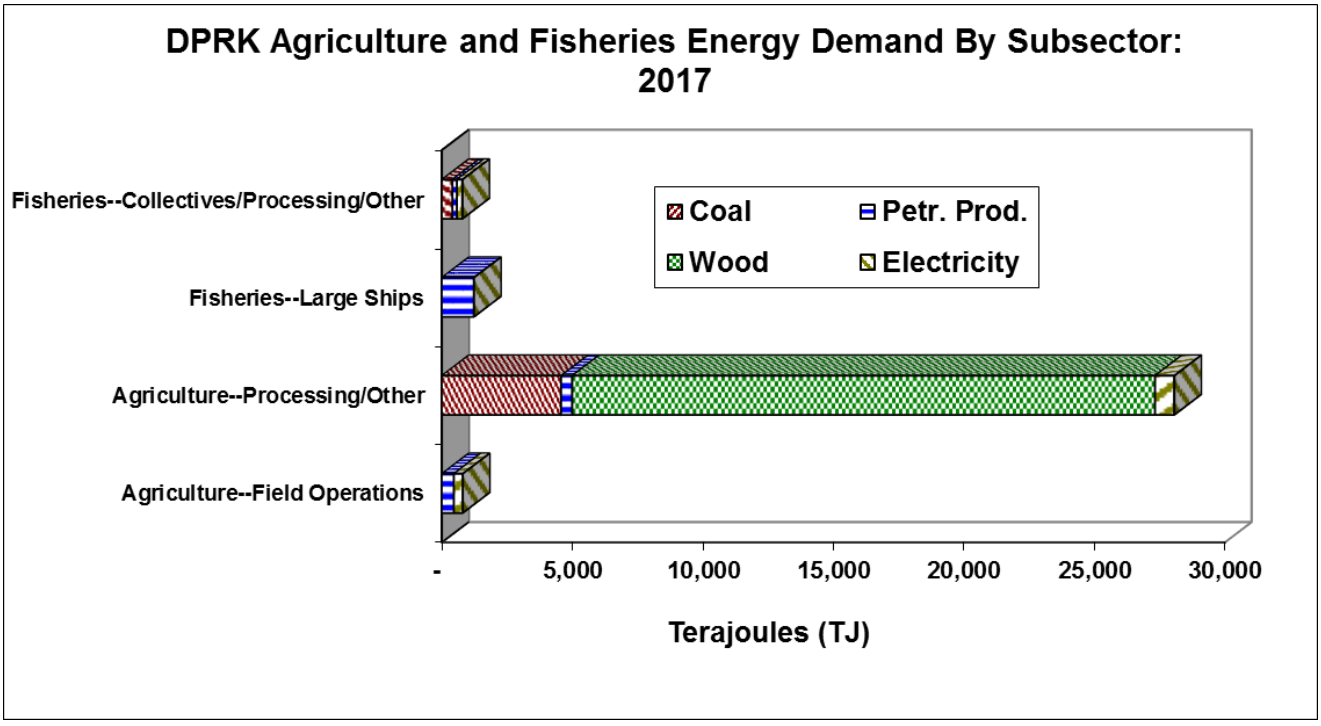

DPRK Agriculture and Fisheries Energy Demand By Subsector: 1990
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
Terajoules (TJ)

