The Nautilus Institute
for Security and Sustainability

FOUNDATIONS OF ENERGY SECURITY FOR THE DPRK: 1990-2009 ENERGY BALANCES, ENGAGEMENT OPTIONS, AND FUTURE PATHS FOR ENERGY AND ECONOMIC REDEVELOPMENT

ATTACHMENTS

WORKPAPERS, BACKGROUND DATA, AND DETAILED RESULTS

Prepared byDavid Von Hippel and Peter Hayes

The Nautilus Institute for Security and Sustainability, in Collaboration with the Korea Energy Economics Institute

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ATTACHMENTS 1 AND 2

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

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Detailed, Petroleum Product, and Summary Energy Balances

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2010/2011 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 1990

Prepared By David Von Hippel
Date Last Modified: 6/9/2011

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	161,944	-	-	-	1,702,954
Domestic Production	1,301,288	-		78,075	149,944				1,529,306
Imports	68,392	110,742	26,622		12,000				217,755
Exports	44,108							-	44,108
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	-	152,024	2,976	9,251	120,464	1,342,099
ENERGY DEMAND	948,006	-	109,384	-	152,021	2,973	9,251	120,467	1,342,103
INDUSTRIAL SECTOR	671,661	-	28,483	-	5,626	-	-	70,242	776,013
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		3,740		1,600			14,850	144,790
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	29,825	-	16,444	-	-	-	-	14,008	60,277
Trucks and other Transport			6,585						6,585
Armaments			263						263
Air Force			2,648						2,648
Naval Forces			6,847						6,847
Military Manufacturing	887							48	935
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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1996

Prepared By David Von Hippel
Date Last Modified: 12/13/2011

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	684,227	39,874	32,211	19,160	167,345	-	-	-	942,817
Domestic Production	684,608	-		19,160	155,348				859,116
Imports	11,614	39,874	39,100		12,000				102,588
Exports	11,994		443		4			-	12,441
Inputs to International Marine Bunkers									-
Stock Changes			6,446						6,446
ENERGY TRANSFORMATION	(251,361)	(39,874)	11,979	(19,160)	(7,916)	2,375	5,128	50,757	(248,074)
Electricity Generation	(207,738)		(25,467)	(19,160)			4,543	82,238	(165,584)
Petroleum Refining		(39,874)	39,874					(213)	(213)
Coal Production/Preparation	(32,773)							(4,438)	(37,211)
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	(8,382)						(1,126)	(16,644)	(26,151)
FUELS FOR FINAL CONSUMPTION	432,866	-	44,190	-	159,429	2,375	5,128	50,757	694,744
ENERGY DEMAND	432,867	-	44,190	-	159,428	2,374	5,128	50,757	694,743
INDUSTRIAL SECTOR	250,538	-	8,685	-	1,909	-	-	24,001	285,133
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		899		581			5,391	52,100
TRANSPORT SECTOR	-	-	16,525	-	829	-	-	4,804	22,157
Road			14,345		829				15,174
Rail	-		779					4,804	5,583
Water	-		501						501
Air			899						899
Non-Specified			-					-	-
RESIDENTIAL SECTOR	121,735	-	1,785	-	117,606	2,374	3,572	6,145	253,219
Urban	92,747		1,649		15,135	1,455	3,572	4,562	119,120
Rural	28,988		136		102,471	919		1,583	134,098
AGRICULTURAL SECTOR	5,155	-	1,502	-	23,767	-	-	1,697	32,121
Field Operations			786					816	1,602
Processing/Other	5,155		716		23,767			880	30,518
FISHERIES SECTOR	509	-	998	-	-	-	-	236	1,743
Large Ships	-		804						804
Collectives/Processing/Other	509		193					236	939
MILITARY SECTOR	25,363	-	13,123	-	5,498	-	-	7,711	51,695
Trucks and other Transport			5,734						5,734
Armaments			211						211
Air Force			1,886						1,886
Naval Forces			5,198						5,198
Military Manufacturing	621		-					33	654
Buildings and Other	24,742		95		5,498			7,678	38,013
PUBLIC/COMMERCIAL SECTORS	26,180		131		2,618		1,555	6,163	36,646
NON-SPECIFIED/OTHER SECTORS			-				-		-
NON-ENERGY USE	3,386		1,442		7,200				12,028
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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2000

Prepared By David Von Hippel
Date Last Modified: 11/28/2011

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	337,701	17,857	40,011	37,705	165,746	-	-	(82)	598,939
Domestic Production	336,565	1,278		37,705	153,735				529,283
Imports	10,454	16,579	41,777		12,012			-	80,822
Exports	9,318		3,010		1			82	12,411
Inputs to International Marine Bunkers									-
Stock Changes			(1,245)						(1,245)
ENERGY TRANSFORMATION	(52,526)	(17,857)	(156)	(37,705)	(6,061)	1,818	2,645	30,848	(78,993)
Electricity Generation	(31,316)		(16,555)	(37,705)			2,451	47,746	(35,379)
Petroleum Refining		(17,857)	17,857					(105)	(105)
Coal Production/Preparation	(16,112)							(2,182)	(18,294)
Charcoal Production					(6,061)	1,818			(4,243)
Coke Production									-
District Heat Production	(978)		(402)				855		(524)
Other Transformation									-
Own Use			(1,056)					(1,903)	(2,959)
Losses	(4,121)						(661)	(12,708)	(17,490)
FUELS FOR FINAL CONSUMPTION	285,175	-	39,855	-	159,685	1,818	2,645	30,767	519,946
ENERGY DEMAND	285,169	-	39,852	-	159,683	1,818	2,645	30,768	519,936
INDUSTRIAL SECTOR	147,882	-	11,792	-	1,130	-		12,618	173,422
Iron and Steel	67,382							3,609	70,991
Cement	19,067		7,052					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	22,926		920		294			2,732	26,873
TRANSPORT SECTOR	-	-	8,665	-	504	-	-	3,237	12,405
Road			6,795		504				7,299
Rail	-		585					3,237	3,821
Water	-		476						476
Air			809						809
Non-Specified			-					-	-
RESIDENTIAL SECTOR	95,055	-	2,207	-	121,601	1,818	1,826	2,744	225,251
Urban	73,246		2,058		19,021	1,117	1,826	2,421	99,690
Rural	21,808		149		102,580	701		323	125,561
AGRICULTURAL SECTOR	3,845	-	1,251	-	19,943	-	-	1,296	26,335
Field Operations			655					680	1,335
Processing/Other	3,845		596		19,943			615	25,000
FISHERIES SECTOR	423	-	828	-	-	-	-	196	1,447
Large Ships	-		668						668
Collectives/Processing/Other	423		161					196	779
MILITARY SECTOR	21,307	-	10,908	-	7,379	-	-	7,420	47,015
Trucks and other Transport			4,187						4,187
Armaments			148						148
Air Force			1,367						1,367
Naval Forces			5,122						5,122
Military Manufacturing	399		-					21	421
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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2005

Prepared By David Von Hippel
Date Last Modified: 11/28/2011

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	391,355	23,547	23,427	44,008	185,798	-	-	(60)	668,074
Domestic Production	435,749	1,278		44,008	173,816				654,851
Imports	35,536	22,270	23,405		12,001			265	93,477
Exports	79,931		186		19			325	80,461
Inputs to International Marine Bunkers									-
Stock Changes			(207)						(207)
ENERGY TRANSFORMATION	(111,976)	(23,547)	13,353	(44,008)	(6,121)	1,836	4,276	37,657	(128,531)
Electricity Generation	(83,890)		(8,736)	(42,575)			3,719	59,592	(71,891)
Petroleum Refining		(23,547)	23,547					(139)	(139)
Coal Production/Preparation	(20,860)							(2,825)	(23,685)
Charcoal Production					(6,121)	1,836			(4,284)
Coke Production									-
District Heat Production	(1,892)		(79)	(1,433)			1,695		(1,709)
Other Transformation									-
Own Use			(1,380)					(3,508)	(4,888)
Losses	(5,335)						(1,137)	(15,463)	(21,935)
FUELS FOR FINAL CONSUMPTION	279,378	-	36,779	-	179,677	1,836	4,276	37,597	539,544
ENERGY DEMAND	279,377	-	36,780	-	179,677	1,836	4,276	37,596	539,543
INDUSTRIAL SECTOR	150,534	-	8,329	-	1,083	-		14,660	174,607
Iron and Steel	52,717							2,824	55,541
Cement	23,878		3,256					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	20,975		1,033		269			2,762	25,039
TRANSPORT SECTOR	-	-	11,869	-	876	-	-	3,587	16,332
Road			9,653		876				10,529
Rail	-		896					3,587	4,484
Water	-		526						526
Air			793						793
Non-Specified			-					-	-
RESIDENTIAL SECTOR	84,886	-	2,221	-	134,550	1,836	2,439	3,887	229,819
Urban	67,806		2,075		24,739	1,132	2,439	3,399	101,591
Rural	17,079		146		109,810	704		488	128,228
AGRICULTURAL SECTOR	4,931	-	1,351	-	24,070	-	-	1,431	31,784
Field Operations			707					590	1,297
Processing/Other	4,931		644		24,070			842	30,487
FISHERIES SECTOR	453	-	924	-	-	-	-	210	1,586
Large Ships	-		751						751
Collectives/Processing/Other	453		173					210	836
MILITARY SECTOR	19,614	-	11,221	-	7,871	-	-	8,746	47,453
Trucks and other Transport			3,641						3,641
Armaments			129						129
Air Force			2,039						2,039
Naval Forces			5,326						5,326
Military Manufacturing	399		-					21	421
Buildings and Other	19,215		85		7,871			8,725	35,896
PUBLIC/COMMERCIAL SECTORS	17,423		174		5,227		1,364	5,074	29,262
NON-SPECIFIED/OTHER SECTORS			-				473		473
NON-ENERGY USE	1,536		690		6,000				8,226
Electricity Gen. (Gross TWhe)*	5.15		0.17	11.15					16.47

**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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2008

Prepared By David Von Hippel
Date Last Modified: 11/28/2011

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	370,238	23,792	28,868	42,575	205,678	-	-	1,058	672,209
Domestic Production	424,584	1,278		42,575	193,678				662,115
Imports	11,533	22,514	29,136		12,000			1,575	76,757
Exports	65,879		267					517	66,663
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(102,860)	(23,792)	6,686	(42,575)	(5,873)	1,762	4,331	39,119	(123,201)
Electricity Generation	(75,804)		(15,471)	(42,575)			4,383	61,617	(67,850)
Petroleum Refining		(23,792)	23,792					(140)	(140)
Coal Production/Preparation	(20,325)							(2,753)	(23,078)
Charcoal Production					(5,873)	1,762			(4,111)
Coke Production									-
District Heat Production	(1,533)		(241)				1,100		(674)
Other Transformation									-
Own Use			(1,394)					(3,493)	(4,887)
Losses	(5,198)						(1,151)	(16,112)	(22,461)
FUELS FOR FINAL CONSUMPTION	267,378	-	35,554	-	199,806	1,762	4,331	40,177	549,008
ENERGY DEMAND	267,374	-	35,553	-	199,806	1,762	4,331	40,177	549,003
INDUSTRIAL SECTOR	147,751	-	7,494	-	1,005	-		15,478	171,727
Iron and Steel	51,776							2,773	54,549
Cement	23,452		3,198					1,533	28,183
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	19,600		699		252			3,846	24,396
TRANSPORT SECTOR	-	-	12,590	-	899	-	-	4,185	17,674
Road			10,807		899				11,706
Rail	-		516					4,185	4,702
Water	-		414						414
Air			853						853
Non-Specified			-					-	-
RESIDENTIAL SECTOR	74,302	-	2,086	-	153,322	1,762	2,824	4,670	238,965
Urban	61,212		1,902		34,093	1,089	2,824	4,058	105,178
Rural	13,090		184		119,228	673		613	133,787
AGRICULTURAL SECTOR	5,147	-	1,251	-	25,126	-	-	1,355	32,879
Field Operations			655					476	1,131
Processing/Other	5,147		596		25,126			879	31,748
FISHERIES SECTOR	453	-	921	-	-	-	-	210	1,584
Large Ships	-		751						751
Collectives/Processing/Other	453		171					210	833
MILITARY SECTOR	19,614	-	10,257	-	7,871	-	-	8,886	46,628
Trucks and other Transport			3,338						3,338
Armaments			101						101
Air Force			2,144						2,144
Naval Forces			4,589						4,589
Military Manufacturing	399		-					21	421
Buildings and Other	19,215		85		7,871			8,865	36,036
PUBLIC/COMMERCIAL SECTORS	18,614		289		5,584		1,508	5,392	31,386
NON-SPECIFIED/OTHER SECTORS							-		-
NON-ENERGY USE	1,493		666		6,000				8,159
Electricity Gen. (Gross TWhe)	5.12		0.21	11.83					17.15

**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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2009

Prepared By David Von Hippel
Date Last Modified: 11/28/2011

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	HEAT	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	356,087	23,418	11,551	42,719	207,034	-	-	1,101	641,910
Domestic Production	445,808	1,278		42,719	195,034				684,839
Imports	3,718	22,140	11,674		12,000			1,565	51,098
Exports	93,440		123					464	94,027
Inputs to International Marine Bunkers									-
Stock Changes			-						-
ENERGY TRANSFORMATION	(91,081)	(23,418)	17,198	(42,719)	(5,972)	1,792	3,998	36,138	(104,065)
Electricity Generation	(62,549)		(4,807)	(42,719)			3,961	56,784	(49,330)
Petroleum Refining		(23,418)	23,418					(138)	(138)
Coal Production/Preparation	(21,341)							(2,890)	(24,231)
Charcoal Production					(5,972)	1,792			(4,180)
Coke Production									-
District Heat Production	(1,733)		(41)				1,100		(674)
Other Transformation									-
Own Use			(1,372)					(2,598)	(3,970)
Losses	(5,458)						(1,063)	(15,020)	(21,541)
FUELS FOR FINAL CONSUMPTION	265,005	-	28,749	-	201,062	1,792	3,998	37,239	537,845
ENERGY DEMAND	265,002	-	28,749	-	201,060	1,791	3,998	37,239	537,840
INDUSTRIAL SECTOR	144,468	-	4,882	-	931	-		14,281	164,562
Iron and Steel	51,776							2,773	54,549
Cement	24,216		1,601					1,485	27,302
Fertilizers	1,903		330					1,498	3,730
Other Chemicals	1,972							1,164	3,136
Pulp and Paper	709				709			164	1,581
Other Metals	16,177							2,814	18,991
Other Minerals	4,843		2,364					227	7,434
Textiles	5,818							494	6,313
Building Materials	19,772							60	19,832
Non-specified Industry	17,283		588		222			3,600	21,693
TRANSPORT SECTOR	-	-	9,690	-	627	-	-	4,240	14,557
Road			8,098		627				8,725
Rail	-		448					4,240	4,688
Water	-		351						351
Air			793						793
Non-Specified			-					-	-
RESIDENTIAL SECTOR	75,642	-	1,718	-	155,758	1,791	2,635	4,401	241,943
Urban	62,349		1,571		34,685	1,108	2,635	3,826	106,174
Rural	13,292		146		121,072	683		575	135,769
AGRICULTURAL SECTOR	4,956	-	1,153	-	24,193	-	-	1,300	31,602
Field Operations			629					454	1,082
Processing/Other	4,956		525		24,193			846	30,520
FISHERIES SECTOR	396	-	820	-	-	-	-	183	1,400
Large Ships	-		670						670
Collectives/Processing/Other	396		150					183	730
MILITARY SECTOR	19,614	-	9,265	-	7,871	-	-	8,007	44,756
Trucks and other Transport			3,338						3,338
Armaments			101						101
Air Force			1,807						1,807
Naval Forces			3,934						3,934
Military Manufacturing	399		-					21	421
Buildings and Other	19,215		85		7,871			7,985	35,156
PUBLIC/COMMERCIAL SECTORS	18,937		362		5,681		1,363	4,828	31,171
NON-SPECIFIED/OTHER SECTORS							-		-
NON-ENERGY USE	989		859		6,000				7,847
Electricity Gen. (Gross TWhe)	3.73		0.20	11.87					15.80

**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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1990:
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

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	21,775	-	3,658	-	28,483
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	690				3,740
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	45	1,798	-	356	16,444
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	45				6,847
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%

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)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1996:
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

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	18,388	518	(426)	-	72,085
Domestic Production	-							-
Imports	39,874	8,545	5,185	24,834	518	17		78,974
Exports						443		443
Inputs to International Marine Bunkers								-
Stock Changes		-	-	6,446				6,446
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	7,536	2,136	3,644	871	44,190
ENERGY DEMAND	-	16,728	13,276	7,536	2,137	3,643	871	44,190
INDUSTRIAL SECTOR	-	-	671	7,111	-	903	-	8,685
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	228				899
TRANSPORT SECTOR	-	10,376	4,999	251	320	-	579	16,525
Road		10,376	3,969					14,345
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	-	-	1,502	-	-	-	-	1,502
Field Operations			786					786
Processing/Other			716					716
FISHERIES SECTOR	-	-	856	142	-	-	-	998
Large Ships			764	40				804
Collectives/Processing/Other			92	102				193
MILITARY SECTOR	-	6,352	5,248	32	1,199	-	292	13,123
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	32				5,198
Military Manufacturing								-
Buildings and Other			95					95
PUBLIC/COMMERCIAL SECTORS					65	65		131
NON-SPECIFIED/OTHER SECTORS			-		-			-
NON-ENERGY USE						1,442		1,442

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ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2000
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	17,857	4,791	8,221	20,809	951	5,240	-	57,868
Domestic Production	1,278							1,278
Imports	16,579	4,791	8,221	22,391	951	5,424		58,356
Exports				2,827		183		3,010
Inputs to International Marine Bunkers								-
Stock Changes		-		(1,245)	-			(1,245)
ENERGY TRANSFORMATION	(17,857)	3,401	3,630	(9,534)	734	946	667	(18,013)
Electricity Generation				(15,783)		(771)		(16,555)
Petroleum Refining	(17,857)	3,401	3,630	6,651	734	2,774	667	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(402)				(402)
Other Transformation								-
Own Use						(1,056)		(1,056)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	8,193	11,851	11,274	1,685	6,186	667	39,855
ENERGY DEMAND	-	8,193	11,852	11,271	1,685	6,185	667	39,852
INDUSTRIAL SECTOR	-	-	633	10,885	-	274	-	11,792
Iron and Steel								-
Cement				7,052				7,052
Fertilizers				69		274		343
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,478				3,478
Textiles								-
Building Materials								
Non-specified Industry			633	286				920
TRANSPORT SECTOR	-	3,452	4,166	238	364	-	445	8,665
Road		3,452	3,344					6,795
Rail			585					585
Water			238	238				476
Air					364		445	809
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	458	1,750	-	2,207
Urban					373	1,686		2,058
Rural					85	64		149
AGRICULTURAL SECTOR	-	-	1,251	-	-	-	-	1,251
Field Operations			655					655
Processing/Other			596					596
FISHERIES SECTOR	-	-	710	118	-	-	-	828
Large Ships			634	33				668
Collectives/Processing/Other			76	85				161
MILITARY SECTOR	-	4,742	5,091	30	824	-	222	10,908
Trucks and other Transport		4,118	69					4,187
Armaments		25	122					148
Air Force		321			824		222	1,367
Naval Forces		277	4,815	30				5,122
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					39	39		78
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						4,121		4,121

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ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2005
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	23,547	2,238	12,741	5,302	2,031	1,115	-	46,974
Domestic Production	1,278							1,278
Imports	22,270	2,238	12,741	5,094	2,031	1,301		45,675
Exports				-		186		186
Inputs to International Marine Bunkers								-
Stock Changes				(207)				(207)
ENERGY TRANSFORMATION	(23,547)	4,899	3,423	2,195	965	1,409	461	(10,195)
Electricity Generation			(1,362)	(6,483)		(891)		(8,736)
Petroleum Refining	(23,547)	4,899	4,785	8,757	965	3,680	461	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(79)				(79)
Other Transformation								-
Own Use						(1,380)		(1,380)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	7,137	16,164	7,497	2,996	2,524	461	36,779
ENERGY DEMAND	-	7,137	16,163	7,498	2,997	2,524	461	36,780
INDUSTRIAL SECTOR	-	-	844	7,076	-	410	-	8,329
Iron and Steel								-
Cement				3,256				3,256
Fertilizers				102		410		512
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,528				3,528
Textiles								-
Building Materials								
Non-specified Industry			844	189				1,033
TRANSPORT SECTOR	-	2,900	7,913	263	602	-	191	11,869
Road		2,900	6,754					9,653
Rail			896					896
Water			263	263				526
Air					602		191	793
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	927	1,294	-	2,221
Urban					828	1,247		2,075
Rural					100	47		146
AGRICULTURAL SECTOR	-	-	1,351	-	-	-	-	1,351
Field Operations			707					707
Collectives/Processing/Other			644					644
FISHERIES SECTOR	-	-	796	128	-	-	-	924
Large Ships			713	38				751
Processing/Other			82	91				173
MILITARY SECTOR	-	4,238	5,259	31	1,423	-	270	11,221
Trucks and other Transport		3,581	60					3,641
Armaments		22	107					129
Air Force		346			1,423		270	2,039
Naval Forces		288	5,007	31				5,326
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					44	131		174
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						690		690

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2008
REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	23,792	5,109	8,236	13,220	2,050	254	-	52,660
Domestic Production	1,278							1,278
Imports	22,514	5,109	8,236	13,220	2,184	387		51,649
Exports				0	133	133		267
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(23,792)	4,956	4,235	(6,265)	975	2,325	460	(17,106)
Electricity Generation			(599)	(14,872)		-		(15,471)
Petroleum Refining	(23,792)	4,956	4,834	8,848	975	3,719	460	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(241)				(241)
Other Transformation								-
Own Use						(1,394)		(1,394)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	10,064	12,471	6,955	3,025	2,579	460	35,554
ENERGY DEMAND	-	10,064	12,470	6,954	3,026	2,580	460	35,553
INDUSTRIAL SECTOR	-	-	503	6,592	-	398	-	7,494
Iron and Steel								-
Cement				3,198				3,198
Fertilizers				100		398		498
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				3,099				3,099
Textiles								-
Building Materials								
Non-specified Industry			503	196				699
TRANSPORT SECTOR	-	6,145	5,384	207	668	-	185	12,590
Road		6,145	4,661					10,807
Rail			516					516
Water			207	207				414
Air					668		185	853
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	797	1,289	-	2,086
Urban					697	1,205		1,902
Rural					100	84		184
AGRICULTURAL SECTOR	-	-	1,251	-	-	-	-	1,251
Field Operations			655					655
Processing/Other			596					596
FISHERIES SECTOR	-	-	793	128	-	-	-	921
Large Ships			713	38				751
Collectives/Processing/Other			80	91				171
MILITARY SECTOR	-	3,919	4,537	27	1,498	-	275	10,257
Trucks and other Transport		3,283	55					3,338
Armaments		17	84					101
Air Force		371			1,498		275	2,144
Naval Forces		248	4,314	27				4,589
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					62	226		289
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						666		666

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ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 2009
REFINED PRODUCTS BY PRODUCT TYPE

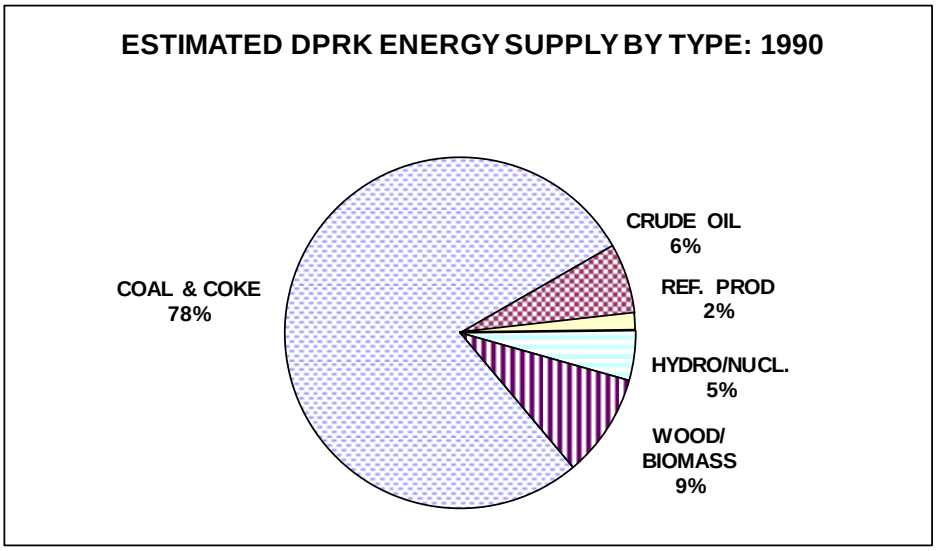
Prepared By David Von Hippel
Date Last Modified: 1/18/2012

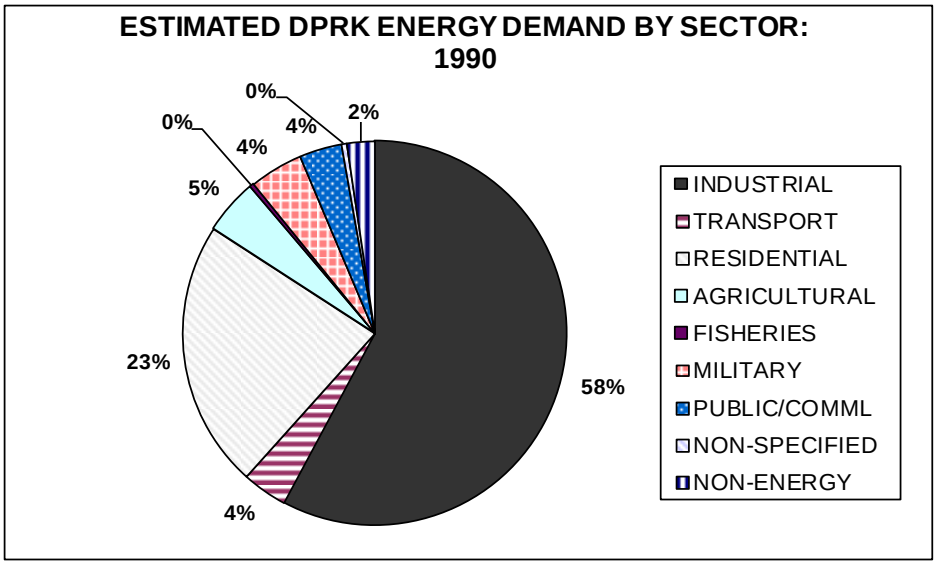
UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	23,418	3,585	5,966	281	1,522	196	-	34,969
Domestic Production	1,278							1,278
Imports	22,140	3,585	5,966	281	1,522	319		33,814
Exports		-	-	-		123		123
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(23,418)	4,864	4,377	4,243	960	2,287	466	(6,220)
Electricity Generation			(381)	(4,426)		-		(4,807)
Petroleum Refining	(23,418)	4,864	4,759	8,709	960	3,660	466	(0)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
District Heat Production				(41)				(41)
Other Transformation								-
Own Use						(1,372)		(1,372)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	8,449	10,343	4,524	2,482	2,483	466	28,749
ENERGY DEMAND	-	8,449	10,342	4,526	2,482	2,483	466	28,749
INDUSTRIAL SECTOR	-	-	403	4,216	-	264	-	4,882
Iron and Steel								-
Cement				1,601				1,601
Fertilizers				66		264		330
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				2,364				2,364
Textiles								-
Building Materials								
Non-specified Industry			403	185				588
TRANSPORT SECTOR	-	4,566	4,156	175	602	-	191	9,690
Road		4,566	3,532					8,098
Rail			448					448
Water			175	175				351
Air					602		191	793
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	655	1,062	-	1,718
Urban					576	996		1,571
Rural					79	67		146
AGRICULTURAL SECTOR	-	-	1,153	-	-	-	-	1,153
Field Operations			629					629
Processing/Other			525					525
FISHERIES SECTOR	-	-	708	113	-	-	-	820
Large Ships			637	33				670
Collectives/Processing/Other			71	79				150
MILITARY SECTOR	-	3,884	3,922	22	1,161	-	275	9,265
Trucks and other Transport		3,283	55					3,338
Armaments		17	84					101
Air Force		371			1,161		275	1,807
Naval Forces		213	3,698	22				3,934
Military Manufacturing								-
Buildings and Other			85					85
PUBLIC/COMMERCIAL SECTORS					63	298		362
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						859		859

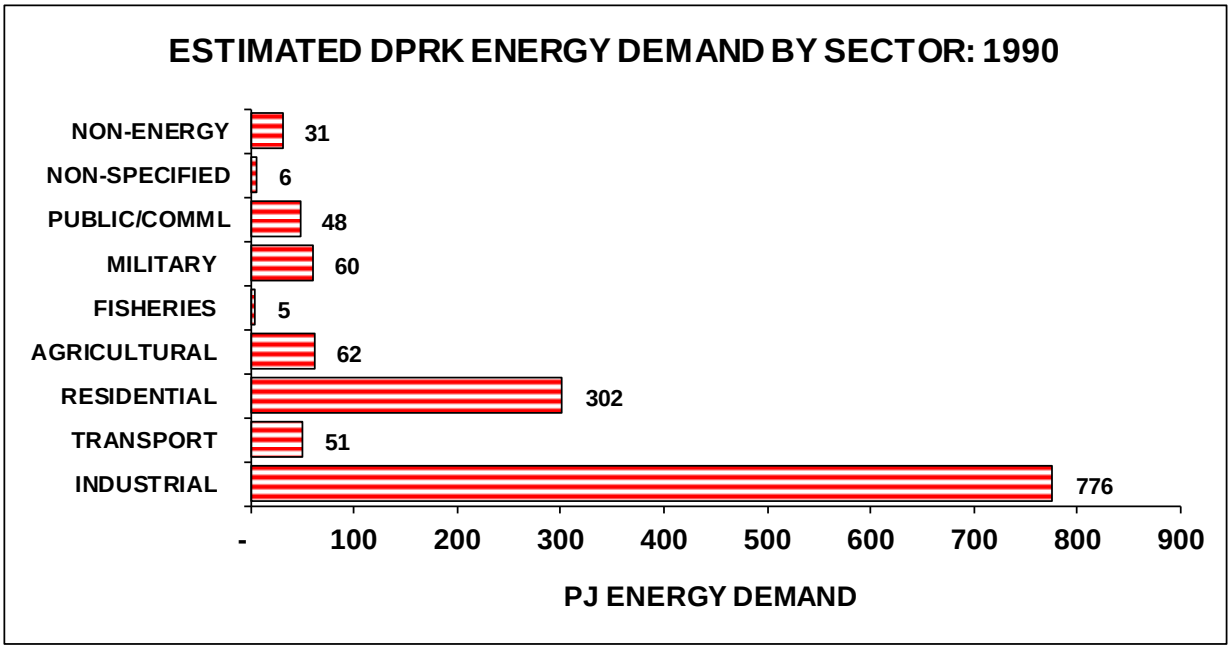
NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 1990

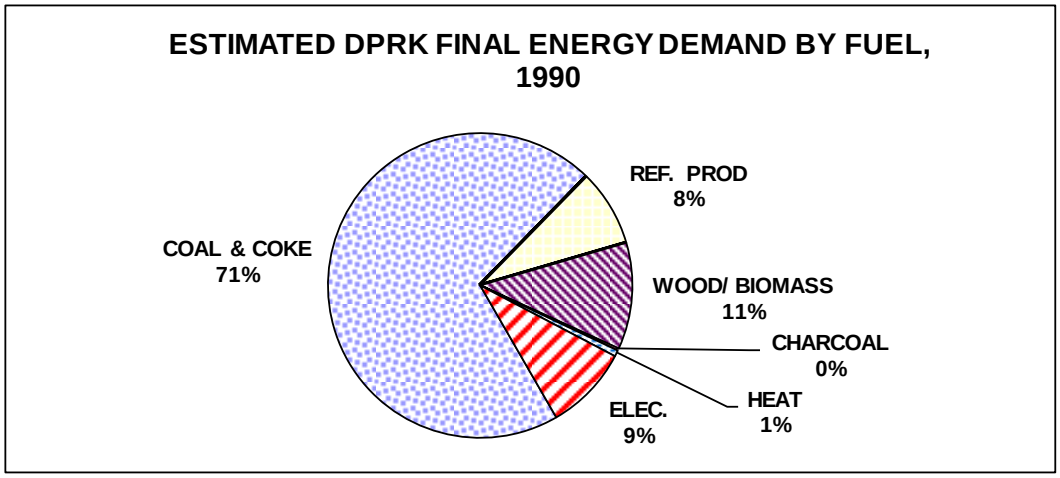
Prepared By David Von Hippel
Date Last Modified: 11/28/2011

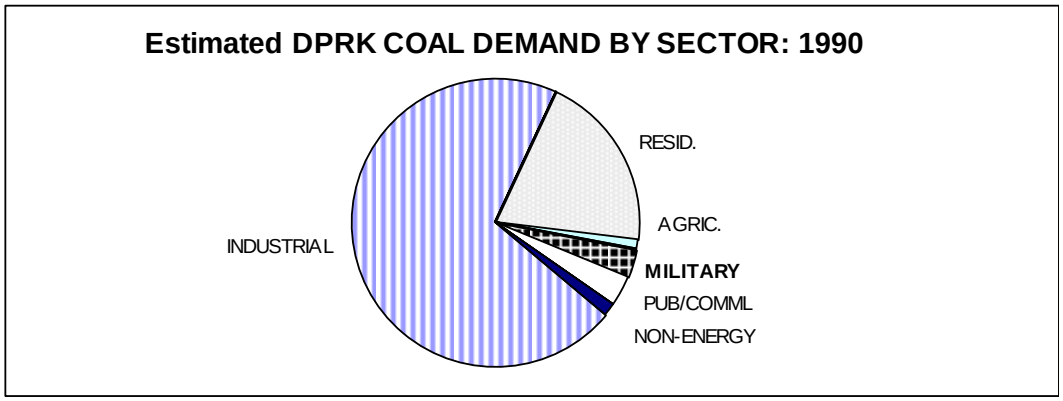
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	1,326	111	27	78	162	-	-	-	1,703
Domestic Production	1,301	-		78	150				1,529
Imports	68	111	27		12				218
Exports	44							-	44
Stock Changes									
ENERGY TRANSF.	(384)	(111)	95	(77)	(10)	3	9	132	(342)
Electricity Generation	(301)		(16)	(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)				3		(1)
Own Use								(12)	(12)
Losses	(16)						(2)	(12)	(29)
FUELS FOR FINAL CONS.	942	-	122	1	152	3	9	132	1,361
ENERGY DEMAND	948	-	109	-	152	3	9	120	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	-	16	-	-	-	-	14	60
PUBLIC/COMML	33	-	0	-	2	-	3	11	48
NON-SPECIFIED			6	-					6
NON-ENERGY	14		6		12				31
Elect. Gen. (Gr. TWhe)	23.43		1.28	21.29					46.00

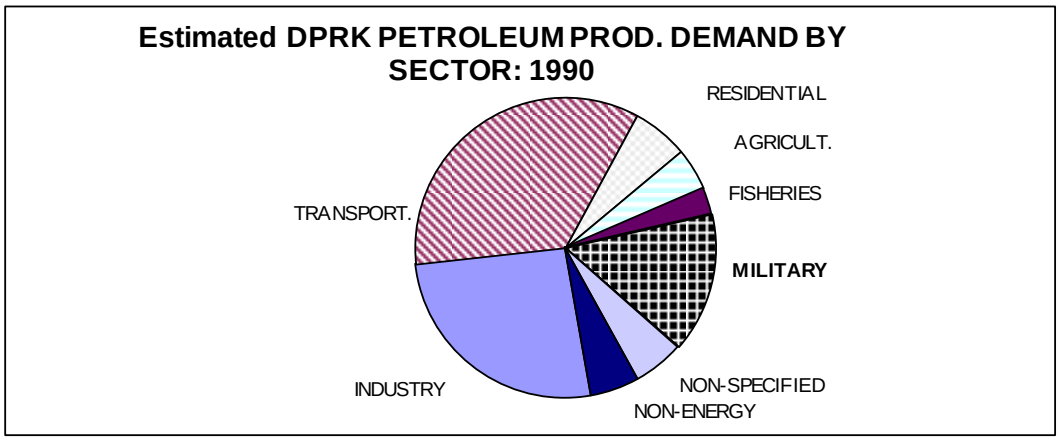

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1990
CRUDE OIL 6%
REF. PROD 2%
HYDRO/NUCL. 5%
WOOD/ BIOMASS 9%
COAL & COKE 78%

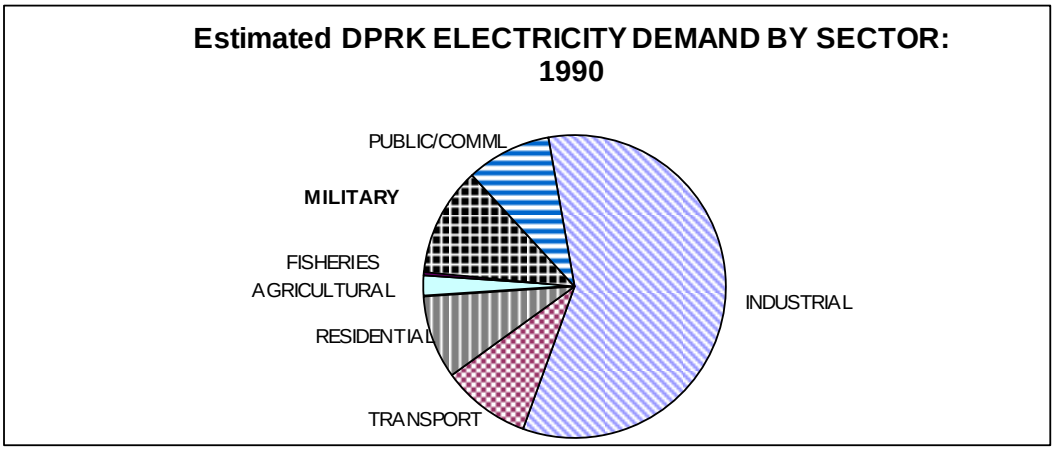

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
0%
2%
4%
0%
4%
5%
23%
58%
4%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


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.

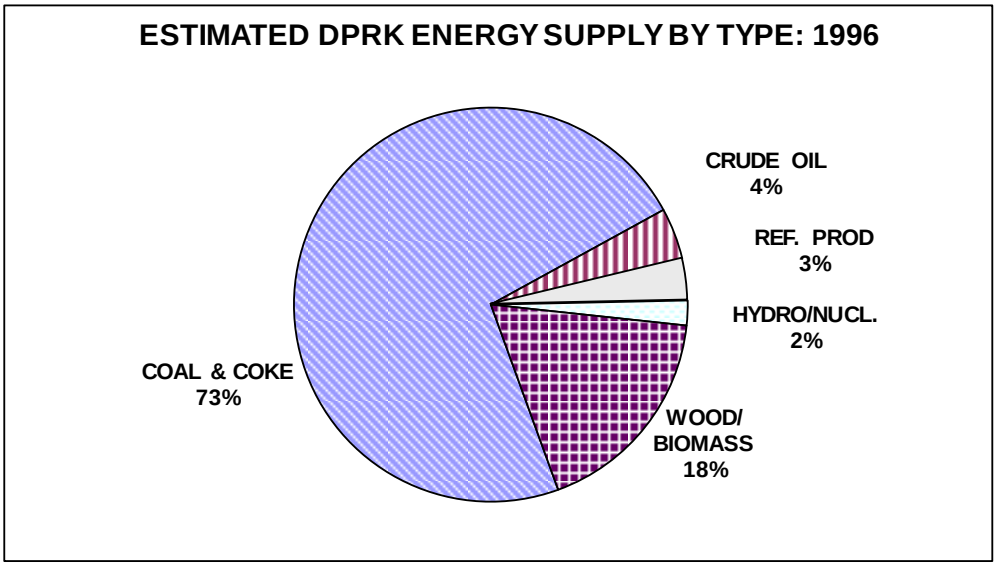

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1990
PUBLIC/COMML
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL

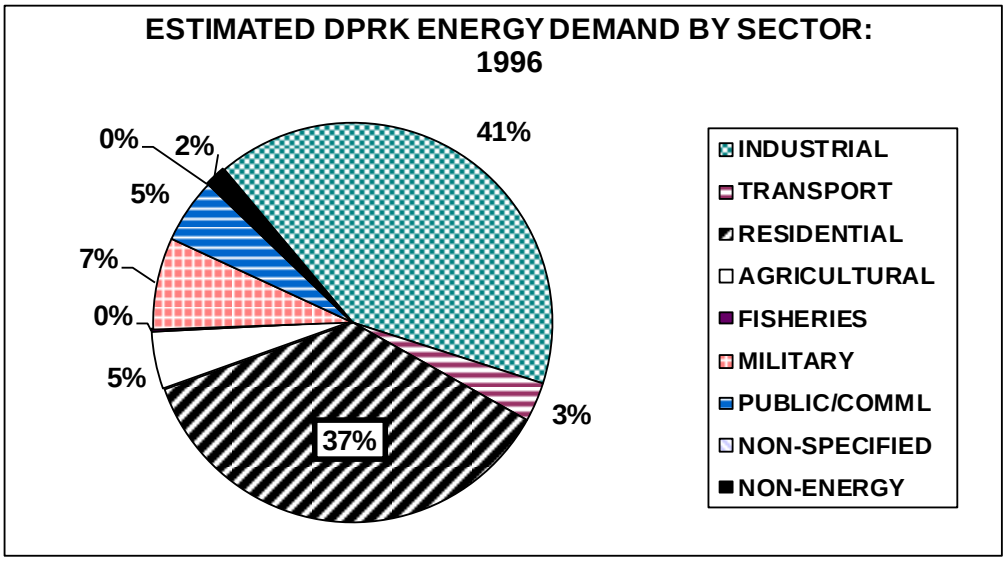
NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 1996

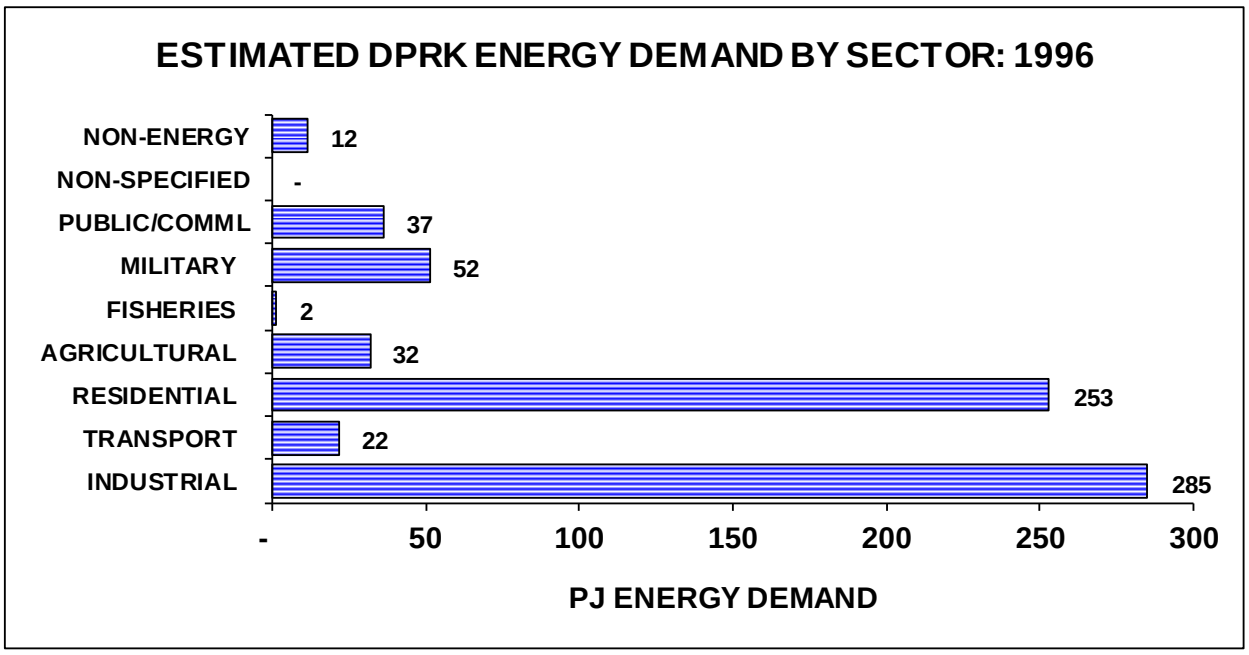
Prepared By David Von Hippel
Date Last Modified: 11/28/2011

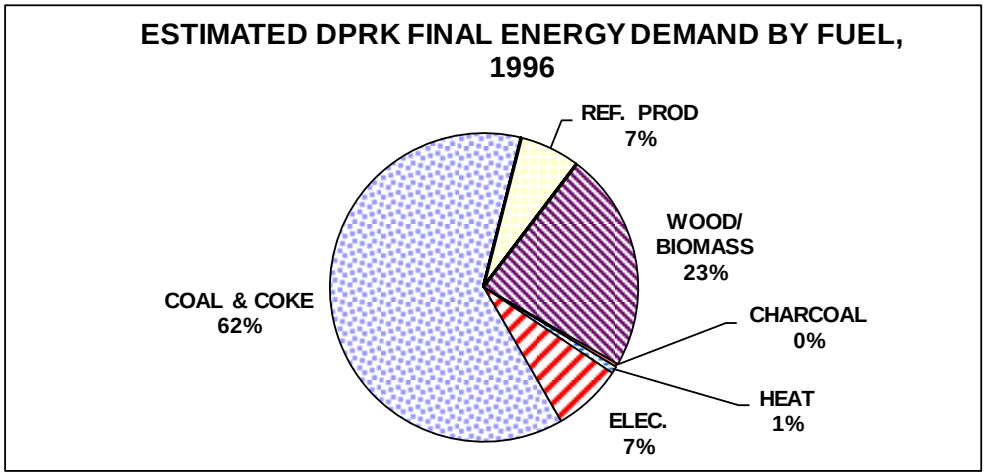
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	684	40	32	19	167	-	-	-	943
Domestic Production	685	-	-	19	155	-		-	859
Imports	12	40	39	-	12	-		-	103
Exports	12	-	0	-	0	-		-	12
Stock Changes	-	-	6	-	-	-		-	6
ENERGY TRANSF.	(251)	(40)	12	(19)	(8)	2	5	51	(248)
Electricity Generation	(208)	-	(25)	(19)	-	-	5	82	(166)
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.	433	-	44	-	159	2	5	51	695
ENERGY DEMAND	433	-	44	-	159	2	5	51	695
INDUSTRIAL	251	-	9	-	2	-	-	24	285
TRANSPORT	-	-	17	-	1	-	-	5	22
RESIDENTIAL	122	-	2	-	118	2	4	6	253
AGRICULTURAL	5	-	2	-	24	-	-	2	32
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

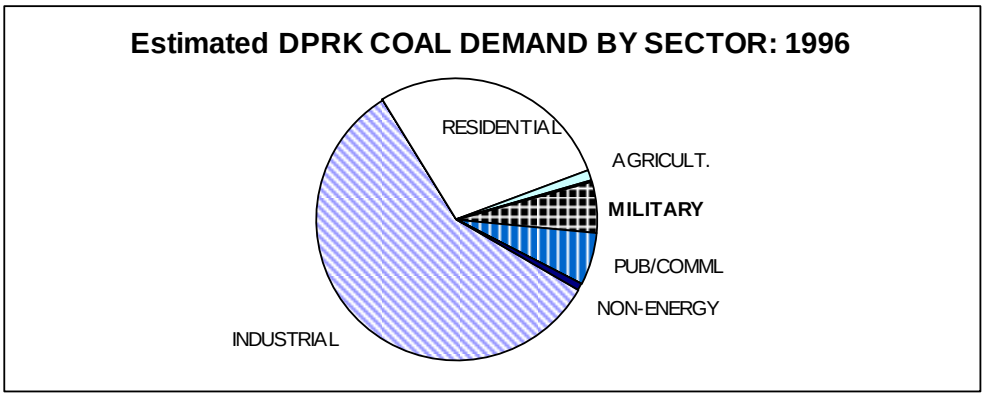
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

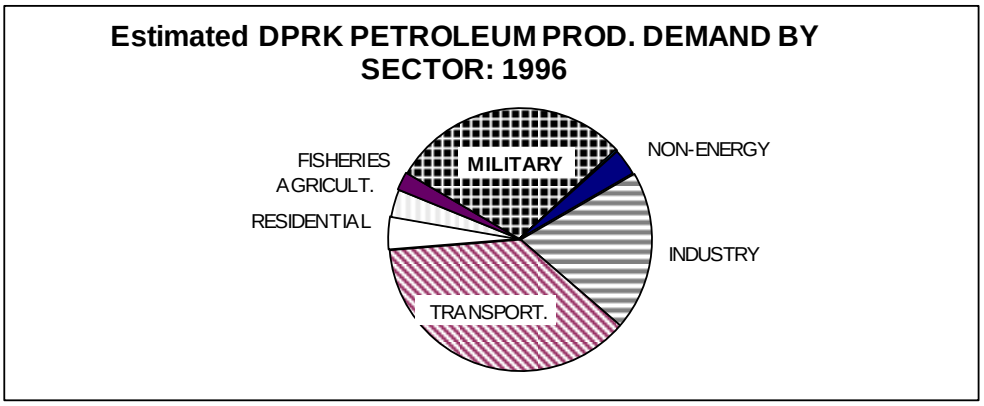

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1996
CRUDE OIL 4%
REF. PROD 3%
HYDRO/NUCL. 2%
WOOD/ BIOMASS 18%
COAL & COKE 73%

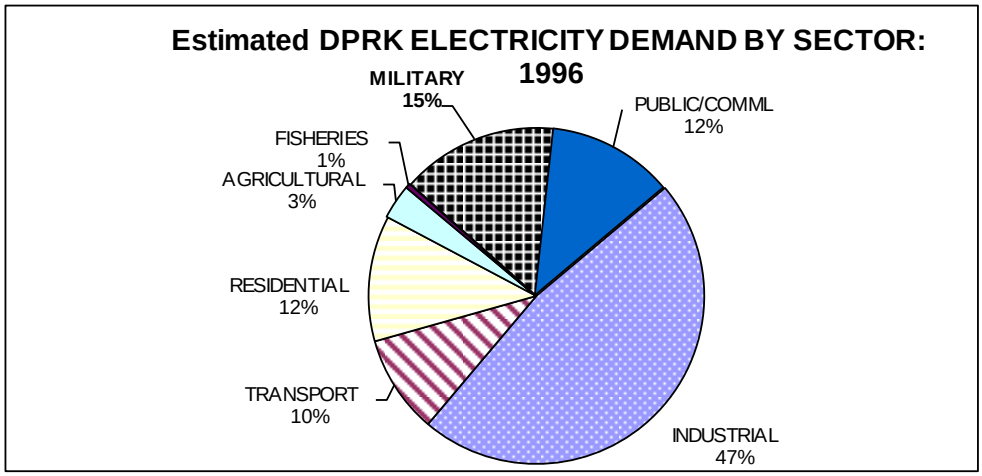

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
41%
3%
37%
5%
0%
7%
5%
2%
0%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
NON-ENERGY 12
NON-SPECIFIED -
PUBLIC/COMML 37
MILITARY 52
FISHERIES 2
AGRICULTURAL 32
RESIDENTIAL 253
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 23%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 62%


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.