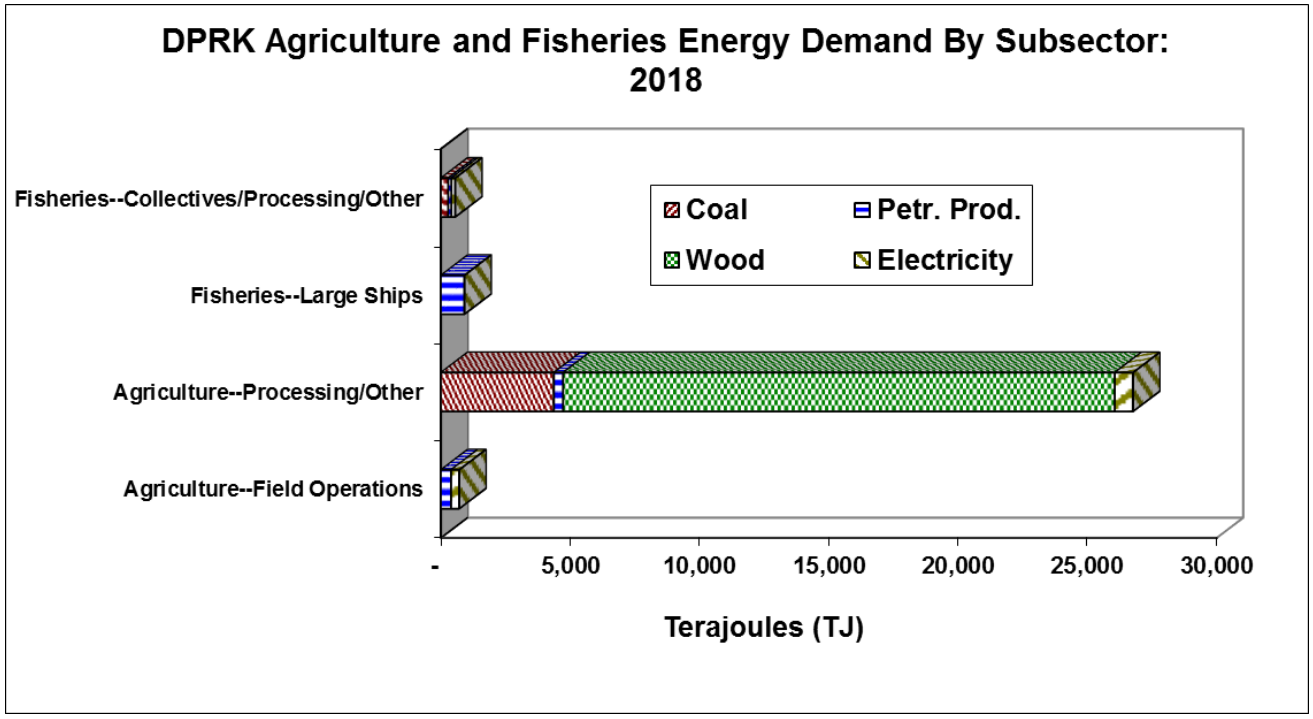

DPRK Agriculture and Fisheries Energy Demand By Subsector: 2010
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)

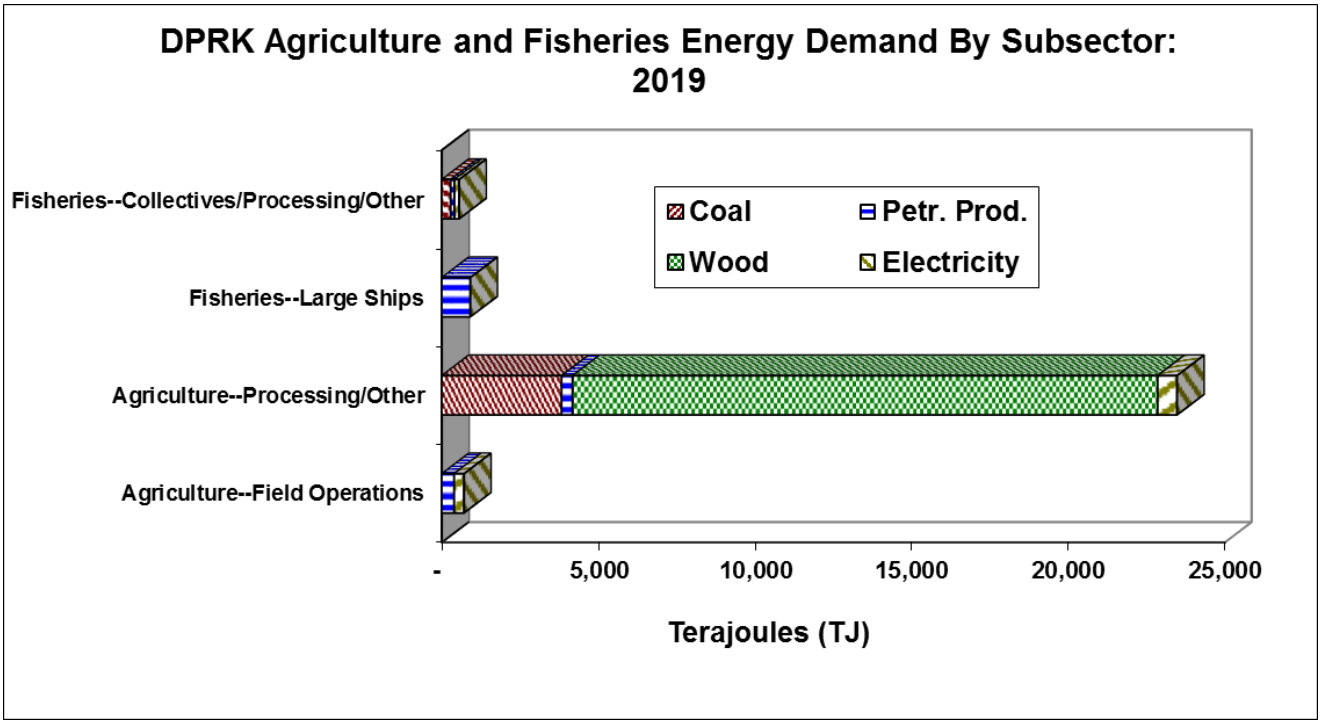

DPRK Agriculture and Fisheries Energy Demand By Subsector: 2014
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)

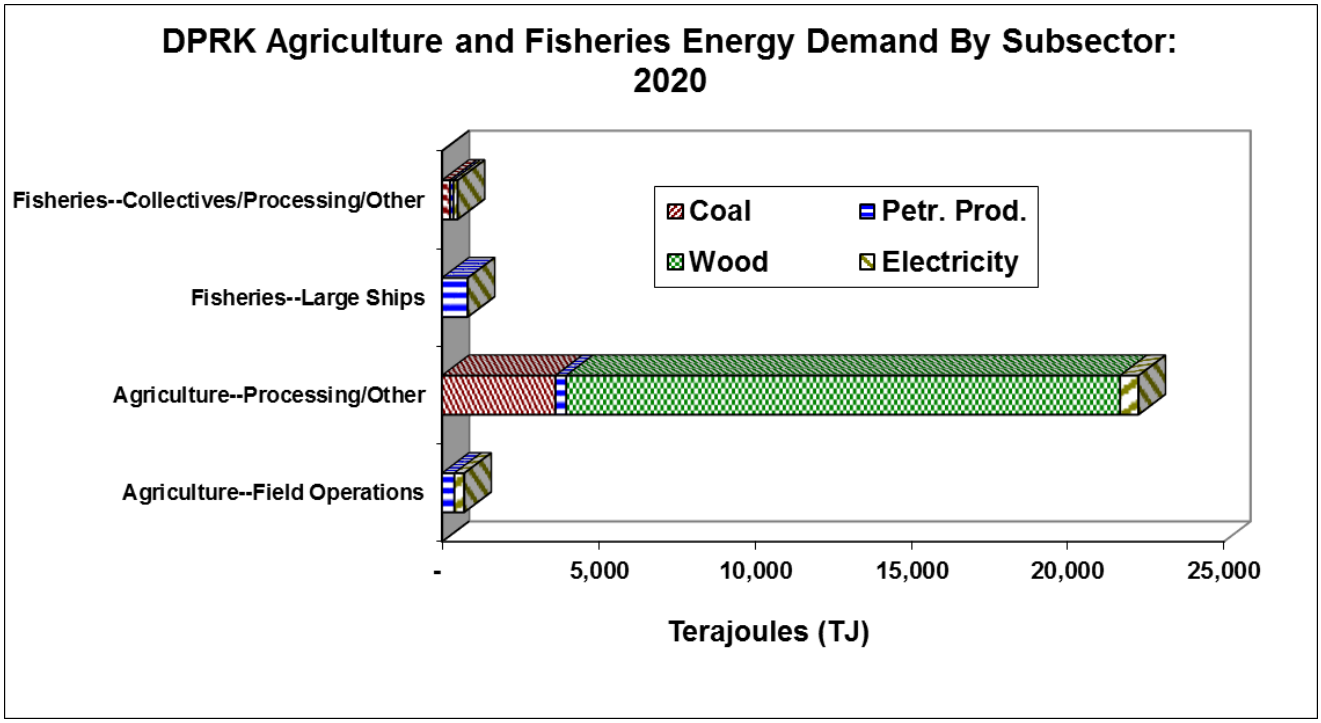

DPRK Agriculture and Fisheries Energy Demand By Subsector: 2015
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)


DPRK Agriculture and Fisheries Energy Demand By Subsector: 2016
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Terajoules (TJ)


DPRK Agriculture and Fisheries Energy Demand By Subsector: 2017
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
Terajoules (TJ)


DPRK Agriculture and Fisheries Energy Demand By Subsector: 2018
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
Terajoules (TJ)


DPRK Agriculture and Fisheries Energy Demand By Subsector: 2019
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
Terajoules (TJ)