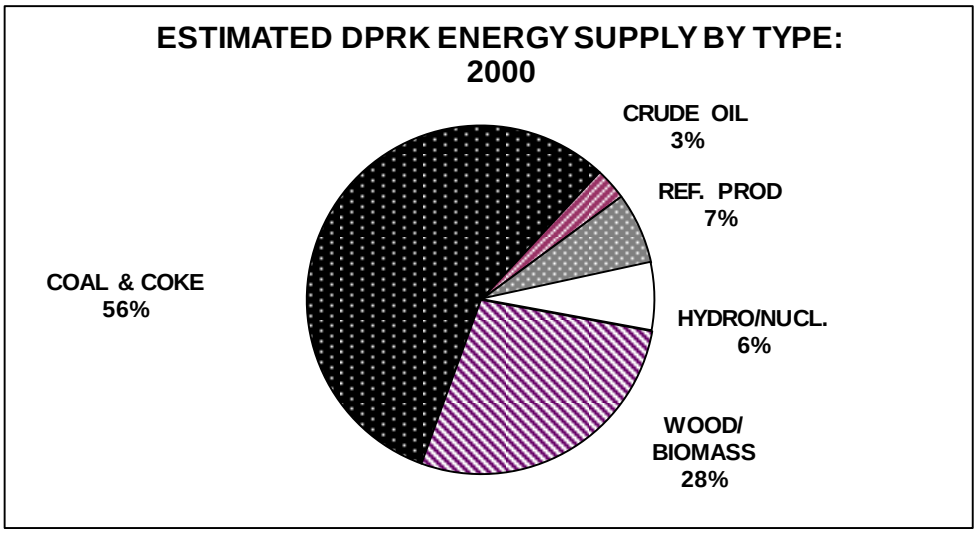

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1996
MILITARY 15%
PUBLIC/COMML 12%
FISHERIES 1%
AGRICULTURAL 3%
RESIDENTIAL 12%
TRANSPORT 10%
INDUSTRIAL 47%

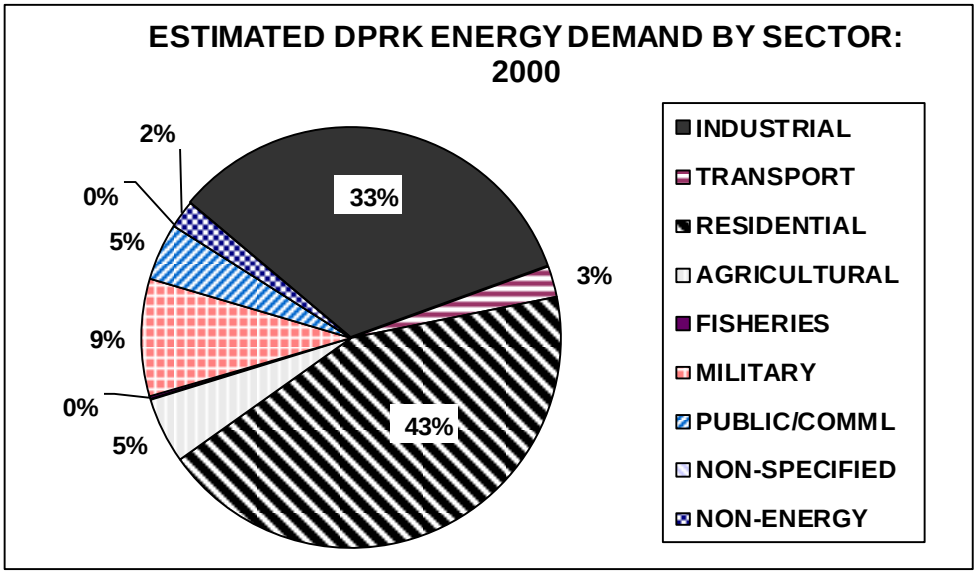
NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 2000

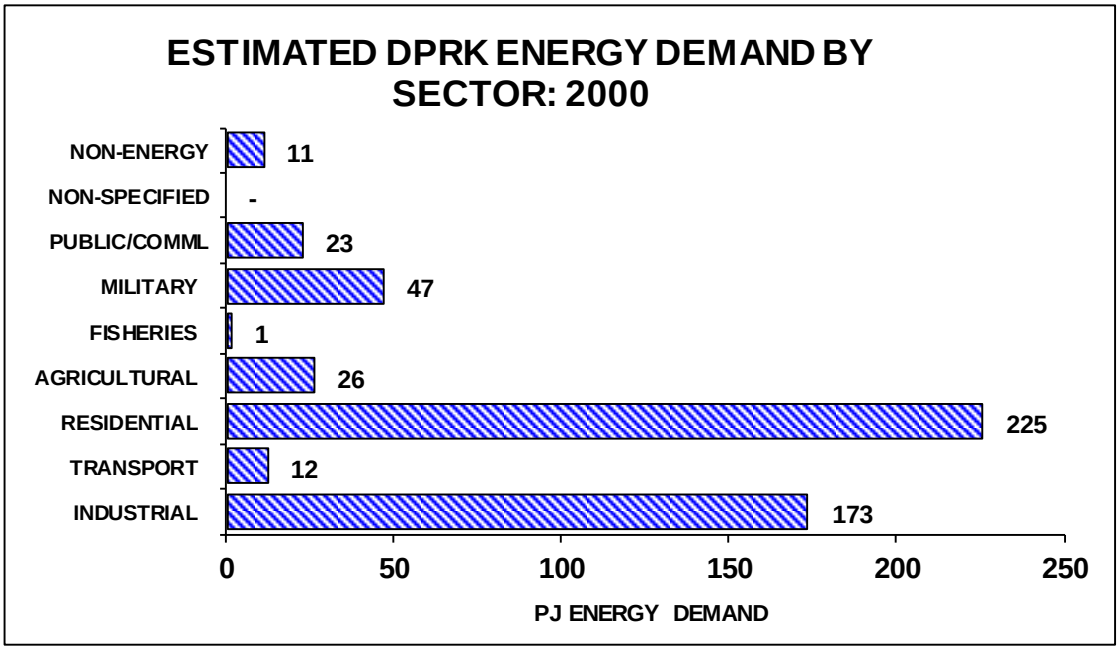
Prepared By David Von Hippel
Date Last Modified: 11/28/2011

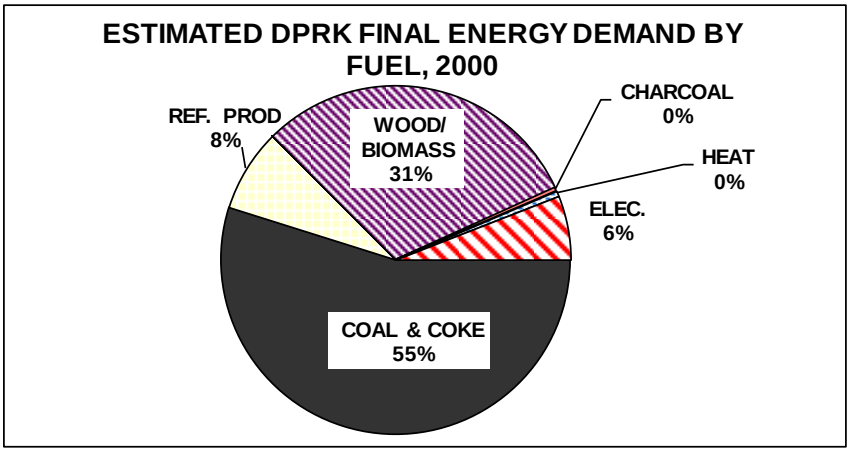
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	338	18	40	38	166	-	-	(0)	599
Domestic Production	337	1	-	38	154	-		-	529
Imports	10	17	42	-	12	-		-	81
Exports	9	-	3	-	0	-		0	12
Stock Changes	-	-	(1)	-	-	-		-	(1)
ENERGY TRANSF.	(53)	(18)	(0)	(38)	(6)	2	3	31	(79)
Electricity Generation	(31)	-	(17)	(38)	-	-	2	48	(35)
Petroleum Refining	-	(18)	18	-	-	-		(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.	285	-	40	-	160	2	3	31	520
ENERGY DEMAND	285	-	40	-	160	2	3	31	520
INDUSTRIAL	148	-	12	-	1	-	-	13	173
TRANSPORT	-	-	9	-	1	-	-	3	12
RESIDENTIAL	95	-	2	-	122	2	2	3	225
AGRICULTURAL	4	-	1	-	20	-	-	1	26
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

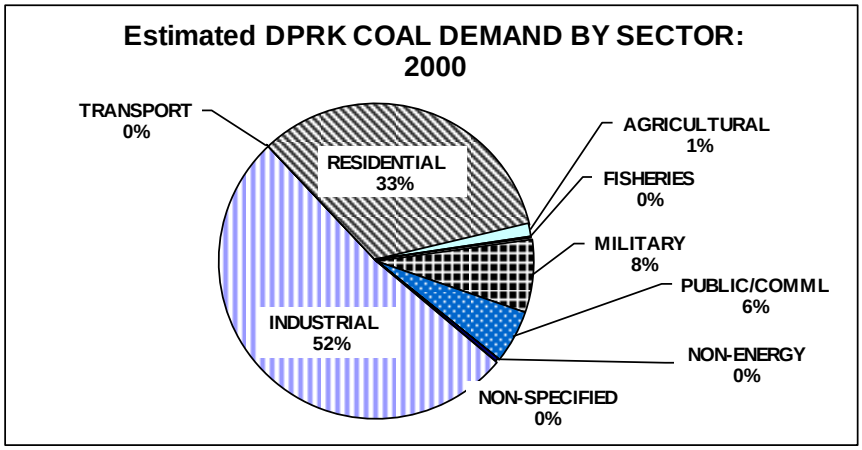
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

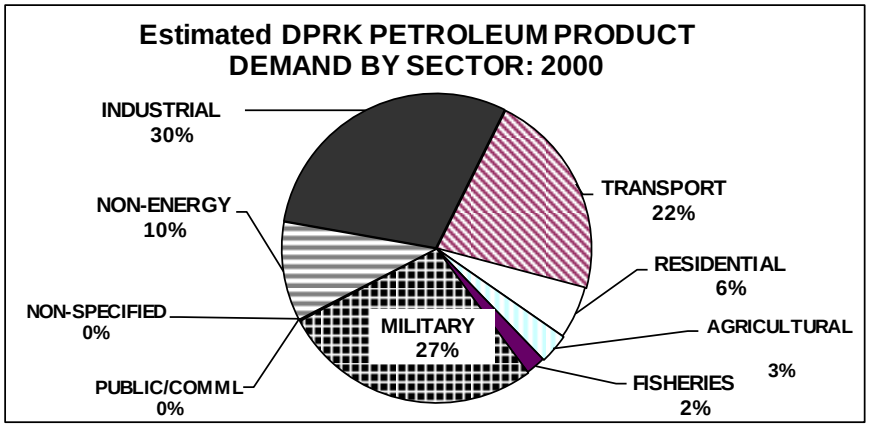

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2000
CRUDE OIL 3%
REF. PROD 7%
HYDRO/NUCL. 6%
WOOD/ BIOMASS 28%
COAL & COKE 56%

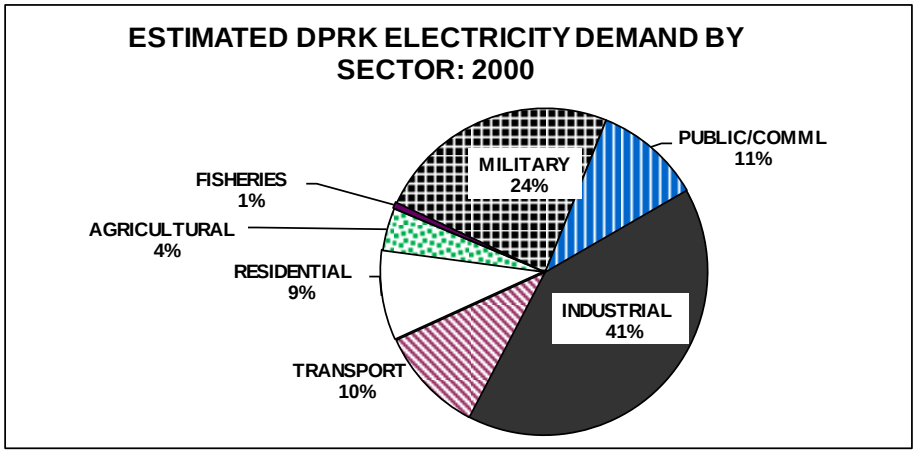

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
2%
0%
5%
9%
0%
5%
33%
3%
43%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
NON-ENERGY 11
NON-SPECIFIED -
PUBLIC/COMML 23
MILITARY 47
FISHERIES 1
AGRICULTURAL 26
RESIDENTIAL 225
TRANSPORT 12
INDUSTRIAL 173
0
50
100
150
200
250
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2000
REF. PROD 8%
WOOD/ BIOMASS 31%
CHARCOAL 0%
HEAT 0%
ELEC. 6%
COAL & COKE 55%


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 22%
NON-ENERGY 10%
RESIDENTIAL 6%
NON-SPECIFIED 0%
MILITARY 27%
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 41%
TRANSPORT 10%

NAUTILUS INSTITUTE

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

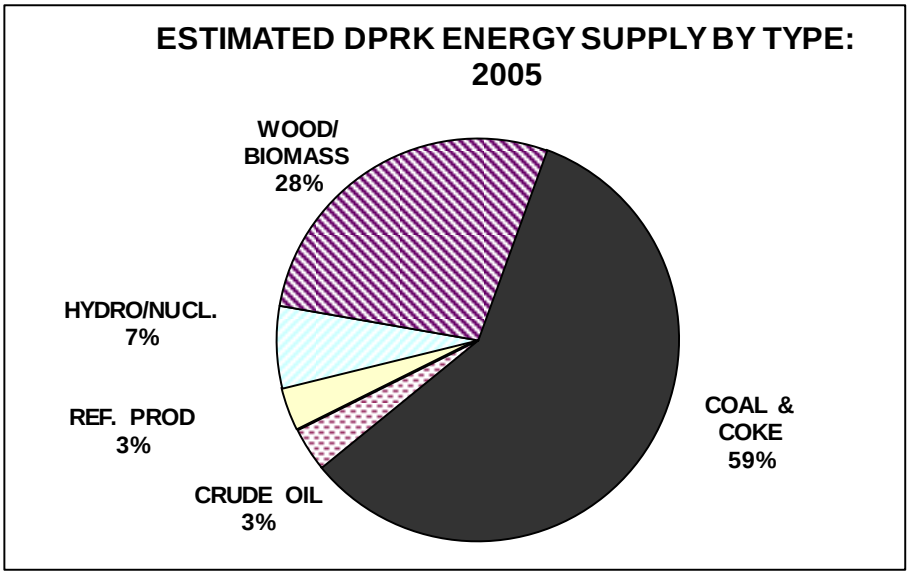
2010/2011 UPDATE

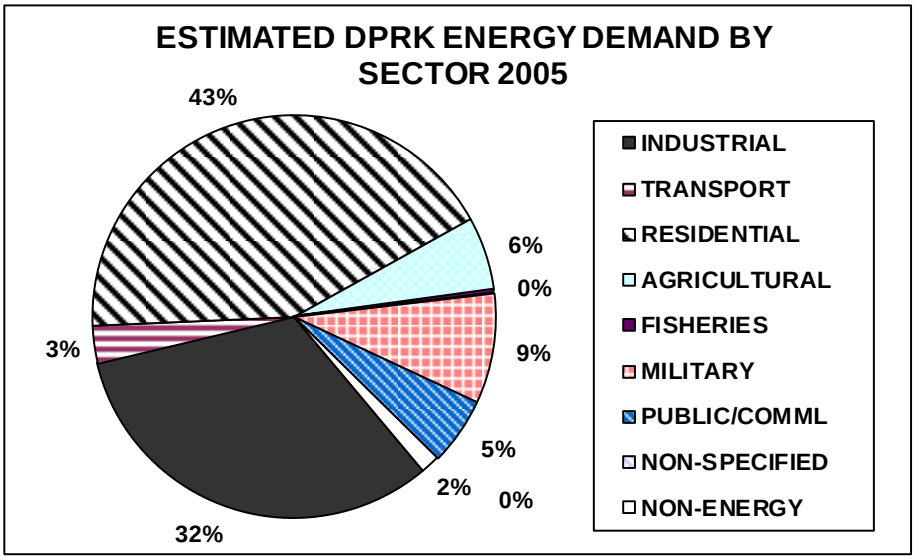
ESTIMATED SUMMARY ENERGY BALANCE FOR 2005

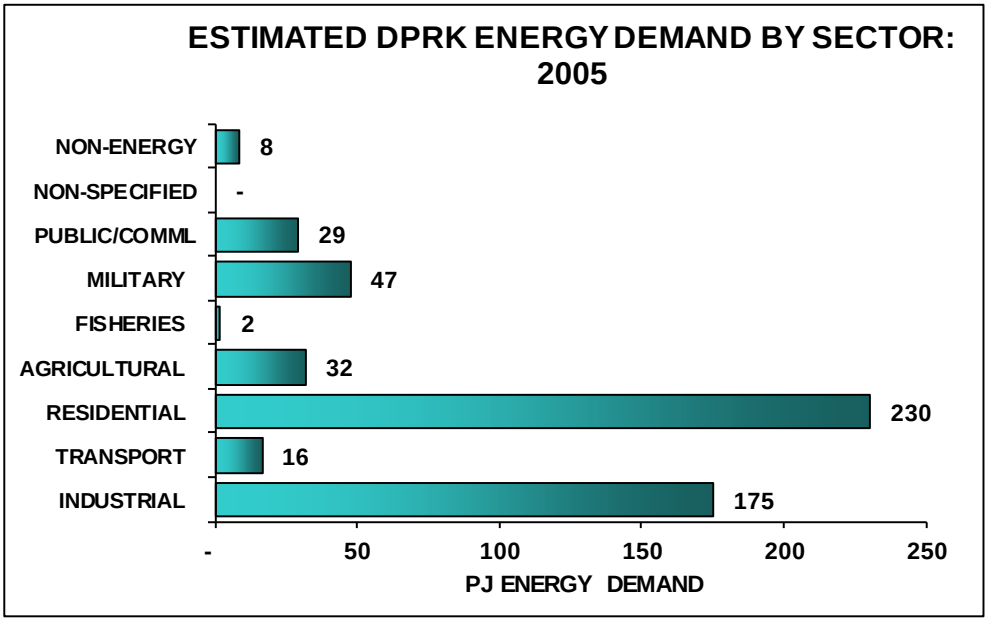
Prepared By David Von Hippel
Date Last Modified: 11/28/2011

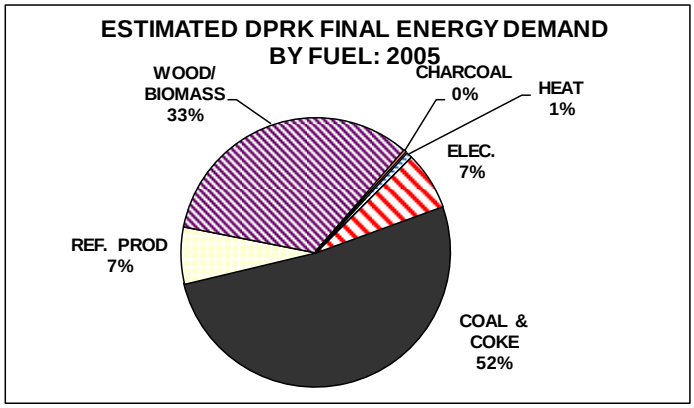
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	391	24	23	44	186	-	-	(0)	668
Domestic Production	436	1	-	44	174	-		-	655
Imports	36	22	23	-	12	-		0	93
Exports	80	-	0	-	0	-		0	80
Stock Changes	-	-	(0)	-	-	-		-	(0)
ENERGY TRANSF.	(112)	(24)	13	(43)	(6)	2	4	38	(127)
Electricity Generation	(84)	-	(9)	(43)	-	-	4	60	(72)
Petroleum Refining	-	(24)	24	-	-	-		(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	-	37	1	180	2	4	38	541
ENERGY DEMAND	279	-	37	-	180	2	4	38	539
INDUSTRIAL	151	-	8	-	1	-	-	15	175
TRANSPORT	-	-	12	-	1	-	-	4	16
RESIDENTIAL	85	-	2	-	135	2	2	4	230
AGRICULTURAL	5	-	1	-	24	-	-	1	32
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	20	-	11	-	8	-	-	9	47
PUBLIC/COMML	17	-	0	-	5	-	1	5	29
NON-SPECIFIED			-	-					-
NON-ENERGY	2		1		6				8
Elect. Gen. (Gr. TWhe)	5.15	-	0.17	11.15	-	-		-	16.47

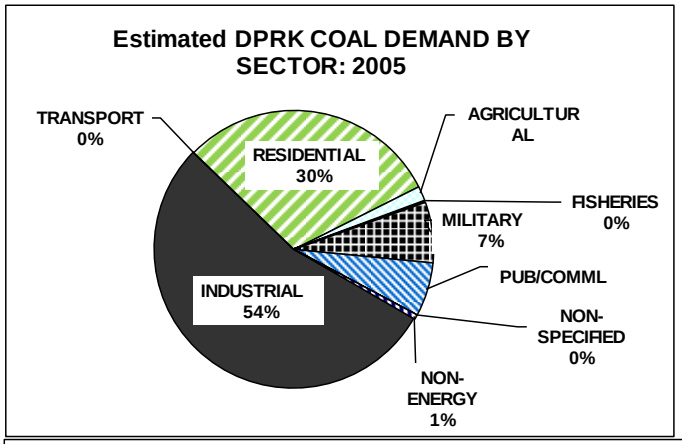
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

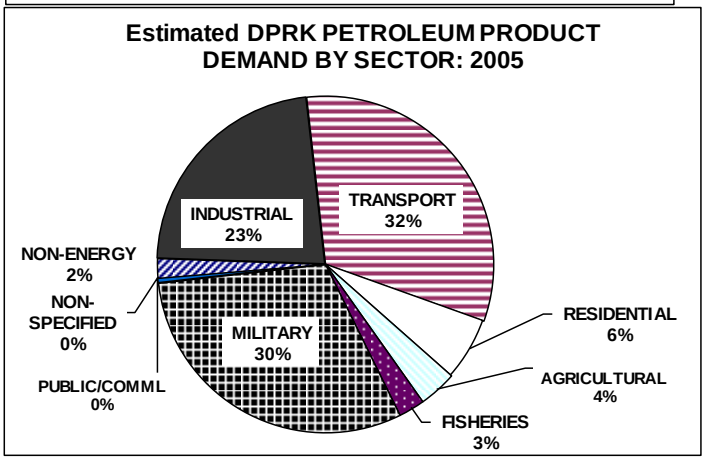

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2005
WOOD/ BIOMASS 28%
HYDRO/NUCL. 7%
REF. PROD 3%
CRUDE OIL 3%
COAL & COKE 59%

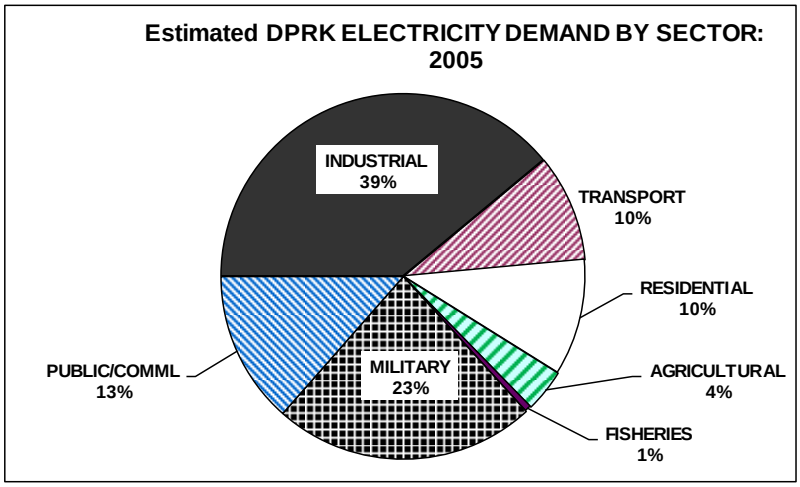

ESTIMATED DPRK ENERGY DEMAND BY SECTOR 2005
43%
6%
0%
9%
5%
0%
2%
32%
3%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2005
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 29
MILITARY 47
FISHERIES 2
AGRICULTURAL 32
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%
AGRICULTUR AL
FISHERIES 0%
MILITARY 7%
PUB/COMML
INDUSTRIAL 54%
NON-SPECIFIED 0%
NON-ENERGY 1%


Estimated DPRK PETROLEUM PRODUCT DEMAND BY SECTOR: 2005
INDUSTRIAL 23%
TRANSPORT 32%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 30%
RESIDENTIAL 6%
AGRICULTURAL 4%
PUBLIC/COMML 0%
FISHERIES 3%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2005
INDUSTRIAL 39%
TRANSPORT 10%
RESIDENTIAL 10%
PUBLIC/COMML 13%
MILITARY 23%
AGRICULTURAL 4%
FISHERIES 1%

NAUTILUS INSTITUTE

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

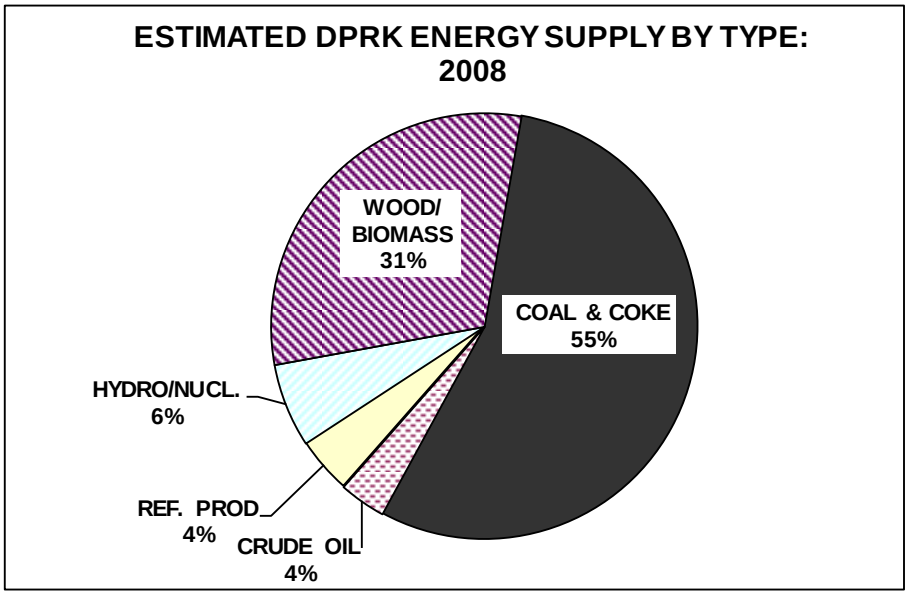
2010/2011 UPDATE

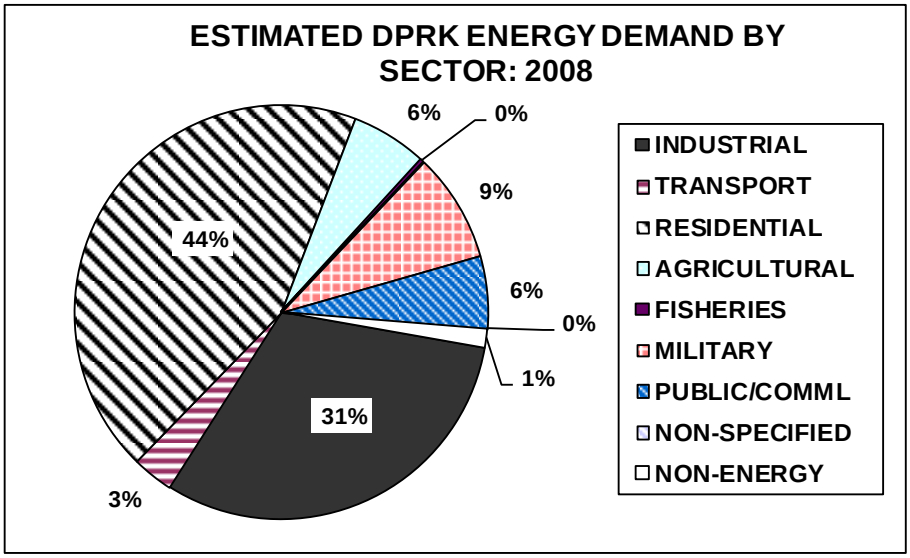
ESTIMATED SUMMARY ENERGY BALANCE FOR 2008

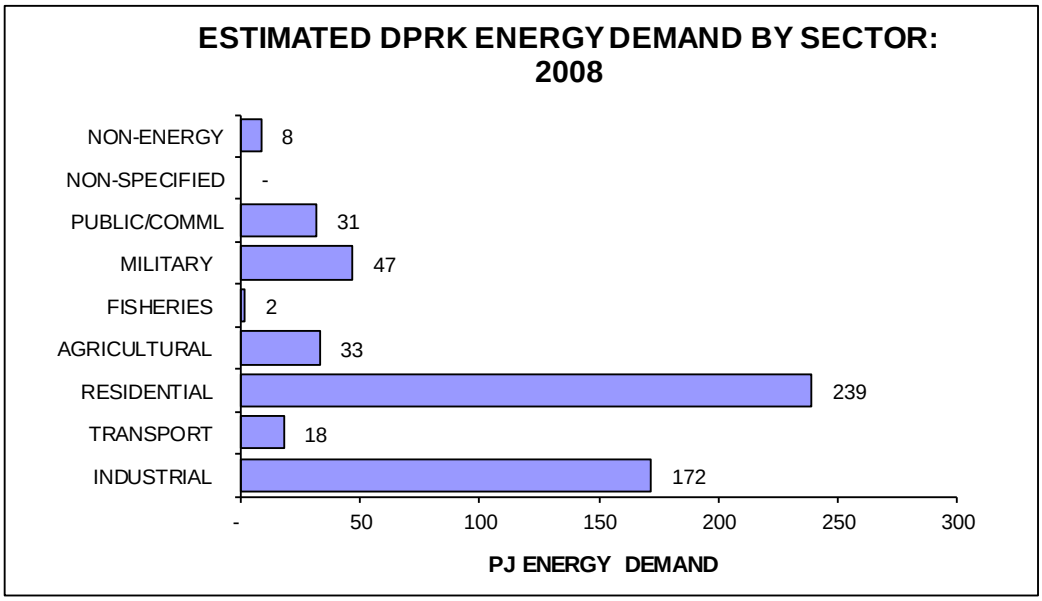
Prepared By David Von Hippel
Date Last Modified: 11/28/2011

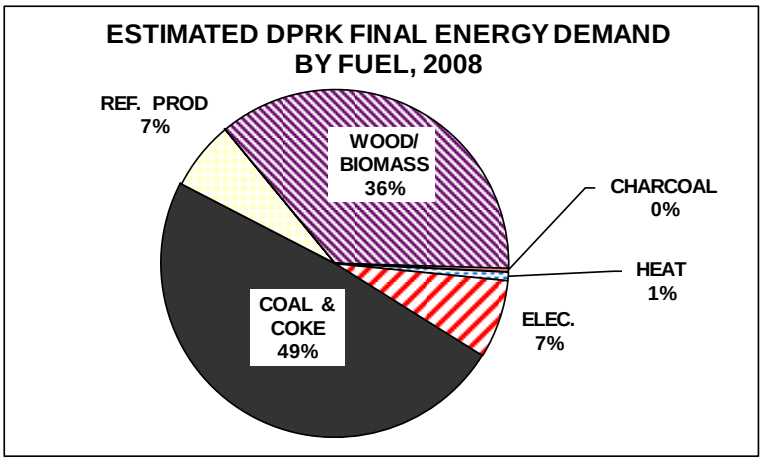
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	370	24	29	43	206	-	-	1	672
Domestic Production	425	1	-	43	194	-		-	662
Imports	12	23	29	-	12	-		2	77
Exports	66	-	0	-	-	-		1	67
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(103)	(24)	7	(43)	(6)	2	4	39	(123)
Electricity Generation	(76)	-	(15)	(43)	-	-	4	62	(68)
Petroleum Refining	-	(24)	24	-	-	-		(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.	267	-	36	-	200	2	4	40	549
ENERGY DEMAND	267	-	36	-	200	2	4	40	549
INDUSTRIAL	148	-	7	-	1	-	-	15	172
TRANSPORT	-	-	13	-	1	-	-	4	18
RESIDENTIAL	74	-	2	-	153	2	3	5	239
AGRICULTURAL	5	-	1	-	25	-	-	1	33
FISHERIES	0	-	1	-	-	-	-	0	2
MILITARY	20	-	10	-	8	-	-	9	47
PUBLIC/COMML	19	-	0	-	6	-	2	5	31
NON-SPECIFIED			-	-					-
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	5.12	-	0.21	11.83	-	-		-	17.15

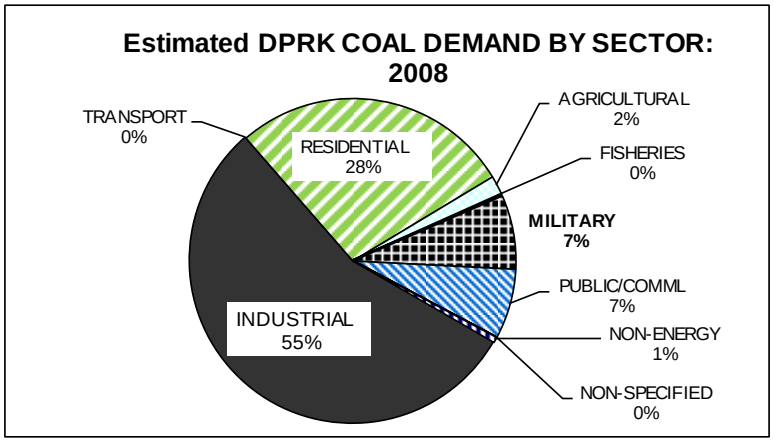
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

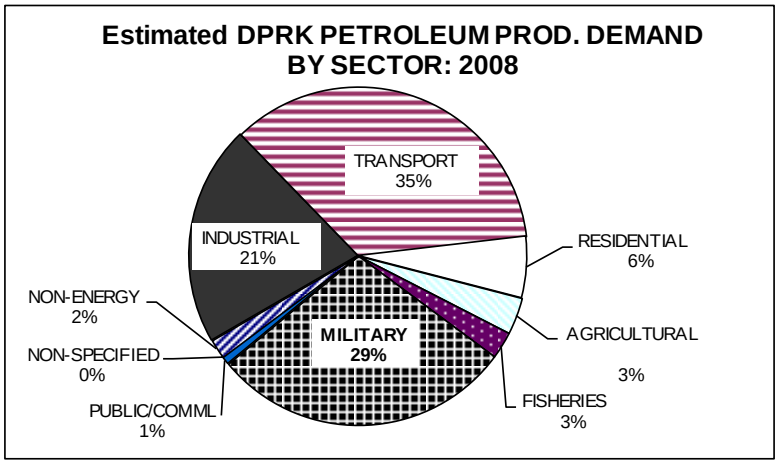

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2008
WOOD/ BIOMASS 31%
COAL & COKE 55%
HYDRO/NUCL. 6%
REF. PROD 4%
CRUDE OIL 4%

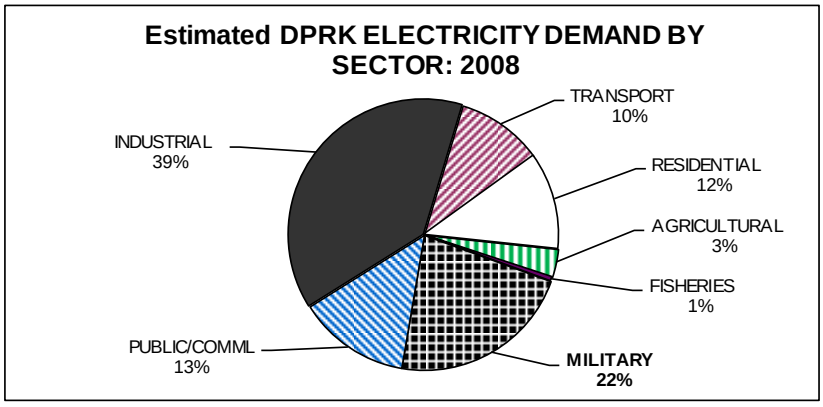

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2008
6%
0%
9%
44%
6%
0%
1%
31%
3%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2008
NON-ENERGY 8
NON-SPECIFIED -
PUBLIC/COMML 31
MILITARY 47
FISHERIES 2
AGRICULTURAL 33
RESIDENTIAL 239
TRANSPORT 18
INDUSTRIAL 172
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2008
REF. PROD 7%
WOOD/ BIOMASS 36%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 49%


Estimated DPRK COAL DEMAND BY SECTOR: 2008
TRANSPORT 0%
RESIDENTIAL 28%
AGRICULTURAL 2%
FISHERIES 0%
MILITARY 7%
PUBLIC/COMML 7%
NON-ENERGY 1%
NON-SPECIFIED 0%
INDUSTRIAL 55%


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2008
TRANSPORT 35%
RESIDENTIAL 6%
AGRICULTURAL 3%
FISHERIES 3%
MILITARY 29%
PUBLIC/COMML 1%
NON-SPECIFIED 0%
NON-ENERGY 2%
INDUSTRIAL 21%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2008
TRANSPORT 10%
RESIDENTIAL 12%
AGRICULTURAL 3%
FISHERIES 1%
MILITARY 22%
PUBLIC/COMML 13%
INDUSTRIAL 39%

NAUTILUS INSTITUTE

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

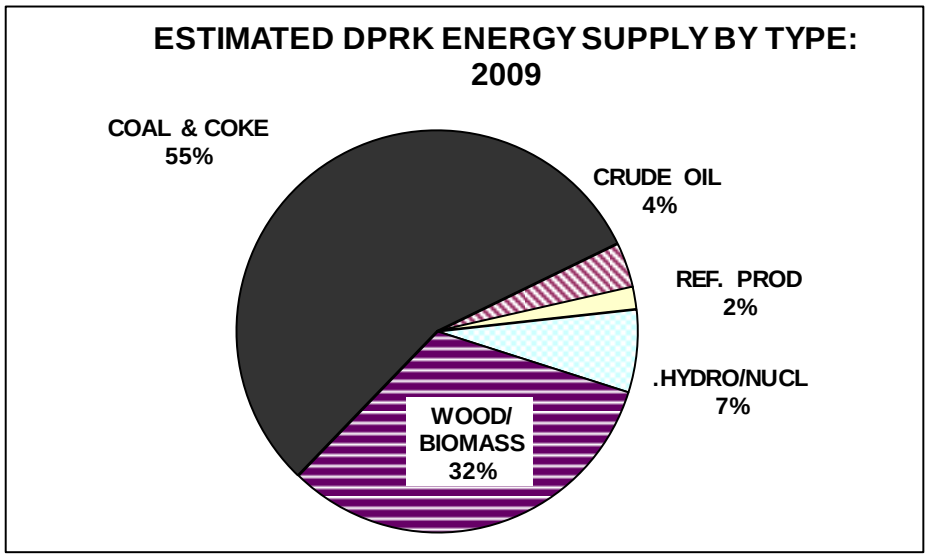
2010/2011 UPDATE

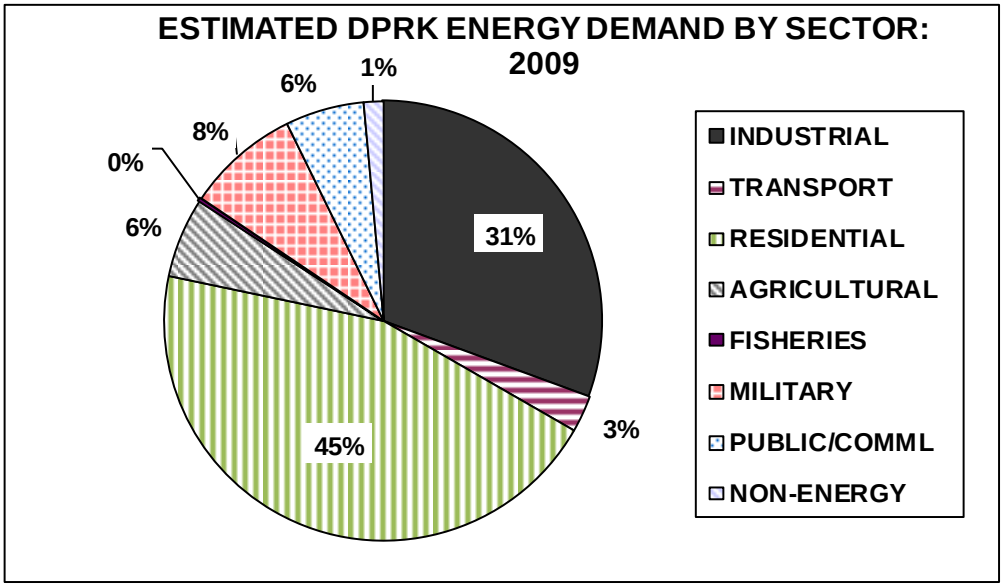
ESTIMATED SUMMARY ENERGY BALANCE FOR 2009

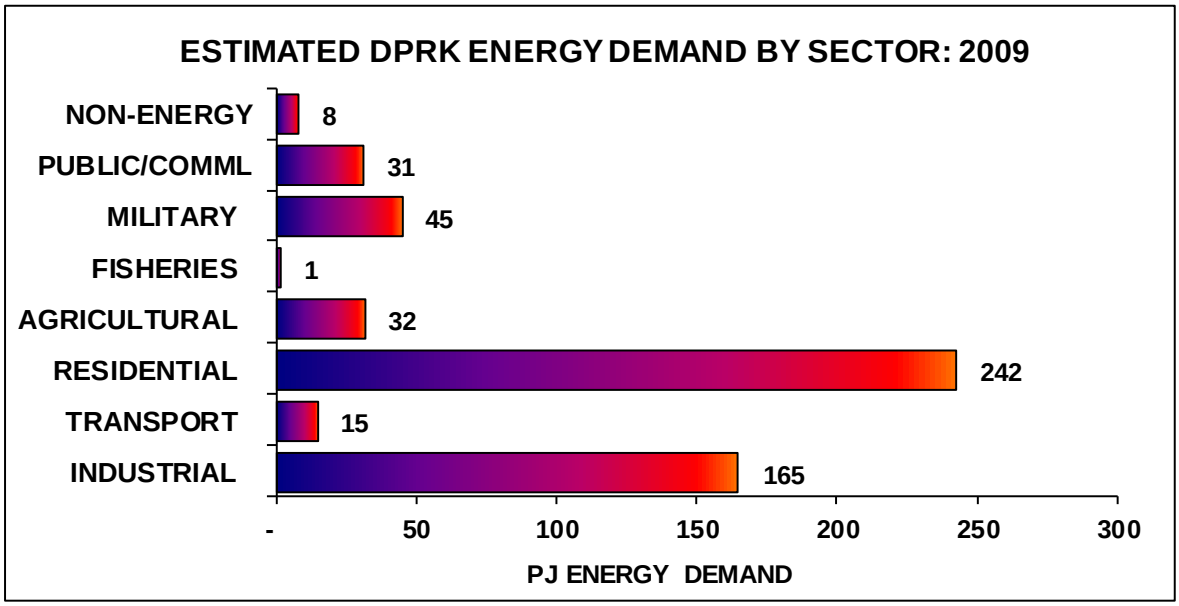
Prepared By David Von Hippel
Date Last Modified: 12/19/2011

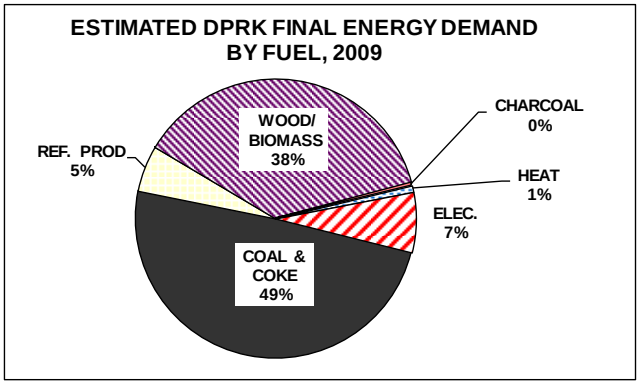
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	HEAT	ELEC.	**TOTAL**
ENERGY SUPPLY	356	23	12	43	207	-	-	1	642
Domestic Production	446	1	-	43	195	-		-	685
Imports	4	22	12	-	12	-		2	51
Exports	93	-	0	-	-	-		0	94
Stock Changes	-	-	-	-	-	-		-	-
ENERGY TRANSF.	(91)	(23)	17	(43)	(6)	2	4	36	(104)
Electricity Generation	(63)	-	(5)	(43)	-	-	4	57	(49)
Petroleum Refining	-	(23)	23	-	-	-		(0)	(0)
Coal Prod./Prep.	(21)	-	-	-	-	-		(3)	(24)
Charcoal Production	-	-	-	-	(6)	2		-	(4)
District Heat Production	(2)		(0)				1		(1)
Own Use	-	-	(1)	-	-	-		(3)	(4)
Losses	(5)	-	-	-	-	-	(1)	(15)	(22)
FUELS FOR FINAL CONS.	265	-	29	-	201	2	4	37	538
ENERGY DEMAND	265	-	29	-	201	2	4	37	538
INDUSTRIAL	144	-	5	-	1	-	-	14	165
TRANSPORT	-	-	10	-	1	-	-	4	15
RESIDENTIAL	76	-	2	-	156	2	3	4	242
AGRICULTURAL	5	-	1	-	24	-	-	1	32
FISHERIES	0	-	1	-	-	-	-	0	1
MILITARY	20	-	9	-	8	-	-	8	45
PUBLIC/COMML	19	-	0	-	6	-	1	5	31
NON-ENERGY	1		1		6				8
Elect. Gen. (Gr. TWhe)	3.73	-	0.20	11.87	-	-		-	15.80

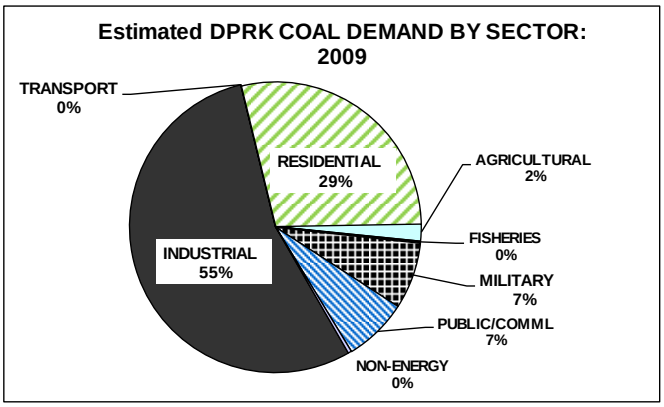
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

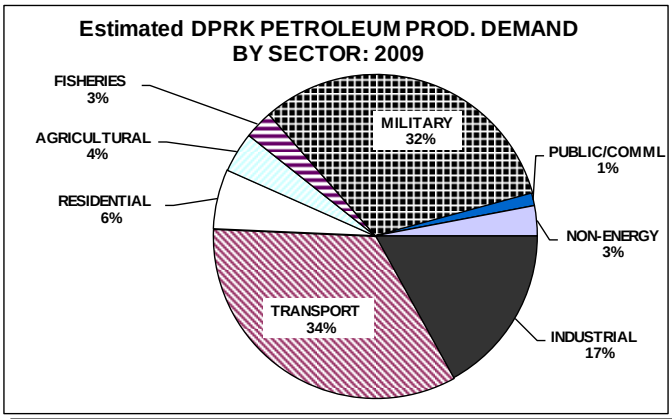

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2009
COAL & COKE 55%
CRUDE OIL 4%
REF. PROD 2%
.HYDRO/NUCL 7%
WOOD/ BIOMASS 32%

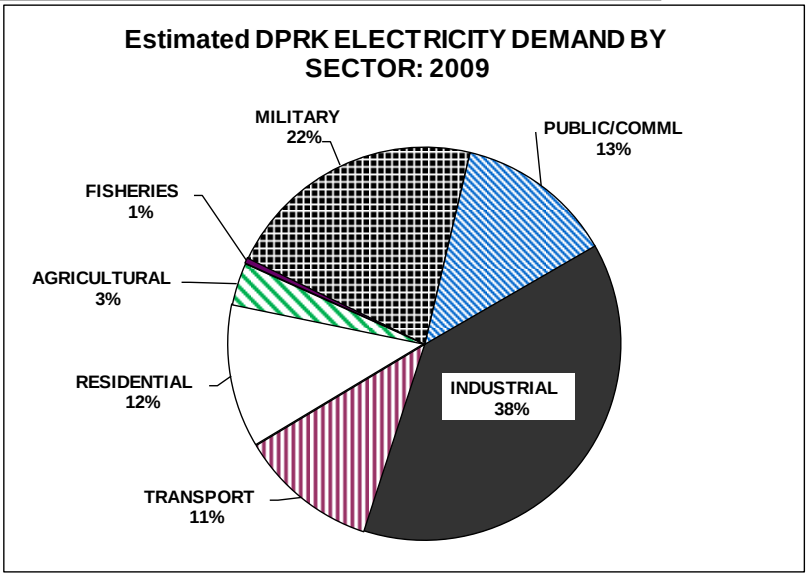

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2009
1%
6%
8%
0%
6%
31%
3%
45%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2009
NON-ENERGY 8
PUBLIC/COMML 31
MILITARY 45
FISHERIES 1
AGRICULTURAL 32
RESIDENTIAL 242
TRANSPORT 15
INDUSTRIAL 165
- 50 100 150 200 250 300
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2009
WOOD/ BIOMASS 38%
CHARCOAL 0%
HEAT 1%
ELEC. 7%
COAL & COKE 49%
REF. PROD 5%


Estimated DPRK COAL DEMAND BY SECTOR: 2009
TRANSPORT 0%
RESIDENTIAL 29%
AGRICULTURAL 2%
FISHERIES 0%
INDUSTRIAL 55%
MILITARY 7%
PUBLIC/COMML 7%
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 1%
AGRICULTURAL 3%
RESIDENTIAL 12%
INDUSTRIAL 38%
TRANSPORT 11%

Workpapers—Energy Supply Sectors

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
COAL EXTRACTION AND PROCESSING, IMPORTS

Prepared By David Von Hippel
Date Last Modified: 8/9/2012

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		
Coal Imports to the DPRK relative to 1993	18%	19%	75.3%	24.2%	7.3%	%	*17, 22*
Coke Imports to the DPRK relative to 1990	52.7%	26%	17%	7.1%	6.1%	%	*12, 22*
Total Estimated Coal+Coke Imports (GJ)	1.16E+07	1.05E+07	3.55E+07	1.15E+07	3.72E+06	7	*Calculated*
Coal Exp. from DPRK rel. to 1993 Exp. to China	298.49%	231.9%	1989.2%	1640%	2325%	%	*18, 19*
Total Estimated Coal Exports (GJ)	1.20E+07	9.32E+06	7.99E+07	6.59E+07	9.34E+07	6	*Calculated*
Domestic Coal Production relative to 1990	52.61%	25.86%	33.49%	32.63%	34.26%	%	*13*
Total Estimated Domestic Coal Production (GJ)	6.85E+08	3.37E+08	4.36E+08	4.25E+08	4.46E+08	8	*Calculated*
Estimated Coal Use in Coal Mining (GJ)	3.28E+07	1.61E+07	2.09E+07	2.03E+07	2.13E+07	7	*Calculated*
Estimated Coal Losses (GJ)	8.38E+06	4.12E+06	5.33E+06	5.20E+06	5.46E+06	6	*Calculated*
Estimated Electricity Use in Coal Mining (GJ)	4.44E+06	2.18E+06	2.82E+06	2.75E+06	2.89E+06	6	*Calculated*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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 2008/2009

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, which are from UN Comtrade *Units: metric tonnes*

Year	Anthracite Coal	Bituminous Coal	Other Non-Agglomerated Coal	**Total Coals (HS 2701)**	Coke; Retort Carbon (HS 2704)	Pitch, Coke from Mineral Tars (HS 2708)	Mineral Tars, Oils from Coal Tars (HS 2707)
1991							
1992				**1,369,165**	123,444	2,033	190
1993				**1,668,080**	83,335	2,671	1,388
1994				**1,552,365**	45,164	5,403	40
1995				**1,105,746**	96,222	23,873	100
1996				**323,772**	100,053	6,152	5
1997				268,440	48,875	2,877	
1998				98,918	84,127	3,104	
1999	2,700	429,574	2,488	434,762	72,970	5,635	*185*
2000	1,024	117,956	53,646	172,627	53,166	4,243	155
2001	200	267,697	151,954	419,851	125,497	4,306	99
2002	969	234,810	26,684	262,463	155,914	4,959	380
2003	4,867	367,315	32,969	405,152	*87,141*	6,179	592
2004	19,011	241,040	4,271	264,322	22,213	4,488	125
2005	4,858	142,419	195	147,471	25,878	5,721	7
2006	1,579	205,249	-	206,828	17,644	5,561	29
2007	-	227,250	-	227,250	7,534	6,186	25
2008	3,343	228,116	345	231,804	7,592	5,901	97
2009	5,674	84,234	483	90,390	3,948	7,635	52
2010				242,121	2,000		

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 2010, which are from UN Comtrade database) are as follows for selected years:

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)	Pitch, Coke from Mineral Tars (HS 2708)	Mineral Tars, Oils from Coal Tars (HS 2707)
1991								
1992					**711,150**			
1993					**154,926**		52	
1994					**64,317**		184	100
1995					**28,836**			318
1996					**33,777**			50
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					2,804,239			920
2006	**2,484,991**		494		2,485,486		229	219
2007	**3,741,267**		2,177		3,743,444			208
2008	**2,537,274**		2,322		2,539,596			5
2009	**3,598,951**		3,083		3,602,034			-
2010	**4,603,099**	1,898	6,346	29,771	4,644,859	3,746		

2005 "total coals" figure inclues 21 tonnes of lignite coal. 2010 total includes HS 2702.