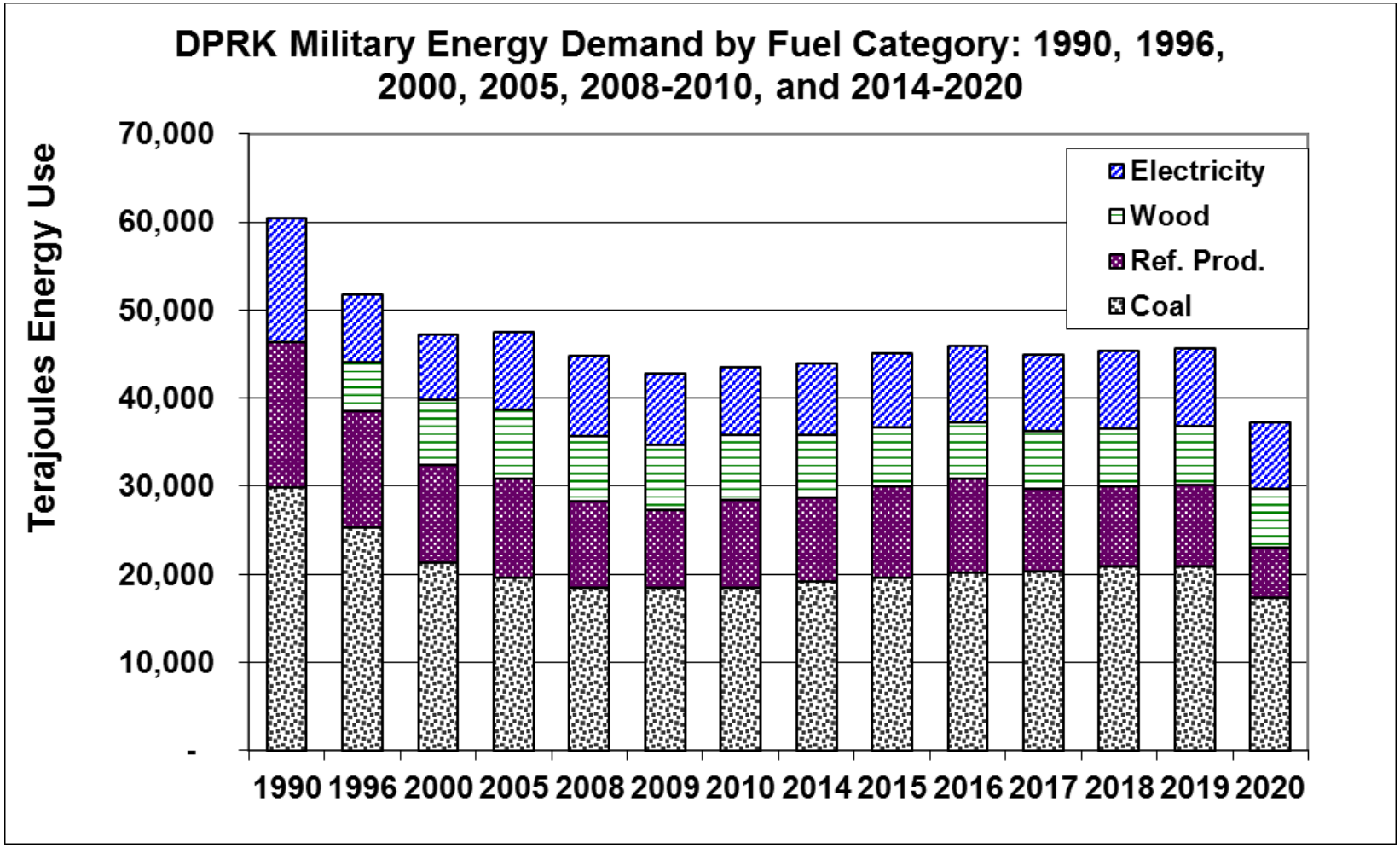

DPRK Agriculture and Fisheries Energy Demand By Subsector: 2020
Fisheries--Collectives/Processing/Other
Fisheries--Large Ships
Agriculture--Processing/Other
Agriculture--Field Operations
Coal
Petr. Prod.
Wood
Electricity
-
5,000
10,000
15,000
20,000
25,000
Terajoules (TJ)