Coal and coal products exports from the DPRK to Japan as indicated in data collected as in ***Source 16***, (Japan Customs Statistics) are as follows for 1990 through 2008:

Mer. ID	Name
27011100	anthracite coal

Year	Tonnes	Average Cost, 1000 Yen/tonne	Value, 1000 Yen	
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	-	-	-	Import statistics for 2009 not yet available as of 9/2010, but value assumed to be zero

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

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 Virtually all coke imported to the DPRK in 1996, 2005, 2008, and 2009 is assumed to come 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 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.

14 "Democratic People's Republic of Korea Fact Sheet", from the Australian Department of Foreign Trade (www.dfat.gov.au/geo/dprk, visited 5/17/2002), lists Australian exports of coal to the DPRK during "2000-2001" with a value of **1.70** *million $AU. Data from http://www.australiancoal.com/exports.htm (visited 5/23/02) show that* 104.4 *million tonnes of "Metallurgical coal" and* 89 *million tonnes of "thermal" coal were exported overall by Australia in 2000-2001, with values, respectively, of* 6367.7 *and* 4194.9 *million $AU. This suggest that the average value per ton of coal shipped was* $ 54.62 *AU per tonne, so that if coal exports to the DPRK were of the same proportions of metallurgical and thermal coals as overall exports, a total of approximately* 31,127 *tonnes of coal would have been exported from Australia to the DPRK in 2000-2001. This estimate is very similar to the value reported by UN Comtrade, see Note 23 below. The 2009 version of the above fact sheet (http://www.dfat.gov.au/geo/fs/dprk.pdf, accessed 9/17/10) shows total recorded Australian exports to the DPRK to be zero for the period 2005 thorugh 2009, so by definition Australian coal exports to the DPRK over that period (at lest official exports) were* 0 *as well.*

15 Data from China Customs Report 2000, pp. 1483-1495 (in Chinese).

16 From/derived from Japan customs statistics, http://www.customs.go.jp/toukei/info/index_e.htm, and http://www.customs.go.jp/toukei/download/index_d012_e.htm (the latter last visited 4/2010).

17 Year 2000 value includes reported coal imports from China and Australia.

18 Year 2000 value includes reported coal exports to China and Japan.

19 China Customs Statistics reported coal exports from China to the DPRK of 147,471 *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.*

20 Following data on coal products imports and exports from source as noted above.

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

Commodity Code	Product/Product Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2708	PITCH,COKE FM MN TARS	4,243.2	4,306.3	4,959.2	6,179.5	4,488.2	5,720.6				
2701	SOLID FUELS FROM COAL	172,627	419,851	262,523	405,152	264,357	147,471	206,828	227,250	231,804	90,390
270111	ANTHRACIT COAL,N AG	1,024	200	969	4,867	19,011	4,858	1,579	-	3,343	5,674
270112	BITUMNOUS COAL,N AG	117,956	267,697	234,810	367,315	241,040	142,419	205,249	227,250	228,116	84,234
270119	OTHER COAL,NT AGGLM	53,646	151,954	26,684	32,969	4,271	195			345	-
270120	OTHER 2701	-	-	60	-	35	-			-	483

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

Commodity Code	Product/Product Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2701	SOLID FUELS FROM COAL	8,143	86,361	406,534	745,339	1,571,348	2,804,260	2,484,991	3,741,267	2,537,274	3,598,951
2706	MINERAL TARS						920	229	208	5	
2702	LIGNITE,EXCLUDING JET						21	494	2,177	2,322	3083

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) 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						
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						

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
OIL IMPORTS, EXPORTS, AND REFINING

Prepared By David Von Hippel
Date Last Modified: **2/27/2012**

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

Total Estimated Refined Product Imports to DPRK, 1996	3.91E+07	GJ	

Estimated Refined Product Exports from DPRK, 2000 (to China)	tonnes	GJ
HFO	-	0.00E+00
LPG/Refinery Gas/Non-Energy	10,450	4.43E+05
Total of above	10,450	4.43E+05

Estimated HFO placed in storage, 1996	155,360	tonnes		8
	6.45E+06	GJ		8

Input Data for the Year 2000					
DPRK Crude Oil Production		30,000	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		
LPG/Refinery Gas/Non-Energy		4,329	1.83E+05		
Total of above		72,464	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		30,000	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	50,909	1.050	2.24E+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	1.228E+05	0.991	5.09E+06	*(see below,*	
LPG/Refinery Gas/Non-Energy	9.67E+03	1.012	4.10E+05	*and note 36)*	
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		4,393	1.86E+05		
Total of above		4,393	1.86E+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 21,481 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		30,000	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	5.11E+06		*Sum of*
Kerosene	50,542	1.032	2.18E+06		*Imports from*
Diesel	1.91E+05	1.032	8.24E+06		*all nations*
HFO	3.19E+05	0.991	1.32E+07		*(see below,*
LPG/Refinery Gas/Non-Energy	9.13E+03	1.012	3.87E+05		*and note 36)*
Total Estimated Refined Product Imports to DPRK, 2008		2.91E+07	GJ		
Estimated Refined Product Exports from DPRK, 2008 (to China and RF)		tonnes	GJ		
HFO		5.50	2.28E+02		*(See notes 32*
LPG/Refinery Gas/Non-Energy		3,148	1.33E+05		*and 44)*
Total of above		3,153	1.34E+05		
Estimated Net HFO placed in storage, 2008		-	tonnes		*26*
		0.00E+00	GJ		*26*

Implied total 2008 crude oil, oil products into the DPRK:	5.16E+07	GJ/yr, which implies annual imports of			
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	9.04E+06	bbl/yr or	
an average of	24,774	bbl per day.			

Input Data for the Year 2009					
DPRK Crude Oil Production		30,000	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*
Extrapolated 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	81,549	1.050	3.59E+06		*Sum of*
Kerosene	35,230	1.032	1.52E+06		*Imports from*
Diesel	1.38E+05	1.032	5.97E+06		*all nations*
HFO	6.78E+03	0.991	2.81E+05		*(see below,*
LPG/Refinery Gas/Non-Energy	7.53E+03	1.012	3.19E+05		*and note 36)*
Total Estimated Refined Product Imports to DPRK, 2009		1.17E+07	GJ		
Estimated Refined Product Exports from DPRK, 2009 (to China)		tonnes	GJ		
HFO		-	0.00E+00		
LPG/Refinery Gas/Non-Energy		2,908	1.23E+05		
Total of above		2,908	1.23E+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:	3.38E+07	GJ/yr, which implies annual imports of			
(at a conversion rate of	7.33	bbl oil equivalent per tonne oil equivalent)	5.92E+06	bbl/yr or	
an average of	16,219	bbl per day.			

		2000	2005	2008	2009	
Crude Oil Imports from China relative to 1996 (rel to 2000 for 2005-on)		42%	134%	136%	134%	
Other Crude Oil Imports (tonnes)		0.00E+00	-	-	-	
Domestic DPRK Crude Oil Production (tonnes)		30,000	30,000	30,000	30,000	
Official Refined Products Imports from China relative to 1996 (rel to 2000 for 2005 through 2009)		172%	127%	100%	108%	
HFO Supplied by KEDO or through 6-Party Talks (tonnes)		3.95E+05	0.00E+00	3.04E+05	0.00E+00	
Total Imports of Refined Products (tonnes)	Gasoline	1.09E+05	5.09E+04	1.16E+05	81,549	*15, 36*
	Kerosene	2.20E+04	4.70E+04	50,542	35,230	*15, 36*
	Diesel	1.90E+05	2.95E+05	1.91E+05	1.38E+05	*15, 36*
	HFO	5.40E+05	1.23E+05	3.19E+05	6.78E+03	*15, 36*
	LPG/Refinery Gas/Non-Energy	6.43E+04	9.67E+03	9.13E+03	7.53E+03	

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				
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)	3.95E+05	0.00E+00			
Estimated Refinery Output, 2000 (tonnes)			Toe/Te		
Heavy Fuel Oil	150,185	-	0.991		
Gasoline	86,949	-	1.050		
Diesel Oil	79,045	-	1.032		
Kerosene	15,809	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	47,427	-	1.012		
Estimated Refinery Fuel Use (toe)	22,844	-			
Estimated Net Refinery Output, 2000 (GJ)			% of Net		
Heavy Fuel Oil	6.23E+06	0.00E+00	39.25%		
Gasoline	3.82E+06	0.00E+00	24.07%		
Diesel Oil	3.42E+06	0.00E+00	21.51%		
Kerosene	6.83E+05	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	1.73E+06	0.00E+00	10.87%		*10*
TOTAL	1.59E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2000 (tonnes)	372,693				
Estimated Net Refinery Output, 2000 (TOE)	379,226	-	379,226		
Refinery use of electricity, kWh/tonne output	73.74	10% higher than in 1996			*28*
Estimated 2000 Refinery use of electricity	29.21	GWh or	1.05E+05	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)	5.29E+05	0.00E+00		
Estimated Refinery Output, 2005 (tonnes)			Toe/Te	
Heavy Fuel Oil	200,957	-	0.991	
Gasoline	116,343	-	1.050	
Diesel Oil	105,767	-	1.032	
Kerosene	21,153	-	1.032	
LPG/Refinery Gas/Non-energy (gross)	63,460	-	1.012	
Estimated Refinery Fuel Use (toe)	30,567	-		
Estimated Net Refinery Output, 2005 (GJ)			% of Net	
Heavy Fuel Oil	8.34E+06	0.00E+00	39.25%	
Gasoline	5.11E+06	0.00E+00	24.07%	
Diesel Oil	4.57E+06	0.00E+00	21.51%	
Kerosene	9.14E+05	0.00E+00	4.30%	
LPG/Refinery Gas/Non-Energy	2.31E+06	0.00E+00	10.87%	*10*
TOTAL	2.12E+07	0.00E+00	100.0%	
Estimated Net Refinery Output, 2005 (tonnes)	498,684			
Estimated Net Refinery Output, 2005 (TOE)	507,425	0	507,425	
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	38.50	GWh or	1.39E+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)	5.35E+05	0.00E+00		
Estimated Refinery Output, 2008 (tonnes)			Toe/Te	
Heavy Fuel Oil	203,135	-	0.991	
Gasoline	117,604	-	1.050	
Diesel Oil	106,913	-	1.032	
Kerosene	21,383	-	1.032	
LPG/Refinery Gas/Non-energy (gross)	64,148	-	1.012	
Estimated Refinery Fuel Use (toe)	30,898	-		
Estimated Net Refinery Output, 2008 (GJ)			% of Net	
Heavy Fuel Oil	8.43E+06	0.00E+00	39.25%	
Gasoline	5.17E+06	0.00E+00	24.07%	
Diesel Oil	4.62E+06	0.00E+00	21.51%	
Kerosene	9.24E+05	0.00E+00	4.30%	
LPG/Refinery Gas/Non-Energy	2.33E+06	0.00E+00	10.87%	*10*
TOTAL	2.15E+07	0.00E+00	100.00%	
Estimated Net Refinery Output, 2008 (tonnes)	504,090			
Estimated Net Refinery Output, 2008 (TOE)	512,926	0	512,926	
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	38.90	GWh or	1.40E+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)	5.26E+05	0.00E+00		
Estimated Refinery Output, 2009 (tonnes)			Toe/Te	
Heavy Fuel Oil	199,805	-	0.991	
Gasoline	115,677	-	1.050	
Diesel Oil	105,160	-	1.032	
Kerosene	21,032	-	1.032	
LPG/Refinery Gas/Non-energy (gross)	63,096	-	1.012	
Estimated Refinery Fuel Use (toe)	30,391	-		
Estimated Net Refinery Output, 2009 (GJ)			% of Net	
Heavy Fuel Oil	8.29E+06	0.00E+00	39.25%	
Gasoline	5.09E+06	0.00E+00	24.07%	
Diesel Oil	4.54E+06	0.00E+00	21.51%	
Kerosene	9.09E+05	0.00E+00	4.30%	
LPG/Refinery Gas/Non-Energy	2.30E+06	0.00E+00	10.87%	*10*
TOTAL	2.11E+07	0.00E+00	100.00%	
Estimated Net Refinery Output, 2009 (tonnes)	495,827			
Estimated Net Refinery Output, 2009 (TOE)	504,518	0	504,518	

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	38.29	GWh or	1.38E+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

Refined Products Imports from and Exports to China, 2008 and 2009 ***(tonnes: See Note 30)***

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

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

	2008		2009	
Commodity	Imports	Exports	Imports	Exports
Heavy Fuel Oil	3,982	-	2,576	-
Gasoline/Aviation Gasoline	43,166		38,738	
Diesel Oil	14,047		10,460	
Kerosene/Jet Fuel	50,542		35,230	
LPG/Refinery Gas/Non-Energy	9,129	3,148	7,533	2,908
Total of Above	120,865	3,148	94,536	2,908

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	6.446E+06	155,360	6.45E+06	1.55E+05	
1997	-1.245E+06	(30,000)	5.20E+06	1.25E+05	
1998	-1.245E+06	(30,000)	3.96E+06	9.54E+04	
1999	-1.245E+06	(30,000)	2.71E+06	6.54E+04	
2000	-1.245E+06	(30,000)	1.47E+06	3.54E+04	
2001	-2.075E+05	(5,000)	1.26E+06	3.04E+04	
2002	-2.075E+05	(5,000)	1.05E+06	2.54E+04	
2003	-2.075E+05	(5,000)	8.45E+05	2.04E+04	
2004	-2.075E+05	(5,000)	6.37E+05	1.54E+04	
2005	-2.075E+05	(5,000)	4.30E+05	1.04E+04	
2006	-2.075E+05	(5,000)	2.22E+05	5.36E+03	
2007	0.000E+00		2.22E+05	5.36E+03	
2008	0.000E+00		2.22E+05	5.36E+03	
2009	0.000E+00		2.22E+05	5.36E+03	

Estimate of 2000, 2005, 2008, and 2009 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	$ 174.26	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		
	3%	are gasoline (based on trade statistics), and		
	32%	are heavy oil or the equivalent, then total		
import from Russia were			2.29E+05	of diesel and
			9.06E+03	of gasoline
			1.14E+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	$ 27.15	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		
	1%	are gasoline, and		
	19%	are heavy oil or the equivalent, then total		
imports from Russia were			3.37E+04	of diesel and
			4.61E+02	of gasoline
			7.96E+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		
	56%	are gasoline (based on trade statistics), and		
	4%	are heavy oil or the equivalent, then total		
			1.73E+03	of diesel and
			2.42E+03	of gasoline
			1.71E+02	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 of crude oil required by that refinery is close enough to the assumed output, that we assume that either the 30,000 tonnes of 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).

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 2008 and 2009 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

Assumed imports from Japan in 2009 relative to 2008	0%	
Total imports of heavy fuel oil from Japan	-	*tonnes*
Total imports of non-energy petrol. products from Japan	-	tonnes

Oil products from Singapore (2008/2009):

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

Assume that imports were

2008	2009	
0%	100%	gasoline and
100%	0%	diesel, thus annual estimated imports were:

2008	2009	
0.00E+00	0.00E+00	tonnes of gasoline and
1.13E+05	4.31E+01	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.

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	
2.00E+04	4.00E+04	tonnes of gasoline and
0.00E+00	6.44E+04	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. This may well be an over-estimate, given that the ROK also imported large quantities of diesel (or rather, non-specified diesel-like fuels) in the same year, 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):

Rough estimate of rate of imports from ROK: 12,000 Bbl/day for *See Note 24*
5% of the year, or an average of 600 Bbl/day.
Assume that these oil products are (or can be used as) 80% diesel
at 0.87 kg/liter for diesel and
and 20% 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 6,606 tonnes of heavy fuel oil and
24,199 of diesel.

Oil Products from Other Countries (2008/2009):

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

Even including all recorded (and in the case of ROK, guessed at) oil products imports, 2009 was an unusually low year for supplies of diesel fuel. We assume that an additional 26,000 tonnes of diesel fuel was available for use in the DPRK in 2009, though the source could have been unrecorded (smuggled) imports, withdrawls from stocks, or possibly (but less likely) refinery output from crude oil imports that were not recorded otherwise. This amount of oil is equivalent to about one cargo delivery 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	16,047
1991	141,423	0	141,423	16,047
1992	132,847	0	132,847	16,047
1993	124,270	0	124,270	16,047
1994	115,694	0	115,694	16,047
1995	107,117	150,000	257,117	16,047
1996	98,541	500,000	598,541	16,047
1997	110,138	500,000	610,138	16,047
1998	121,735	500,000	621,735	16,047
1999	133,333	500,000	633,333	16,047
2000	144,930	394,722	539,652	64,261
2001	140,500	559,613	700,113	14,772
2002	136,071	456,893	592,964	13,497
2003	131,642	0	131,642	12,222
2004	127,213	0	127,213	10,947
2005	122,783	0	122,783	9,671
2006		0		
2007		146,000		
2008		304,000		
2009		0		

See Notes 41 and 42 for 6-PT totals
See Notes 41 and 42 for 6-PT totals
See Notes 41 and 42 for 6-PT totals

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
Gasoline	24.2%	21.8%	20.2%	22.1%	22.1%	22.1%
Aviation Gas	1.03%	2.32%	3.97%	2.08%	2.05%	2.12%
Kero/Jet	8.45%	4.30%	4.37%	4.35%	4.35%	4.35%
Diesel	18.5%	21.5%	21.6%	21.6%	21.6%	21.6%
Residual Oil	36.8%	39.2%	39.6%	39.50%	39.5%	39.5%
LPG	2.0%	4.7%	4.1%	7.14%	7.14%	6.81%
Other	9.0%	6.1%	6.1%	3.24%	3.2%	3.6%
TOTAL	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
12%	28%	25%	43%	43%	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, we assume that a more reasonable figure for ongoing DPRK domestic oil production is 10% *of the reported value (which might also have been misreported due to an error in reporting units, as happens occasionally in the DPRK and elsewhere).*
It is assumed that the oil from this oil goes to the small western refinery, thus the output of the well is adjusted based on the output of the refinery (which is currently assumed not to change from 2000 through 2009).
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. A 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 estimate we are using, though approximately on the same order of magnitude. Both estimates are likely to be quite speculative.*

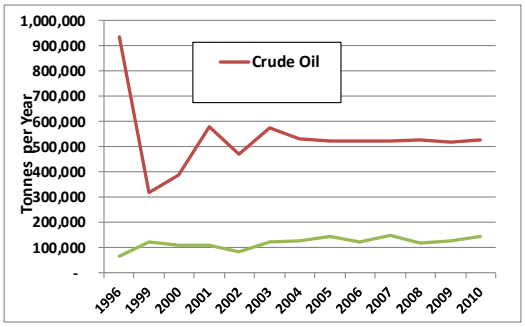
28 Calculated based on 1990 data for China from J.E. Sinton, ed (1992). China Energy Databook. Lawrence Berkeley National Laboratory, Berkeley, CA, USA. (Revised 1996).

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 2010 from UN Comtrade database.)*

Year	Crude Oil	Oil "(Not Crude)"	"PETROLEUM COKE,RESIDU"	"PETROLEUM OTHER GASES"
1996	936,170	66,533	1,845	-
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

Units: metric tonnes



All crude oil shipped to the DPRK from China was recorded as coming from the Dalian district from 1999-2005.

Units: Kilograms

Commodity Code	Product/Product Group	2002	2003	2004	2005	2006	2007	2008	2009
2710	OIL (NOT CRUDE)	82,471,546	124,726,964	127,968,583	145,506,346		147,678,866	117,742,858	90,447,291
271019	OIL (NOT CRUDE) FROM PETROL	63,900,162	78,280,544	89,821,556	104,543,577		122,963,762	74,568,855	51,689,392
27101921	Light diesel oil	3,647,230	20,871,299	34,458,192	46,668,386		12,496,241	14,046,689	10,460,146
27101911	Aviation kerosene	46,649,237	46,307,578	46,572,203	46,994,450		51,205,986	50,542,083	35,229,535
27101993	Basic oils for lubricating oils	2,722,165	3,435,866	2,524,002	3,628,783		1,958,658	1,680,951	1,686,362
27101991	Lubricating oils	6,366,340	4,170,232	2,705,837	2,320,426		1,942,129	3,370,020	1,289,901
27101922	Fuel oils No. 5 ~ No. 7	-	2,569,560	2,600,000	3,573,156		9,422,740	3,981,836	2,575,871
27101929	Other diesel oils and other fuel oils	4,268,282	490,000	-	1,186,911		45,789,974	-	-
27101992	Lubricating grease	246,908	254,890	183,135	167,665		139,217	938,921	141,577
27101994	Liquid paraffin and heavy liquid paraffin	-	990	-	170		-	-	-
27101999	Other lubricating oils, greases and other heavy oil	-	180,129	778,187	3,630		8,817	8,355	306,000

Units: Kilograms

Commodity Code	Product/Product Group	2002	2003	2004	2005	2006	2007	2008	2009
2710	OIL (NOT CRUDE)	82,471,546	124,726,964	127,968,583	145,506,346		147,678,866	117,742,858	90,447,291
271011	LIGHT OILS & PREP (NOT CRUDE)	18,571,384	46,446,418	38,147,027	40,947,469		24,715,104	43,174,003	38,757,899
27101110	Motor gasoline, aviation gasoline	18,328,384	46,199,539	38,144,787	40,893,374		24,574,734	43,165,743	38,737,609
27101130	Rubber solvent, paint solvent, extractive solvent	143,000	188,179	2,240	3,300		140,370	8,260	20,290
27101190	Other light oils and preparations	100,000	-	-	-		-	-	-
27101199	Other light oils and preparations	-	58,700	-	50,795		-	-	-

Units: Metric Tonnes

Commodity Code	Product/Product Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2708	PITCH,COKE FM MN TARS	4,243.2	4,306.3	4,959.2	6,179.5	4,488.2	5,720.6	5,560.9	6,186.5	5,901.5	7,635.3
2711	PETROLEUM,OTHER GASES	46.4	149.8	215.9	232.3	354.4	496.8	755.8	770.1	479.7	543.0
2712	PETROLEUM JELLY;WAXES	87.9	59.0	187.0	157.8	149.0	108.9	133.2	111.2	251.8	117.1
2713	PETROLEUM COKE,RESIDUES	1,617.5	2,065.7	6,547.9	4,369.7	5,283.8	2,864.5	1,533.0	3,083.5	2,330.2	3,283.5
2714	BITMN,ASPHLT;TAR SAND	10.5	2.0	-	26.1	0.5	-	0.5	9.8	42.8	34.0
2715	BITUMEN,TAR RELATED	-	8.0	-	29.0	1.6	1.5	-	-	17.6	111.2

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 and 2010 are as follows:

		2009		2010	
Commodity Code	Product/Product Group	Value (USD)	Volume (kg)	Value (USD)	Volume (kg)
2710	OIL (NOT CRUDE)	$ 69,252,199	126,741,402	$ 104,886,571	145,015,288
271011	LIGHT OILS & PREP (NOT CRUDE)	$26,288,119	50,621,296	$40,629,283	55,501,253
271019	OIL (NOT CRUDE) FROM PETROL	$42,964,080	76,120,106	$64,257,288	89,514,035

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)

1997	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	
236,478	7,175	19,180	19,935	11,704					0	1.805	-	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
271119	OTHER,LIQUEFIED	11,703	10,450	5,874	4,100	4,534	4,315
2711	PETROLEUM,OTHER GASES	11,703	10,490	5,874	4,100	4,534	4,315

		2001	2002	2003	2004	2005	2006	2007	2008	2009
271119	OTHER,LIQUEFIED	8,747	8,558	4,679	6,598	3,844				
271114	VARIOUS,LIQUEFIED	-	-	-	0	549				
2711	PETROLEUM,OTHER GASES	8,747	8,558	4,679	6,598	4,393	4,118	5,230	3,148	2,908

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

Units: Kilograms

Commodity Code	Product/Product Group	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2711	PETROLEUM,OTHER GASES	11,130	46,400	149,800	215,850	232335	354365	496797	755770	770052	479727	543001
271119	OTHER,LIQUEFIED	-	-	17,400	13,850	21550	55707	125294				
271113	BUTANES, LIQUEFIED	11,130	46,400	132,400	202,000	210755	298658	361826				
271111	NATURAL,LIQUEFIED	-	-	-	-	0	0	9677				
271112	PROPANE, LIQUEFIED	-	-	-	-	0	0	0				
271129	OTHER GASES,GASEOUS	-	-	-	-	30	0	0				

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.

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

36 For 2005 and beyond, 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 2008 and 2007:

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"	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) includes the following statistics on exports from Russia to the DPRK of oil products:

	HS271011: Light oils and preparations			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)	Trade Quantity	Trade Value	NetWeight (kg)	Trade Quantity	Trade Value	NetWeight (kg)	Trade Quantity
2000							$1,621,861	6,862,811	6,862,811
2005	$3,867,434	8,704,467	8,704,467	$140,877,871	330,214,190	330,214,190	$144,745,305	338,918,657	338,918,657
2006	$1,779,745	2,879,099	2,879,099	$67,031,085	116,715,130	116,715,130	$68,810,830	119,594,229	119,594,229
2007	$837,987	1,101,248	1,101,248	$69,340,553	133,045,608	133,045,608	$70,178,540	134,146,856	134,146,856
2008	$644,830	460,593	460,593	$25,770,853	41,665,420	41,665,420	$26,415,683	42,126,013	42,126,013
2009	$1,373,927	2,419,666	2,419,666	$1,513,772	1,898,396	1,898,396	$2,887,699	4,318,062	4,318,062

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
27074000	4.3					240,000.00	63,000.00
27082000		60					
27101119							
27101190					752340	633130	371500
27100094	22500	35060		55000	268450		
27101920	10	40000			20	20	
27101930					22500		
27101950							
27101960							
27101990				30000			64400
27122090	12						
27109900				29700			
27129090					10	1.67	5

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
27074000					38,750.00	108,000.00	29,700.00
27079900			0.42	14	14		
27090000				29700			
27101119			85000	564840	259200	970680	618990
27101190			15750	88540	170630	657470	1,377,060
27082000							
27100094		194820	219430	54000	110000		
27101111				174040			
27101920		30	50	50	30	312740	990
27101930					5500	1,345,710	15000
27101950			17500		10		96280
27101980			10	200		80000	50
27101990		80000	632760	553100	131620	526960	182990
27109900			38000		202960		15000
27111400				12,253.00			
27111900							13,280.00
27121010			15	14			
27121090			8	89.66	14	129.3	76.55
27122010			16		59	19.6	80.2
27122090					2.7		
27129010						0.29	
27129090			10	7.07	73	103.38	83.86
27131100			0.08				
27131200			0.04				
27149090			12		0.3		

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) includes the following statistics on exports from the DPRK to Russia of oil products:

Period	Code	Trade Value	NetWeight (kg)	Trade Quantity
2006	271019	$7,646	10,645	10,645
2008	271019	$9,433	3,697	3,697

45 The United Nations "Comtrade" database (http://comtrade.un.org/db/default.aspx, accessed 2/10/11) includes the following statistics on exports to the DPRK from Malaysia of oil products in 2009:

Period	Code	Trade Value	NetWeight (kg)	Trade Quantity
2009	271019	$1,427,390	3,718,477	3,718,477

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

Period	Code	Trade Value	NetWeight (kg)	Trade Quantity	Code Definition
2005	271019	$9,949	394	394	Light petroleum distillates nes
2007	271019	$46,676	11,350	11,350	Light petroleum distillates nes
2008	271019	$2,478,562	5,245,516	5,245,516	Light petroleum distillates nes
2007	340319	$5,491	2	2	Lubricating oil etc containing <70% petroleum oil nes

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

2010/2011 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: DRAFT

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)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
BIOMASS AND WOOD PRODUCTION AND IMPORTS

Prepared By David Von Hippel
Date Last Modified: 1/18/2012

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	1.50E+06	cu.m.			3
Conversion Factor	2.00	cu.m./te			Assumed to be mostly softwood
Conversion Factor	16.00	GJ/te			
Wood Imports, Total	1.20E+07	GJ			
Total Domestic Wood Production	6.81E+07	GJ			
Other Biomass/Crop Wastes Production for Fuel					
Crop Wastes Used in Agriculture:	3.10E+06	te			4
Crop Wastes for Other Uses	2.54E+06	te			Est. based on needs
Conversion Factor	14.5	GJ/te			2
Total Biomass/Crop Wastes Production	8.18E+07	GJ, or	5.64E+06	tonnes	
TOTAL WOOD/BIOMASS PRODUCTION	1.50E+08	GJ			

ESTIMATE OF CURRENT AND FUTURE WOOD/BIOMASS SUPPLY

Category	1996	2000	2005	2008	2009	2…	
Domestic wood production relative to 1990	135.58%	145.83%	166.43%	194.27%	196.26%	…%	6
Domestic wood production (GJ)	9.23E+07	9.93E+07	1.13E+08	1.32E+08	1.34E+08	…07	
Wood used to make charcoal relative to 1990	79.8%	61.1%	61.7%	59.2%	60.2%	…%	6
Wood Used to make charcoal (GJ)	7.92E+06	6.06E+06	6.12E+06	5.87E+06	5.97E+06	…06	
Charcoal production (GJ)	2.37E+06	1.82E+06	1.84E+06	1.76E+06	1.79E+06	…06	
Wood imports relative to 1990	100%	100%	100%	100%	100%	…%	5
Wood imports (GJ)	1.20E+07	1.20E+07	1.20E+07	1.20E+07	1.20E+07	…07	
Biomass/crop wastes production relative to 1990	77.0%	66.5%	73.9%	75.0%	75.0%	…%	6
Biomass/crop wastes production (GJ)	6.30E+07	5.44E+07	6.05E+07	6.14E+07	6.14E+07	…07	
Pulp and Paper Imports from China (tonnes)	4.8	772.7	43.9				7
Pulp and Paper Imports from China (GJ)	7.68E+01	1.24E+04	7.02E+02				
Pulp and Paper Exports to China (tonnes)	225.2	49.2	1,211.6				7
Pulp and Paper Exports to China (GJ)	3.60E+03	7.87E+02	1.94E+04				

THIS SECTION OF THIS WORK SHEET NOT USED FOR THIS ANALYSIS

	1990	1996	2000	2005	2008	2009	
Total Implied Domestic Wood Harvest, tonnes	4.26E+06	5.77E+06	6.21E+06	7.08E+06	8.27E+06	8.35E+06	*Calculated from above*
Total Implied Domestic Wood Harvest, cu. meters	7.20E+06	9.76E+06	1.05E+07	1.20E+07	1.40E+07	1.41E+07	*Calculated from above*

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

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,
-1.83% per year, 1990 to 2000, and -1.93% per year, 2000 to 2005, using the FRA estimates, and
-1.59% per year, 1990 to 2000, and -2.09% per year, 2000 to 2005, and
-2.09% per year, 2005 to 2010, based on data in the summary of the 2011 KFRI report.

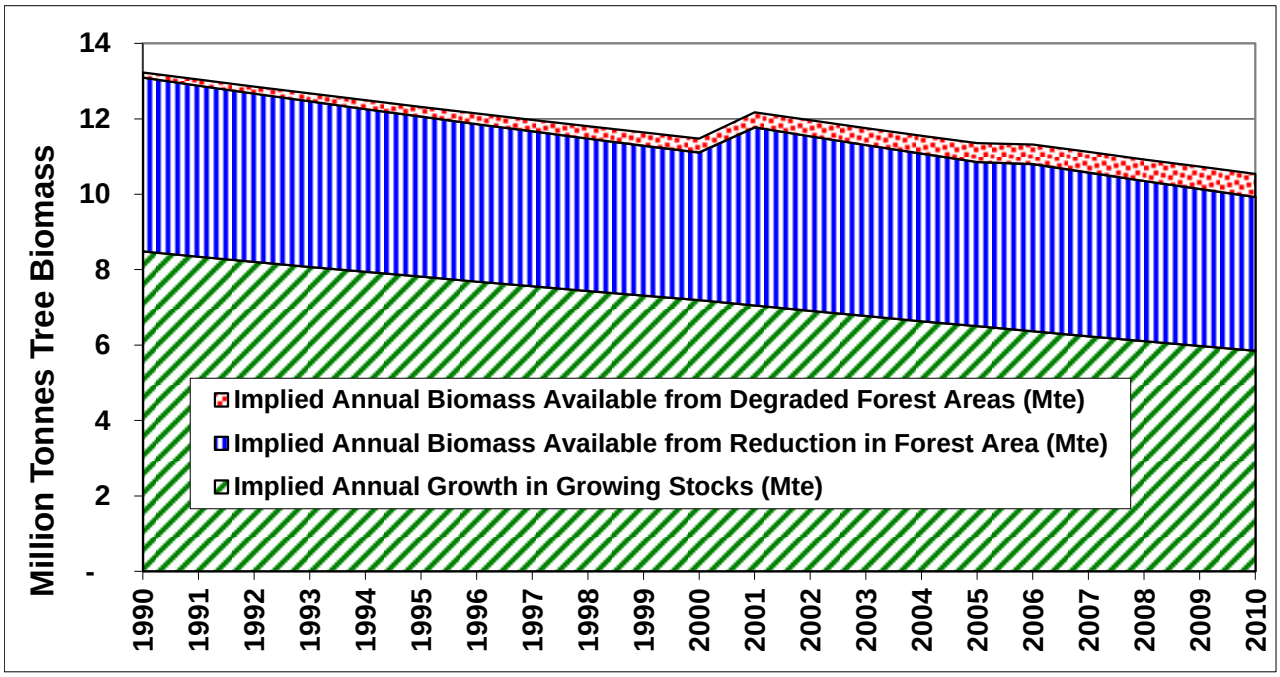
Based roughly on the information above, we make the following estimate of forest area, wood stocks, and wood production over time.

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:	**-1.64%**	per year (average of rates estimated above).
Change in extent of forest lands, 2000 to 2005:	**-2.01%**	per year (average of FRA and KFRI estimates).
Change in extent of forest lands, 2005 to 2010:	**-2.09%**	per year (from KFRI estimates).
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 (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	277	8.48	4.61	13.09	0.74	0.14	13.23
1991	8.07	273	8.34	4.54	12.88	0.87	0.16	13.04
1992	7.93	268	8.20	4.46	12.67	1.00	0.19	12.85
1993	7.80	264	8.07	4.39	12.46	1.13	0.21	12.67
1994	7.68	259	7.94	4.32	12.25	1.26	0.24	12.49
1995	7.55	255	7.81	4.25	12.05	1.39	0.26	12.31
1996	7.43	251	7.68	4.18	11.86	1.51	0.28	12.14
1997	7.31	247	7.55	4.11	11.66	1.6317	0.31	11.97
1998	7.19	243	7.43	4.04	11.47	1.75	0.33	11.80
1999	7.07	239	7.31	3.97	11.28	1.87	0.35	11.63
2000	6.95	235	7.19	3.91	11.10	1.98	0.37	11.47
2001	6.81	230	7.05	4.72	11.77	2.12	0.40	12.17
2002	6.68	226	6.90	4.63	11.53	2.26	0.42	11.96
2003	6.54	221	6.77	4.54	11.30	2.40	0.45	11.75
2004	6.41	217	6.63	4.44	11.07	2.53	0.47	11.55
2005	6.28	212	6.50	4.35	10.85	2.66	0.50	11.35
2006	6.15	208	6.36	4.43	10.79	2.79	0.52	11.32
2007	6.02	204	6.23	4.34	10.57	2.92	0.55	11.11
2008	5.90	199	6.10	4.25	10.35	3.04	0.57	10.92
2009	5.77	195	5.97	4.16	10.13	3.16	0.59	10.72
2010	5.65	191	5.85	4.07	9.92	3.29	0.62	10.54

Values in non-shaded cells are estimates from sources as indicated above. Values in shaded cells are estimates that are calculated based on estimates from literature sources and other inputs.



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 Assumption

6 Adjusted to meet demand.

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**
Chemical Wood Pulp	Production	tonnes	43000	43000	43000	43000	43000	43000	43000
Mechanical Wood Pulp	Production	tonnes	13000	13000	13000	13000	13000	13000	13000
Other Fibre Pulp	Production	tonnes	50000	50000	50000	50000	50000	50000	50000
Other Paper+Paperboard	Production	tonnes	80000	80000	80000	80000	80000	80000	80000
Wood Charcoal	Production	tonnes	102729	131226	141339	149939	151258	152600	153900
Other Indust Roundwd(C)	Production	CUM	300000	300000	500000	500000	500000	500000	500000
Sawlogs+Veneer Logs (C)	Production	CUM	400000	450000	600000	600000	600000	600000	600000
Sawlogs+Veneer Logs (NC)	Production	CUM	200000	250000	400000	400000	400000	400000	400000
Sawnwood (C)	Production	CUM	185000	185000	185000	185000	185000	185000	185000
Sawnwood (NC)	Production	CUM	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 o 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 Frid
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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 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	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)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION FACILITIES

MAJOR THERMAL GENERATING FACILITIES

#	Name		Capacity (MW)	Fuel	Year Completed		***Sources/Notes:***
1	Pyongyang		500	Coal	1968		*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		*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	Unknown	Coal	1990		13
8	Ahnju	1200	Coal	1989		13
9	Hamheung	150	Coal	1989		13, 14
TOTAL OF LISTED PLANTS		**2,750**				

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

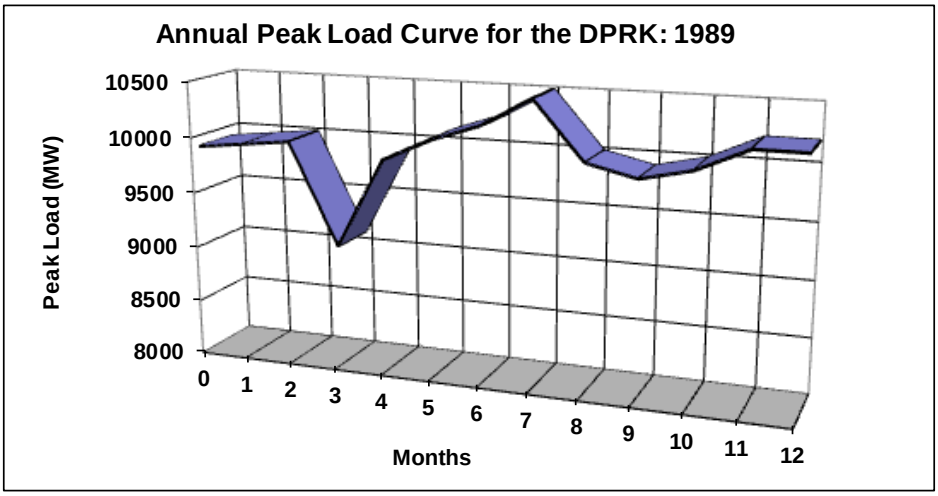
#	Name	Location (city)
1	North Kamgyong	Chongzin
2	Ryanggang	Hyesan
3	Chagang	Kanggye
4	South Hamgyong	Hamhung
5	South Pyongan	Pyongsong
6	Kangwon	Wonsan
7	North Hwanghae	Sariwon
8	Nampo	Nampo
9	South Hwanghae	Haeju
10	Kaesong	Kaesong
11	North Pyongan	Siniju

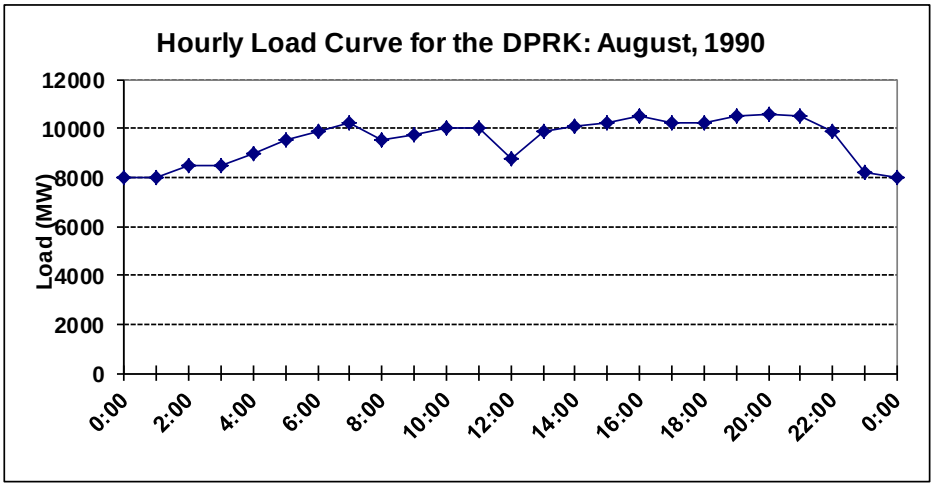
Annual Load Curve for 1989
(Source 1)

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





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).*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION AND FUEL REQUIREMENTS IN 1996 THROUGH 2009

Prepared by David Von Hippel
Date Last Modified: 12/29/2011

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	1.28E+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	9.11E+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)	1.05E+04	2.641E+03	1.48E+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	29.13%	100%	
HFO Input to generation, 2000 (GJ)	N/A	1.32E+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	3.99%	100%	
HFO Input to generation, 2005 (GJ)	N/A	3.52E+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	38.00	25%	22%	*All rough assumptions*
	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Diesel Fuel Use (GJ)	
	8.32E+04	3.00E+05	1.36E+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)	1.18E+04	5.117E+03	1.73E+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	13.58%	100%		
HFO Input to generation, 2008 (GJ)	N/A	1.19E+07	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)	1.51E+06			*For Kaesong; See Note 8*	
Total Electricity Imports (GJ)	1.57E+06				
"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	38.00	11%	22%	*All rough assumptions*
	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Diesel Fuel Use (GJ)	
	3.66E+04	1.32E+05	5.99E+05	

ESTIMATE OF ELECTRICITY GENERATION IN 2009				
				Sources/Notes:
	Hydro Plants	**Coal Plants**	**HFO Plants**	
Changes in Capacity, 1990 to 2009 (MW):	-217.28	150	69.8	
Average 2009 Capacity Factor Relative to 1990 Est.	58.6%	15.2%	10%	
Estimated Gross Generation in 2009 (GWHe)	1.187E+04	3.734E+03	1.73E+02	*See Notes 13, 15*
Gross Generation Efficiency, 2009	100%	21.0%	21.00%	
Fuel Input to generation, 2009 (GJ)	4.27E+07	6.40E+07	2.96E+06	
Fraction of fuel input as HFO	N/A	2.290%	100%	
HFO Input to generation, 2009 (GJ)	N/A	1.47E+06	2.96E+06	
Other Petrol Products (tires) input to gen., 2009 (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 2009	128.89			*See Note 11*
Estimated Power Exports to China, 2009 (GJ)	4.64E+05			
Own Use Fractions, 2009	0.30%	9.00%	8.00%	
Own Use of Electricity (GJ)	1.28E+05	1.21E+06	4.97E+04	
Imports of Electricity from China (GJ)	2.48E+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)	1.54E+06			*For Kaesong; See Note 8*
Total Electricity Imports (GJ)	1.57E+06			
"Emergency Loss" Fractions, 2009	0%	9%	0%	
Emergency Losses, 2009 (GJ)	0	1.21E+06	0	
Implied Net Electricity Output (GWhe)	1.183E+04	3.062E+03	1.589E+02	for use in LEAP
Transmission and Distribution Loss rate (overall), 2009	27.72%			*6*
Transmission and Distribution Losses, 2009 (GJ)	1.50E+07			

Nuclear Generating Capacity as of 2009 (MWe)	0	GWHe	GJ
Ave. Capacity Fact., Nuclear Plants (Gross Generation)	75%	0.00E+00	0.00E+00
Own Use of Electricity at Nuclear Plants	7%	0.00E+00	0.00E+00
Net Nuclear Generation Exported	90%	0.00E+00	0.00E+00
Transmission and Distribution Losses, Exports	5%	0.00E+00	0.00E+00
Net Nuclear Generation Used Domestically	10%	0.00E+00	0.00E+00
	Capacity (MW)	Average Capacity Factor	Average Efficiency
On-site generation with Diesel Fuel	38.00	7%	22%
	Implied (Net) Generation (MWh)	Implied Generation (GJ)	Implied Diesel Fuel Use (GJ)
	2.33E+04	8.39E+04	3.81E+05

All rough assumptions

Conversion Factor:	1.000	toe/te
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 UN estimate of 4500 MW hydro and 5000 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/.
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).*
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, and* 427.95 *GWh in 2009. These figures are rough estimates, but close enough to the capacity of the line to be plausible.*
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 258.26 *GWh.*

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:

Year	kWh
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
Average from 2002:	6,694,037

2010 value 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 the ratio of these 2009 and 2008 estimates,* 92.2% *, 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.*

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 proably 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."

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 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
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2010/2011 UPDATE
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ELECTRICITY GENERATION IN 2005 AND BEYOND

Prepared by David Von Hippel
Date Last Modified: 8/9/2012

Estimate of Status of Electricity Generating Plants as of 2005-2009 *(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
Pukchang	Coal	1,600	*??*	*??*		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*.
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
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 2008 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.
TOTAL IMPLIED DPRK ELECTRICITY OUTPUT, 2008					**17,226**	GWh (See ***Note 15***)
TOTAL IMPLIED DPRK HYDRO OUTPUT FOR 2009					**11,866**	GWh (See ***Note 21***)

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)***

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	0.00E+00	GJ	*Assumption--2009 data not yet available.*

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://www.nautilus.org/projects/dprk-energy/dprk-energy-and-minerals-working-group-2010/01.%20Yoon.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, are as follows for other years:

Year	MWh
2000	22,665
2001	36,289
2002	9,979
2003	31,838
2004	83,350
2005	90,146
2006	141,129
2007	168,502
2008	143,535
2009	128,886
2010	151.710
Average, 2006-2010	116,441

2010 value from UN COMTRADE data for 2010, HS Code 271600.

No data for electricity exports from the DPRK to China are available for 1990 - 1999.

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.*

	Year	tonnes	GJ implied	GJ fuel input to coal-fired power plants	Implied fraction input as tires
Reported Exports by Year are: (metric tonnes)	1990	190	6.61E+03	3.01E+08	0.002%
	1991	927	3.23E+04	2.88E+08	0.011%
	1992	88	3.07E+03	2.75E+08	0.001%
	1993	14	4.87E+02	2.61E+08	0.000%
	1994	none reported	0.00E+00	2.48E+08	0.000%
	1995	237	8.26E+03	2.35E+08	0.004%
	1996	486	1.69E+04	2.21E+08	0.008%
	1997	329	1.14E+04	1.77E+08	0.006%
	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	7.71E+05	4.53E+07	1.704%
	2001	78,882	2.75E+06	5.39E+07	5.097%
	2002	112,928	3.93E+06	6.25E+07	6.292%
	2003	63,312	2.20E+06	7.11E+07	3.100%
	2004	62,972	2.19E+06	7.97E+07	2.751%
	2005	25,599	8.91E+05	8.83E+07	1.009%
	2006	8,558	2.98E+05	8.83E+07	0.337%
	2007	none reported	0.00E+00	8.83E+07	0.000%
	2008	none reported	0.00E+00	8.83E+07	0.000%

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	"
	East Pyongyang	Pyongyang	5	"
	December	Nampo	5	"
TOTAL of Above			304	

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 Source in Note 1 cites estimates of total DPRK generation in 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.

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 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 kw/h", 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-	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-	Fed by 45 km tunnel from Imnam Reservoir.
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-	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	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.
Wenyue or Changchuan		

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.*

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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 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 two 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
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

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ESTiMATE OF DISTRICT HEATING USE

Prepared by David Von Hippel
Date Last Modified: 2/20/2011

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.