DPRK Military Sector Energy Demand By Fuel 1990 through 2018

Units:Terajoules (TJ)	**Fuel Category**				
Year	Coal	Ref. Prod.	Wood	Electricity	**TOTAL**
1990	29,828	16,533	-	14,008	60,369
1996	25,365	13,186	5,498	7,711	51,761
2000	21,308	11,094	7,379	7,420	47,202
2005	19,615	11,253	7,871	8,746	47,486
2008	18,415	9,830	7,379	9,095	44,720
2009	18,415	8,856	7,379	8,142	42,791
2010	18,415	10,018	7,379	7,699	43,512
2014	19,144	9,522	7,130	8,120	43,916
2015	19,622	10,310	6,771	8,399	45,103
2016	20,106	10,805	6,401	8,609	45,921
2017	20,355	9,391	6,482	8,679	44,907
2018	20,852	9,078	6,644	8,819	45,393
2019	20,852	9,272	6,644	8,819	45,587
2020	17,308	5,731	6,644	7,575	37,258

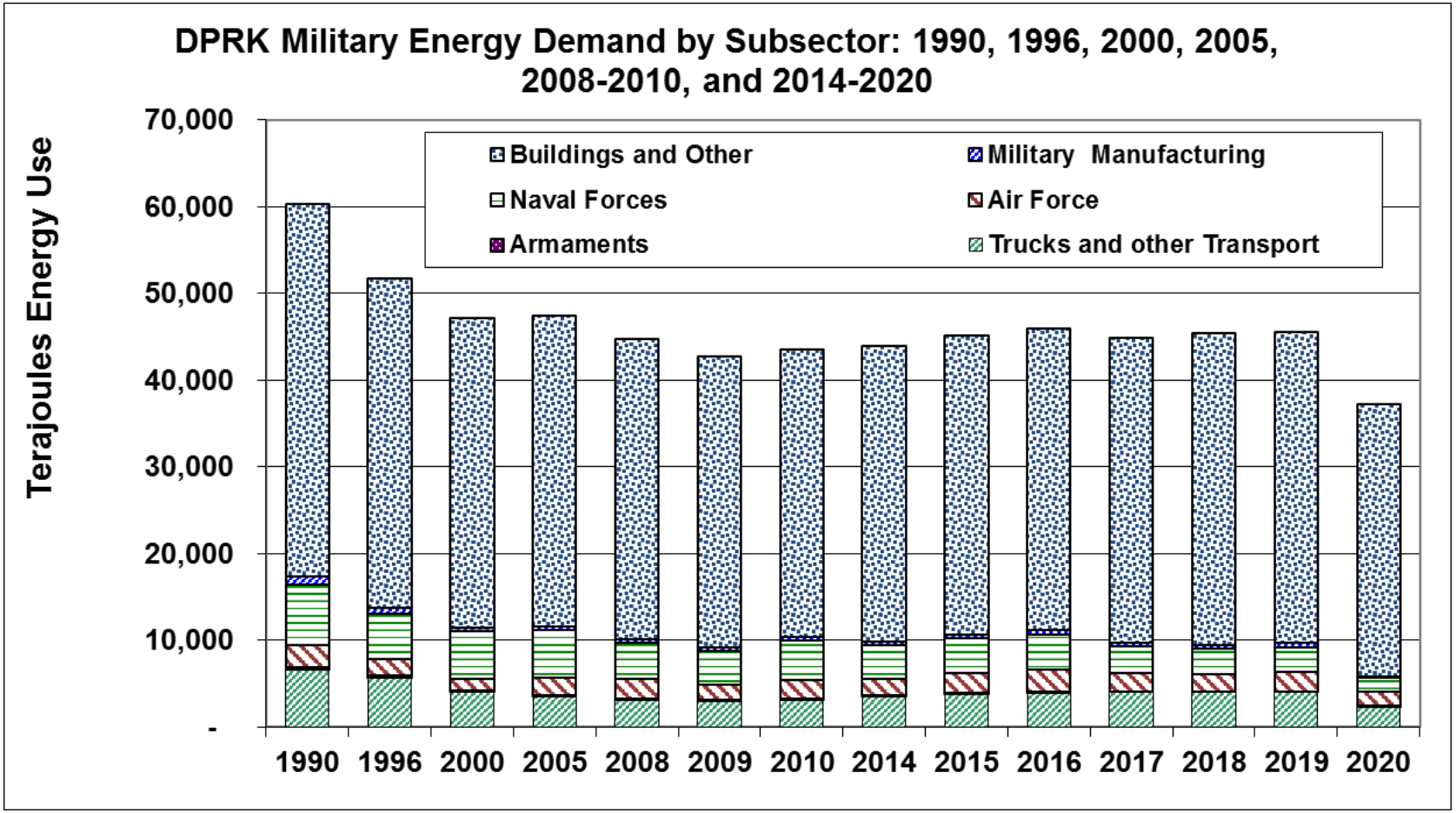
DPRK Military Sector Fraction of National Energy Demand By Fuel 1990 through 2018

Units:Terajoules (TJ)	**Fuel Category**				
Year	Coal	Ref. Prod.	Wood	Electricity	**TOTAL**
1990	3.1%	15.1%	0.0%	11.6%	4.5%
1996	5.9%	29.9%	3.7%	15.2%	7.6%
2000	7.5%	28.2%	4.8%	24.1%	9.2%
2005	7.0%	31.1%	4.3%	23.3%	8.8%
2008	6.8%	28.7%	3.7%	22.8%	8.1%
2009	6.2%	32.2%	3.7%	21.7%	7.5%
2010	6.3%	31.8%	3.6%	21.1%	7.6%
2014	6.3%	30.0%	3.5%	21.7%	7.6%
2015	6.5%	29.7%	3.4%	21.9%	7.8%
2016	6.2%	29.1%	3.4%	22.3%	7.7%
2017	6.1%	30.2%	3.9%	24.2%	7.9%
2018	6.1%	30.1%	4.2%	25.3%	7.9%
2019	6.0%	30.7%	4.2%	25.5%	8.0%
2020	5.7%	23.7%	4.3%	23.7%	7.1%


DPRK Military Energy Demand by Fuel Category: 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules Energy Use
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Electricity
Wood
Ref. Prod.
Coal
1990 1996 2000 2005 2008 2009 2010 2014 2015 2016 2017 2018 2019 2020

DPRK Military Sector Energy Demand By Subsector, 1990 through 2018

Units:Terajoules (TJ)	**Subsector**						
Year	Trucks and other Transport	Armaments	Air Force	Naval Forces	Military Manufacturing	Buildings and Other	**TOTAL**
1990	6,585	263	2,648	6,937	938	42,998	60,369
1996	5,734	211	1,886	5,261	657	38,013	51,761
2000	4,064	148	1,367	5,430	422	35,771	47,202
2005	3,524	129	2,002	5,513	422	35,896	47,486
2008	3,186	101	2,234	4,227	422	34,549	44,720
2009	2,984	101	1,792	3,901	422	33,592	42,791
2010	3,186	103	2,100	4,553	422	33,147	43,512
2014	3,527	96	1,899	3,923	450	34,022	43,916
2015	3,874	102	2,310	3,944	460	34,412	45,103
2016	3,999	111	2,567	4,049	469	34,727	45,921
2017	4,035	85	2,119	3,072	469	35,127	44,907
2018	4,035	85	2,015	2,867	469	35,922	45,393
2019	4,035	85	2,209	2,867	469	35,922	45,587
2020	2,409	47	1,653	1,556	235	31,358	37,258


DPRK Military Energy Demand by Subsector: 1990, 1996, 2000, 2005, 2008-2010, and 2014-2020
Terajoules Energy Use
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
1990
1996
2000
2005
2008
2009
2010
2014
2015
2016
2017
2018
2019
2020

Estimate of Costs to Refurbish DPRK Transmission and Distribution System

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

Rough Estimate of Cost to Refurbish DPRK Electricity System

Prepared By David Von Hippel	
Date Last Modified:	**2/22/2005**

Note: This analysis has not been updated using up-to-date (2020) costs, and in fact it is likely that at this point (2020) refurbishment of the DPRK electricity system would not take the (formerly) conventional approach of simply replacing the main grid, that is, rather, the grid would likely be reconstituted as an assembly of mini-grids connected with modern communications, grid status measurement, and "smart grid" elements. This estimate is thus shown as an illustration, with the original costs in circa 2005 dollars also presented in 2019 dollars.

Assumptions:

1 cm on map is 44 km (estimated based on scale comparison with DPRK map of known scale)

1 est. km is 1.3 actual ground km (rough estimate)

Assumed Costs to Build New Transmission Lines as shown are USD/km, no ROW costs, and include a factor of 1.3 to inflate 1995 dollars to 2005 (estimated based on 1995 and 2005 CPI), and a factor of 0.7 to adjust US costs to probable DPRK costs (rough estimate).