Parameter	1996	2000	2005	2008	2009
District Heat distribution losses	18%	20%	21%	21%	21%
Efficiency of heat-only boilers for DH	65%	62%	62%	62%	62%
Fraction of fuel as HFO for heat-only boilers (assumes same as coal-fired electricity generation)	6.20%	29.13%	3.99%	13.58%	2.3%
Capacity Factor of heat-only DH boilers relative to 1990 estimate	70%	35%	50%	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
Implied Coal input to heat-only DH boilers (GJ/yr)	2,468,266	977,560	1,891,905	1,532,638	1,732,864
Implied HFO input to heat-only DH boilers (GJ/yr)	163,148	401,811	78,624	240,838	40,613
Implied DH used from electricity generation boilers as a fraction of total fuel input	2.05%	5.41%	4.21%	5.00%	6.19%

1990 -->	2.62%

Workpapers—Energy Demand Sectors

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCE
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 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:	6.88	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*
Hwy 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. (Hwy Oil):	6.90E+05	GJ	*Placeholder value*
Oil Consumption, All Industries	2.39E+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)
2010/2011 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
INDUSTRIAL SECTOR ENERGY DEMAND IN 1996, 2000, 2005, 2008, AND 2009

Prepared By David Von Hippel
Date Last Modified: 8/9/2012

ASSUMPTIONS FOR CHANGES IN INDUSTRIAL ENERGY USE, 1996, 2000, 2005, 2008, and 2009

	Production Relative to 1990						Energy Intensity Relative to 1990					
Subsector	**1996**	**2000**	**2005**	**2008**	**2009**	**2010--Dec.**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010--Dec.**
Iron and Steel ***(See Notes 1, 17)***	35%	18.05%	14.50%	14.5%	14.5%	%	110%	115%	112%	110%	110%	%
Cement ***(See Note 2)***	40%	30%	32%	32%	31%	%	110%	115%	112%	110%	110%	%
---- fraction of heat from heavy oil	10%	27.0%	12.0%	12%	6%	%						
Fertilizers ***(See Note 3)***	24.68%	7.5%	11.2%	10.9%	7.2%	%	110%	115%	112%	110%	110%	%
Other Chemicals	30%	18.05%	18.05%	17.0%	16%	%	110%	115%	112%	110%	110%	%
Pulp and Paper	30%	18%	18%	17%	16%	%	110%	115%	112%	110%	110%	%
Other Metals ***(See Note 19)***	30%	18%	60%	62%	62%	%	110%	115%	112%	110%	110%	%
Other Minerals ***(See Note 18)***	30%	30.0%	50%	52%	52%	%	110%	115%	112%	110%	110%	%
---- fraction of heat from heavy oil	80%	80%	50%	43.0%	32.8%							
Textiles	30%	18%	20%	20%	18%	%	110%	115%	112%	110%	110%	%
Building Materials	30%	30%	30%	30%	29%	%	110%	115%	112%	110%	110%	%
Non-Specified Industry--non-oil fuels ***(See Note 20)***	33.00%	16.00%	15.03%	14.30%	12.61%	%	110%	115%	112%	110%	110%	%
Non-Specified Industry--diesel oil	20.0%	18.1%	24.7%	15.0%	12.0%	%	110%	115%	112%	110%	110%	%
Non-Specified Industry--heavy oil	30.0%	36.1%	24.5%	25.8%	24.4%	%	110%	115%	112%	110%	110%	%

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

(See Note 4)

[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**
Iron and Steel	35%	18%	15%	15%	15%
Cement	40%	30%	32%	32%	31%
---- fraction of heat from heavy oil	10%	27%	12%	12%	6%
Fertilizers	25%	8%	11%	11%	7%
Other Chemicals	30%	18%	18%	17%	16%
Pulp and Paper	30%	18%	18%	17%	16%
Other Metals	30%	18%	60%	62%	62%
Other Minerals	30%	30%	50%	52%	52%
Textiles	30%	18%	20%	20%	18%
Building Materials	30%	30%	30%	30%	29%
Non-Specified Industry--non-oil fuels	33%	16%	15%	14%	13%
Non-Specified Industry--diesel oil	20%	18%	20%	12%	12%
Non-Specified Industry--heavy oil	30%	36%	25%	26%	24%

Non-Specified Industry--Electricity for Kaesong	2.62E+05	1.51E+06	1.54E+06	GJ	*See Note 8 in "Electric-96-on" worksheet*

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.*

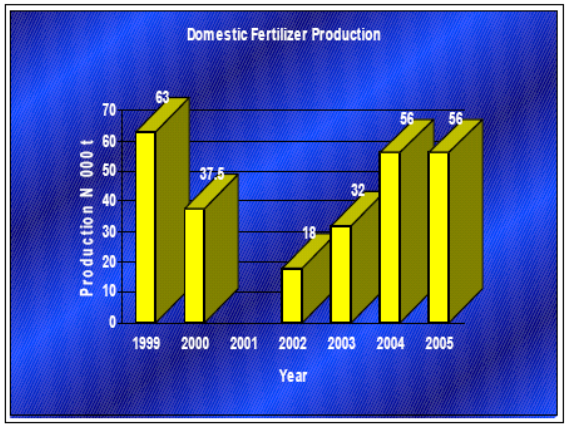

Table 5. Nitrogen Fertilizer Production Units and their Capacity

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.*

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.*

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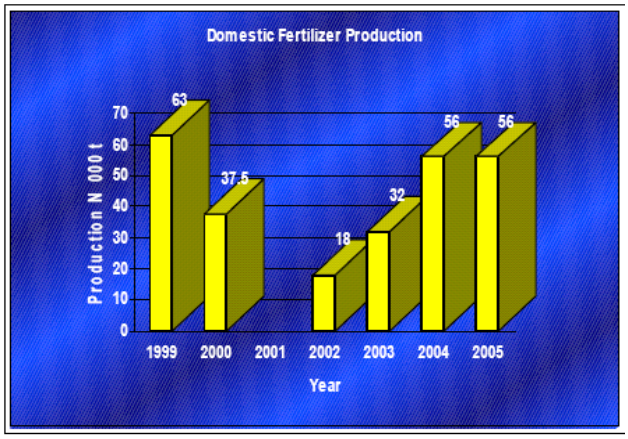

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July 7 Chemical Complex, Undok	Ammonium Nitrate	80	27

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 quantities of nitrogen fertilizer shown imply the following (quantities in thousand tonnes):

Year	*2008*	*2009*	*2010*
Nitrogen fertilizer as Ammonium Sulphate	256.8	*170.09*	*174.35*
Nitrogen fertilizer as N	*54.42*	*36.04*	*36.94*
Fraction of 1990 Production	*10.9%*	*7.2%*	*7.4%*

Fraction of $(NH_4)_2SO_4$ as N: 21.2%

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.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 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	3.90E+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)
2010/2011 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
TRANSPORT SECTOR ENERGY DEMAND IN 1996, 2000, 2005, 2008, AND 2009

Prepared By David Von Hippel
Date Last Modified: 2/19/2012

ASSUMPTIONS FOR CHANGES IN TRANSPORT ENERGY USE, 1996, 2000, 2005, 2008, AND 2009

Sources/Notes:

(See Note 5 for Assumptions for 2000)

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 after 2008:	**0.54%** /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*	

	1996	2000	2005	2008	2009	2010--Dec.		
Total Road Freight rel. to 1990	30.0%	14.0%	25.0%	25.5%	18.0%	THIS SECTION OF THIS WORKSHEET NOT	%	
Fraction Road Freight, biomass truck	7.60%	9.90%	9.64%	9.70%	9.58%		%	*8*
Fraction Road Freight, diesel truck	20.20%	34.35%	66.24%	48.51%	47.31%		%	*9*
Fraction Road Freight, gasoline truck	72.20%	55.75%	24.12%	41.79%	43.11%		%	*Calculated*

	Activity Relative to 1990				Energy Intensity Relative to 1990				
Subsector--End Use	**1996**	**2000**	**2005**	**2008**	**1996**	**2000**	**2005**	**2008**	
Road--Freight--Gasoline	30.3%	10.9%	8.4%	14.9%	110%	110.0%	110.0%	105%	*2*
Road--Freight--Diesel	25.3%	20.1%	69.2%	51.7%	110%	100.0%	100.0%	100%	*2*
Road--Freight--Biomass	49.6%	30.1%	52.4%	53.8%	100%	100%	100%	100%	
Road--Civilian Auto Pass-km	100.0%	75.0%	90.0%	120.0%	105%	103.0%	95.0%	96.0%	*10, 11*
Road--Passenger Bus, Diesel	44.2%	40.0%	70.0%	48.1%	110%	106.0%	105.0%	102%	*3*
Road--Passenger Bus, Gasoline	59.5%	17.0%	14.7%	45.1%	110%	100.0%	100.0%	98%	*3*
Rail--Freight, Diesel	40.0%	30.0%	46.0%	26.5%	100%	100%	100%	100%	*2*
Rail--Freight, Electric	40.0%	33.0%	33.0%	39.0%	105%	100%	100%	100%	*2*
Rail--Passenger, Electric	44.21%	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%	72.0%	80.0%	85.0%	100%	100%	100%	100%	*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	45.0%	67.0%	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--Dec.**	**1996**	**2009**	**2010--Dec.**	
Road--Freight--Gasoline	30.3%	10.9%	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS	110%	103%	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS	*2*
Road--Freight--Diesel	25.3%	35.6%		110%	98%		*2*
Road--Freight--Biomass	49.6%	37.5%		100%	100%		
Road--Civilian Auto Pass-km	100.0%	109.0%		105%	95%		*Assumption*
Road--Passenger Bus, Diesel	44.2%	39.0%		110%	100%		*3*
Road--Passenger Bus, Gasoline	59.5%	34.0%		110%	96%		*3*
Rail--Freight, Diesel	40.0%	23.0%		100%	100%		*2*
Rail--Freight, Electric	40.0%	40.0%		105%	100%		*2*
Rail--Passenger, Electric	44.2%	38.0%		105%	100%		*3*
Water--Freight, Diesel and HFO	40.0%	28.0%		100%	100%		*2*
Air--Passenger: Activity levels (fuel)	75.0%	80.0%		100%	100%		*Assumption*
Air--Passenger: Fraction as Jet Fuel	35.5%	67.0%					*3*
Non-Specified Transport (Oil/Elect.)	0.0%	0.0%		100%	100%		

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

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.

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	1409	2108	2444
PASSENGER MOTOR	8703	1529	629	0	65	145	244
OT SPEC PURPOSE M VEH	8705	75	40	9	10	26	29
MOTORCYCLES	8711	1354	62	30	1	701	3433
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	0	0	0	0	0	0
PART,ACCESS 8711-8713	8714	0	0	0	0	0	0
BICYCLES+OTHER CYCLES	8712	12400	4066	53601	1020	7745	12,958
TRAIL,ET,NT MEC PROPL	8716	0	0	0	0	0	0
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	0	387	132	548	552

RAIL EQUIPMENT IMPORTS TO DPRK FROM CHINA

Units: Number of Vehicles except as noted

Description	HS (code)	2000	2001	2002	2003	2004	2005	
N-S-P RLWAY FRGHT CAR	8606	0	0	53	36	12	176	
LOCOMOTV/R STOCK PRTS	8607	0	0	0	0	0	0	
OT N-EL LCMTV;TENDERS	8602	5	5	13	8	6	7	
RAIL LOCOMOTIVE,ELECT	8601	0	0	3	1	3	12	
RLWAY FXTUR; MECH EQP	8608	83000	83000	83400	61300	80000	57472	*Units: KG*
OT S-PRPL RLWAY COACH	8603	0	0	35	5	47	20	
CONTNR (1+TRANS MODE)	8609	1	1	14	21	4	1	
RLWAY MAINT/SERV VHCL	8604	0	0	0	2	0	2	
N-S-P RWAY PASS COACH	8605	0	0	1	5	0	0	

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
SHIPS AND BOATS	89	23	0	18	183	1295	59
FISH VESSEL;OTH SHIPS	8902	0	0	1	0	5	11
YCHT & OT PLEAS VESSL	8903	20	38	0	19	51	30
TRANSPORT PERSON/GOOD	8901	1	0	4	0	0	4
TUGS AND PUSHER CRAFT	8904	1	0	0	0	0	0
LGT-VESS,FL DOCKS ETC	8905	0	0	0	0	0	0
OT VESSEL,N ROW BOATS	8906	1	0	13	4	9	7
OT FLT STRUCT,RFT,ETC	8907	0	0	0	160	1230	7

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.

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 Works further received Czechoslovakian assistance to build improved trucks. The country's vehicle production capacity has grown to 33.000 units per annum as of 1997 through continuous expansion and diversification of the types of vehicle produced. When China and Russia, major suppliers of parts and fuel, demanded cash instead of barter starting from 1993, the domestic vehicle industry was severely affected. The decline 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%. The 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 transportation, the long ban on private ownership of a car and the absolute control exerted on the population's mobility. Passenger cars in DPRK represent 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 Motorsinvested 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 "Pokkugi") 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 annually 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)

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
RESIDENTIAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 11/28/2011

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 AND 2009 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				*22*
		1996	**2000**	**2005**	**2008**	**2009**	
	Implied population (million)	2.210E+07	2.218E+07	2.333E+07	2.405E+07	2.418E+07	
	Estimated population not in households	1.106E+06	1.044E+06	9.655E+05	9.186E+05	9.030E+05	
	Estimated Persons per Household						
	Urban	4.400	4.234	4.026	3.901	3.859	*21*
	Rural	4.425	4.274	4.086	3.974	3.936	*21*
	Fraction of Households as:						
	Urban	60.27%	60.44%	60.67%	60.80%	60.85%	*21*
	Rural	39.73%	39.56%	39.33%	39.20%	39.15%	*21*
	Number of Households						
	Urban	2,869,730	3,005,533	3,350,571	3,579,626	3,641,784	
	Rural	1,891,971	1,966,822	2,172,292	2,307,845	2,343,540	
	TOTAL	4,761,701	4,972,355	5,522,864	5,887,471	5,985,324	

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

Fraction of Households using Coal Cooking/Heat		**1996**	**2000**	**2005**	**2008**	**2009**
Urban	***(See Note 37)***	81.7%	77.0%	72.4%	64.8%	64.9%
Rural	***(See Note 37)***	38.00%	33.00%	26.00%	18.76%	18.76%

Coal Use per Household relative to 1990:		**1996**	**2000**	**2005**	**2008**	**2009**
Urban	***(See Note 38)***	75%	60%	53%	50%	50%
Rural	***(See Note 38)***	60%	50%	45%	45%	45%

		1996	**2000**	**2005**	**2008**	**2009**
Fraction of Urban Households Using District Heating		8.29%	7.99%	7.60%	7.37%	7.29%
Electricity and Heat Use per HH relative to 1990:						
Urban	***(See Notes 23, 31, 32)***	57.50%	29.14%	36.69%	41.00%	38.00%
Rural	***(See Notes 24, 31)***	45.4%	8.9%	12.2%	14.4%	13.3%

Fraction of Households using Wood/Biomass Heat		**1996**	**2000**	**2005**	**2008**	**2009**
Urban	***(See Note 34)***	10%	15%	20%	27.78%	27.78%
Rural	***(See Note 34)***	60%	65%	72%	79.244%	79.24%

Wood/Biomass Use per Household rel. to 1990:		**1996**	**2000**	**2005**	**2008**	**2009**
Urban	***(See Note 35)***	100%	80%	70%	65%	65%
Rural	***(See Note 36)***	90%	80%	70%	65%	65%

Charcoal Use per Household rel. to 1990:	**1996**	**2000**	**2005**	**2008**	**2009**
Urban	75%	55%	50%	45%	45%
Rural	75%	55%	50%	45%	45%

	1996	**2000**	**2005**	**2008**	**2009**	
Fraction of Households using Kero/LPG for cooking						
Urban	13.0%	12.0%	9.0%	6.93%	6.93%	*33*
Rural	1.5%	1.4%	1.2%	0.971%	0.971%	*33*
Kero/LPG Use per Household rel. to 1990:						
Urban	47.4%	61.2%	73.8%	82.2%	66.8%	
---fraction of Urban use as Kero	26.1%	18.1%	39.9%	36.6%	36.6%	*33*
Rural ***(See Note 25)***	50.0%	57%	58.5%	85.5%	67.0%	
---fraction of Rural use as Kero	90.0%	57%	68.0%	54.3%	54.3%	*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.

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 is assume to have trended downward over time due to lower availability.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
AGRICULTURAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 11/21/2011

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	

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN AGRICULTURAL SECTOR

(Notes 10, 15)

	1996	2000	2005	2008	2009		
Area Cropped Relative to 1990:	100%	100%	100%	100%	100%	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSI	*Assumption*
Use of Tractors, etc. Relative to 1990:	30%	25%	27%	25%	24%		*8*
Use of Electricity in Fields Relative to 1990:	90%	75%	65%	52.5%	50%		*11*
Coal Use, Processing/Other, Rel. to 1990:	52.88%	39.44%	50.574%	52.79%	50.83%		*8*
Oil Use, Processing/Other, Rel. to 1990:	30.0%	25.0%	27.0%	25%	22%		*8*
Elect. Use, Processing/Other, Rel. to 1990:	52.9%	37.0%	50.6%	52.8%	50.8%		*8*
Biomass Use, Processing/Other, Rel. to 1990:	52.88%	44.37%	53.55%	55.90%	53.82%		*8*

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://nautilus.wpengine.netdna-cdn.com/wp-content/uploads/2011/12/0679Aden1.ppt.

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-equivalent harvests, based on the following output statistics:

Year	Million tonnes cereal Equivalent production
1990	6.940
1996	4.077
2000	3.421
2005	4.129
2008	4.31
2009	4.15

Value for 1990 is estimated based on data from 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. The ratios of 1990 and 1996 total paddy and *maize production were used with the 1996 value for cereal equivalent production below to create an estimated value for 1990 consistent with the other values in the time series shown in the table.*
Values for 1996 and 2000 are from 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
Value for 2005 is from 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.

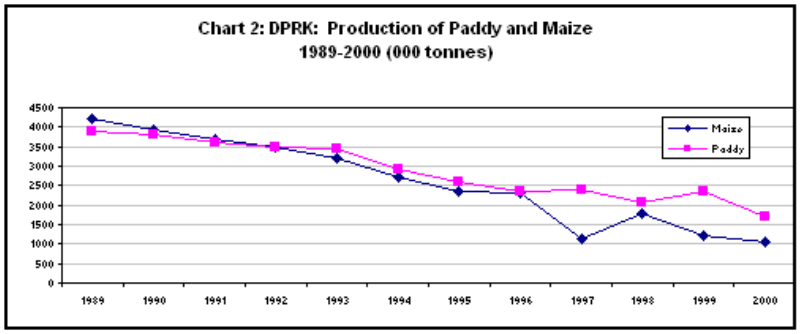
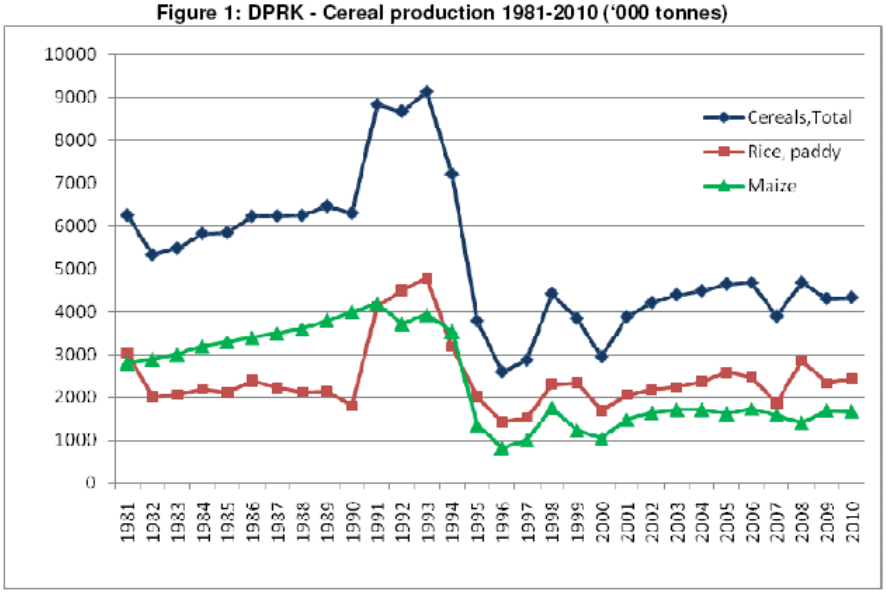


Figure for cereals production in 2008 is as quoted in several sources, including S. Haggard and M. Nolan, "The North Korean Food Situation, Too Early to Break Out the Champagne", Asia Pacific Bulletin, Number 27, February 5, 2009, available as www.eastwestcenter.org/fileadmin/stored/pdfs/apb027.pdf.
Figure is roughly consistent with UN FAO statistics shown in Note 16, below, for DPRK agricultural production in 2008.

Figure for cereals production in 2009 is estimated 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 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
Coal Use, Processing/Other, Rel. to 1990:	90%	80%	85%	85%	85%
Elect. Use, Processing/Other, Rel. to 1990:	90%	75%	85%	85%	85%
Biomass Use, Processing/Other, Rel. to 1990:	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

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
FISHERIES SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 8/3/2011

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	
10,000	2,250	8	Large Factory Ships	*Composite estimate based on sources 1, 4, and 6*
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	0.0072977	
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	2.26E+05	GJ		*Calculated*
Diesel Oil Use, Processing/Other	1.51E+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	1.13E+06	GJ		*Calculated*
Total Coal Use, Fisheries Sector	1.13E+06	GJ		*Calculated*
Electricity Use: Processing/Other	5.24E+05	GJ		*Calculated*
Total Electricity Use, Fisheries Sector	5.24E+05	GJ		*Calculated*

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN FISHERIES SECTOR

(See Note 3)

	1996	2000	2005	2008	2009	2	
Large Ships Fishing Effort Relative to 1990:	30%	25%	28%	28%	25%	THIS SECTION OF THIS WORKSHEET	*Assumption*
Fishing Collectives Fishing Effort Relative to 1990:	30%	25%	28%	25%	23%		*Assumption*
Oil/Coal Use, Processing/Other Relative to 1990:	45%	37%	40%	40%	35%		*Assumption*
Elect. Use, Processing/Other Relative to 1990:	45%	37%	40%	40%	35%		*Assumption*

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). 2005 information on DPRK fisheries from the UN FAO "Fishstat" database shows a very slight reduction in output between 2000 and 2005, but as the same values are used for several years in a row, our assumption is that no reliable data on total fisheries output in the DPRK have been made available to the UN.

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
PUBLIC/COMMERCIAL SECTOR

Prepared By David Von Hippel
Date Last Modified: 4/7/2011

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)

	1996	2000	2005	2008	2009	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS	
Public/Commercial Floor space per unit residential floor space relative to 1990:	100%	95.0%	95.0%	95%	95%		*7*
Public/Commercial Floor space (sq.m.)	4.247E+07	4.226E+07	4.711E+07	5.033E+07	5.120E+07		
Implied floorspace relative to 1990	106.93%	106.39%	118.60%	126.71%	128.91%		
Coal use per square meter relative to 1990:	75%	45%	45%	45%	45%		*12*
Elect. and Heat use per square meter relative to 1990:	55%	29.14%	43.5%	45%	40%		*13*
Other Public/Comm'l elect use rel to 1990.	55.0%	29.14%	43.5%	45%	40%		*13*
Wood/Biomass Use as a fraction of coal use:	10%	20%	30%	30%	30%		*10*
Oil use as a fraction of coal use:	0.5%	0.5%	1.0%	1.55%	1.91%		*11*
Fraction of Oil Use as Kerosene (remainder assumed LPG	50.0%	50.0%	25.0%	21.5%	17.5%		

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.

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* 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).

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

2010/2011 UPDATE

BACK-UP CALCULATIONS AND DATA: ENERGY USED IN MILITARY BUILDINGS AND OTHER FACILITIES

Prepared By David Von Hippel
Date Last Modified: 11/21/2011

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	8.87E+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	6.85E+06	GJ/yr	*5*
	Oil Use, Buildings and Other	1.00E+05	GJ/yr	*1*
	Total Oil Use, Military Sector	1.64E+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	4.75E+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 and 2005 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	80%		*Assumption*
	2009 Coal/Wood Use, Buildings and Other, relative to 1990	80%		*Assumption*
	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	85%		*Assumption*
	2009 Oil Use, Buildings and Other, relative to 1990	85%		*Assumption*
	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%		
	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	63.5%		*Assumption*
	2009 Elect. Use, Buildings and Other, relative to 1990	57.2%		*Assumption*

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* 694,565 *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.*

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

2010/2011 UPDATE

BACK-UP CALCULATIONS AND DATA: OTHER/NON-SPECIFIED SECTOR

Prepared By David Von Hippel
Date Last Modified: 10/27/2010

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**		
Oil used in unspecified/other sectors	0%	0%	0%	0%	0%		*Assumption*
Heat from Yongbyon Nuclear Reactor	0%	0%	100%	0%	0%		*3*

THIS SECTION OF THIS

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).

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
NON-ENERGY RESOURCE USES

Prepared By David Von Hippel
Date Last Modified: 3/3/2011

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	

ESTIMATE OF CURRENT AND FUTURE NON-ENERGY USE OF FUELS

Values Relative to 1990	**1996**	**2000**	**2005**	**2008**	**2009**		
Coal, Oil feedstock for ammonia production	24.7%	8%	11%	11%	7%	THIS SECTION OF THIS WORKSHEET NOT USED	*3*
Oil Use: Other Non-Energy Products	24.70%	38.00%	11.95%	11.54%	14.88%		*6*
Wood/biomass used as roundwood:	60%	50%	50%	50%	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 to make production plus imports minus exports of "LPG/Refinery Fuel/Non-Energy Products" balance demand.

Additional Summary Figures and Tables

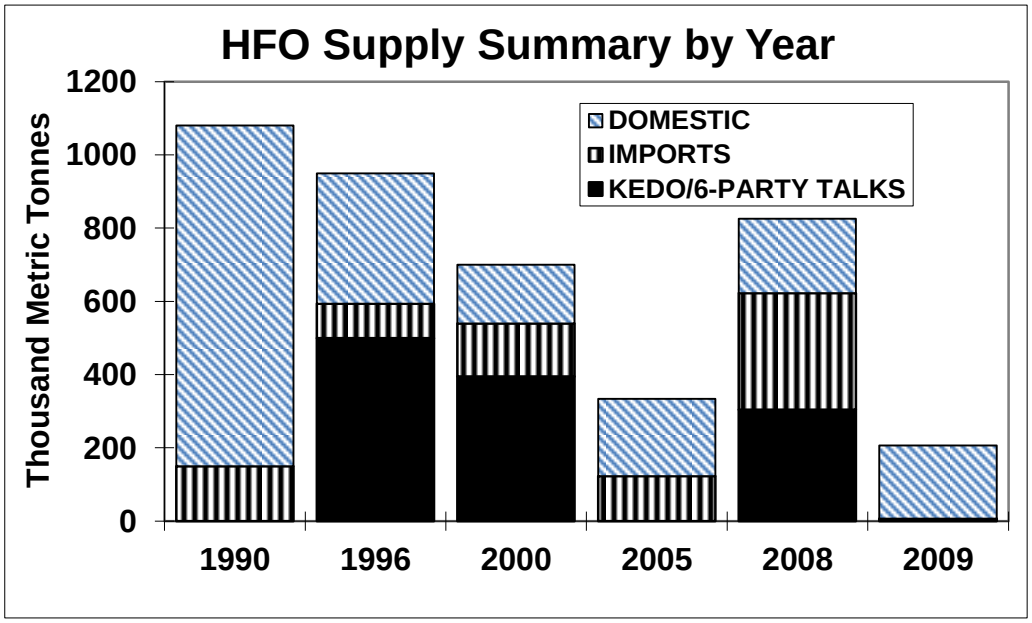
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ADDITIONAL GRAPHS AND FIGURES

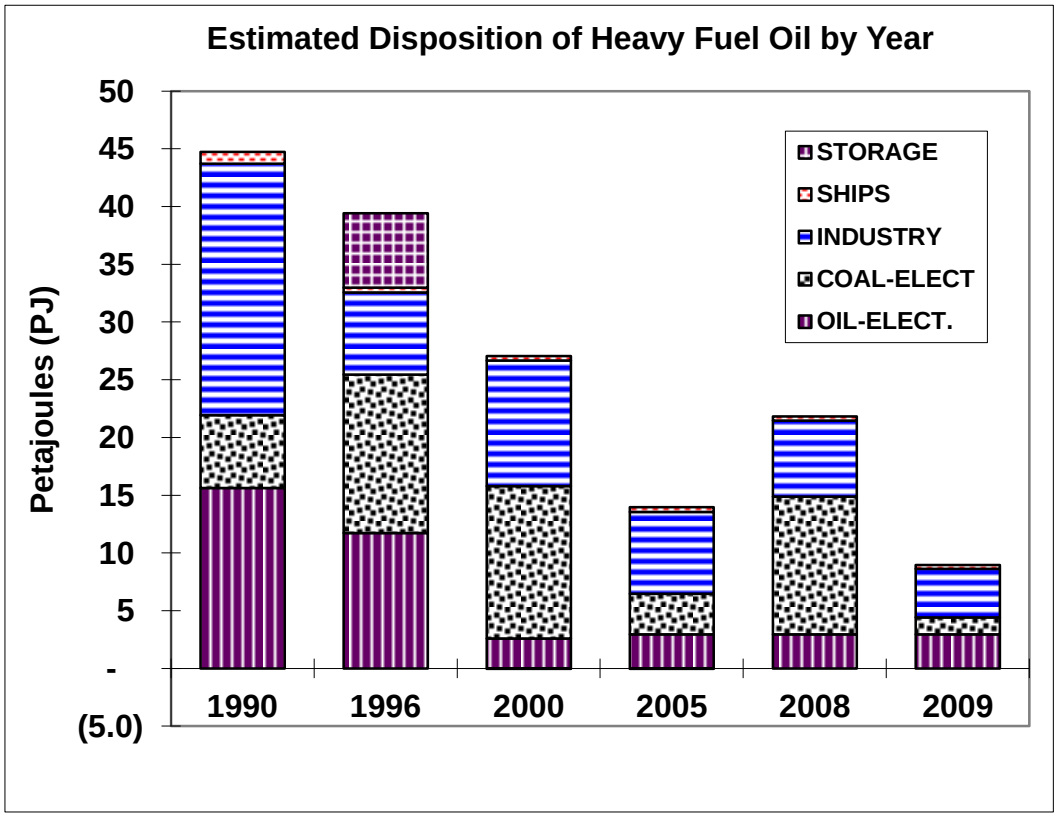
HFO Supply Summary: Thousand tonnes

	YEAR					
SOURCE	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
KEDO/6-PARTY TALKS	**0**	500	395	-	304	-
IMPORTS	150	94	145	123	319	7
DOMESTIC	**930.4**	356	160	211	203	200
TOTAL	1,080	950	700	334	826	207
KEDO/6-PARTY TALKS	0%	53%	56%	0%	37%	0%
IMPORTS	14%	10%	21%	37%	39%	3%
DOMESTIC	86%	37%	23%	63%	25%	97%
TOTAL	100%	100%	100%	100%	100%	100%

HFO Demand Summary: Petajoules (PJ)

	YEAR					
CONSUMER	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
OIL-ELECT.	15.6	11.7	2.6	3.0	3.0	3.0
COAL-ELECT	6.3	13.7	13.2	3.5	11.9	1.5
INDUSTRY	21.8	7.1	10.9	7.1	6.6	4.2
SHIPS	1.0	0.4	0.4	0.4	0.36	0.31
STORAGE	**-**	6.4	(0.03)	(0.01)	-	-
TOTAL	**44.8**	**39.4**	**27.0**	**14.0**	**21.8**	**9.0**
OIL-ELECT.	35%	30%	10%	21%	14%	33%
COAL-ELECT	14%	35%	49%	25%	55%	16%
INDUSTRY	49%	18%	40%	51%	30%	47%
SHIPS	2%	1%	1%	3%	2%	3%
STORAGE	0%	16%	0%	0%	0%	0%
TOTAL	**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	5.1	0.6	0.3
Domestic Refining	38.6	14.8	6.7	8.8	8.8	8.7
TOTAL	**44.8**	**39.6**	**26.2**	**13.9**	**22.1**	**9.0**


HFO Supply Summary by Year
Thousand Metric Tonnes
1200
1000
800
600
400
200
0
DOMESTIC
IMPORTS
KEDO/6-PARTY TALKS
1990
1996
2000
2005
2008
2009


Estimated Disposition of Heavy Fuel Oil by Year
Petajoules (PJ)
50
45
40
35
30
25
20
15
10
5
-
(5.0)
STORAGE
SHIPS
INDUSTRY
COAL-ELECT
OIL-ELECT.
1990
1996
2000
2005
2008
2009

Demand Summary for Other Refined Products: Terajoules

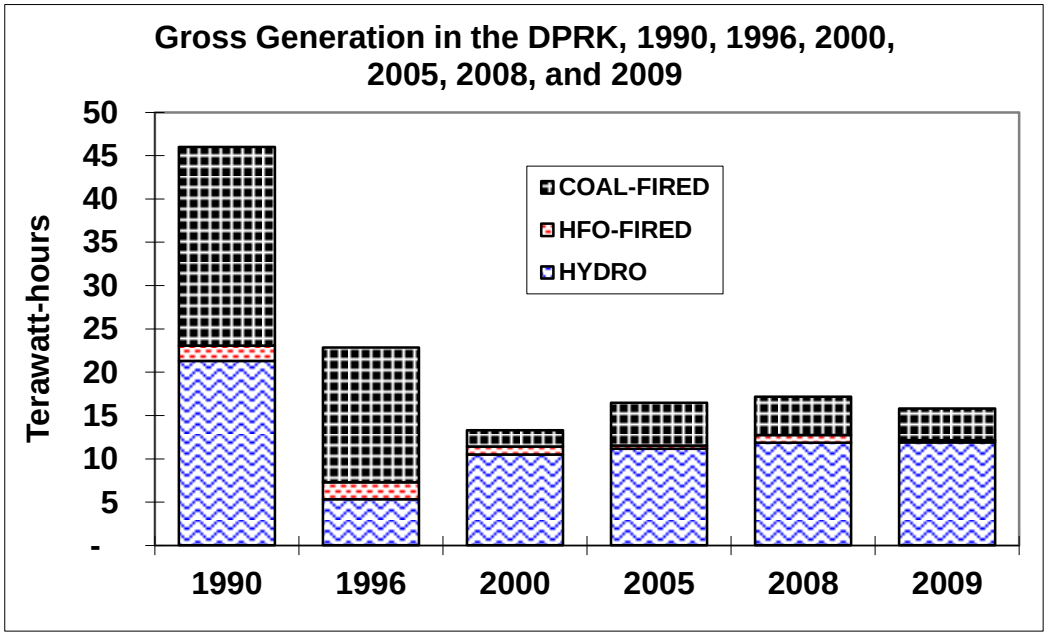
	DIESEL OIL					
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
INDUSTRIAL	3,050	671	633	844	503	403
TRANSPORT	12,926	4,999	4,166	7,913	5,384	4,156
RESIDENTIAL	-	-	-	-	-	-
AGRICULTURAL	5,005	1,502	1,251	1,351	1,251	1,153
FISHERIES	2,777	856	710	796	793	708
MILITARY	6,859	5,248	5,091	5,259	4,537	3,922
NON-SPECIFIED/OTHER	1,700	-	-	-	-	-
TOTAL	32,607	13,276	11,852	16,163	12,470	10,342
INDUSTRIAL	9%	5%	5%	5%	4%	4%
TRANSPORT	40%	38%	35%	49%	43%	40%
RESIDENTIAL	0%	0%	0%	0%	0%	0%
AGRICULTURAL	15%	11%	11%	8%	10%	11%
FISHERIES	9%	6%	6%	5%	6%	7%
MILITARY	21%	40%	43%	33%	36%	38%
NON-SPECIFIED/OTHER	5%	0%	0%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%

	GASOLINE					
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
INDUSTRIAL	-	-	-	-	-	-
TRANSPORT	23,220	10,376	3,452	2,900	6,145	4,566
RESIDENTIAL	-	-	-	-	-	-
AGRICULTURAL	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-
MILITARY	7,386	6,352	4,742	4,238	3,919	3,884
TOTAL	30,606	16,728	8,193	7,137	10,064	8,449
INDUSTRIAL	-	-	-	-	-	-
TRANSPORT	76%	62%	42%	41%	61%	54%
RESIDENTIAL	0%	0%	0%	0%	0%	0%
AGRICULTURAL	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%
MILITARY	24%	38%	58%	59%	39%	46%
TOTAL	100%	100%	100%	100%	100%	100%

	KEROSENE/JET FUEL					
SECTOR	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
INDUSTRIAL	-	-	-	-	-	-
TRANSPORT	399	320	364	602	668	602
RESIDENTIAL	4,473	553	458	927	797	655
AGRICULTURAL	-	-	-	-	-	-
FISHERIES	-	-	-	-	-	-
MILITARY	1,798	1,199	824	1,423	1,498	1,161
TOTAL	6,670	2,071	1,646	2,953	2,963	2,419
INDUSTRIAL	-	-	-	-	-	-
TRANSPORT	6%	15%	22%	20%	23%	25%
RESIDENTIAL	67%	27%	28%	31%	27%	27%
AGRICULTURAL	0%	0%	0%	0%	0%	0%
FISHERIES	0%	0%	0%	0%	0%	0%
MILITARY	27%	58%	50%	48%	51%	48%
TOTAL	100%	100%	100%	100%	100%	100%

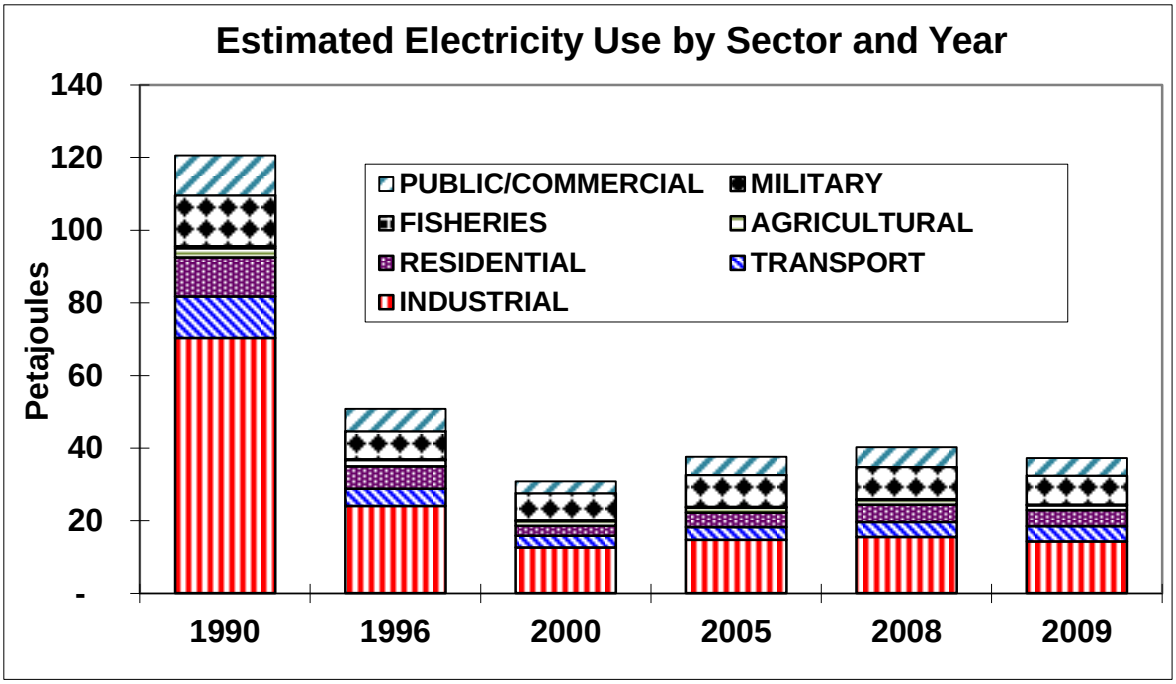
Supply Summary for Electricity: Terawatt-hours of Gross Generation

	YEAR					
GENERATION	1990	1996	2000	2005	2008	2009
HYDRO	21.3	5.3	10.5	11.1	11.8	11.9
HFO-FIRED	1.8	1.9	0.9	0.4	0.9	0.3
COAL-FIRED	22.9	15.6	1.9	4.9	4.4	3.6
TOTAL	46	22.8	13.3	16.5	17.2	15.8
HYDRO	46%	23%	79%	68%	69%	75%
HFO-FIRED	4%	8%	7%	2%	5%	2%
COAL-FIRED	50%	68%	14%	30%	26%	23%
TOTAL	100%	100%	100%	100%	100%	100%



Demand Summary for Electricity: Petajoules

	ELECTRICITY					
SECTOR	1990	1996	2000	2005	2008	2009
INDUSTRIAL	70	24	13	15	15	14
TRANSPORT	11	5	3	4	4	4
RESIDENTIAL	11	6	3	4	5	4
AGRICULTURAL	3	2	1	1	1	1
FISHERIES	1	0	0	0	0	0
MILITARY	14	8	7	9	9	8
PUBLIC/COMMERCIAL	11	6	3	5	5	5
TOTAL	120	51	31	38	40	37
INDUSTRIAL	58%	47%	41%	39%	39%	38%
TRANSPORT	10%	9%	11%	10%	10%	11%
RESIDENTIAL	9%	12%	9%	10%	12%	12%
AGRICULTURAL	2%	3%	4%	4%	3%	3%
FISHERIES	0%	0%	1%	1%	1%	0%
MILITARY	12%	15%	24%	23%	22%	22%
PUBLIC/COMMERCIAL	9%	12%	11%	13%	13%	13%
TOTAL	100%	100%	100%	100%	100%	100%



SUMMARY TABLE OF ELECTRICTY SUPPLY AND DEMAND
Units: TWh

	YEAR					
GENERATION	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
HYDRO	21.3	5.3	10.5	11.1	11.8	11.9
HFO-FIRED	1.8	1.9	0.9	0.4	0.9	0.3
COAL-FIRED	22.9	15.6	1.9	4.9	4.4	3.6
NUCLEAR	-	-	-		-	-
TOTAL	46.0	22.8	17.2	15.8	16.5	15.8
EXPORTS	-	-	(0.0)	(0.1)	(0.1)	(0.1)
COAL PROD.	(2.4)	(1.2)	(0.6)	(0.8)	(0.8)	(0.8)
OWN USE	(3.4)	(2.8)	(0.5)	(1.0)	(1.0)	(0.7)
LOSSES	(6.6)	(4.6)	(3.5)	(4.3)	(4.5)	(4.2)
TOTAL DEMAND	33.5	14.1	8.5	10.4	11.2	10.3
INDUSTRIAL	19.5	6.7	3.5	4.1	4.3	4.0
TRANSPORT	3.2	1.3	0.9	1.0	1.2	1.2
RESIDENTIAL	3.0	1.7	0.8	1.1	1.3	1.2
AGRICULTURAL	0.7	0.5	0.4	0.4	0.4	0.4
FISHERIES	0.1	0.1	0.1	0.1	0.1	0.1
MILITARY	3.9	2.1	2.1	2.4	2.5	2.2
PUBLIC/COMM'L	3.0	1.7	0.9	1.4	1.5	1.3

DPRK Industrial Energy Demand By Subsector: 1990 and 1996

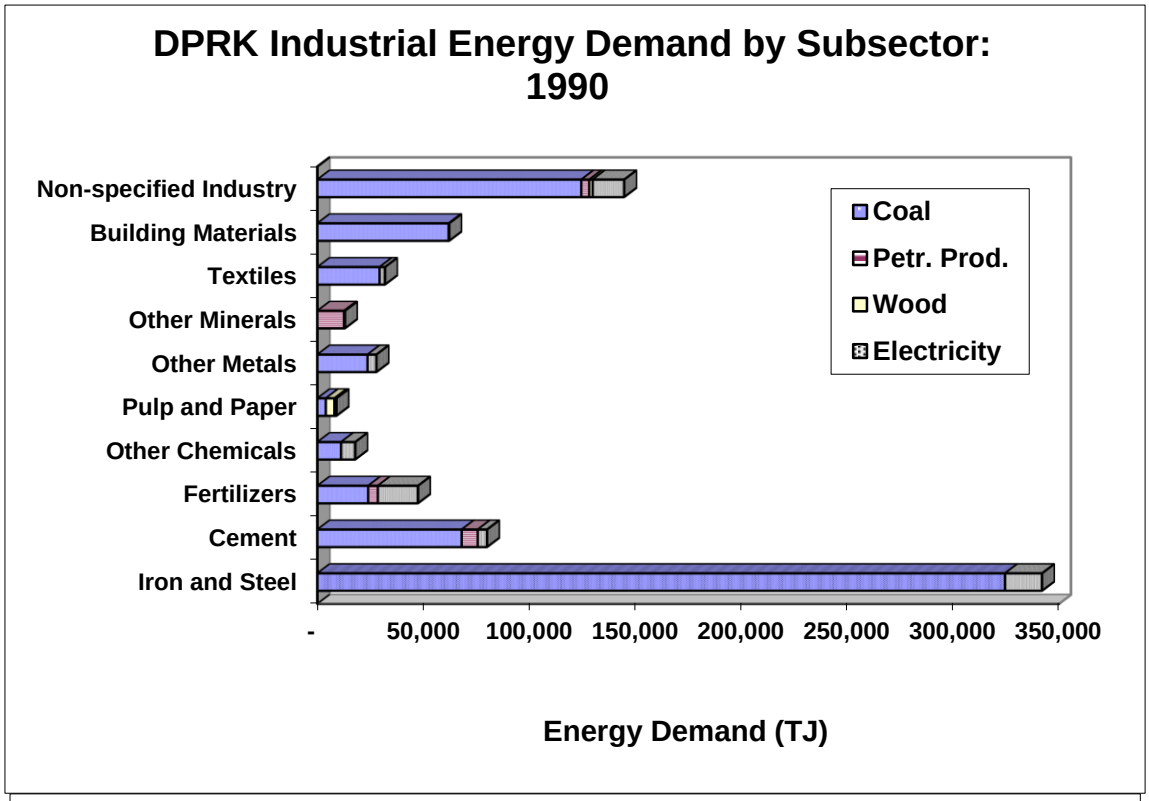
Units: Terajoules (TJ)	**1990**				**1996**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	324,615	-	-	17,388	124,977	-	-	6,694
Cement	68,139	7,571	-	4,356	29,981	3,331	-	1,917
Fertilizers	23,994	4,573	-	18,891	6,515	1,129	-	5,130
Other Chemicals	11,203	-	-	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	3,740	1,600	14,850	45,230	899	581	5,391
TOTAL	671,661	28,483	5,626	70,242	250,538	8,685	1,909	24,001

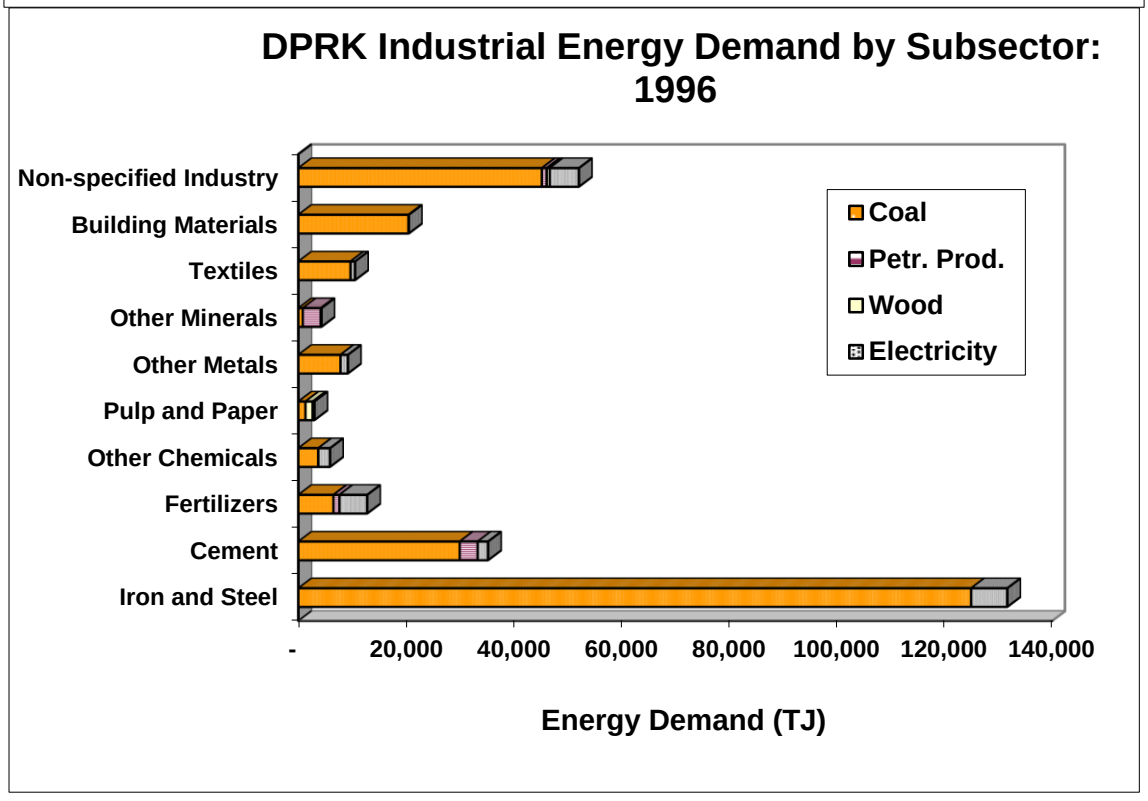
DPRK Industrial Energy Demand By Subsector: 2000 and 2005

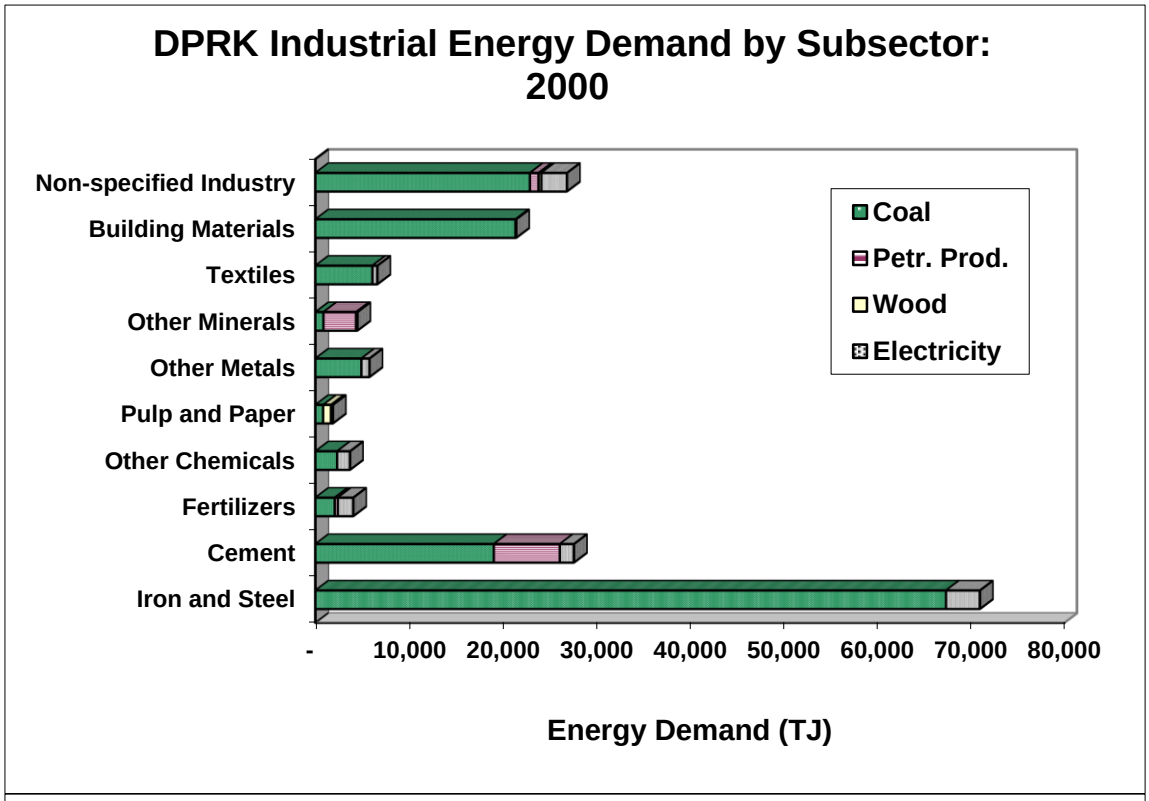
Units: Terajoules (TJ)	**2000**				**2005**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	67,382	-	-	3,609	52,717	-	-	2,824
Cement	19,067	7,052	-	1,503	23,878	3,256	-	1,561
Fertilizers	2,070	343	-	1,629	3,010	512	-	2,370
Other Chemicals	2,325	-	-	1,373	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	22,926	920	294	2,732	20,975	1,033	269	2,762
TOTAL	147,882	11,792	1,130	12,618	150,534	8,329	1,083	14,660

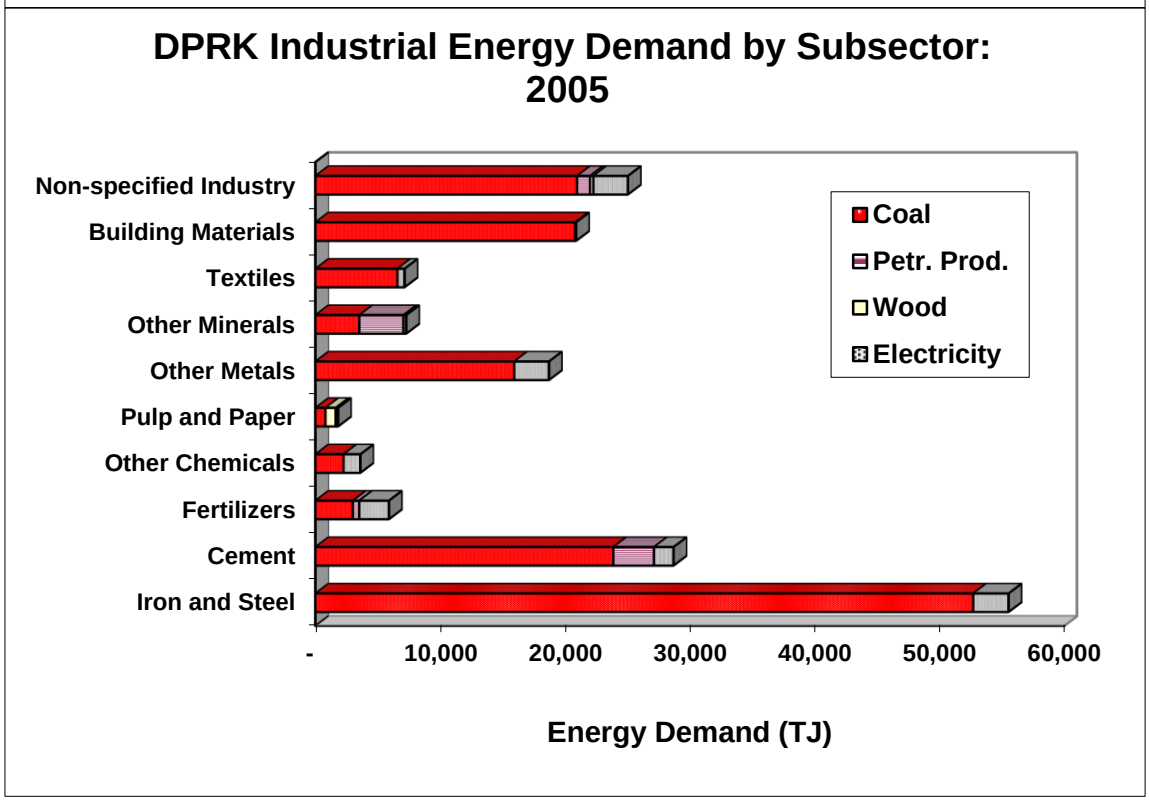
DPRK Industrial Energy Demand By Subsector: 2008 and 2009

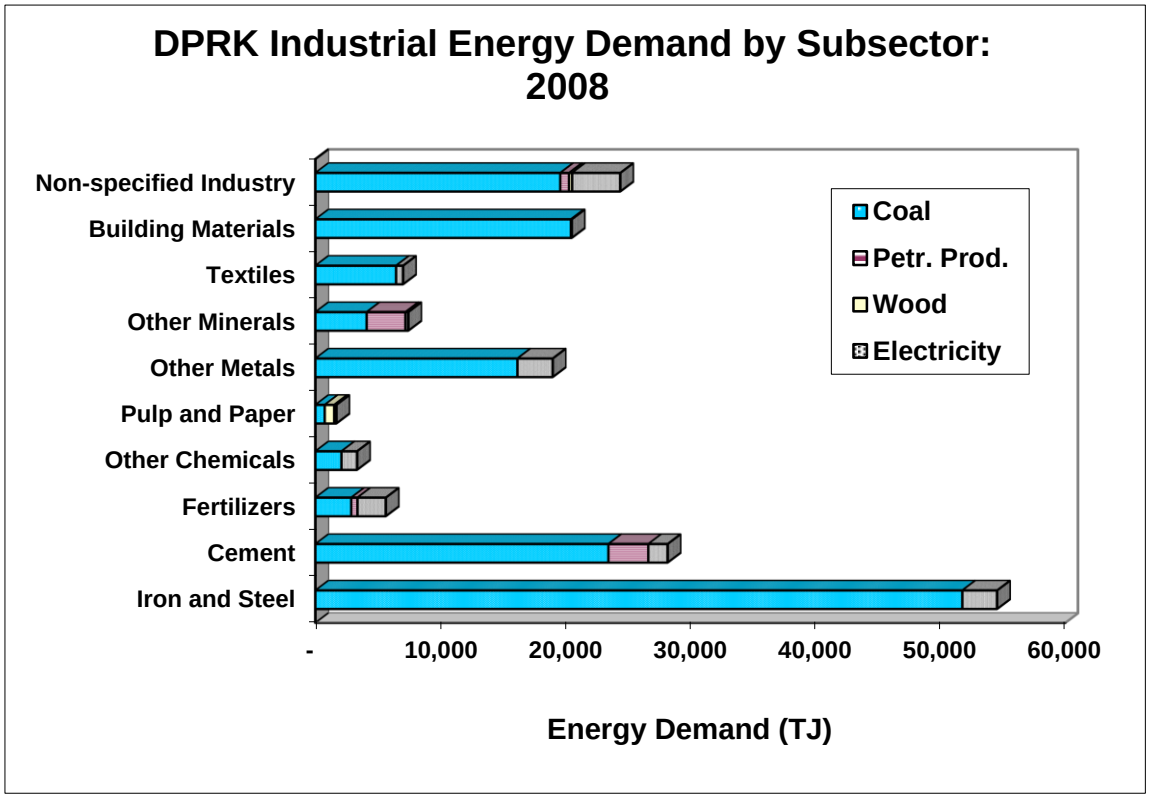
Units: Terajoules (TJ)	**2008**				**2009**			
Subsector	Coal	Petr. Prod.	Wood	Electricity	Coal	Petr. Prod.	Wood	Electricity
Iron and Steel	51,776	-	-	2,773	51,776	-	-	2,773
Cement	23,452	3,198	-	1,533	24,216	1,601	-	1,485
Fertilizers	2,872	498	-	2,261	1,903	330	-	1,498
Other Chemicals	2,095	-	-	1,237	1,972	-	-	1,164
Pulp and Paper	753	-	753	174	709	-	709	164
Other Metals	16,177	-	-	2,814	16,177	-	-	2,814
Other Minerals	4,108	3,099	-	227	4,843	2,364	-	227
Textiles	6,465	-	-	549	5,818	-	-	494
Building Materials	20,453	-	-	62	19,772	-	-	60
Non-specified Industry	19,600	699	252	3,846	17,283	588	222	3,600
TOTAL	147,751	7,494	1,005	15,478	144,468	4,882	931	14,281

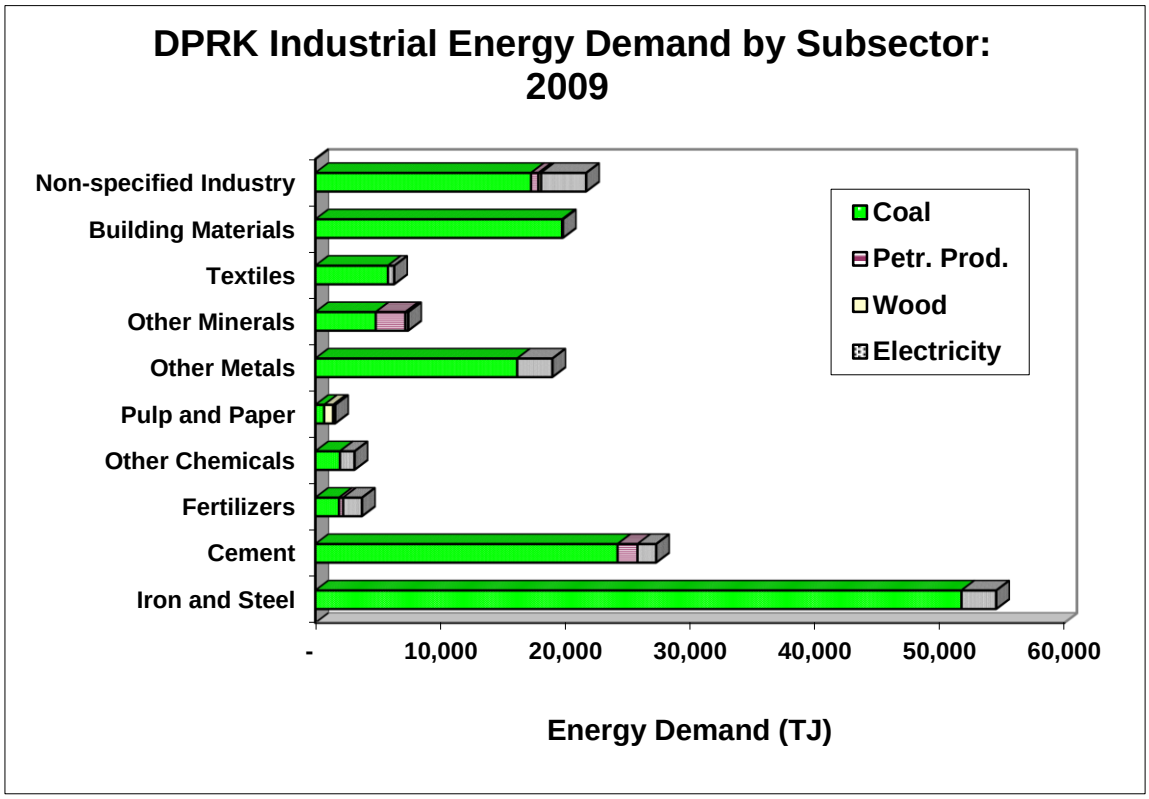

DPRK Industrial Energy Demand by Subsector: 1990
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
50,000
100,000
150,000
200,000
250,000
300,000
350,000
Energy Demand (TJ)

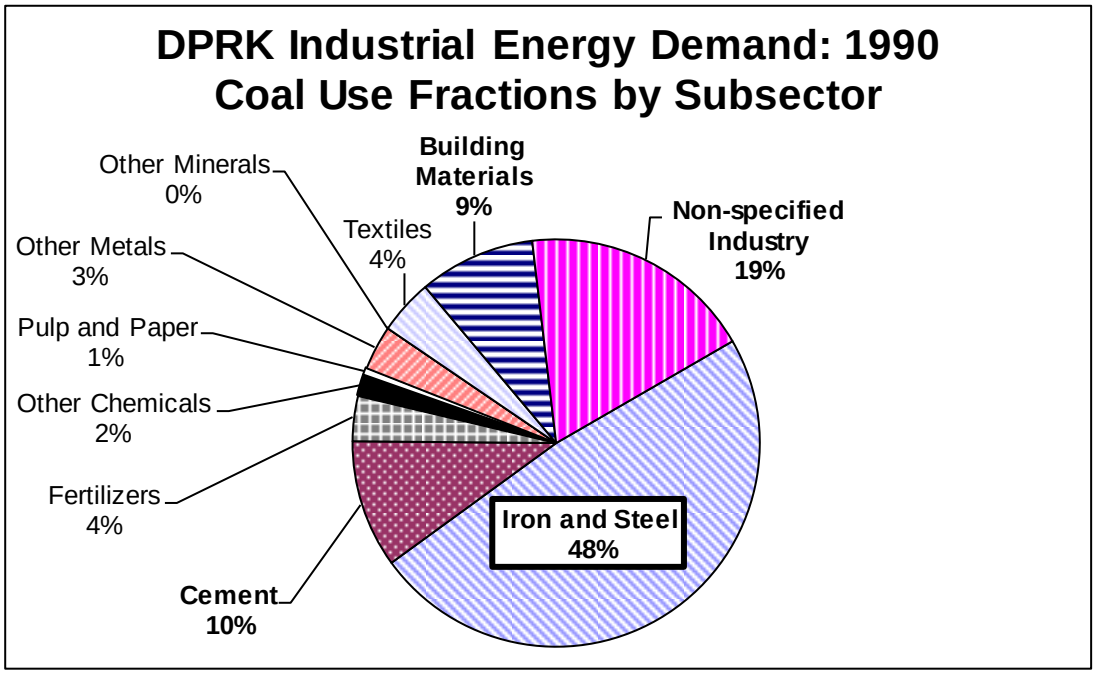

DPRK Industrial Energy Demand by Subsector: 1996
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Energy Demand (TJ)

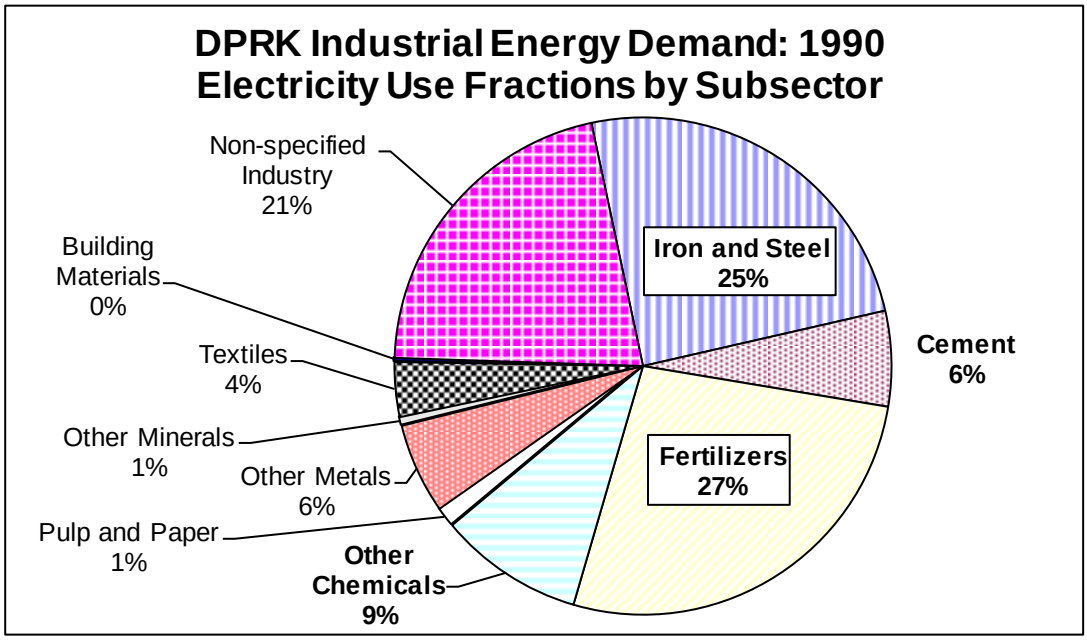

DPRK Industrial Energy Demand by Subsector: 2000
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Energy Demand (TJ)

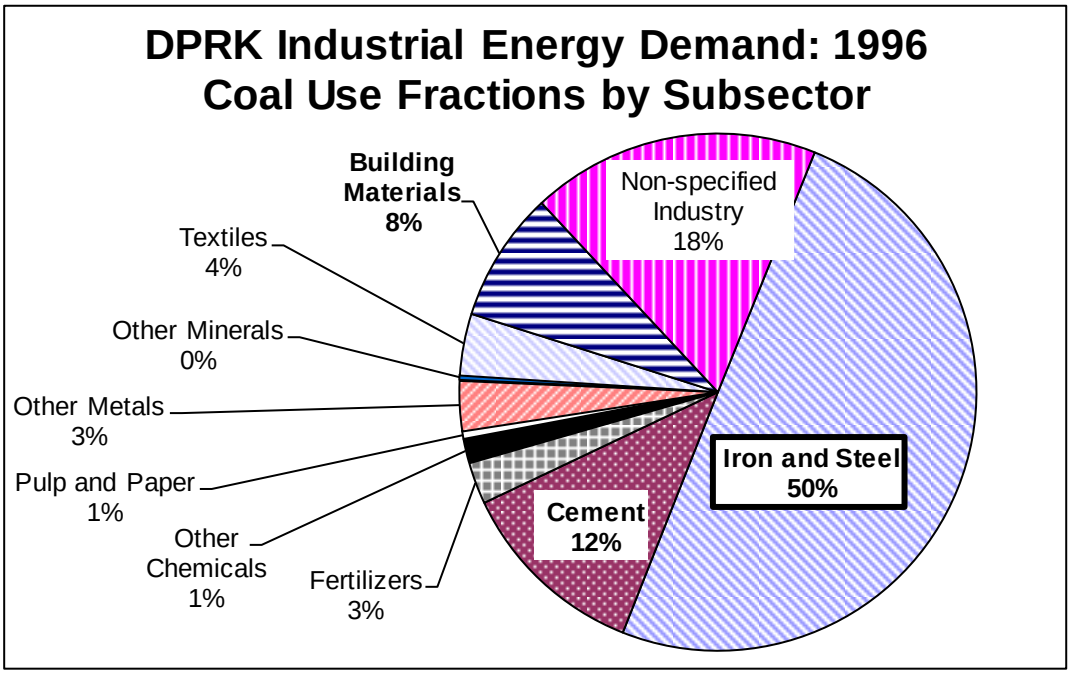

DPRK Industrial Energy Demand by Subsector: 2005
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
Energy Demand (TJ)

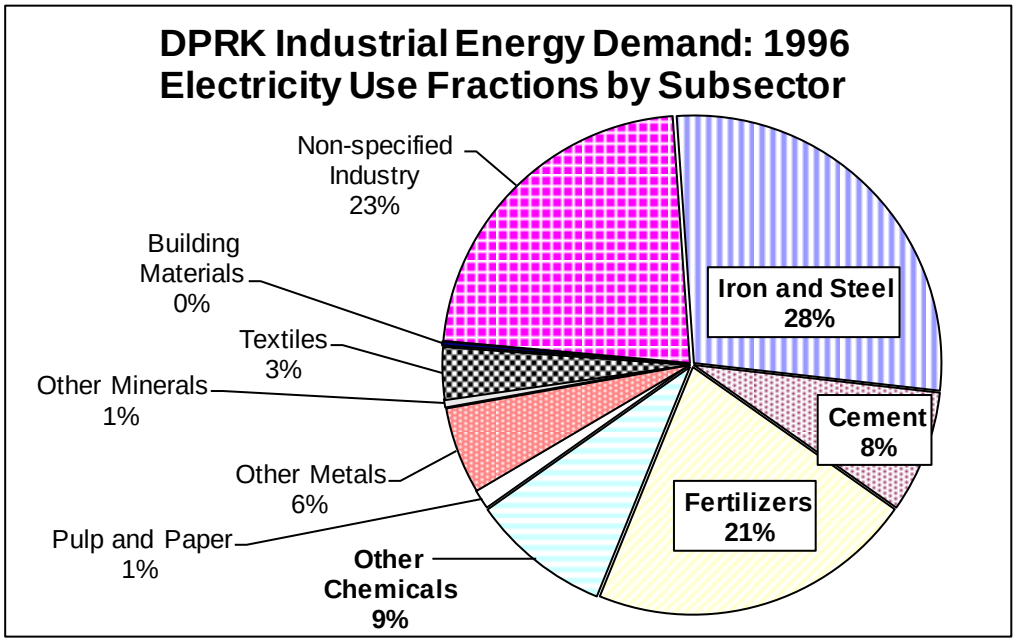

DPRK Industrial Energy Demand by Subsector: 2008
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
Energy Demand (TJ)

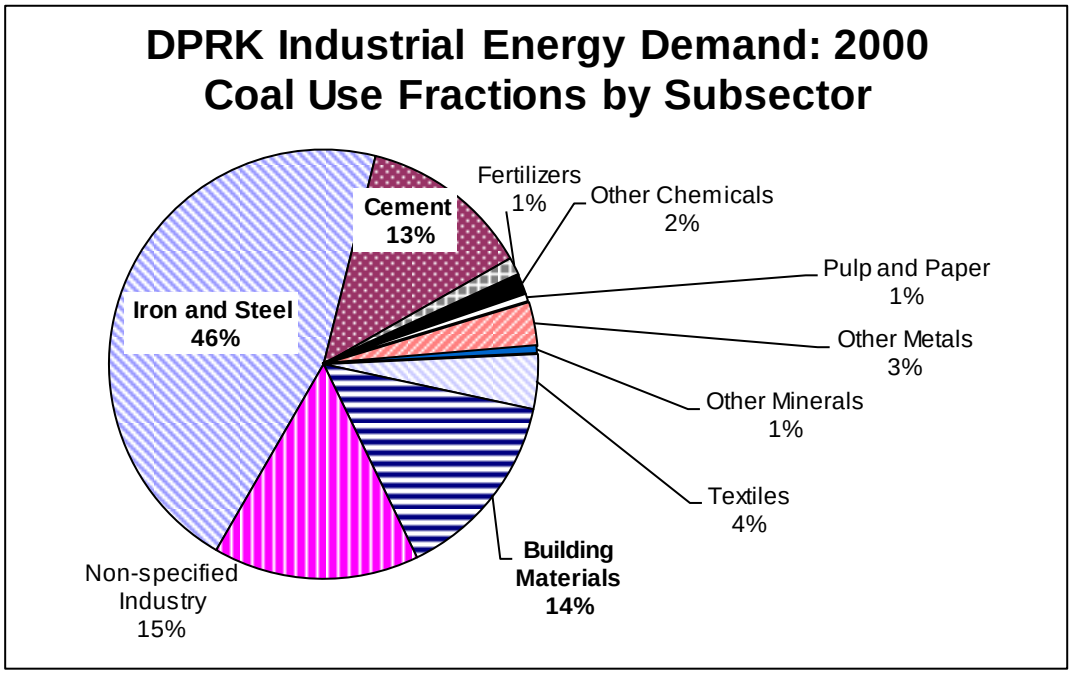

DPRK Industrial Energy Demand by Subsector: 2009
Non-specified Industry
Building Materials
Textiles
Other Minerals
Other Metals
Pulp and Paper
Other Chemicals
Fertilizers
Cement
Iron and Steel
Coal
Petr. Prod.
Wood
Electricity
-
10,000
20,000
30,000
40,000
50,000
60,000
Energy Demand (TJ)

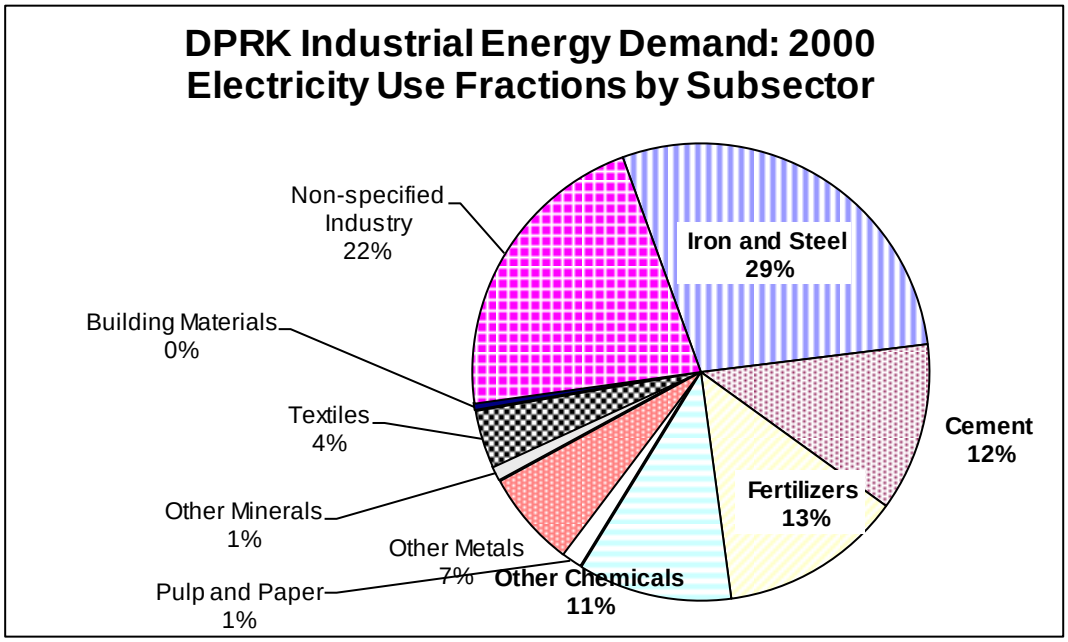

DPRK Industrial Energy Demand: 1990
Coal Use Fractions by Subsector
Other Minerals 0%
Building Materials 9%
Textiles 4%
Non-specified Industry 19%
Other Metals 3%
Pulp and Paper 1%
Other Chemicals 2%
Fertilizers 4%
Iron and Steel 48%
Cement 10%

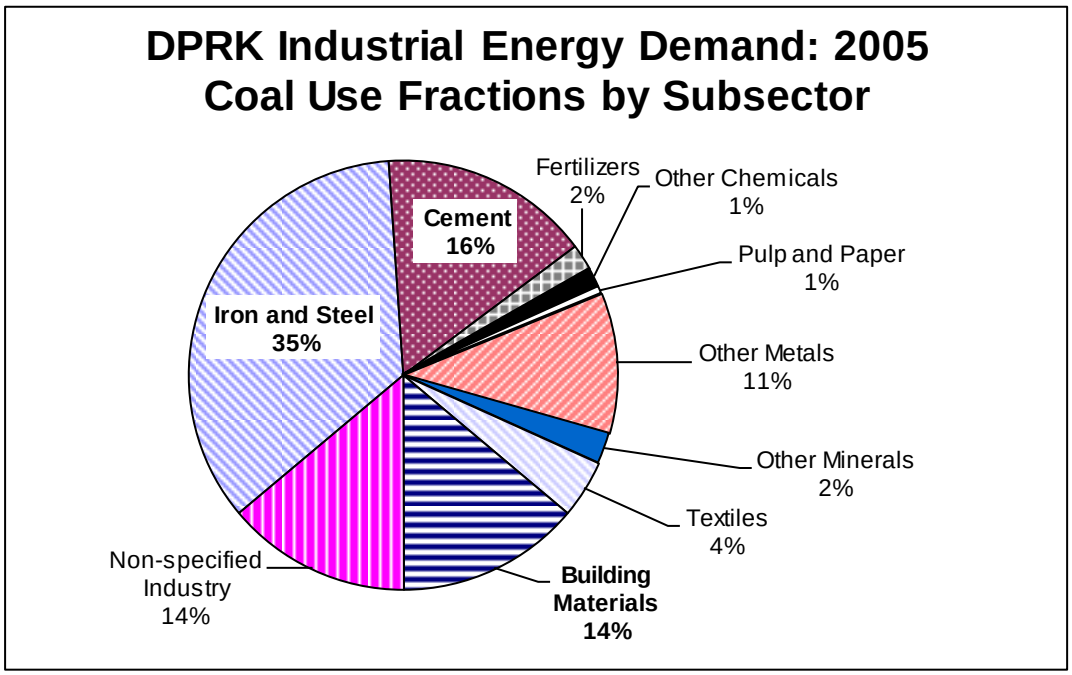

DPRK Industrial Energy Demand: 1990
Electricity Use Fractions by Subsector
Non-specified Industry 21%
Iron and Steel 25%
Building Materials 0%
Cement 6%
Textiles 4%
Other Minerals 1%
Fertilizers 27%
Other Metals 6%
Pulp and Paper 1%
Other Chemicals 9%

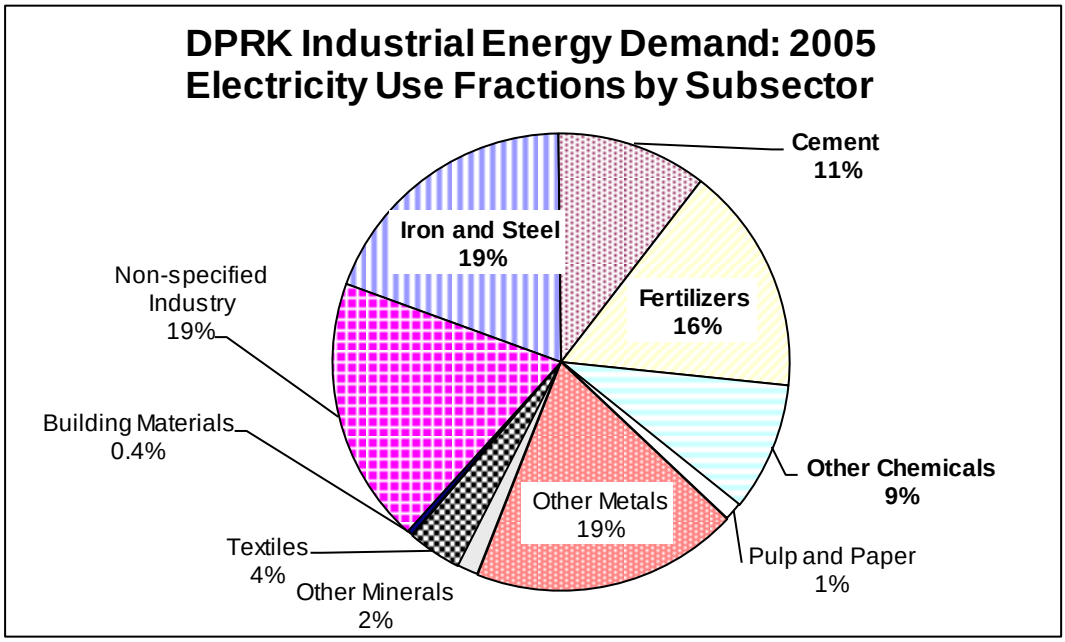

DPRK Industrial Energy Demand: 1996
Coal Use Fractions by Subsector
Building Materials 8%
Textiles 4%
Other Minerals 0%
Other Metals 3%
Pulp and Paper 1%
Other Chemicals 1%
Fertilizers 3%
Cement 12%
Iron and Steel 50%
Non-specified Industry 18%

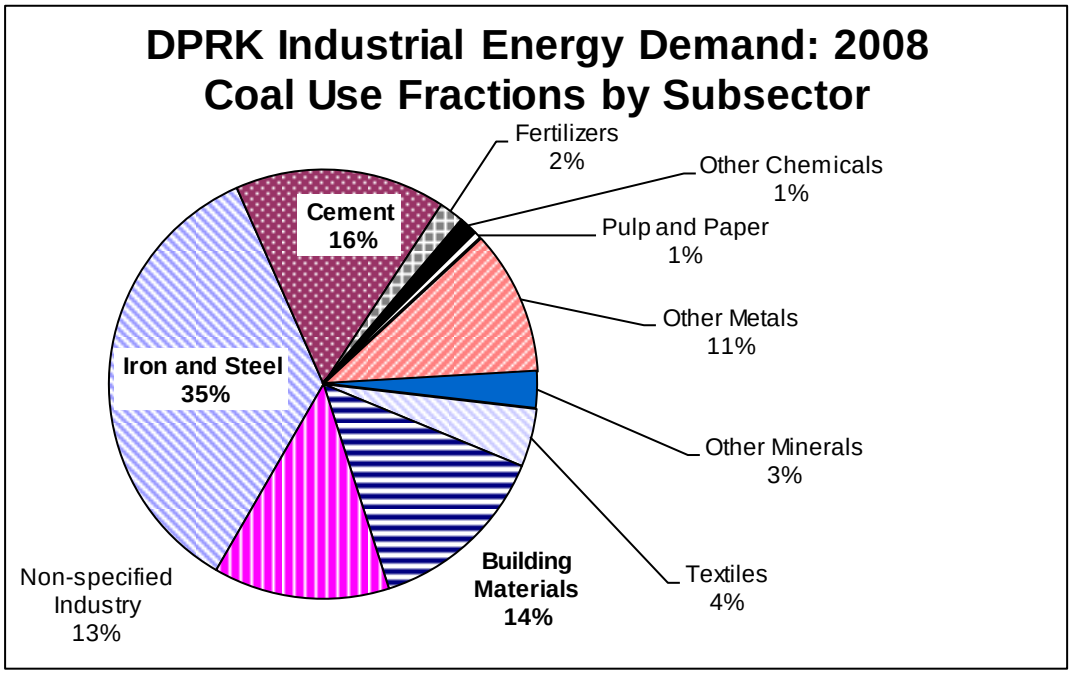

DPRK Industrial Energy Demand: 1996
Electricity Use Fractions by Subsector
Non-specified Industry 23%
Building Materials 0%
Textiles 3%
Other Minerals 1%
Other Metals 6%
Pulp and Paper 1%
Other Chemicals 9%
Fertilizers 21%
Cement 8%
Iron and Steel 28%

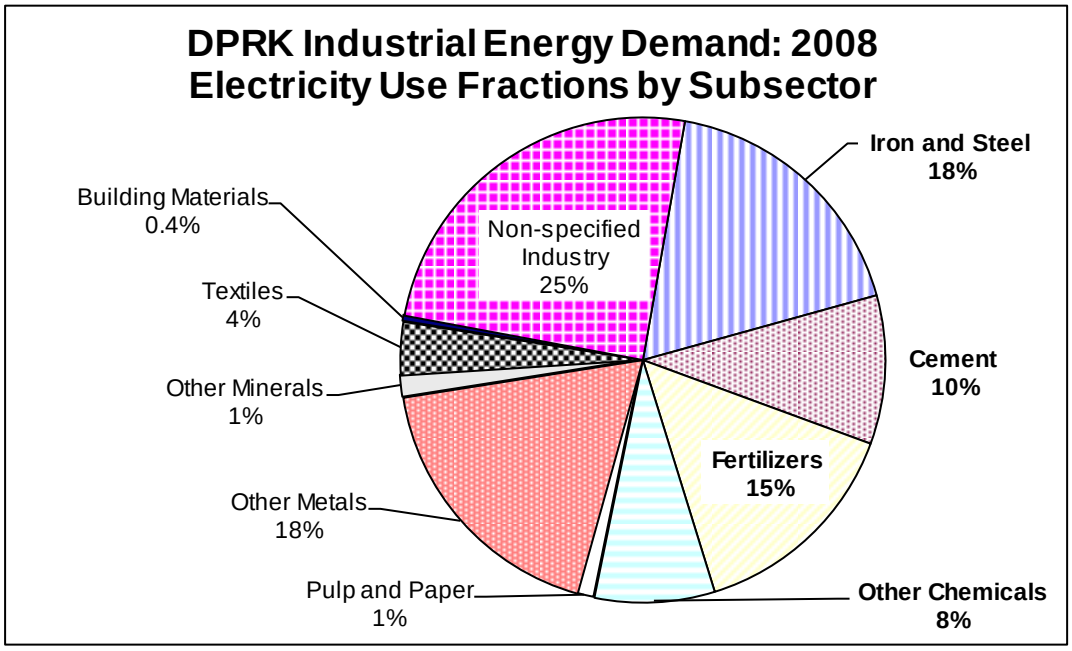

DPRK Industrial Energy Demand: 2000
Coal Use Fractions by Subsector
Cement 13%
Fertilizers 1%
Other Chemicals 2%
Pulp and Paper 1%
Other Metals 3%
Other Minerals 1%
Textiles 4%
Building Materials 14%
Non-specified Industry 15%
Iron and Steel 46%

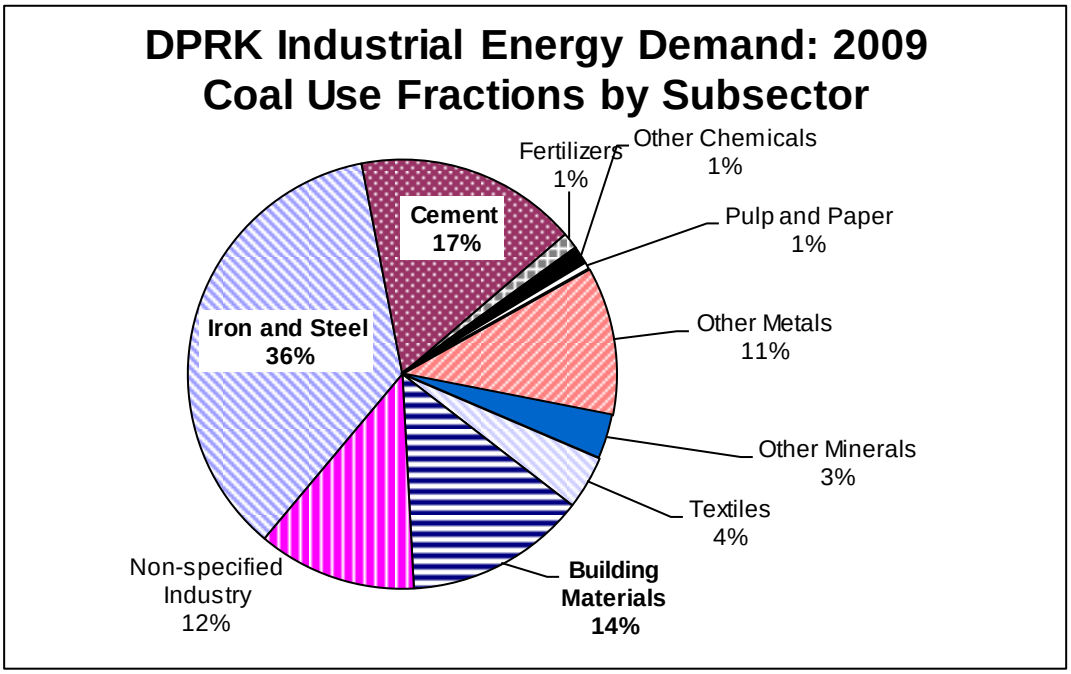

DPRK Industrial Energy Demand: 2000
Electricity Use Fractions by Subsector
Non-specified Industry 22%
Iron and Steel 29%
Building Materials 0%
Textiles 4%
Cement 12%
Other Minerals 1%
Fertilizers 13%
Other Metals 7%
Other Chemicals 11%
Pulp and Paper 1%

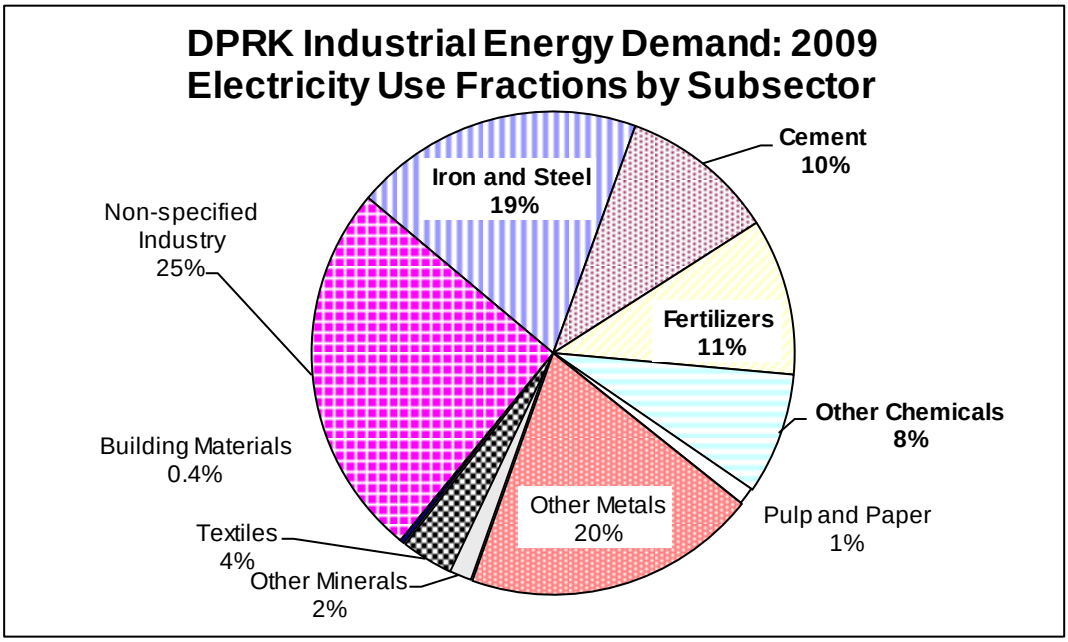

DPRK Industrial Energy Demand: 2005
Coal Use Fractions by Subsector
Fertilizers 2%
Other Chemicals 1%
Pulp and Paper 1%
Other Metals 11%
Other Minerals 2%
Textiles 4%
Building Materials 14%
Non-specified Industry 14%
Cement 16%
Iron and Steel 35%


DPRK Industrial Energy Demand: 2005
Electricity Use Fractions by Subsector
Cement 11%
Fertilizers 16%
Other Chemicals 9%
Pulp and Paper 1%
Other Metals 19%
Other Minerals 2%
Textiles 4%
Building Materials 0.4%
Non-specified Industry 19%
Iron and Steel 19%


DPRK Industrial Energy Demand: 2008
Coal Use Fractions by Subsector
Fertilizers 2%
Other Chemicals 1%
Pulp and Paper 1%
Other Metals 11%
Other Minerals 3%
Textiles 4%
Building Materials 14%
Non-specified Industry 13%
Iron and Steel 35%
Cement 16%

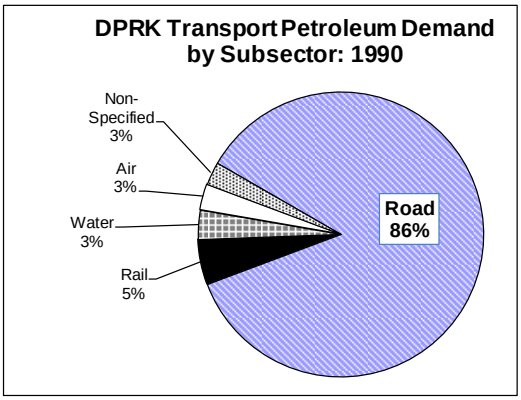

DPRK Industrial Energy Demand: 2008
Electricity Use Fractions by Subsector
Iron and Steel 18%
Cement 10%
Other Chemicals 8%
Pulp and Paper 1%
Other Metals 18%
Other Minerals 1%
Textiles 4%
Building Materials 0.4%
Non-specified Industry 25%
Fertilizers 15%

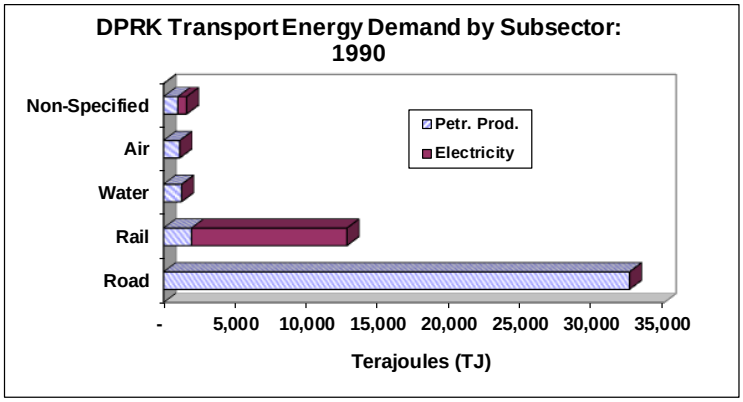


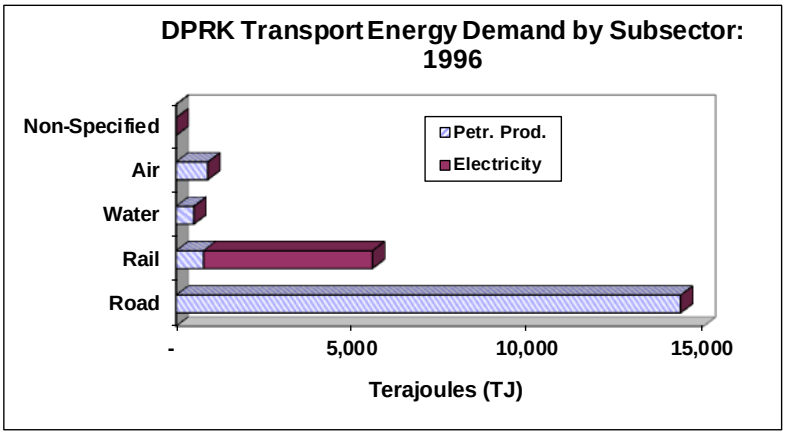


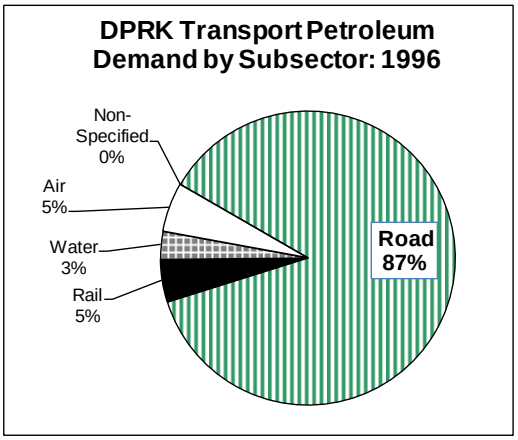
DPRK Transport Energy Demand By Subsector: 1990, 1996, 2000, annd 2005

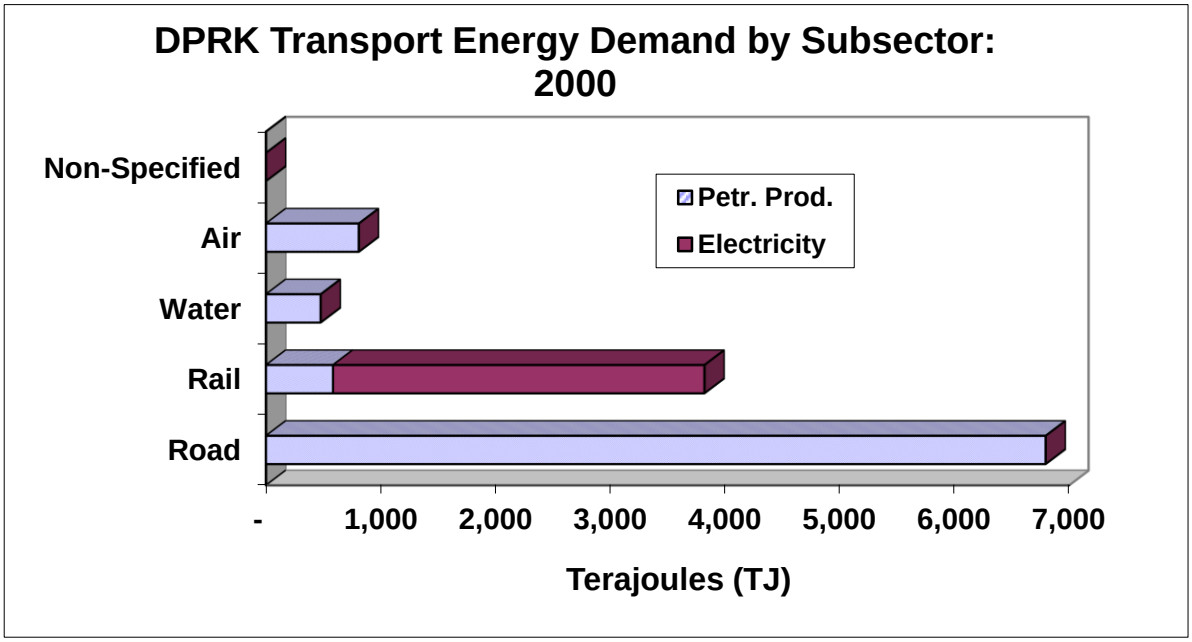
Units: Terajoules (TJ)	**1990**		**1996**		**2000**		**2005**		**2008**		**2009**	
Subsector	Petr. Prod.	Electricity	Petr. Prod.	Electricity	Petr. Prod.	Electricity	Petr. Prod.	Electricity	Petr. Prod.	Electricity	Petr. Prod.	Electricity
Road	32,571	-	14,345	-	6,795	-	9,653	-	10,807	-	8,098	-
Rail	1,949	10,870	779	4,804	585	3,237	896	3,587	516	4,185	448	4,240
Water	1,253	-	501	-	476	-	526	-	414	-	351	-
Air	1,123	-	899	-	809	-	793	-	853	-	793	-
Non-Specified	1,000	600	-	-	-	-	-	-	-	-	-	-

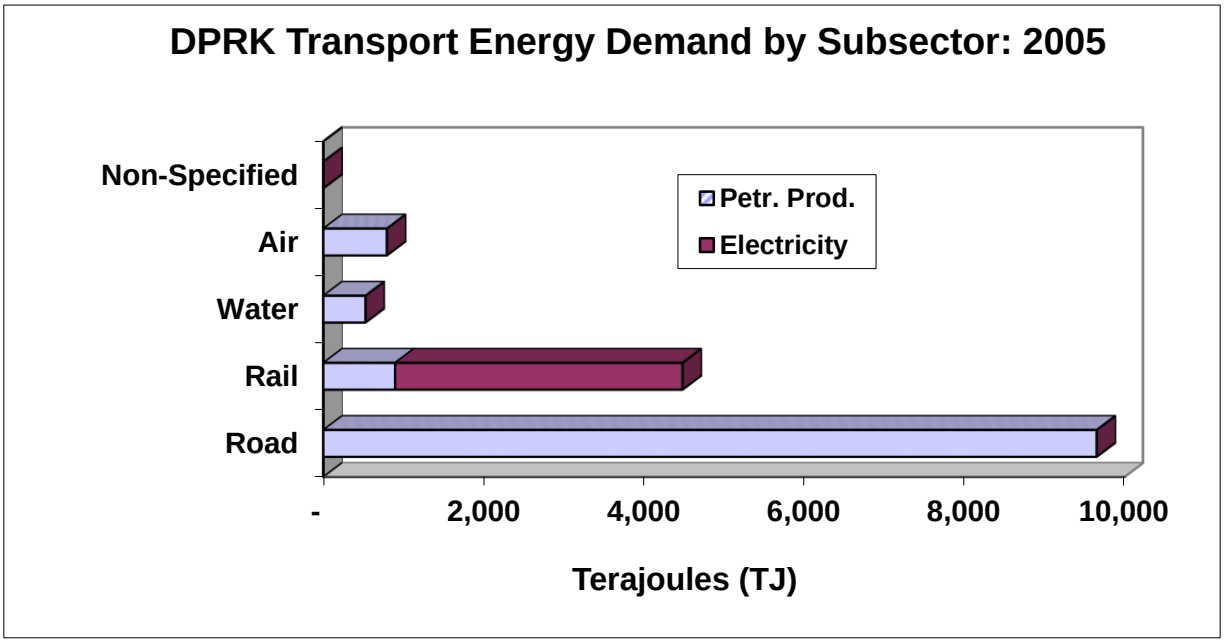

DPRK Transport Petroleum Demand by Subsector: 1990
Non-Specified 3%
Air 3%
Water 3%
Rail 5%
Road 86%