Assumed Substation Refurbishment Cost, USD/peak kW served: $30 *(See Note 3)*

Assumed Peak MW to be served by substations and the distribution system: 12000

(Based roughly on 1990 loads, plus ~15-20% reserve margin to account for non-coincident loads).

Assumed Distrubution System Refurbishment Cost, USD/peak kW served: $200 *(See Note 4)*

Inflator, 2005 to 2019 US dollars:	1.3169

ESTIMATE OF COSTS BY COMPONENT

Transmission and Distribution Refurbishment Costs

Voltage	Length on Map (cm) *(Note 1)*	Implied km	Assumed Costs of New Trans Lines (USD/km) *(Note 2)*	Implied Costs of Refurbishing Systems (million USD)
220 kV	33	1,888	$ 227,500	$ 429
154 kV	6	343	$ 182,000	$ 62
110 kV	22	1,258	$ 136,500	$ 172
66 kV	37	2,116	$ 72,800	$ 154
Total Transmission Lines		**5,606**	km	**$ 818**
Substation Costs				**$ 360**
Distribution Costs				**$ 2,400**
Total of Above:				**$ 3,578**

Generation System Refurbishment Cost Estimates

	Refurbishment Costs, USD/kW		Total MW *(See Note 5)*	Implied Costs of Refurbishing Systems (million USD)		
Type of Plant	Low Est.	High Est.		Low Est.	High Est.	
Hydro	150	300	4500	**$ 675**	**$ 1,350**	*(See Note 6)*
Thermal	350	700	3600	**$ 1,260**	**$ 2,520**	*(See Note 7)*
TOTAL			8100	**$ 1,935**	**$ 3,870**	

	Low Est.	High Est.	
OVERALL TOTAL WITH T&D	**$ 5,513**	**$ 7,448**	2005 USD
OVERALL TOTAL WITH T&D	**$ 7,260**	**$ 9,808**	2019 USD

Notes and Sources

Note 1*: DPRK Grid Map measured was provided by confidential ROK source to Nautilus in ~1998.*

Note 2*: Very approximate power line costs derived from table below, as found at* http://www.eia.doe.gov/cneaf/pubs_html/feat_trans_capacity/table2.html

Table FE2. Typical Costs and Capacity of New Transmission Lines (1995 Dollars)

Voltage	Type of Supporting Tower and Number of Circuits	Size of Power Line	Normal Rating MW	Cost per Circuit per Mile[a]
	Above Ground			
60 kV	wood pole, single	4/0 AWG	32	$120,000
60 kV	wood pole, single	397.5 kcmil	56	$125,000
60 kV	wood pole, single	715.5 kcmil	79	$130,000
115 kV	wood pole, single	4/0 AWG	64	$130,000
115 kV	wood pole, single	397.5 kcmil	108	$135,000
115 kV	wood pole, single	715.5 kcmil	151	$140,000
115 kV	steel pole, single	715.5 kcmil	151	$250,000
115 kV	steel pole, single	715.5 kcmil, bundled	302	$400,000
115 kV	steel pole, double	715.5 kcmil	151	$160,000
115 kV	steel pole, double	715.5 kcmil, bundled	302	$250,000
230 kV	steel pole, single	1,113 kcmil	398	$360,000
230 kV	steel pole, single	1,113 kcmil, bundled	796	$530,000
230 kV	steel pole, single	2,300 kcmil, bundled	1,060	$840,000
230 kV	steel pole, double	1,113 kcmil	398	$230,000
230 kV	steel pole, double	1,113 kcmil, bundled	796	$350,000
230 kV	steel pole, double	2,300 kcmil, bundled	1,060	$550,000
	Underground			
115 kV	underground cable	200 MVA	180	$3,300,000
230 kV	underground cable	400 MVA	360	$3,700,000

[a]These costs do not include right-of-way costs.

AWG = American wire gauge.

kcmil = One kcmil is 1,000 circular mils, a measure of wire cross-area.

kV = Kilovolts.

MVA = Megavolt amperes.

MW = Megawatts.

Source: CSA Energy Consultants, "Existing Electric Transmission and Distribution Upgrade Possibilities, "(Arlington, VA, July 18, 1995), p. 9.