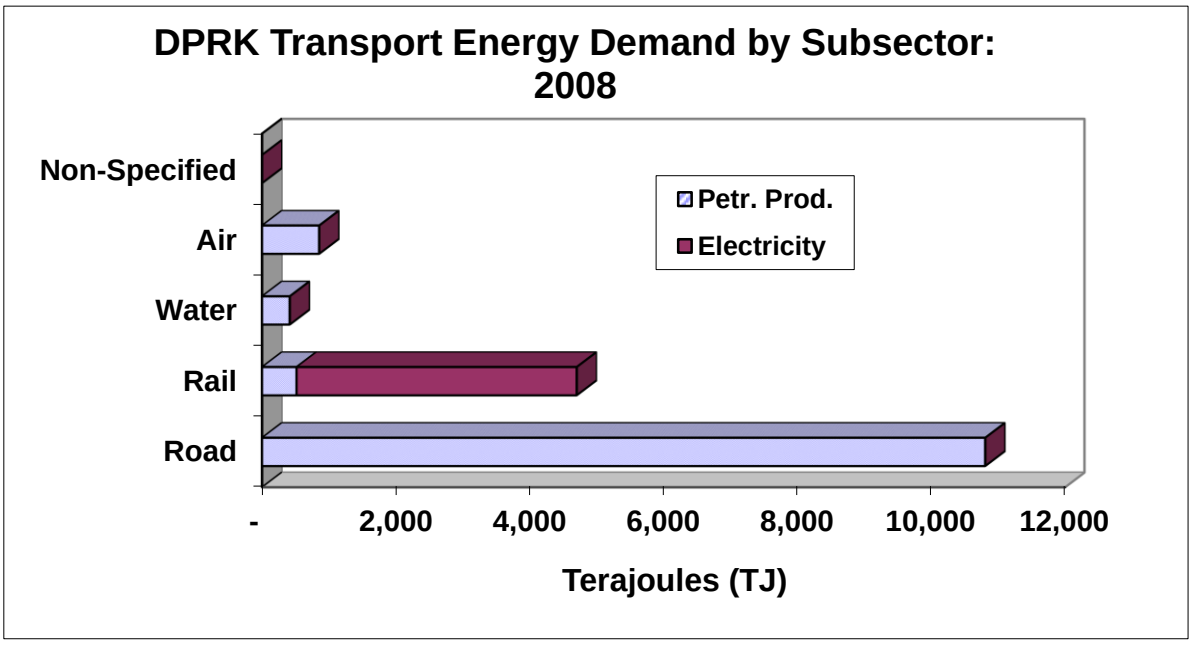

DPRK Transport Energy Demand by Subsector: 1990
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
- 5,000 10,000 15,000 20,000 25,000 30,000 35,000
Terajoules (TJ)

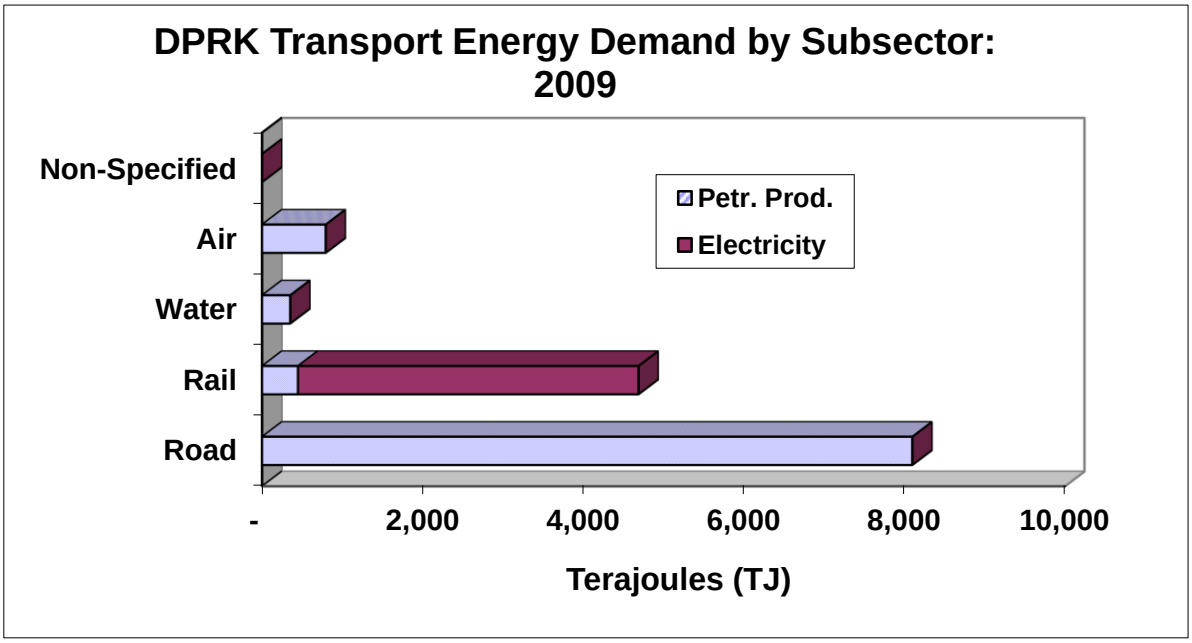

DPRK Transport Energy Demand by Subsector: 1996
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
- 5,000 10,000 15,000
Terajoules (TJ)


DPRK Transport Petroleum Demand by Subsector: 1996
Non-Specified 0%
Air 5%
Water 3%
Rail 5%
Road 87%


DPRK Transport Energy Demand by Subsector: 2000
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
- 1,000 2,000 3,000 4,000 5,000 6,000 7,000
Terajoules (TJ)


DPRK Transport Energy Demand by Subsector: 2005
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
-
2,000
4,000
6,000
8,000
10,000
Terajoules (TJ)

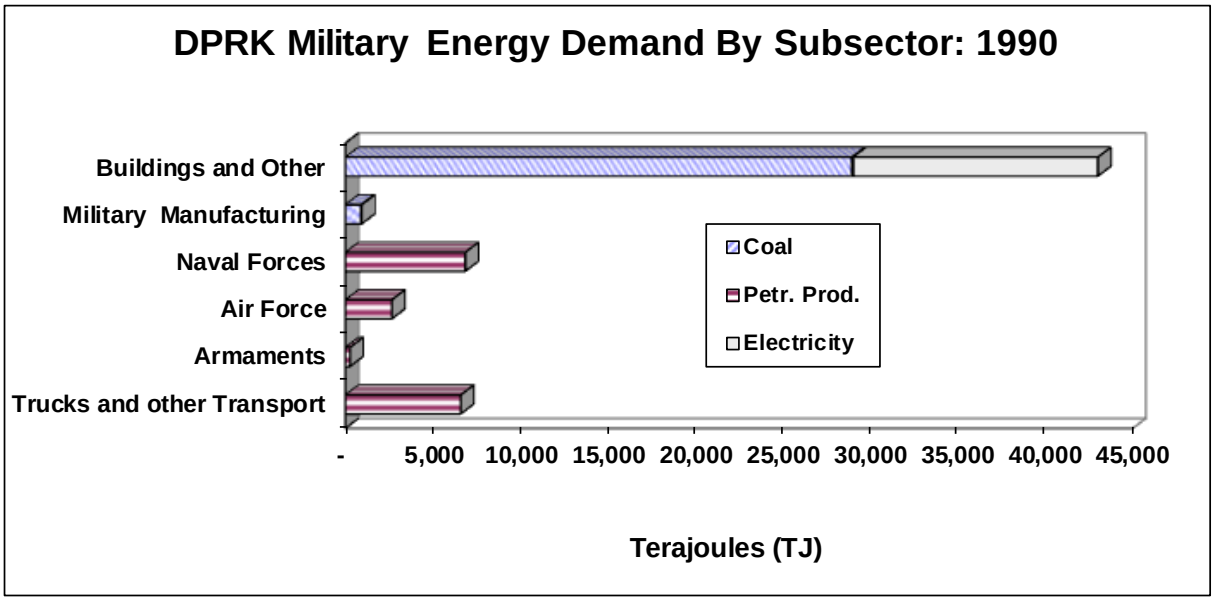

DPRK Transport Energy Demand by Subsector: 2008
Non-Specified
Air
Water
Rail
Road
Petr. Prod.
Electricity
-
2,000
4,000
6,000
8,000
10,000
12,000
Terajoules (TJ)

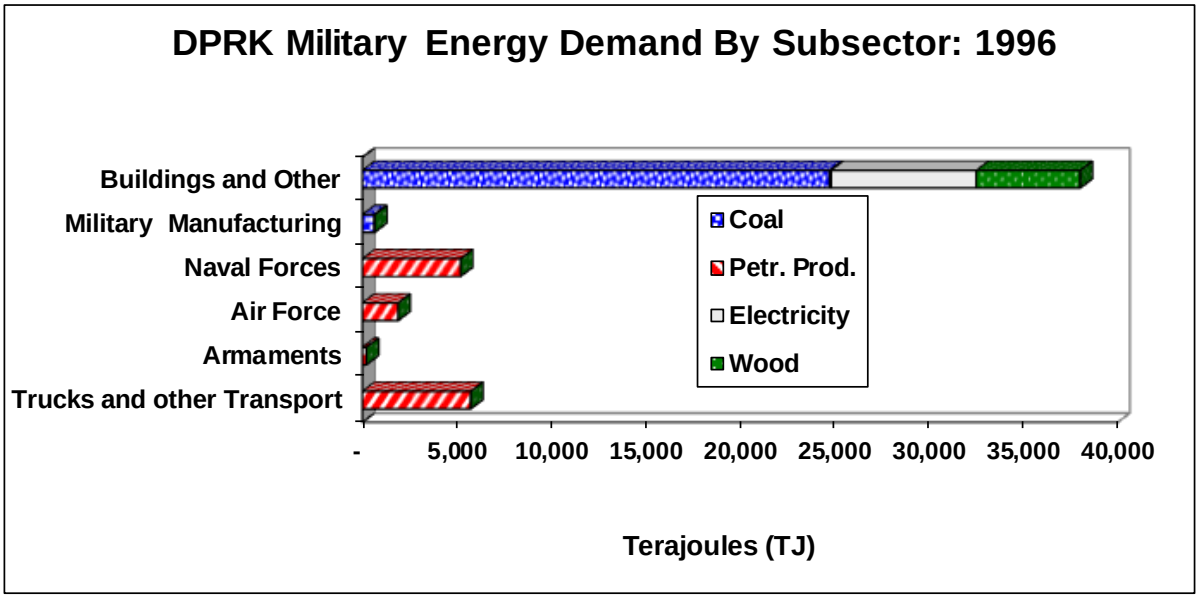


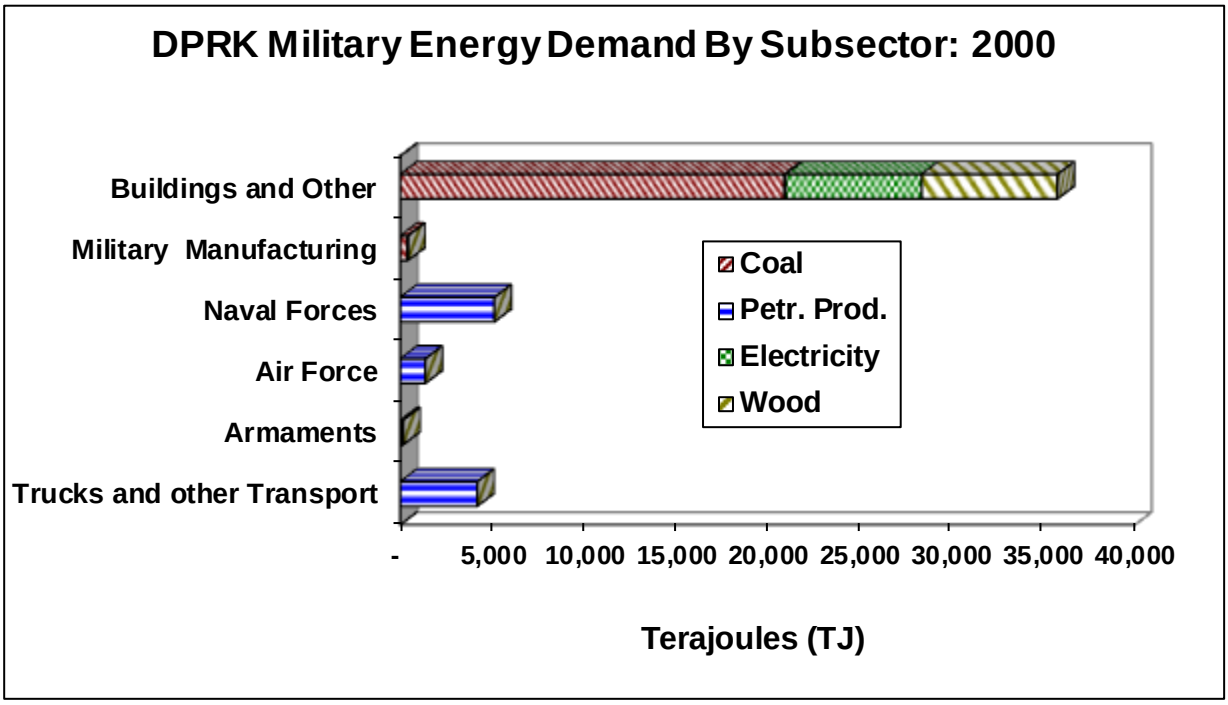
DPRK Military Energy Demand By Subsector: 1990, 1996, 2000, 2005, 2008, 2009

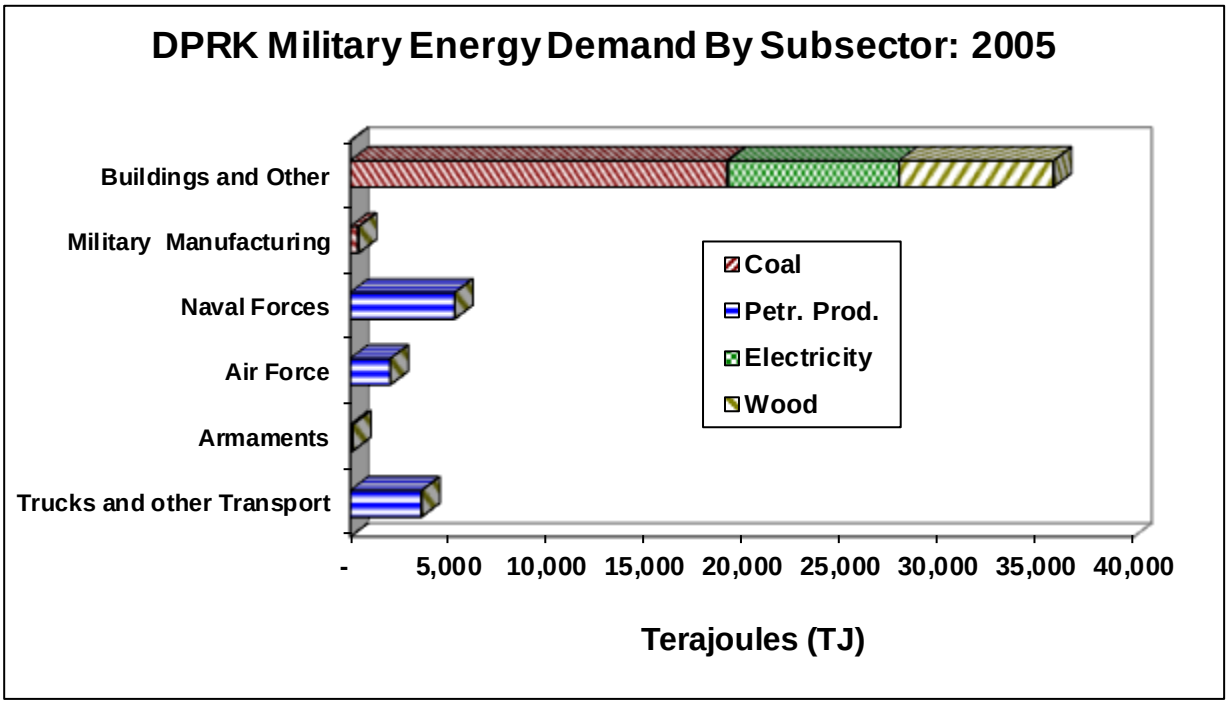
Units: Terajoules (TJ)	**1990**			**1996**				**2000**			
Subsector	Coal	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	-	6,585	-	-	-	5,734	-	-	-	4,187	-
Armaments	-	263	-	-	-	211	-	-	-	148	-
Air Force	-	2,648	-	-	-	1,886	-	-	-	1,367	-
Naval Forces	-	6,847	-	-	-	5,198	-	-	-	5,122	-
Military Manufacturing	887	-	48	621	-	-	33	399	-	-	21
Buildings and Other	28,938	100	13,960	24,742	5,498	95	7,678	20,908	7,379	85	7,399

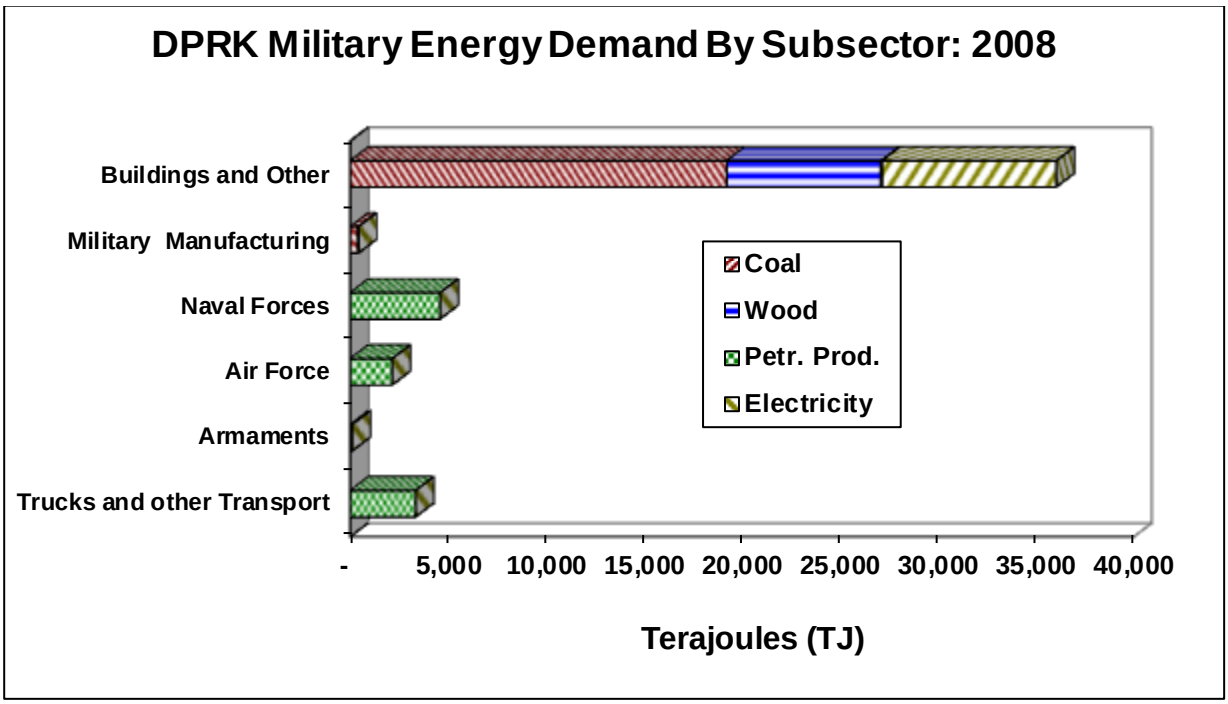
	2005				**2008**				**2009**			
Subsector	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity	Coal	Wood	Petr. Prod.	Electricity
Trucks and other Transport	-	-	3,641	-	-	-	3,338	-	-	-	3,338	-
Armaments	-	-	129	-	-	-	101	-	-	-	101	-
Air Force	-	-	2,039	-	-	-	2,144	-	-	-	1,807	-
Naval Forces	-	-	5,326	-	-	-	4,589	-	-	-	3,934	-
Military Manufacturing	399	-	-	21	399	-	-	21	399	-	-	21
Buildings and Other	19,215	7,871	85	8,725	19,215	7,871	85	8,865	19,215	7,871	85	7,985

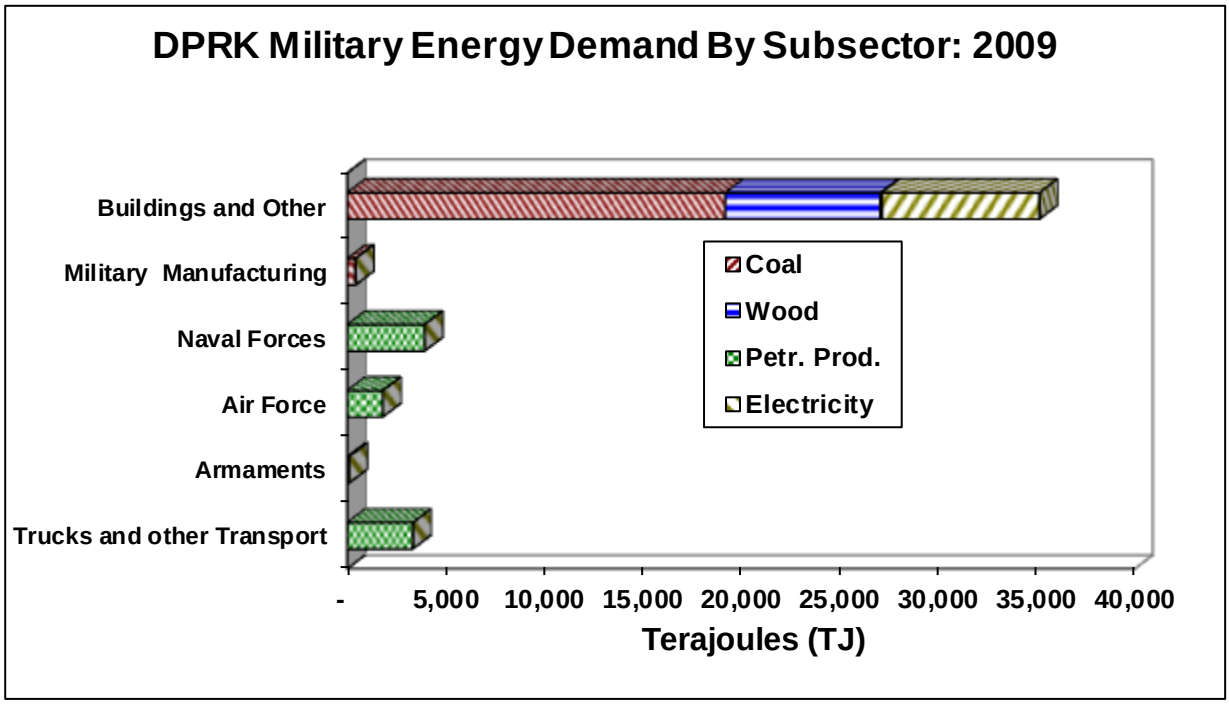

DPRK Military Energy Demand By Subsector: 1990
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
Terajoules (TJ)

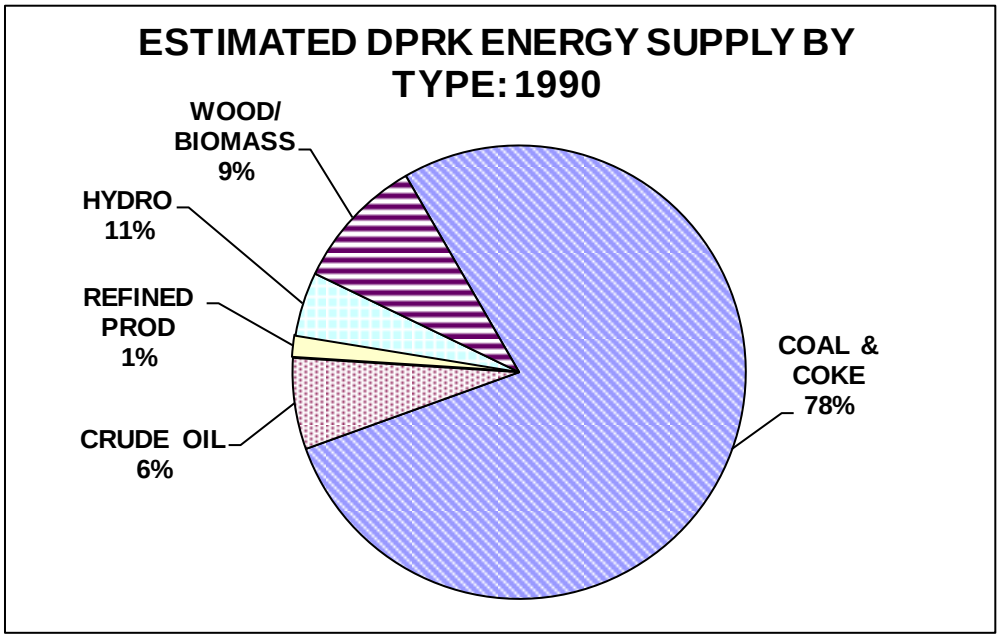

DPRK Military Energy Demand By Subsector: 1996
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
Wood
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

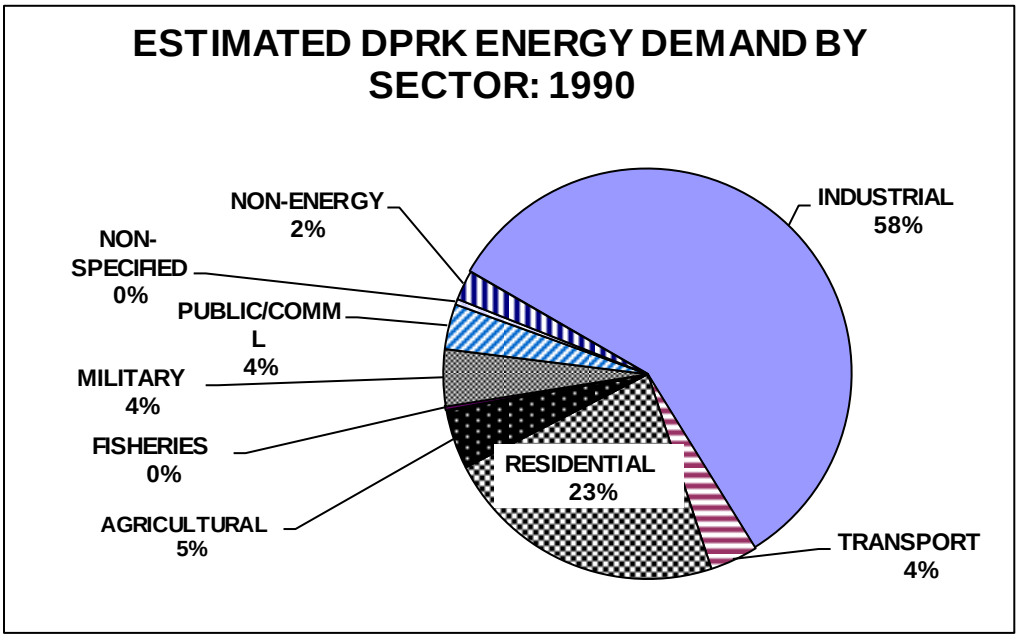

DPRK Military Energy Demand By Subsector: 2000
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
Wood
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

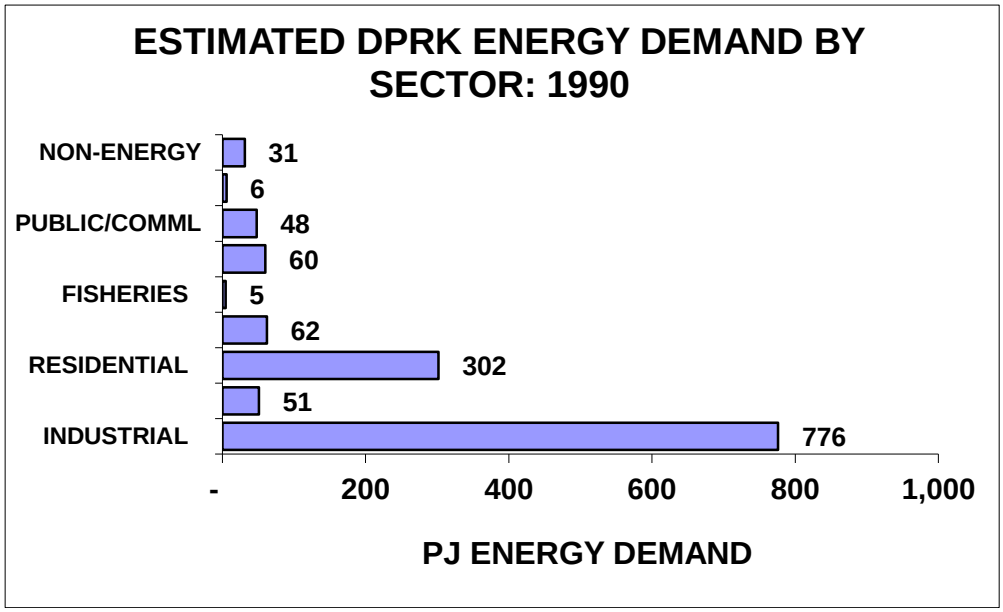

DPRK Military Energy Demand By Subsector: 2005
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Petr. Prod.
Electricity
Wood
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

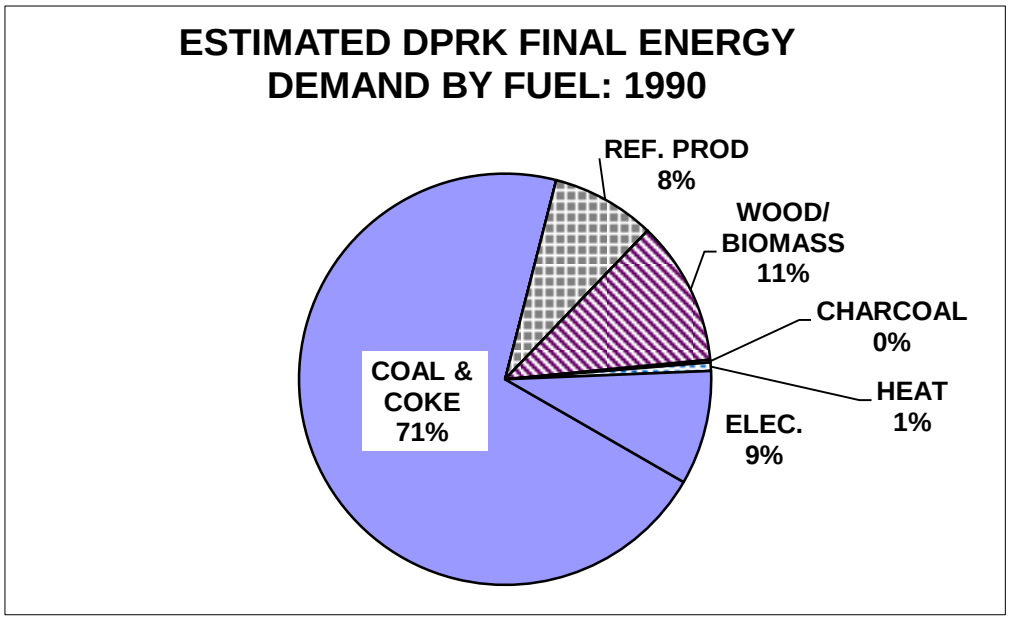

DPRK Military Energy Demand By Subsector: 2008
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
Petr. Prod.
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

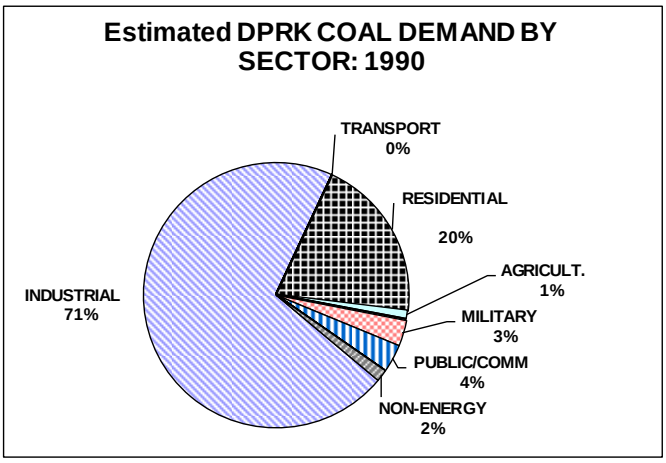

DPRK Military Energy Demand By Subsector: 2009
Buildings and Other
Military Manufacturing
Naval Forces
Air Force
Armaments
Trucks and other Transport
Coal
Wood
Petr. Prod.
Electricity
-
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Terajoules (TJ)

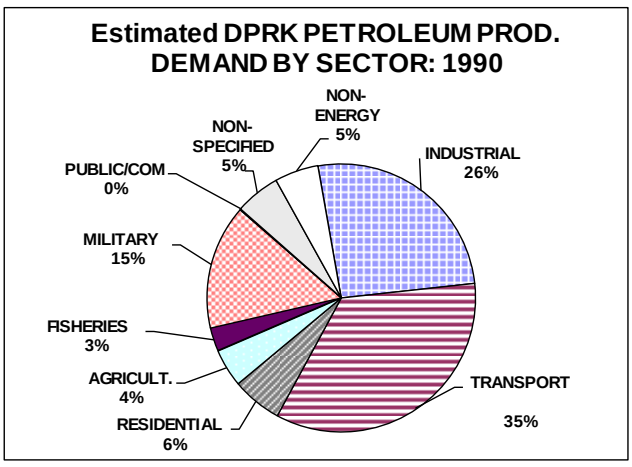

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1990
WOOD/ BIOMASS 9%
HYDRO 11%
REFINED PROD 1%
CRUDE OIL 6%
COAL & COKE 78%

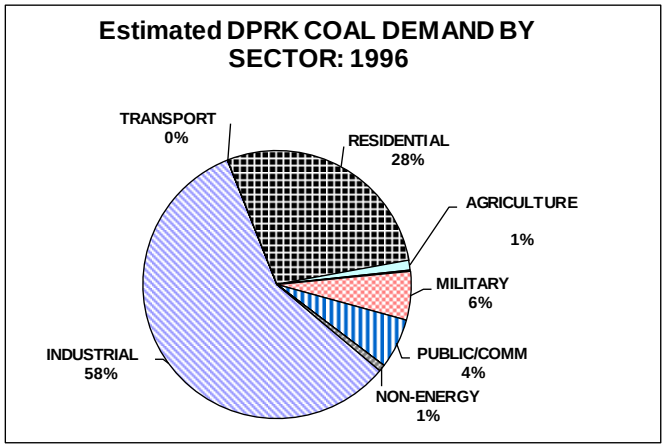

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY 2%
NON-SPECIFIED 0%
PUBLIC/COMML 4%
MILITARY 4%
FISHERIES 0%
AGRICULTURAL 5%
RESIDENTIAL 23%
INDUSTRIAL 58%
TRANSPORT 4%

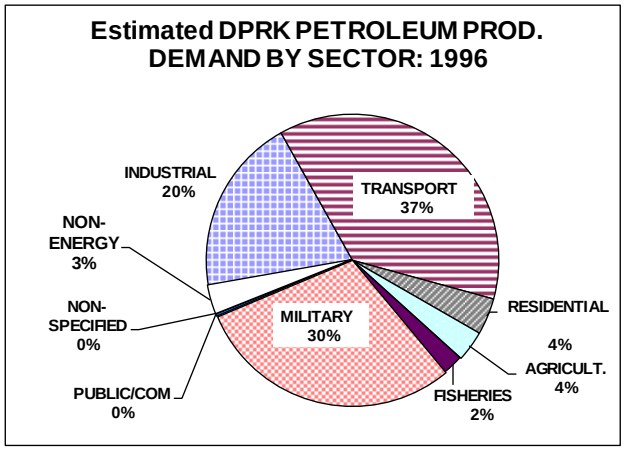

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY
31
6
PUBLIC/COMML
48
60
FISHERIES
5
62
RESIDENTIAL
302
51
INDUSTRIAL
776
-
200
400
600
800
1,000
PJ ENERGY DEMAND

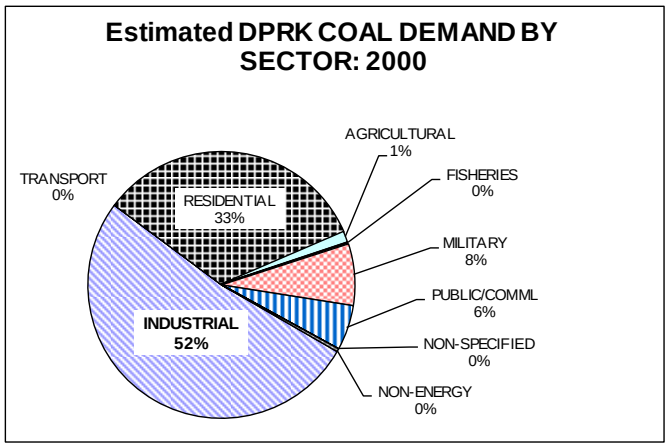

ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL: 1990
REF. PROD 8%
WOOD/ BIOMASS 11%
CHARCOAL 0%
HEAT 1%
ELEC. 9%
COAL & COKE 71%

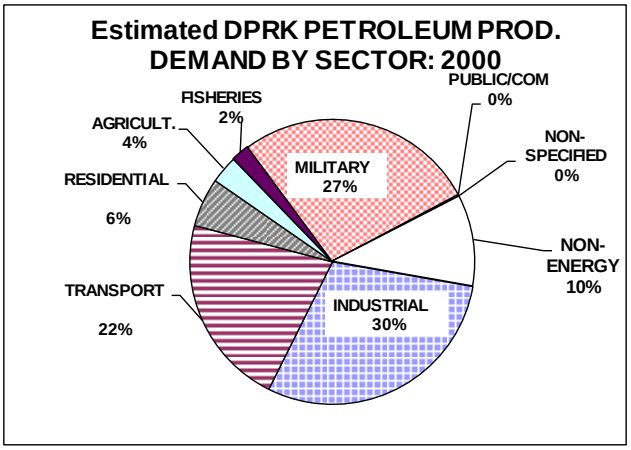

Estimated DPRK COAL DEMAND BY SECTOR: 1990
TRANSPORT 0%
RESIDENTIAL 20%
AGRICULT. 1%
MILITARY 3%
PUBLIC/COMM 4%
NON-ENERGY 2%
INDUSTRIAL 71%

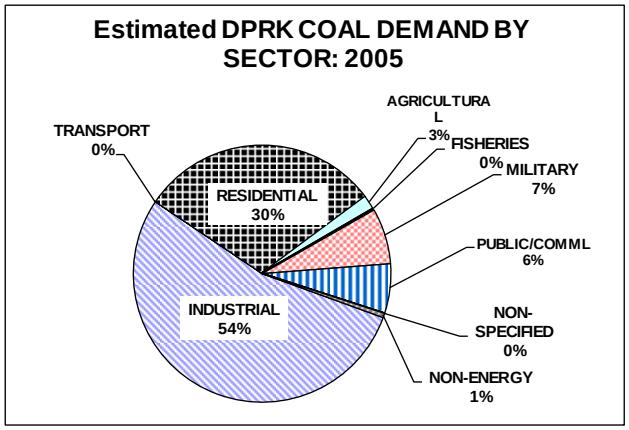

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 1990
NON-ENERGY 5%
NON-SPECIFIED 5%
INDUSTRIAL 26%
PUBLIC/COM 0%
MILITARY 15%
FISHERIES 3%
AGRICULT. 4%
RESIDENTIAL 6%
TRANSPORT 35%

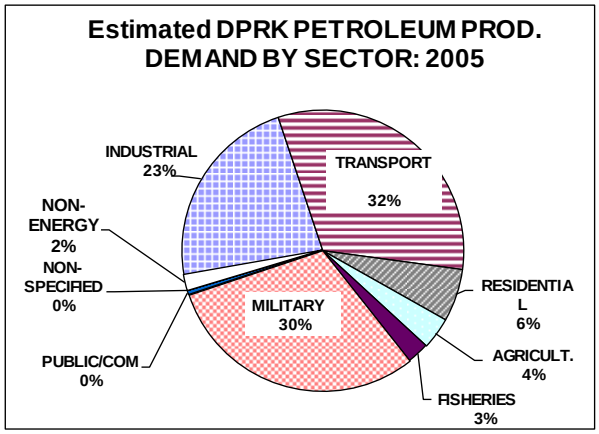

Estimated DPRK COAL DEMAND BY SECTOR: 1996
TRANSPORT 0%
RESIDENTIAL 28%
AGRICULTURE 1%
MILITARY 6%
PUBLIC/COMM 4%
NON-ENERGY 1%
INDUSTRIAL 58%

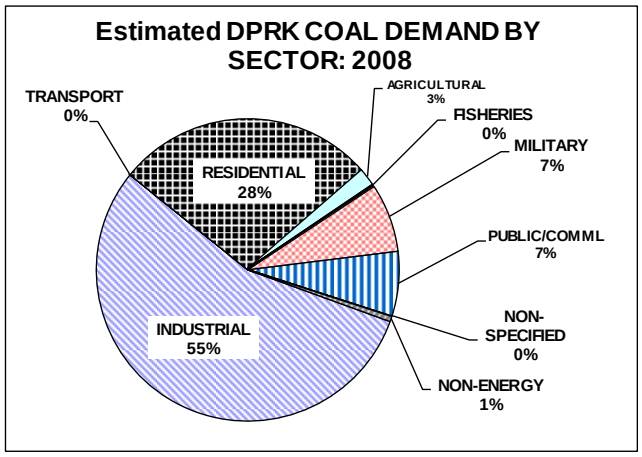

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 1996
INDUSTRIAL 20%
TRANSPORT 37%
NON-ENERGY 3%
NON-SPECIFIED 0%
MILITARY 30%
RESIDENTIAL 4%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 2%

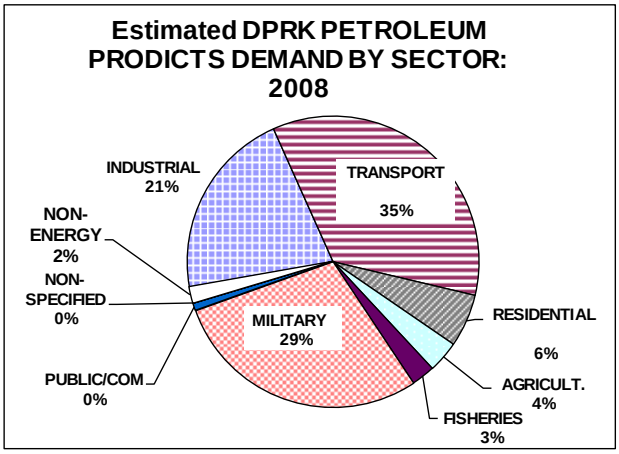

Estimated DPRK COAL DEMAND BY SECTOR: 2000
AGRICULTURAL 1%
TRANSPORT 0%
RESIDENTIAL 33%
FISHERIES 0%
MILITARY 8%
PUBLIC/COMML 6%
INDUSTRIAL 52%
NON-SPECIFIED 0%
NON-ENERGY 0%

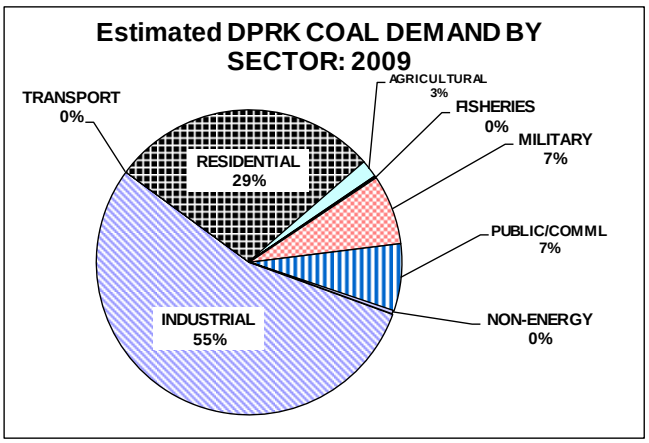

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2000
PUBLIC/COM 0%
FISHERIES 2%
AGRICULT. 4%
NON-SPECIFIED 0%
RESIDENTIAL 6%
MILITARY 27%
NON-ENERGY 10%
TRANSPORT 22%
INDUSTRIAL 30%

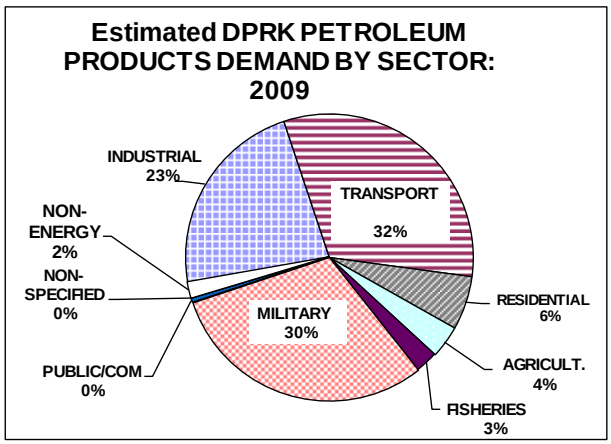

Estimated DPRK COAL DEMAND BY SECTOR: 2005
AGRICULTURAL 3%
TRANSPORT 0%
FISHERIES 0%
MILITARY 7%
RESIDENTIAL 30%
PUBLIC/COMML 6%
INDUSTRIAL 54%
NON-SPECIFIED 0%
NON-ENERGY 1%

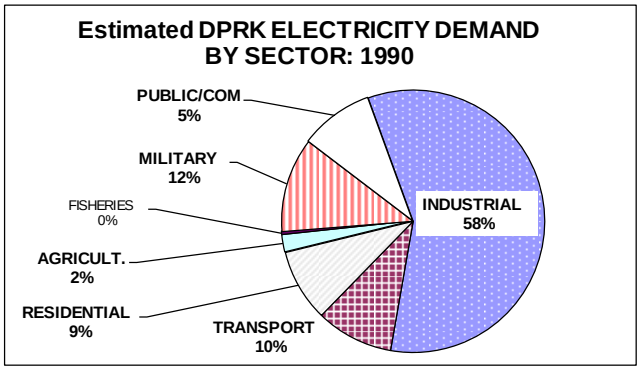

Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2005
INDUSTRIAL 23%
TRANSPORT 32%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 30%
RESIDENTIAL 6%
AGRICULT. 4%
PUBLIC/COM 0%
FISHERIES 3%

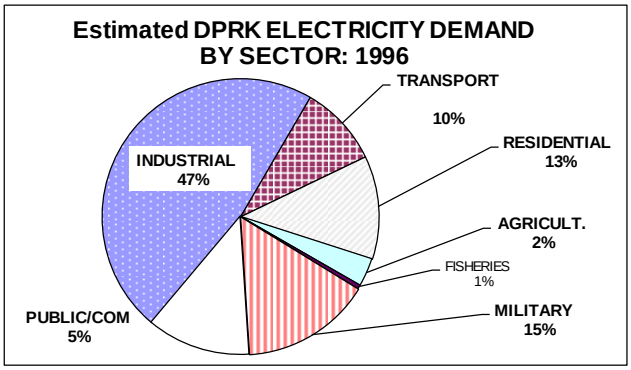

Estimated DPRK COAL DEMAND BY SECTOR: 2008
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 7%
RESIDENTIAL 28%
PUBLIC/COMML 7%
NON-SPECIFIED 0%
INDUSTRIAL 55%
NON-ENERGY 1%

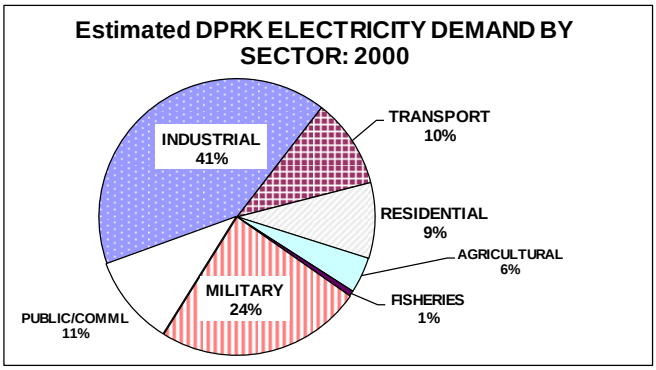

Estimated DPRK PETROLEUM PRODICTS DEMAND BY SECTOR: 2008
INDUSTRIAL 21%
TRANSPORT 35%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 29%
RESIDENTIAL 6%
PUBLIC/COM 0%
AGRICULT. 4%
FISHERIES 3%

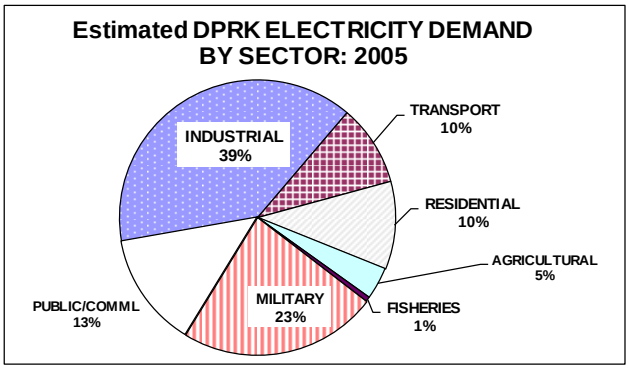

Estimated DPRK COAL DEMAND BY SECTOR: 2009
TRANSPORT 0%
AGRICULTURAL 3%
FISHERIES 0%
MILITARY 7%
RESIDENTIAL 29%
PUBLIC/COMML 7%
INDUSTRIAL 55%
NON-ENERGY 0%

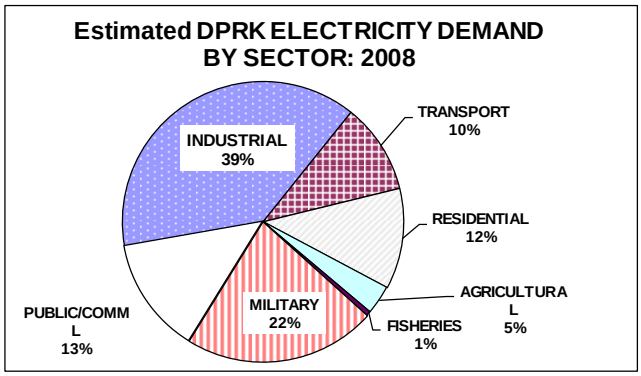

Estimated DPRK PETROLEUM PRODUCTS DEMAND BY SECTOR: 2009
INDUSTRIAL 23%
TRANSPORT 32%
NON-ENERGY 2%
NON-SPECIFIED 0%
MILITARY 30%
RESIDENTIAL 6%
PUBLIC/COM 0%
AGRICULT. 4%
FISHERIES 3%

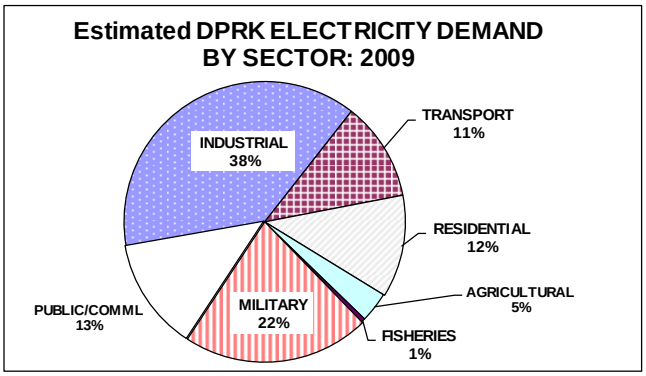

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1990
PUBLIC/COM 5%
MILITARY 12%
FISHERIES 0%
INDUSTRIAL 58%
AGRICULT. 2%
RESIDENTIAL 9%
TRANSPORT 10%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1996
TRANSPORT 10%
RESIDENTIAL 13%
INDUSTRIAL 47%
AGRICULT. 2%
FISHERIES 1%
PUBLIC/COM 5%
MILITARY 15%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2000
INDUSTRIAL 41%
TRANSPORT 10%
RESIDENTIAL 9%
AGRICULTURAL 6%
MILITARY 24%
FISHERIES 1%
PUBLIC/COMML 11%


Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 2005
INDUSTRIAL 39%
TRANSPORT 10%
RESIDENTIAL 10%
AGRICULTURAL 5%
PUBLIC/COMML 13%
MILITARY 23%
FISHERIES 1%


Estimated DPRK ELECTRICITY DEMAND
BY SECTOR: 2008
INDUSTRIAL
39%
TRANSPORT
10%
RESIDENTIAL
12%
AGRICULTURA
L
5%
FISHERIES
1%
MILITARY
22%
PUBLIC/COMM
L
13%


Estimated DPRK ELECTRICITY DEMAND
BY SECTOR: 2009
INDUSTRIAL
38%
TRANSPORT
11%
RESIDENTIAL
12%
AGRICULTURAL
5%
FISHERIES
1%
MILITARY
22%
PUBLIC/COMML
13%

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)	-	-	-	-

DPRK Energy Supply By Fuel and Source: 1996

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	685	-	-	19	155
Imports	12	40	39	-	12
Exports	(12)	-	(0)	-	(0)

DPRK Energy Supply By Fuel and Source: 2000

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	337	1	-	38	154
Imports	10	17	42	-	12
Exports	(9)	-	(3)	-	(0)

DPRK Energy Supply By Fuel and Source: 2005

Units:Petajoules (PJ)

Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	436	1	-	44	174
Imports	36	22	23	-	12
Exports	(80)	-	(0)	-	(0)

DPRK Energy Supply By Fuel and Source: 2008

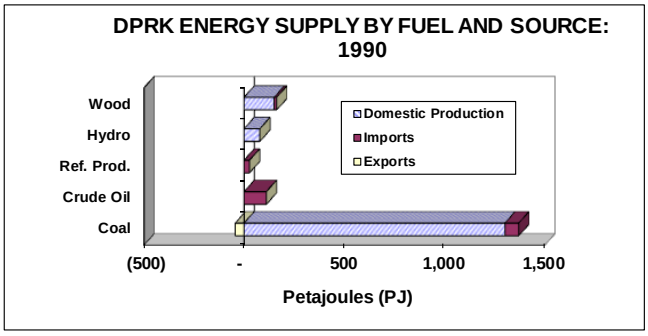
Units:Petajoules (PJ)

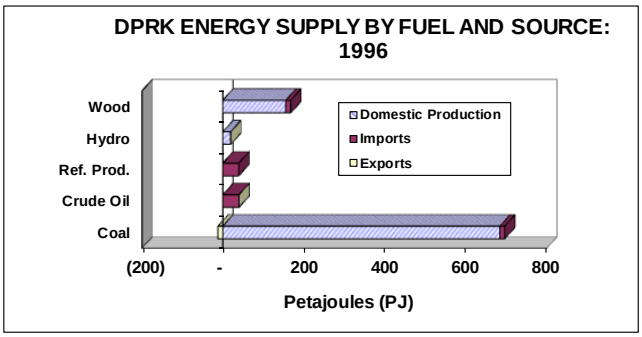
Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	425	1	-	43	194
Imports	12	23	29	-	12
Exports	(66)	-	(0)	-	-

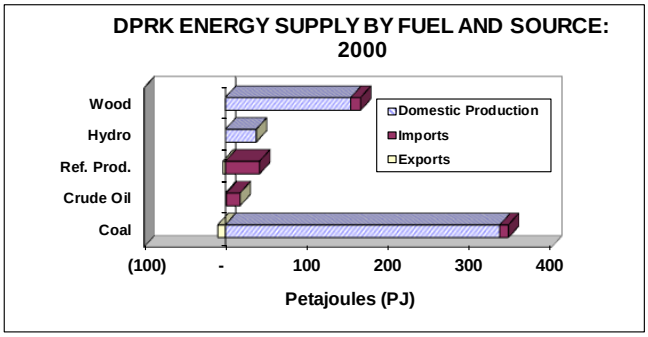
DPRK Energy Supply By Fuel and Source: 2009

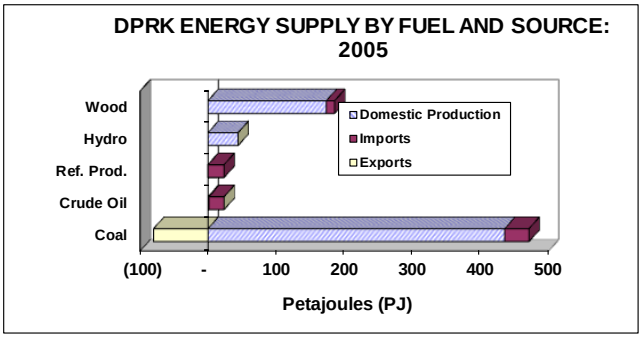
Units:Petajoules (PJ)

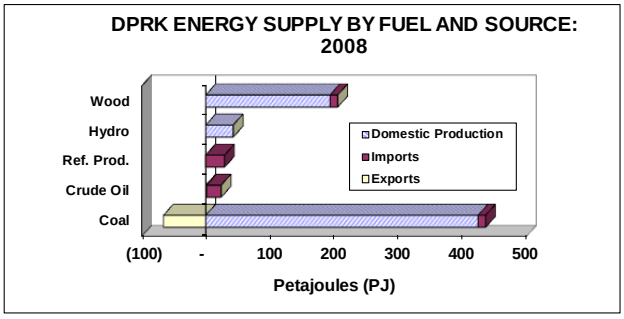
Source	Coal	Crude Oil	Ref. Prod.	Hydro	Wood
Domestic Production	446	1	-	43	195
Imports	4	22	12	-	12
Exports	(93)	-	(0)	-	-

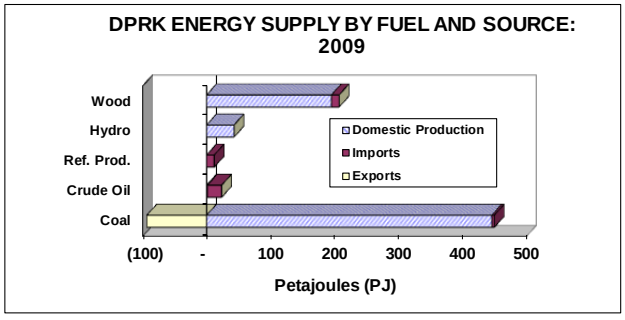












DPRK Residential Sector Energy Demand By Fuel and Subsector: 1990 and 1996

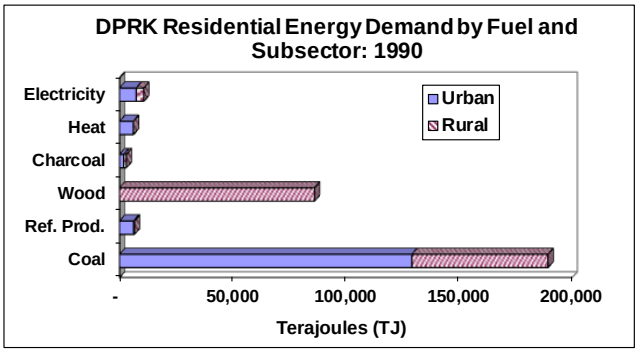
Units:Terajoules (TJ)	**1990**						**1996**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	129,155	6,256	-	1,814	6,134	7,420	92,747	1,649	15,135	1,455	3,572	4,562
Rural	60,119	344	86,140	1,159	-	3,298	28,988	136	102,471	919	-	1,583

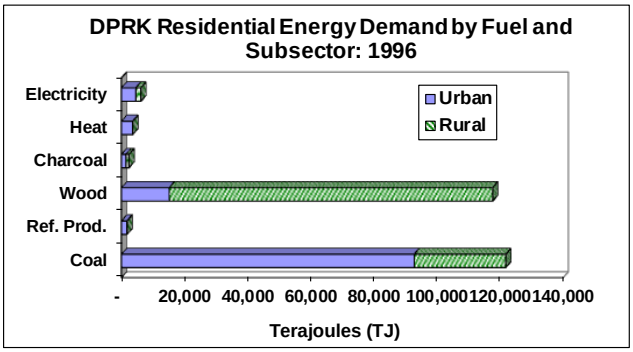
DPRK Residential Sector Energy Demand By Fuel and Subsector: 2000 and 2005

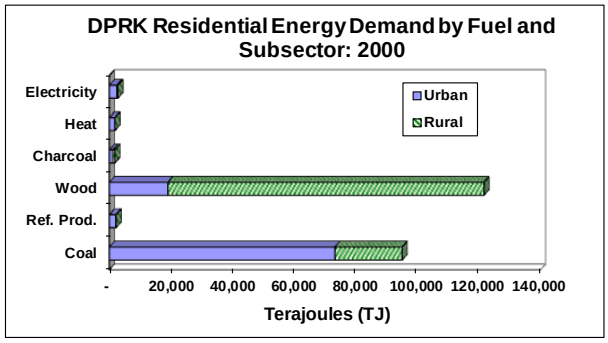
Units:Terajoules (TJ)	**2000**						**2005**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	73,246	2,058	19,021	1,117	1,826	2,421	67,806	2,075	24,739	1,132	2,439	3,399
Rural	21,808	149	102,580	701	-	323	17,079	146	109,810	704	-	488

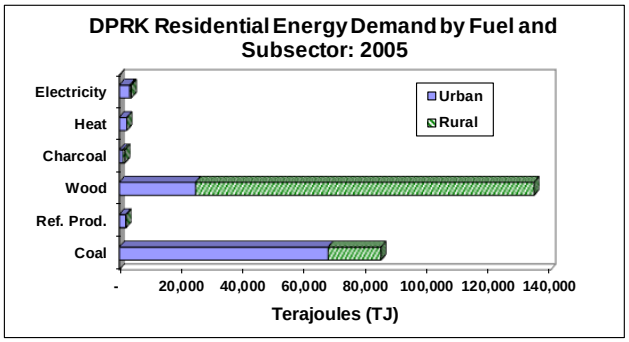
DPRK Residential Sector Energy Demand By Fuel and Subsector: 2008 and 2009

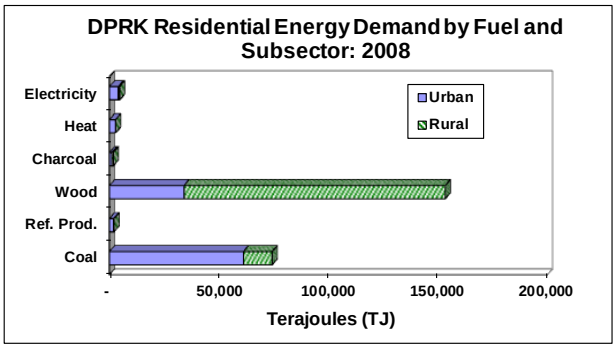
Units:Terajoules (TJ)	**2008**						**2009**					
Source	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity	Coal	Ref. Prod.	Wood	Charcoal	Heat	Electricity
Urban	61,212	1,902	34,093	1,089	2,824	4,058	62,349	1,571	34,685	1,108	2,635	3,826
Rural	13,090	184	119,228	673	-	613	13,292	146	121,072	683	-	575

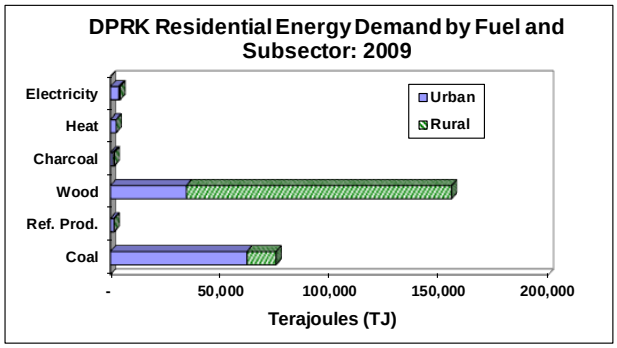












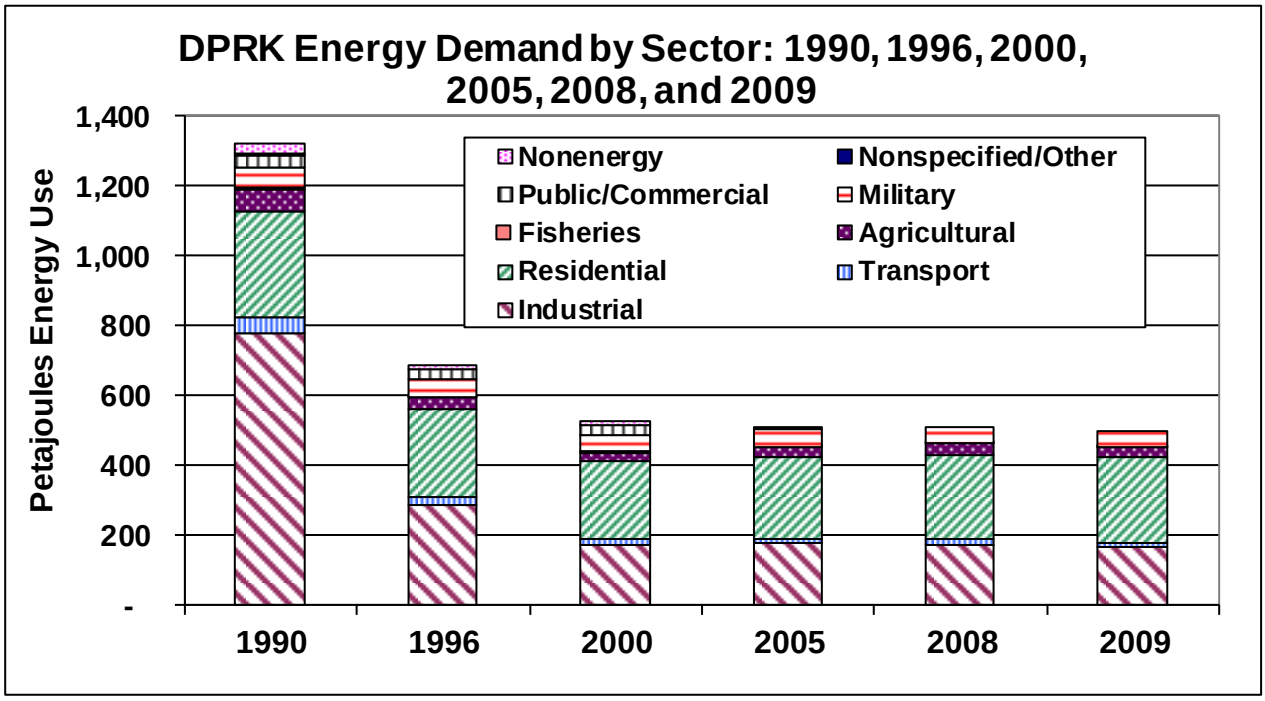
DPRK Energy Demand By Sector: 1990, 1996, 2000, 2005, 2008, and 2009

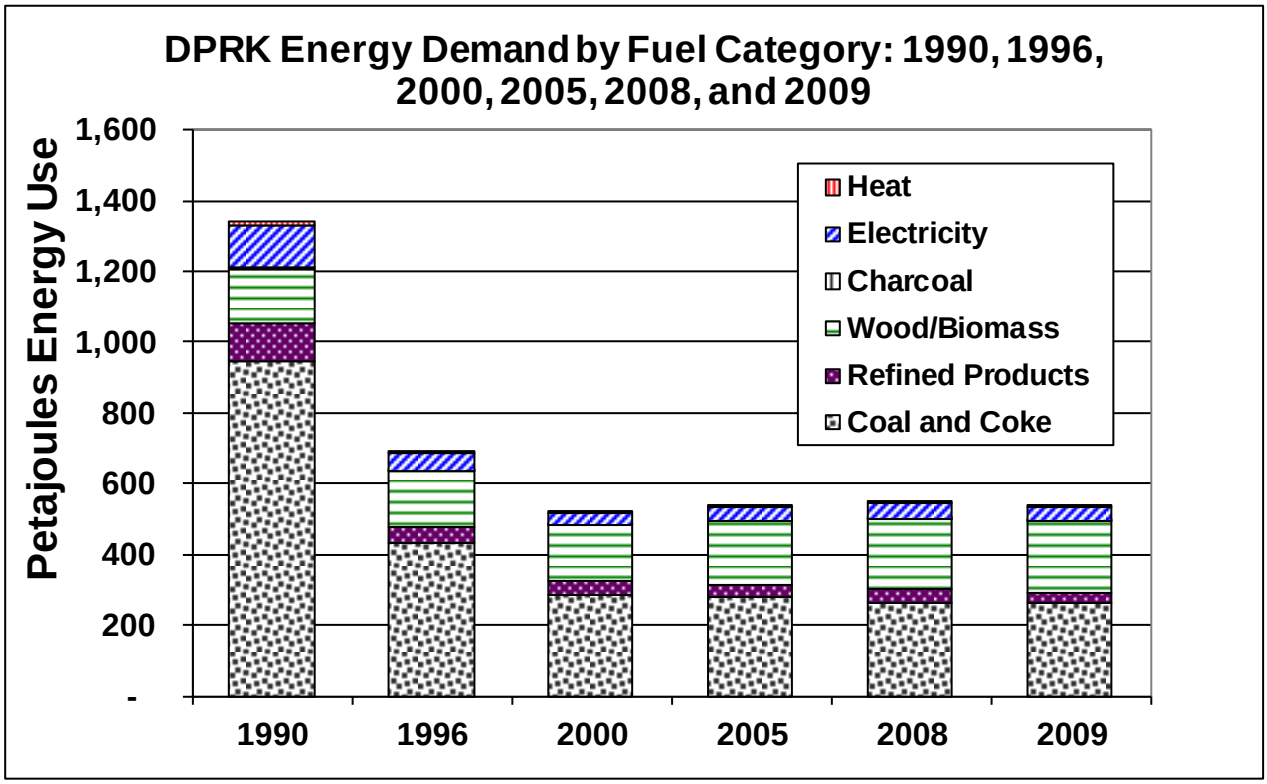
Units: Petajoules (PJ)

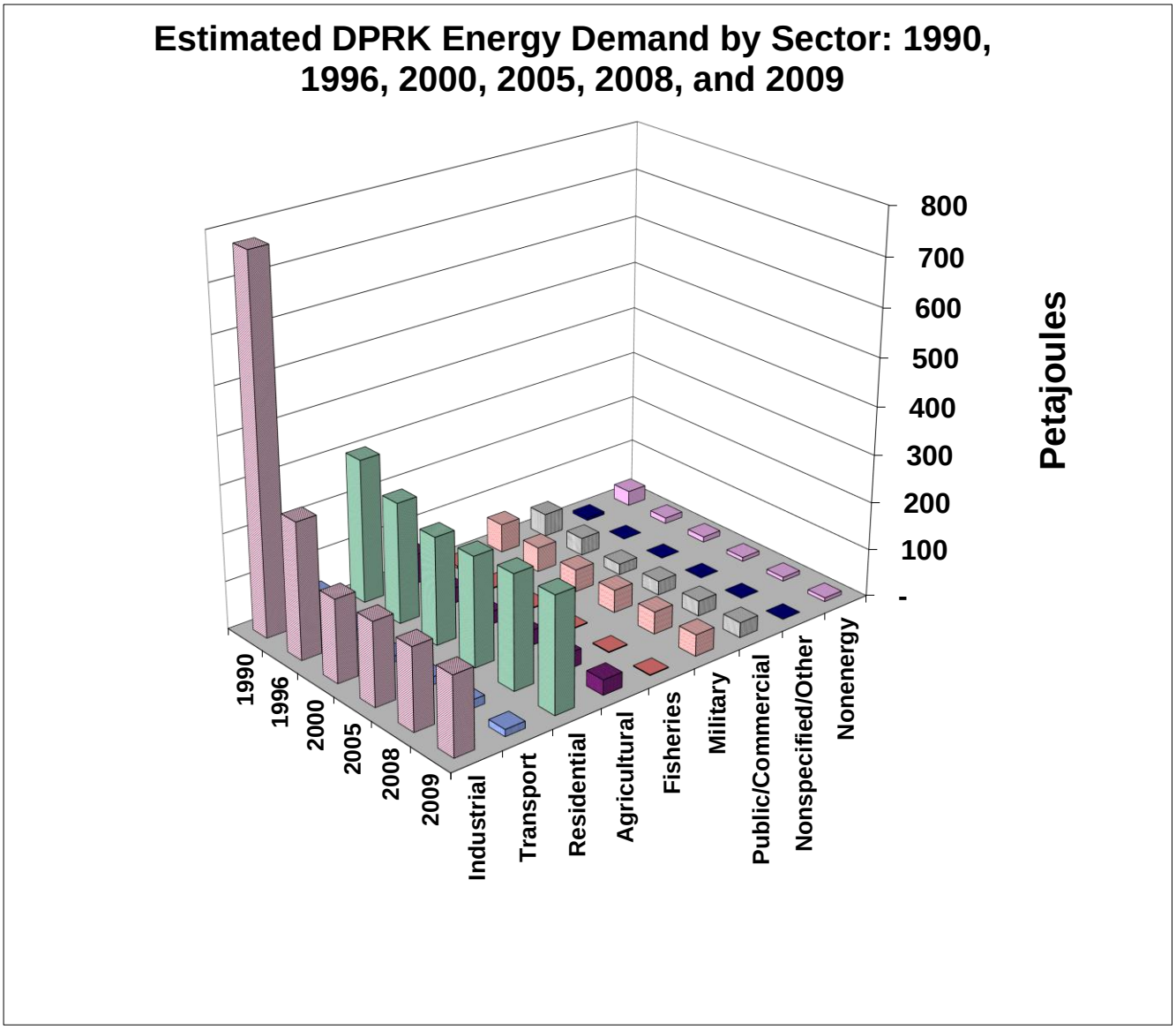
SECTOR	1990	1996	2000	2005	2008	2009
Industrial	776	285	173	175	172	165
Transport	51	22	12	16	18	15
Residential	302	253	225	230	239	242
Agricultural	62	32	26	32	33	32
Fisheries	5	2	1	2	2	1
Military	60	52	47	47	47	45
Public/Commercial	48	37	23	29	31	31
Nonspecified/Other	6	-	-	-	-	-
Nonenergy	31	12	11	8	8	8
TOTAL	**1,342**	**695**	**520**	**539**	**549**	**538**

DPRK Energy Demand By Fuel Category: 1990, 1996, 2000, 2005, 2008, and 2009
Units: Petajoules (PJ)

SECTOR	1990	1996	2000	2005	2008	2009
Coal and Coke	948	433	285	279	267	265
Refined Products	109	44	40	37	36	29
Wood/Biomass	152	159	160	180	200	201
Charcoal	3	2	2	2	2	2
Heat	9	5	3	4	4	4
Electricity	120	51	31	38	40	37
TOTAL	**1,342**	**695**	**520**	**539**	**549**	**538**


DPRK Energy Demand by Sector: 1990, 1996, 2000, 2005, 2008, and 2009
Petajoules Energy Use
1,400
1,200
1,000
800
600
400
200
-
1990
1996
2000
2005
2008
2009
Nonenergy
Nonspecified/Other
Public/Commercial
Military
Fisheries
Agricultural
Residential
Transport
Industrial


DPRK Energy Demand by Fuel Category: 1990, 1996, 2000, 2005, 2008, and 2009
Petajoules Energy Use
1,600
1,400
1,200
1,000
800
600
400
200
-
1990
1996
2000
2005
2008
2009
Heat
Electricity
Charcoal
Wood/Biomass
Refined Products
Coal and Coke


Estimated DPRK Energy Demand by Sector: 1990, 1996, 2000, 2005, 2008, and 2009
800
700
600
500
400
300
200
100
-
Petajoules
1990
1996
2000
2005
2008
2009
Industrial
Transport
Residential
Agricultural
Fisheries
Military
Public/Commercial
Nonspecified/Other
Nonenergy

Estimates of Cost and Savings of Selected Energy Efficiency Measures

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: END-USERS

Prepared By David Von Hippel
Date Last Modified: 1/4/2012

BASED ON YEAR 2009 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 2009 costs:	151%		*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	51,776	60%	31,066	
Cement	24,216	100%	24,216	
Fertilizers	1,903	100%	1,903	*1*
Other Chemicals	1,972	100%	1,972	
Pulp and Paper	709	100%	709	
Other Metals	16,177	100%	16,177	
Other Minerals	4,843	100%	4,843	
Textiles	5,818	100%	5,818	
Non-specified Industry	17,283	100%	17,283	
Agricultural Processing	4,956	100%	4,956	
Military Manufacturing	399	100%	399	

TOTAL EST COAL USE IN BOILERS AND FURNACES		109,342	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:		37.5%		*6, 19*
ESTIMATED POTENTIAL COAL SAVINGS		41,003	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces		537	Yuan/(tce/yr)	7
Per Unit Upgrade Costs, Boilers and Furnaces	$	5.82	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$	238,792,210		

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	62,349	90%	56,114	*2*
Public/Commercial	19,215	100%	19,215	
Military Buildings	18,937	100%	18,937	

TOTAL EST COAL USE IN BOILERS AND FURNACES	94,266	TJ/yr	
Fractional Savings Potential, Boilers and Furnaces:	23.0%		*8, 19*
ESTIMATED POTENTIAL COAL SAVINGS	21,681	TJ/yr	
Per Unit Upgrade Costs, Boilers and Furnaces	300	Yuan/(tce/yr)	*8*
Per Unit Upgrade Costs, Boilers and Furnaces	$ 3.25	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 70,495,862		
Fract. Savings Potent., Building Envelope Improvements:	20%		*12*
ESTIMATED POTENTIAL COAL SAVINGS	14,517	TJ/yr	
Per Unit Upgrade Costs, Building Envelope Improvements:	275	Yuan/(tce/yr)	*12*
Per Unit Upgrade Costs, Building Envelope Improvements:	$ 2.98	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 43,268,112		

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	62,349	90%	56,114
Residential/Rural	13,292	90%	11,963
Public/Commercial	19,215	100%	19,215
Military Buildings	18,937	100%	18,937

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	2,925	TJ/yr	
Potential coal savings from solar water heat, residential/rural	932	TJ/yr	
Potential coal savings from solar water heat, public/commercial	769	TJ/yr	
Potential coal savings from solar water heat, military buildings	2,651	TJ/yr	
TOTAL of above	7,277	TJ/yr	
Estimated cost per household of solar water heater	$400	per unit	
(Based roughly on 2010 costs of solar water heaters in China)			
Implied capital cost per unit energy savings, residential units (urban)	$51	per GJ/yr ($2009)	
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	$38.19	per GJ/yr ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 130,813,077		

Coal Use in Household cooking and heating stoves:

Residential/Rural Coal Use (TJ)	13,292	TJ/yr	
Residential/Urban Cooking Coal Use	6,235	TJ/yr	
TOTAL EST COAL USE IN DOMESTIC STOVES	19,527	TJ/yr	
Fractional Savings Potential, Domestic Stoves:	25.0%		*9*
ESTIMATED POTENTIAL COAL SAVINGS	4,882	TJ/yr	
Per Unit Upgrade Costs, Domestic Stoves	100	Yuan/(tce/yr)	*9*
Per Unit Upgrade Costs, Domestic Stoves	$ 1.08	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 5,291,033		

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	2,773	50%	1,387
Cement	1,485	95%	1,411
Fertilizers	1,498	50%	749
Other Chemicals	1,164	50%	582
Pulp and Paper	164	95%	156
Other Metals	2,814	20%	563
Other Minerals	227	95%	215
Textiles	494	95%	470
Non-specified Industry	3,600	80%	2,880
Agricultural Processing	846	95%	677
Military Manufacturing	21	80%	20

TOTAL EST ELECT USE, IND. MOTORS & DRIVES	9,110	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11, 19*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,367	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 58.81	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 80,361,607		

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	3,826	10%	383
Public/Commercial	7,985	30%	2,396
Military Buildings	4,828	30%	1,448

TOTAL EST ELECT USE, IND. MOTORS & DRIVES	4,226	TJ/yr	
Fractional Savings Potential, Motor Improvements	15.0%		*11*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	634	TJ/yr	
Per Unit Upgrade Costs, Electric Motors	0.10	Yuan/kWh	*11*
Per Unit Upgrade Costs, Electric Motors	$ 58.81	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 37,282,021		

Electricity Use: Lighting

Sector/Subsector	Total TJ/yr	Fraction in Lighting	Total TJ/yr Lighting
		Note 13	
Industrial (All)	14,281	5%	714
Residential/Rural	575	50%	287
Residential/Urban	3,826	50%	1,913
Public/Commercial	7,985	50%	3,993
Military Buildings	4,828	50%	2,414

TOTAL EST ELECT USE, RESIDENTIAL LIGHTING	2,200	TJ/yr	
Fractional Savings Potential, Lighting Improvements	30.0%		*14*
Fraction of households lamps already CFLs	20.0%		
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	528	TJ/yr	
Per Unit Costs: CFL Replacement of Incandescent	0.10	Yuan/kWh	*14*
Per Unit Upgrade Costs, Residential Lighting	$ 58.81	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 31,054,972		
TOTAL EST ELECT USE, NON-RESIDENTIAL LIGHTING	7,120	TJ/yr	
Fractional Savings Potential, Lighting Improvements	50.0%		*15*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	3,560	TJ/yr	
Per Unit Costs: CFL Replacement of Incandescent	0.015	Yuan/kWh	*15*
Per Unit Upgrade Costs, Non-Residential Lighting	$ 41.94	/(GJ/yr) ($2009)	
TOTAL EST. ENERGY EFFICIENCY INVESTMENT	$ 149,331,643		

Petroleum Fuel Use: Medium-Sized Trucks

Fuel Use: Civilian Transport/Freight (gasoline trucks only)	1,743	TJ/yr	
Freight transported by gasoline trucks	2.44E+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):	16,296		
Fuel Use: Military Trucks (2 1/2 tonne only)	3,737	TJ/yr	
Total number 2 1/2 tonne military trucks in active service	38,022		
Total number of 2.5 tonne trucks in service:	54,317		
Fraction of trucks to be replaced	66%		*Rough Est.*
Fraction of energy use represented by trucks replaced	90%		*Rough Est.*
Fractional energy savings by replacing trucks	43%		*16*
TOTAL ENERGY SAVED	2,140	TJ/yr	
Cost per truck to replace	$ 20,000		*17*
TOTAL COST OF NEW TRUCKS	$ 716,988,248		

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.*

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.*

12 *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).)*

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 compact fluorescent (CFL) bulbs save 75% of the energy of incandescent bulbs, and that CFLs can be used to replace incandescent bulbs for roughly 80 percent of residential incandescent bulb lighting use. Costs based on Sathaye, 1992, and are 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. Note that extensive use of CFLs will require that DPRK power grid be upgraded to reduce voltage fluctuations and improve power factors. An addendum to this 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).

15 Assumption based primarily on industrialized-country costs (as in Von Hippel and Verzola, 1994).

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 Cost of 2 1/2 tonne Isuzu truck in US was approximately $30,000 in the mid-1990s, but is likely at least double that as of 2005. Assuming that a large portion of the price is profit for the vendor, import duties, and profit for Isuzu, and further, that the cost of producing similar trucks in the DPRK (for example, under license to Isuzu) will be lower than in Japan due to lower wage rates and factor prices, we have estimated a cost per truck of $20,000 US (2005 dollars). This may still be too high, as the average value of trucks imported to the DPRK from China in 2005 was under $10,000 (though some or many of these units may have been used).

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: ELECTRICITY SUPPLY

Prepared By David Von Hippel
Date Last Modified: 1/4/2012

BASED ON YEAR 2009 ACTIVITIES

GENERAL ASSUMPTIONS/CONVERSION FACTORS			
Currency Conversion: 1990 Yuan to 1990 $US:	4.755		*Note 1*
Fraction of total investment represented by annualized CCE:	15%		*Note 2*
Inflator to convert 1990 costs to 2009 costs:	164%		*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	67,357	TJ/yr	
Fractional Savings Potential, Boilers:	30.0%		*3*
ESTIMATED POTENTIAL COAL/HFO SAVINGS	20,207	TJ/yr	
Per Unit Upgrade Costs, Boilers	537	Yuan/(tce/yr)	*3*
Per Unit Upgrade Costs, Boilers	$ 6.33	/(GJ/yr) ($2009)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Boilers	$ 127,811,722		

Own Use of electricity in Coal and HFO-Fired Power Plants	1,260	TJ/yr	
Potential reduction in "Own Use" in Coal/HFO-Fired Plants:	50.0%		*4*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	630	TJ/yr	
Per Unit Upgrade Costs, Plant Self-Use	0.12	Yuan/kWh	
Per Unit Upgrade Costs, Plant Self-Use	$ 76.64	/(GJ/yr) ($2009)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: Self Use	$ 79,164,953		

Emergency Losses of electricity in Coal/HFO-Fired Power Plant	1,210	TJ/yr	
Potential red. in Emergency Losses in Coal-Fired Plants:	90%		*6*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	1,089	TJ/yr	
Per Unit Upgrade Costs, Reduction in Emergency Losses	0.075	Yuan/kWh	*6*
Per Unit Upgrade Costs, Reduction in Emergency Losses	$ 47.90	/(GJ/yr) ($2009)	
EST. ENERGY EFFICIENCY INVESTMENT: Emer. Losses	$ 52,161,262		

Transmission and Distribution Losses of Electricity	15,020	TJ/yr	*7*
Potential reduction in Transmission and Distribution Losses:	37.5%		*5*
ESTIMATED POTENTIAL ELECTRICITY SAVINGS	5,633	TJ/yr	
Per Unit Upgrade Costs, Electricity T&D	0.075	Yuan/kWh	*5*
Per Unit Upgrade Costs, Electricity T&D	$ 47.90	/(GJ/yr) ($2009)	
ESTIMATED ENERGY EFFICIENCY INVESTMENT: T&D	$ 269,820,015		

DPRK Wind Power Resource	???	MW	
Total Wind Power Generation Implemented, 2012 to 2020	500	MW	
Capacity factor of Wind generators	25%		*7*
Energy Produced by Wind Generators (year 10)	1,095	GWhe/yr	
Energy Produced by Wind Generators (year 10)	3,942	TJ/yr	
Installed Capital Cost of Wind Generators (per unit capacity)	$ 1,500	per kW	*8*
Variable Operations and Maintenance Costs	$ 0.016	per KWhe	*9*
Total Capital Costs of installed Wind Generators	$ 750,000,000		
Capital Costs, Wind Power, per unit output	$ 190	/(GJ/yr) ($2009)	
Total of Other Generation Costs (year 10)	$ 17,958,000	per yr ($2009)	

Sources/Notes:

1 *1990 Value from Microsoft Encarta, 1994.*

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.*

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.*

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.

9 *Rough estimate. Source above shows recent O&M costs in the US of about $10/MWhe, but for larger wind turbines than would likely be installed in the US. Still, though 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.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
BACK-UP CALCULATIONS AND DATA:
POTENTIAL ENERGY EFFICIENCY IMPROVEMENTS: SUMMARY

Prepared By David Von Hippel
Date Last Modified: 1/4/2012

BASED ON YEAR 2009 ACTIVITIES

Inflator for 2009 to 2009 (*Note 1*):	1.000

MEASURES TO SAVE COAL:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2009
Industrial Boiler and Furnace Improvements	41,003		$ 238,792,210
Residential and Public/Commercial/Military Boiler Impr.	21,681		$ 70,495,862
Building Envelope Improvements	14,517		$ 43,268,112
Solar Water Heating	7,277		$ 130,813,077
Domestic Stove/Heater Improvements	4,882		$ 5,291,033
Electric Utility Boiler Improvements	20,207		$ 127,811,722
TOTALS	109,567	TJ/yr	$ 616,472,016
Avoided Losses of Coal During Transport:	1,096	TJ/yr	
TOTAL COAL SUPPLY SAVINGS	110,663	TJ/yr	
Fraction of 2009 Total Coal Supply	31.1%		
Investment required, $ per GJ/yr of Coal Supply Savings			**$ 5.57**
Investment required, $ per tce/yr of Coal Supply Savings			**$ 163**

MEASURES TO SAVE/GENERATE ELECTRICITY:

Measure	Estimated Energy Energy Savings Potential, TJ/yr		Total Estimated Investment Cost, $US 2009
Industrial Motors and Drives	1,367		$ 80,361,607
Motors and Drives in other Sectors	634		$ 37,282,021
Residential Lighting	528		$ 31,054,972
Non-residential Lighting	3,560		$ 149,331,643
Own Use reduction in Power Plants	630		$ 79,164,953
Reduction of Emergency Use in Power Plants	1,089		$ 52,161,262
Transmission and Distribution Improvements	5,633		$ 269,820,015
Wind-powered Electricity Generation	3,942		$ 750,000,000
TOTALS	17,382	TJ/yr	$ 1,449,176,474
Additional Avoided T&D Losses (based on 2009 Rates)	1,688	TJ/yr	
TOTAL ELECTRICITY SUPPLY SAVINGS/GENERATION	19,070	TJ/yr	
Fraction of 2005 Total Electricity Generation	33.6%		
Investment required, $ per GJ/yr of Electricity Supply Savings/Generation			**$ 75.99**
Investment required, $ per MWh/yr of Electricity Supply Savings/Generation			**$ 274**

MEASURE TO SAVE PETROLEUM PRODUCTS:

Measure	Estimated Energy Energy Savings Potential, TJ/yr	Total Estimated Investment Cost, $US 2009
Improvements in 2 1/2 tonne truck fleet	2,140	716,988,248
Fraction of 2009 Total Refined Products Use	7.4%	
Fract. of 2009 Total Refined Prod. Use in Road Transport	26.4%	
Investment required, $ per GJ/yr of refined products Savings		**$ 335.10**
Investment required, $ per toe/yr of petroleum products Savings		**$ 14,021**

ESTIMATED EMISSIONS REDUCTION (Rough Calculations)

	Sulfur Oxides (tonnes)	Nitrogen Oxides (tonnes)	Carbon Dioxide (tonnes)
MEASURES TO SAVE COAL	50,410	31,403	7,890,272
MEASURES TO SAVE ELECTRICITY	13,257	8,379	2,120,241

Estimates of Acid Gas and Greenhouse Gas Emissions

NAUTILUS INSTITUTE

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)

2010/2011 UPDATE

ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 1990

Prepared By David Von Hippel
Date Last Modified: 1/20/2012

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	2.15E+02	1.92E+02	2.31E+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**

NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 1996

Prepared By David Von Hippel
Date Last Modified: 1/20/2012

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.90	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	0.379	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	**6.44E+07**	**5.29E+06**	**0.00E+00**	**0.00E+00**	**6.97E+07**
Methane from Combustion	**1.14E+03**	**7.06E+02**	**2.41E+03**	**4.43E+00**	**4.27E+03**
Methane from Production	**3.72E+05**	**0.00E+00**	**0.00E+00**	**1.99E+02**	**3.72E+05**
Nitrous Oxide from Combustion	**3.03E+03**	**2.47E+02**	**1.06E+03**	**5.54E+01**	**4.39E+03**
Sulfur Oxides from Combustion	**4.11E+05**	**2.32E+04**	**0.00E+00**	**0.00E+00**	**4.34E+05**
Nitrogen Oxides from Combustion	**2.56E+05**	**1.69E+04**	**1.83E+04**	**9.58E+02**	**2.92E+05**

Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**6.97E+07**	**3.76E+05**	**4.39E+03**	**4.34E+05**	**2.92E+05**
ENERGY SUPPLY	0.00E+00	3.72E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	3.65E+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	6.40E+03	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	2.52E+07	8.92E+02	1.23E+03	1.59E+05	9.98E+04
Electricity Generation	2.17E+07	6.08E+02	1.02E+03	1.37E+05	8.51E+04
Coal Prod./Prep.	3.12E+06	5.57E+01	1.47E+02	2.00E+04	1.25E+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	4.45E+07	3.58E+03	3.16E+03	2.75E+05	1.92E+05
INDUSTRIAL	2.45E+07	5.22E+02	1.16E+03	1.56E+05	9.75E+04
TRANSPORT	1.21E+06	1.79E+02	6.36E+01	4.94E+03	4.05E+03
RESIDENTIAL	1.17E+07	2.11E+03	1.39E+03	7.49E+04	6.13E+04
AGRICULTURAL	6.01E+05	4.04E+02	1.95E+02	3.60E+03	5.20E+03
FISHERIES	1.21E+05	1.08E+01	5.78E+00	6.10E+02	4.32E+02
MILITARY	3.38E+06	2.62E+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	4.27E+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	788	0.96	756	1.5
Kerosene/Jet Fuel	51	1.045	53	0.032
LPG	87	1.13	98	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				**0.379**

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DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2000

Prepared By David Von Hippel
Date Last Modified: **1/20/2012**

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.69	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	0.387	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	**3.18E+07**	**4.00E+06**	**0.00E+00**	**0.00E+00**	**3.58E+07**
Methane from Combustion	**5.65E+02**	**5.37E+02**	**2.45E+03**	**3.39E+00**	**3.55E+03**
Methane from Production	**1.85E+05**	**0.00E+00**	**0.00E+00**	**1.53E+02**	**1.85E+05**
Nitrous Oxide from Combustion	**1.50E+03**	**1.88E+02**	**1.07E+03**	**4.24E+01**	**2.80E+03**
Sulfur Oxides from Combustion	**2.03E+05**	**1.76E+04**	**0.00E+00**	**0.00E+00**	**2.21E+05**
Nitrogen Oxides from Combustion	**1.27E+05**	**1.28E+04**	**1.85E+04**	**7.33E+02**	**1.59E+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**	**2.80E+03**	**2.21E+05**	**1.59E+05**
ENERGY SUPPLY	0.00E+00	1.85E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	1.80E+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	4.15E+02	3.11E+02	3.64E+04	2.32E+04
Electricity Generation	4.21E+06	2.19E+02	1.99E+02	2.55E+04	1.59E+04
Coal Prod./Prep.	1.54E+06	2.74E+01	7.25E+01	9.84E+03	6.13E+03
Charcoal Production	0.00E+00	1.53E+02	2.97E+01	0.00E+00	5.13E+02
District Heat Production	1.23E+05	5.68E+00	5.81E+00	7.52E+02	4.68E+02
Own Use	7.72E+04	1.06E+01	3.70E+00	3.16E+02	2.52E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.99E+07	3.29E+03	2.49E+03	1.84E+05	1.35E+05
INDUSTRIAL	1.50E+07	3.74E+02	7.09E+02	9.39E+04	5.91E+04
TRANSPORT	6.33E+05	9.47E+01	3.39E+01	2.59E+03	2.13E+03
RESIDENTIAL	9.22E+06	2.13E+03	1.30E+03	5.87E+04	5.16E+04
AGRICULTURAL	4.58E+05	3.38E+02	1.61E+02	2.72E+03	4.18E+03
FISHERIES	1.01E+05	9.00E+00	4.80E+00	5.06E+02	3.59E+02
MILITARY	2.83E+06	2.63E+02	1.86E+02	1.63E+04	1.16E+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

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ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	196	1.07	209	0.12
Diesel	283	1.035	293	0.4
Heavy Oil	646	0.96	620	1.5
Kerosene/Jet Fuel	40	1.045	42	0.032
LPG	148	1.13	167	0.00016
Aviation Gasoline	16	1.07	17	0.04
Weighted Average: Sulfur content in kg/GJ				**0.193**
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				**0.387**

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2010/2011 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2005

Prepared By David Von Hippel
Date Last Modified: **1/20/2012**

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.62	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	0.308	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**	**3.44E+06**	**0.00E+00**	**0.00E+00**	**4.02E+07**
Methane from Combustion	**6.54E+02**	**4.63E+02**	**2.77E+03**	**3.43E+00**	**3.89E+03**
Methane from Production	**2.75E+05**	**0.00E+00**	**0.00E+00**	**1.54E+02**	**2.75E+05**
Nitrous Oxide from Combustion	**1.73E+03**	**1.62E+02**	**1.21E+03**	**4.28E+01**	**3.15E+03**
Sulfur Oxides from Combustion	**2.35E+05**	**1.39E+04**	**0.00E+00**	**0.00E+00**	**2.49E+05**
Nitrogen Oxides from Combustion	**1.46E+05**	**1.11E+04**	**2.09E+04**	**7.41E+02**	**1.79E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**4.02E+07**	**2.79E+05**	**3.15E+03**	**2.49E+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	2.33E+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	4.27E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.09E+07	4.37E+02	5.46E+02	6.83E+04	4.35E+04
Electricity Generation	8.64E+06	2.30E+02	4.08E+02	5.39E+04	3.40E+04
Coal Prod./Prep.	1.99E+06	3.55E+01	9.39E+01	1.27E+04	7.94E+03
Charcoal Production	0.00E+00	1.54E+02	3.00E+01	0.00E+00	5.18E+02
District Heat Production	1.86E+05	4.00E+00	8.79E+00	1.18E+03	7.39E+02
Own Use	1.01E+05	1.38E+01	4.83E+00	4.13E+02	3.30E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.93E+07	3.60E+03	2.60E+03	1.80E+05	1.35E+05
INDUSTRIAL	1.50E+07	3.44E+02	7.08E+02	9.44E+04	5.93E+04
TRANSPORT	8.67E+05	1.33E+02	4.77E+01	3.55E+03	2.94E+03
RESIDENTIAL	8.25E+06	2.32E+03	1.34E+03	5.25E+04	4.93E+04
AGRICULTURAL	5.69E+05	4.07E+02	1.95E+02	3.42E+03	5.11E+03
FISHERIES	1.11E+05	1.00E+01	5.27E+00	5.53E+02	3.93E+02
MILITARY	2.69E+06	2.71E+02	1.83E+02	1.53E+04	1.11E+04
PUBLIC/COMML	1.67E+06	1.15E+02	1.16E+02	1.07E+04	7.30E+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:

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ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

Product	kTOE	TE/TOE	kTE	%S
Gasoline	170	1.07	182	0.12
Diesel	386	1.035	400	0.4
Heavy Oil	334	0.96	321	1.5
Kerosene/Jet Fuel	72	1.045	75	0.032
LPG	60	1.13	68	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.154**
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				**0.308**

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DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2010/2011 UPDATE
ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2008

Prepared By David Von Hippel
Date Last Modified: **1/20/2012**

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	73.62	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	0.308	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	**3.48E+07**	**3.85E+06**	**0.00E+00**	**0.00E+00**	**3.87E+07**
Methane from Combustion	**6.18E+02**	**5.20E+02**	**3.09E+03**	**3.29E+00**	**4.23E+03**
Methane from Production	**2.62E+05**	**0.00E+00**	**0.00E+00**	**1.48E+02**	**2.62E+05**
Nitrous Oxide from Combustion	**1.64E+03**	**1.82E+02**	**1.35E+03**	**4.11E+01**	**3.21E+03**
Sulfur Oxides from Combustion	**2.22E+05**	**1.57E+04**	**0.00E+00**	**0.00E+00**	**2.38E+05**
Nitrogen Oxides from Combustion	**1.38E+05**	**1.24E+04**	**2.34E+04**	**7.11E+02**	**1.75E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.87E+07**	**2.66E+05**	**3.21E+03**	**2.38E+05**	**1.75E+05**
ENERGY SUPPLY	0.00E+00	2.62E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.27E+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	3.52E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	1.06E+07	4.85E+02	5.28E+02	6.49E+04	4.17E+04
Electricity Generation	8.37E+06	2.84E+02	3.95E+02	5.11E+04	3.25E+04
Coal Prod./Prep.	1.94E+06	3.46E+01	9.15E+01	1.24E+04	7.73E+03
Charcoal Production	0.00E+00	1.48E+02	2.88E+01	0.00E+00	4.97E+02
District Heat Production	1.64E+05	5.01E+00	7.74E+00	1.01E+03	6.41E+02
Own Use	1.02E+05	1.39E+01	4.88E+00	4.17E+02	3.33E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.81E+07	3.89E+03	2.68E+03	1.73E+05	1.33E+05
INDUSTRIAL	1.46E+07	3.30E+02	6.93E+02	9.25E+04	5.80E+04
TRANSPORT	9.20E+05	1.40E+02	5.04E+01	3.77E+03	3.12E+03
RESIDENTIAL	7.24E+06	2.60E+03	1.43E+03	4.60E+04	4.75E+04
AGRICULTURAL	5.82E+05	4.23E+02	2.03E+02	3.52E+03	5.30E+03
FISHERIES	1.11E+05	9.98E+00	5.26E+00	5.52E+02	3.93E+02
MILITARY	2.62E+06	2.62E+02	1.79E+02	1.50E+04	1.09E+04
PUBLIC/COMML	1.80E+06	1.24E+02	1.24E+02	1.15E+04	7.83E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NON-ENERGY	1.89E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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ESTIMATE OF SOx EMISSION FACTOR FOR REFINED PRODUCTS

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Gasoline	170	1.07	182	0.12
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Heavy Oil	334	0.96	321	1.5
Kerosene/Jet Fuel	72	1.045	75	0.032
LPG	60	1.13	68	0.00016
Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.154**
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				**0.308**

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ESTIMATED GHG AND ACID GAS EMISSIONS FROM FUELS PRODUCTION AND COMBUSTION FOR THE YEAR 2009

Prepared By David Von Hippel
Date Last Modified: 1/20/2012

EMISSION FACTORS: kg/GJ fuel combustion/production

GHG/POLLUTANT	COAL & COKE	REFINED PROD.	WOOD/ BIOMASS	CHAR-COAL	*Notes*
Carbon Dioxide from Combustion	95.3	72.87	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	**3.34E+07**	**2.53E+06**	**0.00E+00**	**0.00E+00**	**3.60E+07**
Methane from Combustion	**5.94E+02**	**3.41E+02**	**3.11E+03**	**3.34E+00**	**4.05E+03**
Methane from Production	**2.88E+05**	**0.00E+00**	**0.00E+00**	**1.50E+02**	**2.88E+05**
Nitrous Oxide from Combustion	**1.57E+03**	**1.19E+02**	**1.36E+03**	**4.18E+01**	**3.10E+03**
Sulfur Oxides from Combustion	**2.14E+05**	**1.00E+04**	**0.00E+00**	**0.00E+00**	**2.24E+05**
Nitrogen Oxides from Combustion	**1.33E+05**	**8.15E+03**	**2.35E+04**	**7.23E+02**	**1.65E+05**

SUMMARY EMISSIONS RESULTS: Tonnes of Emissions by Balance Category

	CARBON DIOXIDE	METHANE	NITROUS OXIDE	SULFUR OXIDES	NITROGEN OXIDES
TOTAL	**3.60E+07**	**2.92E+05**	**3.10E+03**	**2.24E+05**	**1.65E+05**
ENERGY SUPPLY	0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00
Domestic Production	0.00E+00	2.38E+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	4.99E+04	0.00E+00	0.00E+00	0.00E+00
ENERGY TRANSF.	8.62E+06	3.58E+02	4.36E+02	5.40E+04	3.46E+04
Electricity Generation	6.31E+06	1.54E+02	2.98E+02	3.95E+04	2.49E+04
Coal Prod./Prep.	2.03E+06	3.63E+01	9.60E+01	1.30E+04	8.12E+03
Charcoal Production	0.00E+00	1.50E+02	2.93E+01	0.00E+00	5.06E+02
District Heat Production	1.68E+05	3.35E+00	7.94E+00	1.07E+03	6.69E+02
Own Use	1.00E+05	1.37E+01	4.80E+00	4.10E+02	3.28E+02
Losses	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENERGY DEMAND	2.73E+07	3.84E+03	2.66E+03	1.70E+05	1.31E+05
INDUSTRIAL	1.41E+07	2.98E+02	6.69E+02	8.97E+04	5.62E+04
TRANSPORT	7.08E+05	1.07E+02	3.83E+01	2.90E+03	2.39E+03
RESIDENTIAL	7.34E+06	2.64E+03	1.45E+03	4.67E+04	4.83E+04
AGRICULTURAL	5.57E+05	4.07E+02	1.96E+02	3.37E+03	5.09E+03
FISHERIES	9.77E+04	8.88E+00	4.65E+00	4.87E+02	3.47E+02
MILITARY	2.55E+06	2.52E+02	1.76E+02	1.48E+04	1.06E+04
PUBLIC/COMML	1.83E+06	1.27E+02	1.26E+02	1.17E+04	7.98E+03
NON-SPECIFIED	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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Aviation Gasoline	11	1.07	12	0.04
Weighted Average: Sulfur content in kg/GJ				**0.132**
Fraction of Sulfur emitted as SO_x				100%
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PRODUCTION AND COMBUSTION FOR THE YEARS 1996, 2000, 2005, 2008, and 2009