Note 3: Substation costs of $23/kW served for rural ~69kV substation, $33/kW for suburban ~138 kV substation, from http://www.pserc.wisc.edu/ecow/get/publicatio/2002public/krishfop2002pserc.pdf

Note 4: *D. Von Hippel, working with Syrian colleagues, estimated a cost of distribution additions of about $275 per kW of peak distribution power addressed for additions in the late 1990s and early 2000s. In Egypt, for a municipal utility, an estimate for future additions of about $70 per kW of peak distribution power was used. An audit of distribution costs at several indian Utilities (http://www.tni.org/reports/energy/performance.pdf) showed a range of about* 0.54 *to* 1.04 *Rupee per kWh, or about USD* 0.012 *to* 0.024 *per kWh, at a rate of return of about* 20%. *This suggests an investment cost of about USD* 0.062 *to* 0.119 *per kWh/yr distributed, which, assuming an average load factor of* 70% *or* 6132 *(kWh/yr)/kW, yields a per-kW charge of* 379 *to* 730 *USD/kW peak power distributed, which sounds too high, but may in fact be not out-of-the-question, when operating costs are included.*

Table 8: 'Distribution Cost' (DC) of urban utilities

Utility	DC (Rs./U)	RR as % of DC
TPC	0.54	18%
NPC	0.54	33%
BSES	0.75	20%
SEC	0.56	20%
Mumbai DU	1.04	22%
CESC	1.07	4%

Notes:
1. *RR is the Reasonable Return Allowed to the utility (attributed to the distribution function)*
2. *The data for BSES and NPC are for the FY 99-00 and for others they are for the FY 00-01*

Note 5: *Generation capacities are the sum of our total estimates for 1990, plus additions between 1990 and 2000. For Hydro, this includes both larger and (purported) smaller hydro (about 2/3 large, identified plants). For thermal plants (all but 200 MW coal-fired), this includes mostly identified larger units.*

Note 6: *A report on a hydro refurbishing projectin in Macedonia, working on power plants that are 40-50 years old and probably somewhat smaller, on average (unit size) than the larger hydro stations in the DPRK, reports a contract of about $110/kW for a combination of energy efficiency, control, and other measures. It is not clear whether this includes replacing generators, though it may include some work on them.*
http://www.emersonprocess.com/home/library/articles/macedonia/macedonia_pwr-eng-intl-0203.pdf
The range estimate provided assumes that most of the work needed will be on the turbine and electrical side, and that any impoundment works will either be fairly minimal or done very inexpensively (low labor costs).

Note 7: *Very rough estimates spanning the range from the costs of a gas-fired combustion turbine with minimal site costs (mostly equipment costs), to nearly-full costs for a Chinese-style coal plant including emissions control.*
These would not include costs for off-site fuel supply infrastructure.

DPRK Industrial Energy Intensity Estimates as of 1990

ENERGY INTENSITY ESTIMATES USED IN ESTIMATES OF FUEL USE IN THE DPRK INDUSTRIAL SECTOR, 1990

Industrial Subsector	Output Units	Fuel Use Intensity (tce/Unit)*	Electricity Use Intensity (kWh/Unit)*
Iron and Steel	te crude steel	1.85	805
Cement	te clinker	0.235	110
---Fraction of input fuel as coal		90%	
Fertilizers--Ammonium	te NH_3	1.71	5,760
---Additional Heavy Oil and Naptha used as Feedstock		0.55	
Fertilizers--Superphosphate	te P_2O_5	9.71	16,258
Other Chemicals--Carbide	te Ca Carbide	0.82	4,571
Other Chemicals--Caustic Soda	te	0.96	2,413
Pulp and Paper**	te pulp	0.89	1,674
Other Metals--Zinc	te	2.72	4,228
Other Metals--Copper	te	1.88	1,364
Other Metals--Aluminum	te	2.11	17,655
Other Metals--Lead	te	2.96	203
Other Minerals***	te Magnesia	0.43	110
Building Materials--Glass	50 kg case	0.0339	34
Building Materials--Bricks	10,000 pieces	2.39	
Textiles--Printing and Dyeing	running meter	4.39E-04	
Textiles--Vinalon fiber	te	6.032	5,400

* Intensities shown are adjusted upward to take into account 10 and 15 percent "intensity inflators" used when applying energy intensities from Chinese and Russian data (respectively) to DPRK Industrial sub-sectors. Fuel is coal except as noted.

** Assumes that half of non-electric fuel use for paper production is provided by mill wastes and other wood by-products (but fuel use intensity shown includes both use of wood and coal).

*** Intensity shown for magnesite production is use of heavy fuel oil (not coal) per tonne of product.

Please see "Industry" section of Attachment 1 for detailed notes and data sources.