Estimate of Sulfur Oxide Emissions, Thousand Tonnes of Sulfur Dioxide

	YEAR					
Source of Emissions	**1990***	**1996**	**2000**	**2005**	**2008**	**2009**
Electricity Generation	186.7	136.5	25.5	53.9	51.1	39.5
District Heat Production	2.1	1.6	0.8	1.2	1.0	1.1
Coal Production/Preparation	38.5	20.0	9.8	12.7	12.4	13.0
Own Use	1.8	0.7	0.3	0.4	0.4	0.4
Industrial Sector	418.8	155.6	93.9	94.4	92.5	89.7
Transport Sector	11.3	4.9	2.6	3.5	3.8	2.9
Residential Sector	117.6	74.9	58.7	52.5	46.0	46.7
Agricultural Sector	7.5	3.6	2.7	3.4	3.5	3.4
Fisheries Sector	1.6	0.6	0.5	0.6	0.6	0.5
Military Sector	23.1	19.4	16.3	15.3	15.0	14.8
Public/Commercial	20.0	16.0	9.6	10.7	11.5	11.7
TOTAL*	830.8	433.9	220.7	248.8	237.7	223.6

* 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**
Electricity Generation	117.5	85.1	15.9	34.0	32.5	24.9
District Heat Production	1.3	1.0	0.5	0.7	0.6	0.7
Coal Production/Preparation	24.0	12.5	6.1	7.9	7.7	8.1
Own Use	1.4	0.5	0.3	0.3	0.3	0.3
Charcoal Production	0.8	0.7	0.5	0.5	0.5	0.5
Industrial Sector	262.6	97.5	59.1	59.3	58.0	56.2
Transport Sector	9.3	4.0	2.1	2.9	3.1	2.4
Residential Sector	84.4	61.3	51.6	49.3	47.5	48.3
Agricultural Sector	10.3	5.2	4.2	5.1	5.3	5.1
Fisheries Sector	1.2	0.4	0.4	0.4	0.4	0.3
Military Sector	15.3	13.5	11.6	11.1	10.9	10.6
Public/Commercial	12.6	10.3	6.3	7.3	7.8	8.0
TOTAL*	542.1	292.0	158.6	179.0	174.8	165.4

* 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**
Electricity Generation	29.7	21.7	4.2	8.6	8.4	6.3
District Heat Production	0.3	0.2	0.1	0.2	0.2	0.2
Coal Production/Preparation	6.0	3.1	1.5	2.0	1.9	2.0
Own Use	0.4	0.2	0.1	0.1	0.1	0.1
Industrial Sector	66.1	24.5	15.0	15.0	14.6	14.1
Transport Sector	2.8	1.2	0.6	0.9	0.9	0.7
Residential Sector	18.5	11.7	9.2	8.3	7.2	7.3
Agricultural Sector	1.3	0.6	0.5	0.6	0.6	0.6
Fisheries Sector	0.3	0.1	0.1	0.1	0.1	0.1
Military Sector	4.0	3.4	2.8	2.7	2.6	2.5
Public/Commercial	3.1	2.5	1.5	1.7	1.8	1.8
Non-Energy	1.7	0.4	0.2	0.2	0.2	0.1
TOTAL*	134.9	69.7	35.8	40.2	38.7	36.0

* 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**
Electricity Generation	0.7	0.6	0.2	0.2	0.3	0.2
District Heat Production	0.0	0.0	0.0	0.0	0.0	0.0
Coal Production/Preparation	718.3	371.9	184.7	275.3	261.8	287.9
Own Use	0.1	0.0	0.0	0.0	0.0	0.0
Charcoal Production	0.2	0.2	0.2	0.2	0.1	0.2
Industrial Sector	1.5	0.5	0.4	0.3	0.3	0.3
Transport Sector	0.4	0.2	0.1	0.1	0.1	0.1
Residential Sector	1.8	2.1	2.1	2.3	2.6	2.6
Agricultural Sector	0.8	0.4	0.3	0.4	0.4	0.4
Fisheries Sector	0.0	0.0	0.0	0.0	0.0	0.0
Military Sector	0.2	0.3	0.3	0.3	0.3	0.3
Public/Commercial	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL*	724.1	376.3	188.3	279.3	266.2	292.0

* 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**
Electricity Generation	1.40	1.02	0.20	0.41	0.40	0.30
District Heat Production	0.02	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
Own Use	0.02	0.01	0.00	0.00	0.00	0.00
Charcoal Production	0.05	0.04	0.03	0.03	0.03	0.03
Industrial Sector	3.13	1.16	0.71	0.71	0.69	0.67
Transport Sector	0.14	0.06	0.03	0.05	0.05	0.04
Residential Sector	1.50	1.39	1.30	1.34	1.43	1.45
Agricultural Sector	0.38	0.19	0.16	0.20	0.20	0.20
Fisheries Sector	0.02	0.01	0.00	0.01	0.01	0.00
Military Sector	0.19	0.20	0.19	0.18	0.18	0.18
Public/Commercial	0.16	0.14	0.09	0.12	0.12	0.13
TOTAL*	7.31	4.39	2.80	3.15	3.21	3.10

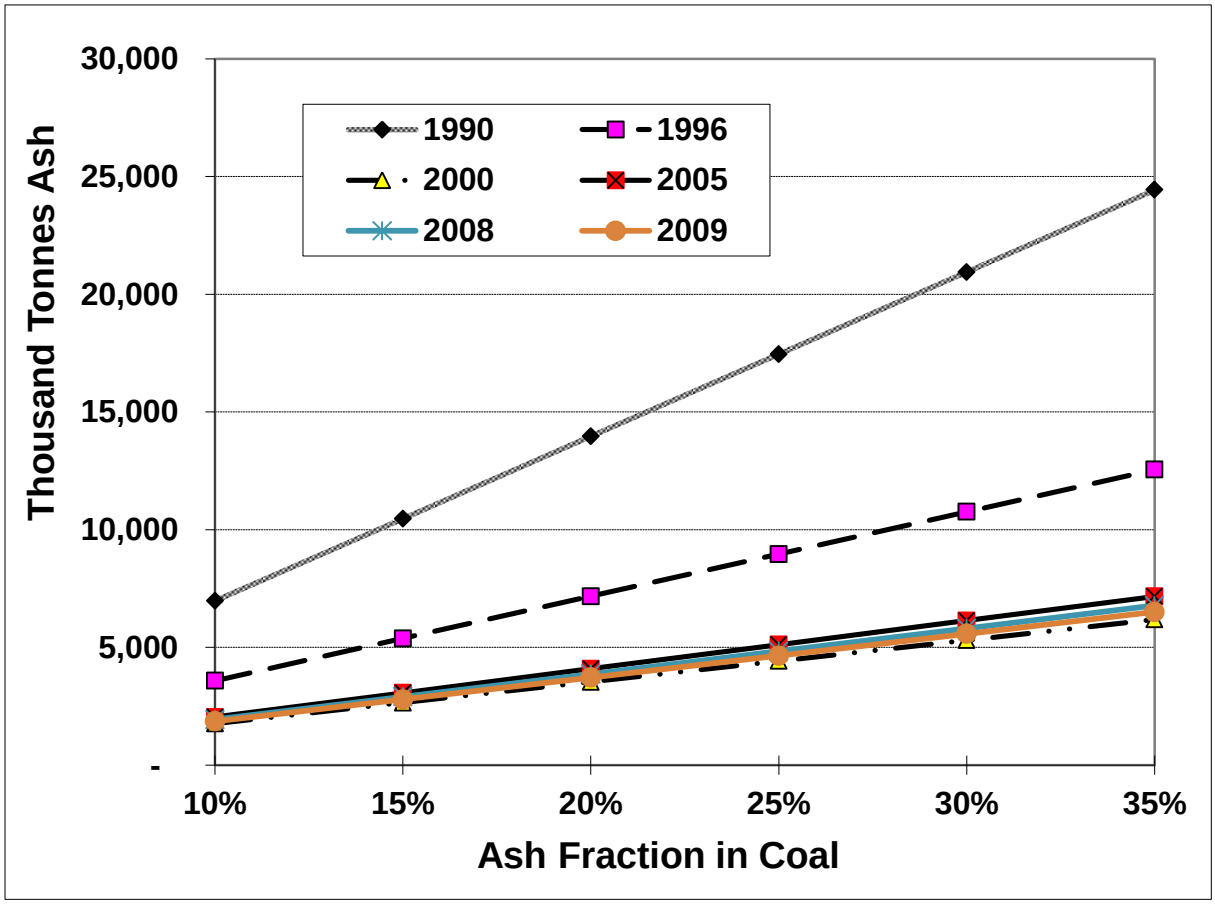
* Value for 1990 includes emissions from non-specified consumption at 0.02 thousand tonnes.

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**
Electricity Generation	3,200	2,207	333	891	805	664
District Heat Production	36	26	10	20	16	18
Coal Production/Preparation	670	348	171	222	216	227
Industrial Sector	7,135	2,661	1,571	1,599	1,569	1,535
Residential Sector	2,011	1,293	1,010	902	789	804
Agricultural Sector	104	55	41	52	55	53
Military Sector	317	269	226	208	208	208
Public/Commercial	347	278	166	185	198	201
Non-Energy	146	36	11	16	16	11
TOTAL	13,965	7,174	3,539	4,096	3,873	3,720
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
	13,965	**7,174**	**3,539**	**4,096**	**3,873**	**3,720**
10%	6,982	3,587	1,769	2,048	1,936	1,860
15%	10,474	5,380	2,654	3,072	2,905	2,790
20%	13,965	7,174	3,539	4,096	3,873	3,720
25%	17,456	8,967	4,424	5,120	4,841	4,650
30%	20,947	10,761	5,308	6,143	5,809	5,580
35%	24,438	12,554	6,193	7,167	6,777	6,511



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	434	292	70
2000	221	159	36
2005	249	179	40
2008	238	175	39
2009	224	165	36

SUMMARY OF SO_x and NO_x Emissions, 1990, 1996, 2000, 2005, 2008, and 2009

Units: Thousand Tonnes	SULFUR OXIDES						NITROGEN OXIDES					
	1990	1996	2000	2005	2008	2009	1990	1996	2000	2005	2008	2009
TOTAL	**830.8**	**433.9**	**220.7**	**248.8**	**237.7**	**223.6**	**542.1**	**292.0**	**158.6**	**179.0**	**174.8**	**165.4**
ENERGY TRANSFORMATION	229.1	158.8	36.4	68.3	64.9	54.0	145.1	99.8	23.2	43.5	41.7	34.6
Electricity Generation	186.7	136.5	25.5	53.9	51.1	39.5	117.5	85.1	15.9	34.0	32.5	24.9
District Heat Production	2.1	1.6	0.8	1.2	1.0	1.1	1.3	1.0	0.5	0.7	0.6	0.7
Coal Production/Preparation	38.5	20.0	9.8	12.7	12.4	13.0	24.0	12.5	6.1	7.9	7.7	8.1
Own Use	1.8	0.7	0.3	0.4	0.4	0.4	1.4	0.5	0.3	0.3	0.3	0.3
Charcoal Production	-	-	-	-	-	-	0.8	0.7	0.5	0.5	0.5	0.5
ENERGY DEMAND	601.6	275.1	184.2	180.5	172.8	169.6	397.1	192.2	135.4	-	-	-
INDUSTRIAL	418.8	155.6	93.9	94.4	92.5	89.7	262.6	97.5	59.1	59.3	58.0	56.2
TRANSPORT	11.3	4.9	2.6	3.5	3.8	2.9	9.3	4.0	2.1	2.9	3.1	2.4
RESIDENTIAL	117.6	74.9	58.7	52.5	46.0	46.7	84.4	61.3	51.6	49.3	47.5	48.3
AGRICULTURAL	7.5	3.6	2.7	3.4	3.5	3.4	10.3	5.2	4.2	5.1	5.3	5.1
FISHERIES	1.6	0.6	0.5	0.6	0.6	0.5	1.2	0.4	0.4	0.4	0.4	0.3
MILITARY	23.1	19.4	16.3	15.3	15.0	14.8	15.3	13.5	11.6	11.1	10.9	10.6
PUBLIC/COMML	20.0	16.0	9.6	10.7	11.5	11.7	12.6	10.3	6.3	7.3	7.8	8.0
NON-SPECIFIED	1.8	-	-	-	-	-	1.4	-	-	-	-	-

SUMMARY OF GHG Emissions, 1990, 1996, 2000, 2005, 2008, and 2009

Units: Thousand Tonnes	CARBON DIOXIDE						METHANE					
	1990	1996	2000	2005	2008	2009	1990	1996	2000	2005	2008	2009
TOTAL	134,869	69,719	35,796	40,236	38,655	35,955	724.09	376.30	188.33	279.30	266.18	292.04
ENERGY TRANSFORMATION	36,502	25,223	5,941	10,916	10,569	8,616	1.14	0.89	0.42	0.44	0.49	0.36
Electricity Generation	29,720	21,686	4,205	8,641	8,366	6,313	0.72	0.61	0.22	0.23	0.28	0.15
District Heat Production	331	247	123	186	164	168	0.01	0.01	0.01	0.00	0.01	0.00
Coal Production/Preparation	6,015	3,124	1,536	1,989	1,938	2,035	718.25	371.89	184.65	275.29	261.83	287.88
Own Use	436	166	77	101	102	100	0.06	0.02	0.01	0.01	0.01	0.01
Charcoal Production	-	-	-	-	-	-	0.25	0.20	0.15	0.15	0.15	0.15
ENERGY DEMAND	98,367	44,495	29,855	29,319	28,086	27,338	4.81	3.58	3.29	3.60	3.89	3.84
INDUSTRIAL	66,113	24,519	14,960	14,960	14,633	14,129	1.45	0.52	0.37	0.34	0.33	0.30
TRANSPORT	2,770	1,208	633	867	920	708	0.41	0.18	0.09	0.13	0.14	0.11
RESIDENTIAL	18,526	11,736	9,223	8,255	7,236	7,337	1.77	2.11	2.13	2.32	2.60	2.64
AGRICULTURAL	1,295	601	458	569	582	557	0.79	0.40	0.34	0.41	0.42	0.41
FISHERIES	337	121	101	111	111	98	0.03	0.01	0.01	0.01	0.01	0.01
MILITARY	4,045	3,377	2,828	2,690	2,619	2,547	0.22	0.26	0.26	0.27	0.26	0.25
PUBLIC/COMML	3,119	2,505	1,496	1,674	1,796	1,832	0.08	0.09	0.08	0.11	0.12	0.13
NON-SPECIFIED	435	-	-	-	-	-	0.06	-	-	-	-	-

Units: Thousand Tonnes	NITROUS OXIDE					
	1990	1996	2000	2005	2008	2009
TOTAL	7.31	4.39	2.80	3.15	3.21	3.10
ENERGY TRANSFORMATION	1.77	1.23	0.31	0.55	0.53	0.44
Electricity Generation	1.40	1.02	0.20	0.41	0.40	0.30
District Heat Production	0.02	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
Own Use	0.02	0.01	0.00	0.00	0.00	0.00
Charcoal Production	0.05	0.04	0.03	0.03	0.03	0.03
ENERGY DEMAND	5.54	3.16	2.49	2.60	2.68	2.66
INDUSTRIAL	3.13	1.16	0.71	0.71	0.69	0.67
TRANSPORT	0.14	0.06	0.03	0.05	0.05	0.04
RESIDENTIAL	1.50	1.39	1.30	1.34	1.43	1.45
AGRICULTURAL	0.38	0.19	0.16	0.20	0.20	0.20
FISHERIES	0.02	0.01	0.00	0.01	0.01	0.00
MILITARY	0.19	0.20	0.19	0.18	0.18	0.18
PUBLIC/COMML	0.16	0.14	0.09	0.12	0.12	0.13
NON-SPECIFIED	0.02	-	-	-	-	-

Estimates of DPRK Air Pollutant Emissions in 2009, Thousand Tonnes

Source of Emissions	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	Methane	Nitrous Oxide
Electricity Generation	39.5	24.9	6,313	0.15	0.30
District Heat Production	1.1	0.7	168	0.00	0.01
Coal Production/Preparation	13.0	8.1	2,035	287.88	0.10
Own Use	0.4	0.3	100	0.01	0.00
Charcoal Production	-	0.5	-	0.2	0.03
Industrial Sector	89.7	56.2	14,129	0.3	0.67
Transport Sector	2.9	2.4	708	0.1	0.04
Residential Sector	46.7	48.3	7,337	2.6	1.45
Agricultural Sector	3.4	5.1	557	0.4	0.20
Fisheries Sector	0.5	0.3	98	0.0	0.00
Military Sector	14.8	10.6	2,547	0.3	0.18
Public/Commercial	11.7	8.0	1,832	0.1	0.13
TOTAL	**223.6**	**165.4**	**35,824**	**292.0**	**3.10**

ATTACHMENT 2

WORKPAPERS AND DETAILED RESULTS:

ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK: UPDATE THROUGH THE YEAR 2009

ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK UPDATE 2010

SUMMARY: FUEL USE IN EQUIPMENT AND MILITARY MANUFACTURING, 1990, 1996, 2000, 2005, 2008, AND 2009

		1990			1996	2000	2005	2008	2009
MILITARY BRANCH **Equipment**	Est. Number in Service	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fuel Cons GJ	Fuel Cons GJ	Fuel Cons GJ	Fuel Cons GJ
GROUND FORCES									
Tanks	5,832	2.05E+05	3.0%	1.2%	1.64E+05	1.15E+05	1.01E+05	7.87E+04	7.87E+04
Amphibious Vehicles	900	1.04E+04	0.2%	0.1%	8.35E+03	5.85E+03	5.11E+03	4.00E+03	4.00E+03
Armored Fighting Vehicles	4,015	4.50E+04	0.7%	0.3%	3.60E+04	2.52E+04	2.21E+04	1.73E+04	1.73E+04
Truck/Tank-Mounted Guns, Missiles	516	2.64E+03	0.0%	0.0%	2.12E+03	1.49E+03	1.30E+03	1.02E+03	1.02E+03
Jeeps and Motorcycles	9,045	2.15E+05	3.1%	1.2%	1.87E+05	1.37E+05	1.19E+05	1.09E+05	1.09E+05
2 1/2 Ton Trucks	72,403	6.23E+06	90.9%	36.0%	5.42E+06	3.96E+06	3.44E+06	3.15E+06	3.15E+06
Other Trucks and Utility Equipment	1,632	1.44E+05	2.1%	0.8%	1.30E+05	9.47E+04	8.24E+04	7.55E+04	7.55E+04
TOTAL: Ground Forces	94,343	6.85E+06	100.0%	39.6%	5.94E+06	4.33E+06	3.77E+06	3.44E+06	3.44E+06
AIR FORCE									
Fighters	748	1.76E+06	66.4%	10.2%	1.17E+06	8.06E+05	1.39E+06	1.47E+06	1.14E+06
Bombers	82	3.96E+04	1.5%	0.2%	2.64E+04	1.81E+04	3.13E+04	3.30E+04	2.56E+04
Transport	308	2.76E+05	10.4%	1.6%	2.32E+05	1.76E+05	2.10E+05	2.15E+05	2.15E+05
Helicopters	275	8.03E+04	3.0%	0.5%	6.02E+04	4.52E+04	6.02E+04	6.02E+04	6.02E+04
TOTAL: Aircraft	1,413	2.15E+06	81.3%	12.5%	1.49E+06	1.05E+06	1.69E+06	1.77E+06	1.44E+06
Service (Ground) Vehicles	6,235	4.94E+05	18.7%	2.9%	3.95E+05	3.21E+05	3.46E+05	3.71E+05	3.71E+05
TOTAL: Air Force		2.65E+06	100.0%	15.3%	1.89E+06	1.37E+06	2.04E+06	2.14E+06	1.81E+06
NAVY									
Frigates	1	4.48E+04	0.7%	0.3%	3.19E+04	2.99E+04	3.13E+04	2.69E+04	2.24E+04
Corvettes	2	1.79E+04	0.3%	0.1%	1.28E+04	1.20E+04	1.25E+04	1.07E+04	8.95E+03
Missile Attack Boats	39	1.07E+06	15.7%	6.2%	7.66E+05	7.19E+05	7.52E+05	6.45E+05	5.37E+05
Patrol and Mine Craft	351	5.05E+06	73.8%	29.2%	3.60E+06	3.38E+06	3.54E+06	3.03E+06	2.52E+06
Amphibious Craft	324	2.31E+05	3.4%	1.3%	4.53E+05	6.57E+05	6.57E+05	5.84E+05	5.84E+05
Submarines	84	5.56E+04	0.8%	0.3%	5.56E+04	5.00E+04	5.00E+04	4.45E+04	4.45E+04
TOTAL: Naval Vessels	801	6.48E+06	94.6%	37.5%	4.92E+06	4.84E+06	5.04E+06	4.34E+06	3.72E+06
Service (Land) Vehicles	4,077	3.71E+05	5.4%	2.1%	2.81E+05	2.77E+05	2.88E+05	2.48E+05	2.13E+05
TOTAL: Naval Forces		6.85E+06	100.0%	39.6%	5.20E+06	5.12E+06	5.33E+06	4.59E+06	3.93E+06
MILITARY MANUFACTURING: Coal Use		8.87E+05	**GJ/yr**	5.1%	6.21E+05	3.99E+05	3.99E+05	3.99E+05	3.99E+05
MILITARY MANUFACTURING: Electricity Use		4.75E+04	**GJ/yr**	0.3%	3.33E+04	2.14E+04	2.14E+04	2.14E+04	2.14E+04
TOTAL, ALL MILITARY ENERGY USES ABOVE		**1.73E+07**	**GJ/yr**	**100%**	**1.37E+07**	**1.12E+07**	**1.16E+07**	**1.06E+07**	**9.60E+06**

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN DPRK
SUMMARY OF KEY ACTIVITY LEVEL ASSUMPTIONS FOR 1990, AND ESTIMATES FOR 1990, 1996, 2000, 2005, 2008, AND 2009

Detailed Data and Results	
Prepared By:	David Von Hippel
Date Last Modified:	**3/3/2011**

UPDATE 2010/2011

GROUND FORCES		
	Trucks and General Use Vehicles	Tanks, Amph. Veh., Armored Veh., Other Arms
Hours of Maneuvers Per Year, 1990:	1000	100
Hours of Maneuvers Per Year, 1996:	870	80
Hours of Maneuvers Per Year, 2000:	680	60
Hours of Maneuvers Per Year, 2005	620	55
Hours of Maneuvers Per Year, 2008	660	50
Hours of Maneuvers Per Year, 2009	660	50

AIRCRAFT							
Mission Hours Per Year:	1990	1996	2000	2005	2008	2009	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS
Fighters/Bombers	24	16	11	19	20	16	
Transport Aircraft	50	42	32	38	39	39	
Helicopters	32	24	18	24	24	24	
Ave. airspeed--Fract. of Maximum	80%	80%	80%	80%	80%	80%	

MILITARY SHIPS AND BOATS						
Active Hours Per Year in:	1990	1996	2000	2005	2008	2009
Amphibious	50	50	45	45	40	40
Submarines	100	100	90	90	80	80
Other Vessels	800	570	535	560	480	400
Ave. power use--Fract. of Maximum	50%	50%	50%	50%	50%	50%

PROJECTION OF ENERGY REQUIRMENTS FOR MILITARY PRODUCT MANUFACTURING	
Ratio of Military Equipment Output in 1996 versus 1990:	0.7
Ratio of Military Equipment Output in 2000 versus 1990:	0.45
Ratio of Military Equipment Output in 2005 versus 1990:	0.45
Ratio of Military Equipment Output in 2008 versus 1990:	0.45
Ratio of Military Equipment Output in 2009) versus 1990:	0.45

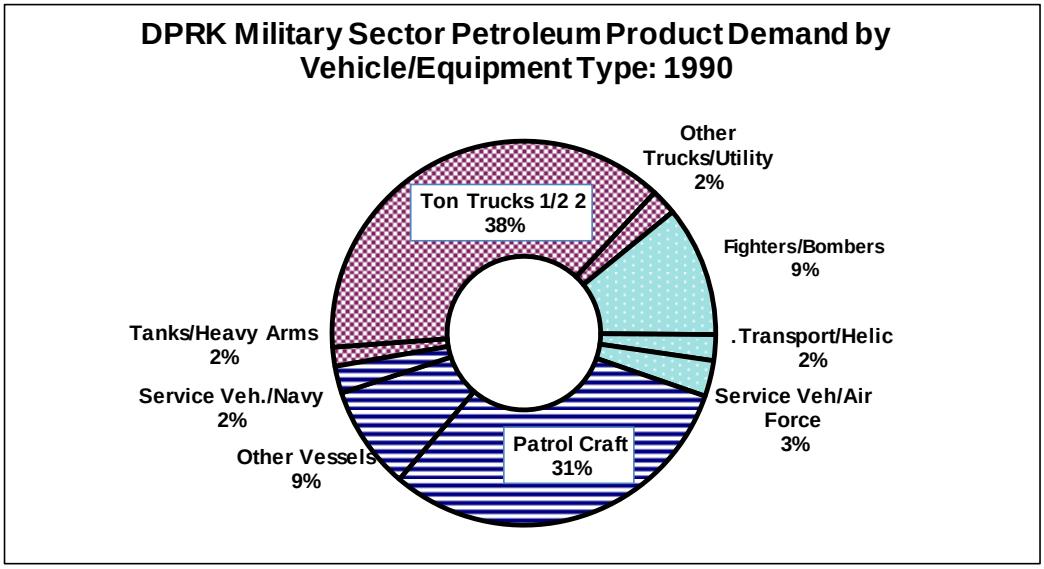
ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN DPRK
SUMMARY: FUEL USE IN EQUIPMENT, ALL MILITARY BRANCHES--1990, 1996, 2000, 2005, 2008, AND 2009

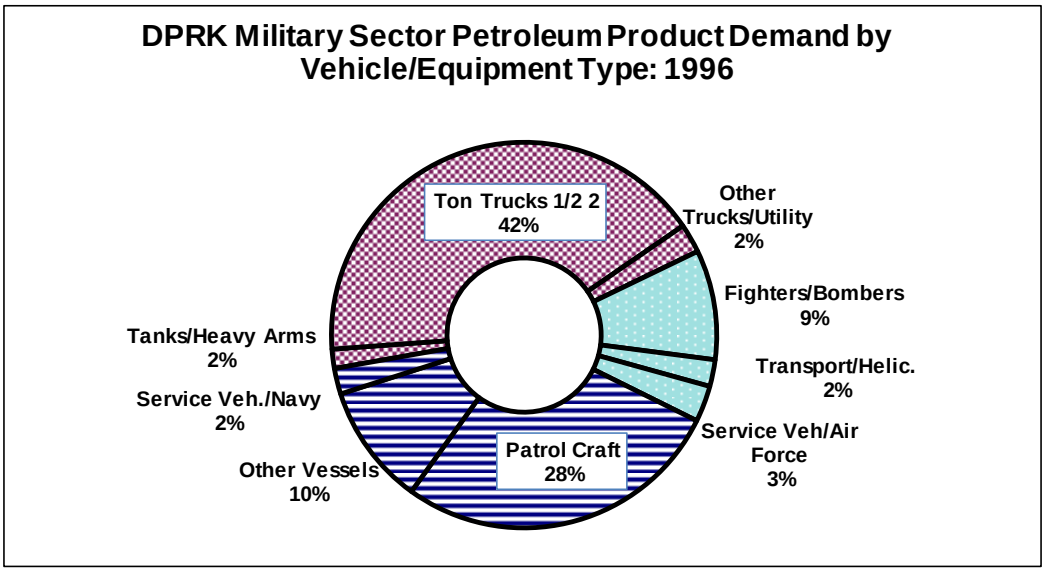
Summary Graphics	
Prepared By:	David Von Hippel
Date Last Modified:	**11/18/2011**

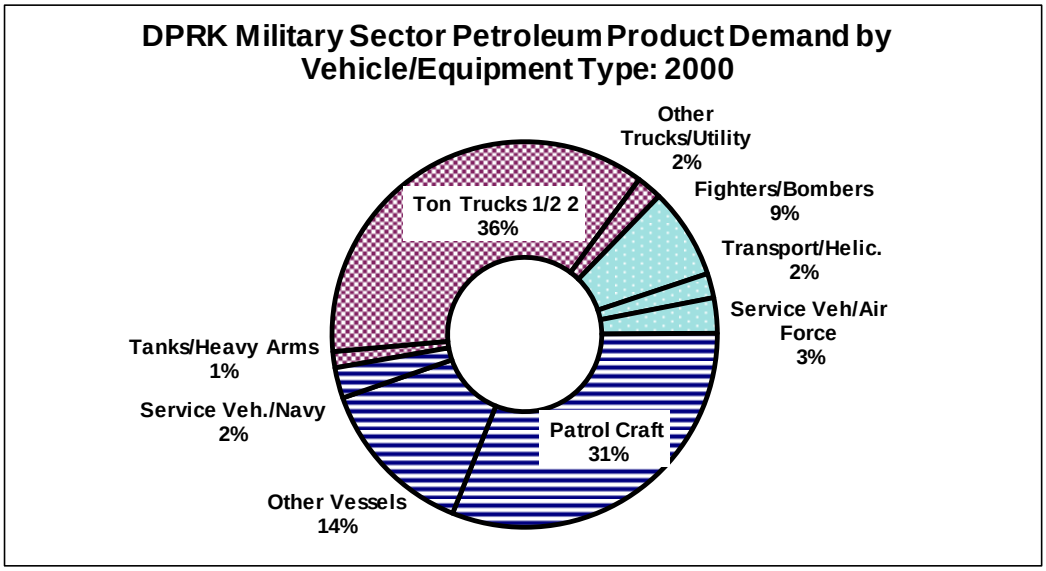
UPDATE 2010/2011

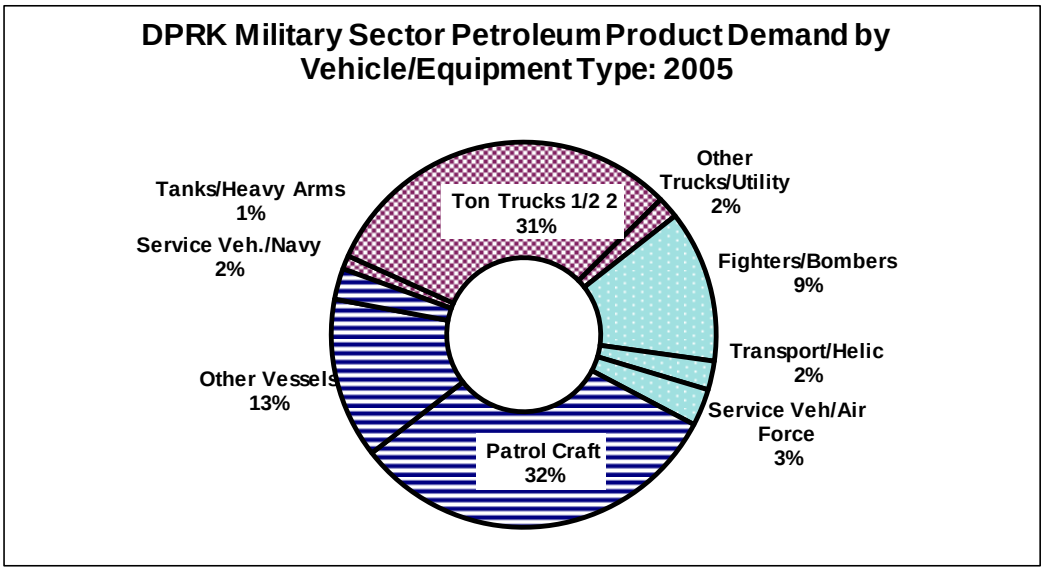
	1990			1996			2000		
MILITARY BRANCH **Equipment**	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fraction of Branch	Fraction of Total
GROUND FORCES									
Tanks/Heavy Arms	2.63E+05	3.8%	1.6%	2.11E+05	3.5%	1.6%	1.48E+05	3.4%	1.4%
2 1/2 Ton Trucks	6.23E+06	90.9%	38.1%	5.42E+06	91.1%	41.6%	3.96E+06	91.3%	36.5%
Oth Trucks/Utility	3.59E+05	5.2%	2.2%	3.17E+05	5.3%	2.4%	2.31E+05	5.3%	2.1%
TOTAL: Ground Forces	6.85E+06	100.0%	41.9%	5.94E+06	100.0%	45.6%	4.33E+06	100.0%	40.0%
AIR FORCE									
Fighters/Bombers	1.80E+06	67.9%	11.0%	1.20E+06	63.6%	9.2%	8.24E+05	60.3%	7.6%
Transport/Helic.	3.56E+05	13.4%	2.2%	2.92E+05	15.5%	2.2%	2.22E+05	16.2%	2.0%
Service (Grnd) Veh.	4.94E+05	18.7%	3.0%	3.95E+05	21.0%	3.0%	3.21E+05	23.5%	3.0%
TOTAL: Air Force	2.65E+06	100.0%	16.2%	1.89E+06	100.0%	14.5%	1.37E+06	100.0%	12.6%
NAVY									
Patrol Craft	5.05E+06	73.8%	30.9%	3.60E+06	69.2%	27.6%	3.38E+06	65.9%	31.2%
Other Vessels	1.42E+06	20.8%	8.7%	1.32E+06	25.4%	10.1%	1.47E+06	28.6%	13.6%
Service (Land) Veh.	3.71E+05	5.4%	2.3%	2.81E+05	5.4%	2.2%	2.77E+05	5.4%	2.6%
TOTAL: Naval Forces	6.85E+06	100.0%	41.9%	5.20E+06	100.0%	39.9%	5.12E+06	100.0%	47.3%
TOTAL MILITARY EQUIP ENERGY USE	**1.63E+07**	**GJ/yr**	**100%**	**1.30E+07**	**GJ/yr**	**100%**	**1.08E+07**	**GJ/yr**	**100%**

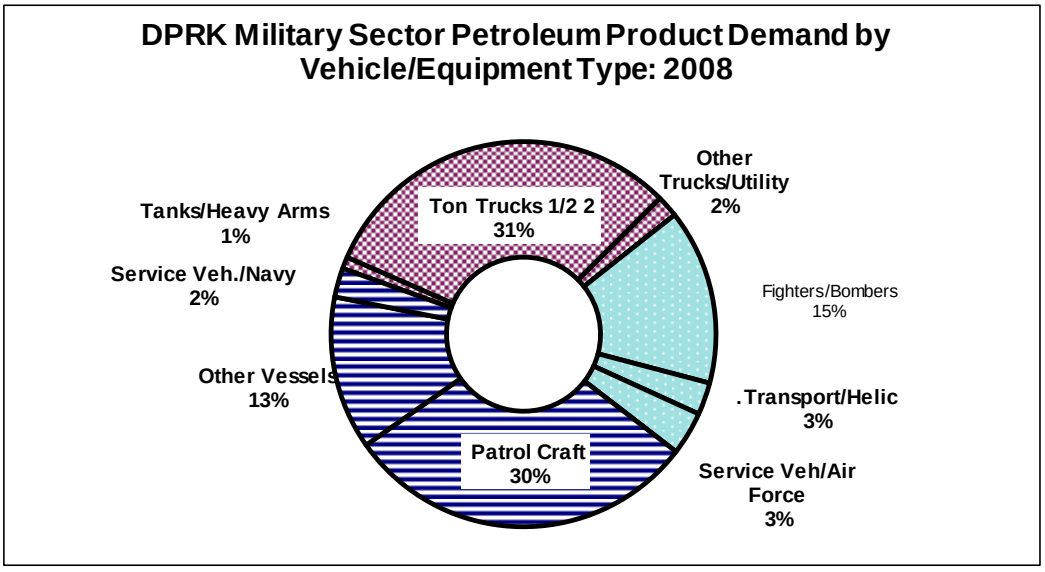
	2005			2008			2009		
MILITARY BRANCH **Equipment**	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fraction of Branch	Fraction of Total
GROUND FORCES									
Tanks/Heavy Arms	1.29E+05	3.4%	1.2%	1.01E+05	2.9%	1.0%	1.01E+05	2.9%	1.1%
2 1/2 Ton Trucks	3.44E+06	91.2%	30.9%	3.15E+06	91.7%	31.0%	3.15E+06	91.7%	34.4%
Oth Trucks/Utility	2.01E+05	5.3%	1.8%	1.84E+05	5.4%	1.8%	1.84E+05	5.4%	2.0%
TOTAL: Ground Forces	3.77E+06	100.0%	33.9%	3.44E+06	100.0%	33.8%	3.44E+06	100.0%	37.5%
AIR FORCE									
Fighters/Bombers	1.42E+06	69.8%	12.8%	1.50E+06	69.9%	14.7%	1.16E+06	64.3%	12.6%
Transport/Helic.	2.70E+05	13.2%	2.4%	2.75E+05	12.8%	2.7%	2.75E+05	15.2%	3.0%
Service (Grnd) Veh.	3.46E+05	17.0%	3.1%	3.71E+05	17.3%	3.6%	3.71E+05	20.5%	4.0%
TOTAL: Air Force	2.04E+06	100.0%	18.3%	2.14E+06	100.0%	21.1%	1.81E+06	100.0%	19.7%
NAVY									
Patrol Craft	3.54E+06	66.4%	31.7%	3.03E+06	66.0%	29.8%	2.52E+06	64.2%	27.5%
Other Vessels	1.50E+06	28.2%	13.5%	1.31E+06	28.6%	12.9%	1.20E+06	30.4%	13.0%
Service (Land) Veh.	2.88E+05	5.4%	2.6%	2.48E+05	5.4%	2.4%	2.13E+05	5.4%	2.3%
TOTAL: Naval Forces	5.33E+06	100.0%	47.8%	4.59E+06	100.0%	45.1%	3.93E+06	100.0%	42.9%
TOTAL MILITARY EQUIP ENERGY USE	**1.11E+07**	**GJ/yr**	**100%**	**1.02E+07**	**GJ/yr**	**100%**	**9.18E+06**	**GJ/yr**	**100%**

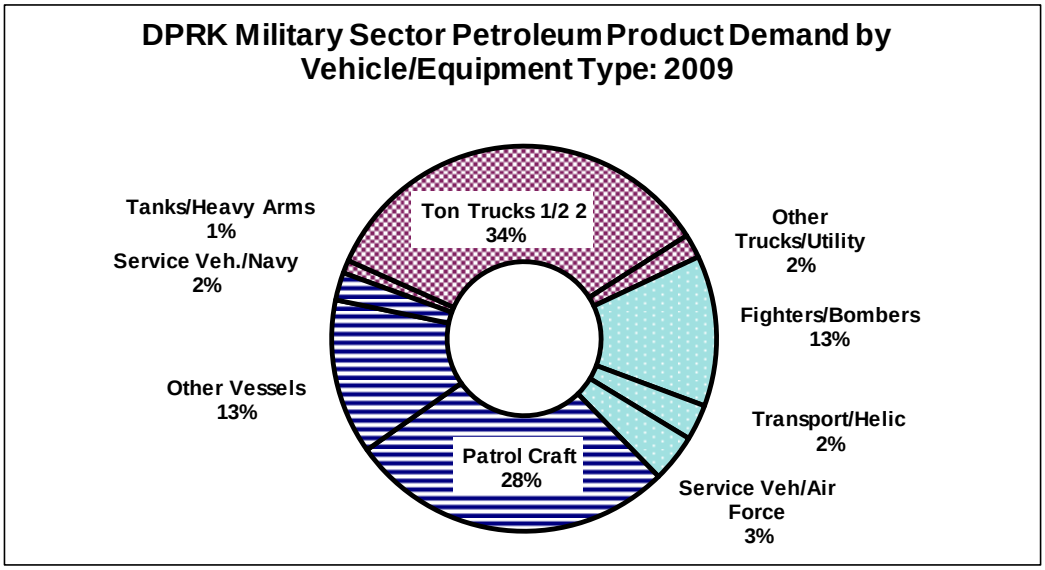

DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 1990
Other Trucks/Utility 2%
Ton Trucks 1/2 2 38%
Fighters/Bombers 9%
Tanks/Heavy Arms 2%
.Transport/Helic 2%
Service Veh./Navy 2%
Service Veh/Air Force 3%
Other Vessels 9%
Patrol Craft 31%


DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 1996
Ton Trucks 1/2 2 42%
Other Trucks/Utility 2%
Fighters/Bombers 9%
Tanks/Heavy Arms 2%
Transport/Helic. 2%
Service Veh./Navy 2%
Service Veh/Air Force 3%
Other Vessels 10%
Patrol Craft 28%


DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 2000
Other Trucks/Utility 2%
Ton Trucks 1/2 2 36%
Fighters/Bombers 9%
Transport/Helic. 2%
Service Veh/Air Force 3%
Tanks/Heavy Arms 1%
Service Veh./Navy 2%
Patrol Craft 31%
Other Vessels 14%


DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 2005
Tanks/Heavy Arms 1%
Service Veh./Navy 2%
Other Vessels 13%
Ton Trucks 1/2 2 31%
Patrol Craft 32%
Other Trucks/Utility 2%
Fighters/Bombers 9%
Transport/Helic 2%
Service Veh/Air Force 3%


DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 2008
Tanks/Heavy Arms 1%
Service Veh./Navy 2%
Other Vessels 13%
Ton Trucks 1/2 2 31%
Patrol Craft 30%
Other Trucks/Utility 2%
Fighters/Bombers 15%
.Transport/Helic 3%
Service Veh/Air Force 3%


DPRK Military Sector Petroleum Product Demand by Vehicle/Equipment Type: 2009
Tanks/Heavy Arms 1%
Service Veh./Navy 2%
Other Vessels 13%
Ton Trucks 1/2 2 34%
Patrol Craft 28%
Other Trucks/Utility 2%
Fighters/Bombers 13%
Transport/Helic 2%
Service Veh/Air Force 3%

ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK:
MILITARY GROUND VEHICLES AND ARMAMENTS **UPDATE 2010/2011**

Prepared By:	David Von Hippel
Date Last Modified:	**11/18/2011**

Summary Input Data and Results	**Trucks and General Use Vehicles**	**Tanks, Amph. Veh., Armored Veh., Other Arms**
Hours of Ground Maneuvers Per Year, 1990:	**1000**	**100**
Hours of Ground Maneuvers Per Year, 1996:	**870**	**80**
Hours of Ground Maneuvers Per Year, 2000:	**680**	**60**
Hours of Ground Maneuvers Per Year, 2005:	**620**	**55**
Hours of Ground Maneuvers Per Year, 2008:	**660**	**50**
Hours of Ground Maneuvers Per Year, 2009:	**660**	**50**

						1990				**1996**			**2000**		
Vehicle Types	Est. Number	Fuel Economy Range (km per Gallon)		Fract. of Time in Use	Ave. Speed when in Use	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ	Fraction of Total	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ
Notes				*1*	*2*										
Tanks	5,832	1.97	2.08	50%	25	50	5.46E+06	2.05E+05	3.0%	40	4.36E+06	1.64E+05	30	3.06E+06	1.15E+05
Amphibious Vehicles	900	1.04	26.50	50%	20	50	2.78E+05	1.04E+04	0.2%	40	2.22E+05	8.35E+03	30	1.56E+05	5.85E+03
Armored Fighting Vehicles	4,015	6.53	7.50	50%	30	50	1.38E+06	4.50E+04	0.7%	40	1.11E+06	3.60E+04	30	7.76E+05	2.52E+04
Truck/Tank-Mounted Guns, Missiles	516	1.97	6.44	25%	20	25	7.06E+04	2.64E+03	0.0%	20	5.65E+04	2.12E+03	15	3.96E+04	1.49E+03
Jeeps and Motorcycles	9,045	26.50	50	50%	30	500	6.61E+06	2.15E+05	3.1%	435	5.75E+06	1.87E+05	340	4.20E+06	1.37E+05
2 1/2 Ton Trucks	72,403	8.63		50%	30	500	1.91E+08	6.23E+06	90.9%	435	1.67E+08	5.42E+06	340	1.22E+08	3.96E+06
Other Trucks and Utility Equipment	1,632	3.85	8.63	50%	25	500	3.97E+06	1.44E+05	2.1%	435	3.45E+06	1.30E+05	340	2.52E+06	9.47E+04
TOTALS	94,343						2.09E+08	6.85E+06	100.0%		1.81E+08	5.94E+06		1.32E+08	4.33E+06
Diesel Consumption							8.69E+06	3.27E+05	4.8%		7.16E+06	2.69E+05		5.09E+06	1.91E+05
Gasoline Consumption							2.00E+08	6.52E+06	95.2%		1.74E+08	5.68E+06		1.27E+08	4.14E+06

	2005			2008			2009		
Vehicle Types	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ
Notes									
Tanks	27.5	2.67E+06	1.01E+05	25	2.09E+06	7.87E+04	25	2.09E+06	7.87E+04
Amphibious Vehicles	27.5	1.36E+05	5.11E+03	25	1.07E+05	4.00E+03	25	1.07E+05	4.00E+03
Armored Fighting Vehicles	27.5	6.79E+05	2.21E+04	25	5.31E+05	1.73E+04	25	5.31E+05	1.73E+04
Truck/Tank-Mounted Guns, Missiles	13.75	3.46E+04	1.30E+03	12.5	2.71E+04	1.02E+03	12.5	2.71E+04	1.02E+03
Jeeps and Motorcycles	310	3.65E+06	1.19E+05	330	3.35E+06	1.09E+05	330	3.35E+06	1.09E+05
2 1/2 Ton Trucks	310	1.06E+08	3.44E+06	330	9.69E+07	3.15E+06	330	9.69E+07	3.15E+06
Other Trucks and Utility Equipment	310	2.19E+06	8.24E+04	330	2.01E+06	7.55E+04	330	2.01E+06	7.55E+04
TOTALS		1.15E+08	3.77E+06		1.05E+08	3.44E+06		1.05E+08	3.44E+06
Diesel Consumption		4.44E+06	1.67E+05		3.69E+06	1.39E+05		3.69E+06	1.39E+05
Gasoline Consumption		1.11E+08	3.60E+06		1.01E+08	3.30E+06		1.01E+08	3.30E+06

Notes:

1 This fraction is assumed to be 25% for vehicles used primarily in engineering operations, 50% for most others.

2 Average speed applies to most, but not necessarily all, vehicles in class.

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK
MILITARY GROUND VEHICLES AND ARMAMENTS UPDATE 2010/2011

Detailed Data and Results

Prepared By:	David Von Hippel
Date Last Modified:	**11/18/2011**

COMMON ASSUMPTIONS & PARAMETERS

GROUND FORCES	Trucks and General Use Vehicles	Tanks, Amph. Veh., Armored Veh., Other Arms	
Hours of Maneuvers Per Year, 1990:	**1000**	**100**	***Note 25***
Hours of Maneuvers Per Year, 1996:	**870**	**80**	
Hours of Maneuvers Per Year, 2000:	**680**	**60**	***Note 24***
Hours of Maneuvers Per Year, 2005:	**620**	**55**	***Note 27***
Hours of Maneuvers Per Year, 2008:	**660**	**50**	
Hours of Maneuvers Per Year, 2009:	**660**	**50**	
Fraction of Stock Unuseable:	**20%**		***Note 21***

Conversion Factor:	**3.8**	liters/gal
Diesel Energy Content:	**0.037584**	GJ/liter
Gasoline Energy Content:	**0.03253**	GJ/liter

Estimate of Number of Vehicles In Military Fleet

MOTORIZED EQUIPMENT, BY TYPE, PER UNIT

Branch or Unit of Ground Forces	Number	Personnel per Unit	TOTAL Personnel	Notes	TANKS			AMPHIBIOUS VEH. AND TANK RTVR						ARMORED FTG. VEHICLES		GUNS, MISSILES	
					Medium T-54/55	Med: T62/ 63/PT-76	ASLT	PT-76 Lt Amph	PTS Trk Amph	K-61 Trk Amph	GAZ-46	AMPHI FERRY	Tank Retriever	BTR-60	BRDM	AAG ZSU-57	BM-21 (URAL-375)
Reserve Infantry Divisions	26	10,359	269,334	*1*	31	2							1				
Reserve-Infantry Brigades	18	8,296	149,328	*2*													
Infantry Divisions	30	10,359	310,770	*1*	31	2							1				
Truck Mobile Divisions	1	8,194	8,194	*5*	93			16					8	330			18
Infantry Brigades	4	8,296	33,184	*2*													
Truck Mobile Brigades	20	4,781	95,620	*4*		31		5						99	15		
Armored Brigades	15	2,481	37,215	*3*	6	133							7	58	3	6	6
Special Operations Brigades	22			*6*													
Elite Training Regiments	5	1,490	7,450				95	10					6				
Engineering River Regiments	5	1,660	8,300							60	7	12					
SAM Regiments	5	1,112	5,560														
AAA Regiments	5	529	2,645													30	
FROG Battalions	10	173	1,730														
Command and Support	1	338	338														
Artillery Regiments	3	735	2,205														
MRL Regiment	1	751	751														30
AAA Regiments	2	529	1,058														
Engineering Regiment	1	1,206	1,206						10	20							
Signal Battalion	1	299	299														
Decon Battalion	1	315	315														
ATGM Company	1	81	81														
Field Hospital	1	435	435														
TOTAL INDICATED LAND FORCES			936,018		1,919	2,727	475	166	10	320	35	60	199	3,180	345	240	138
Reported Ground Personnel	(as of 1990)		1.07E+06	*7, 23, 26*			5,121						790		3,525		
TRUED-UP LAND FORCES	True-Up Factor, '90/'96:		1.14		2,185	3,106	541	189	11	364	40	68	227	3,622	393	273	157
Equipment Totals by Category							5,832						900		4,015		

Estimate of Number of Vehicles In Military Fleet					**MOTORIZED EQUIPMENT, BY TYPE, PER UNIT**														
Branch or Unit of Ground Forces	Number	Personnel per Unit	TOTAL Personnel	Notes	**GUNS, MISSILES (Cont.)**			**LIGHT VEH.**			**TRUCKS AND UTILITY VEHICLES**								
					BM-20,24 (ZIL-151,7)	FROG 3/5 (PT-76)	FROG 7 (ZIL-135)	JEEPS	Motor-Cycles	**2.5 T Truck**	Dump	Zil-135	Zil-151	KRAZ-214	GAZ-63	Zil-157V	Power Boats	Oth Hvy Equip.
Reserve Infantry Divisions	26	10,359	269,334	*1*				57	29	692								
Reserve-Infantry Brigades	18	8,296	149,328	*2*				39	29	503								
Infantry Divisions	30	10,359	310,770	*1*				57	29	692								
Truck Mobile Divisions	1	8,194	8,194	*5*				56		255								
Infantry Brigades	4	8,296	33,184	*2*				39	29	503								
Truck Mobile Brigades	20	4,781	95,620	*4*				28	8	376								
Armored Brigades	15	2,481	37,215	*3*				26		162								
Special Operations Brigades	22			*6*														
Elite Training Regiments	5	1,490	7,450					14	14	133								
Engineering River Regiments	5	1,660	8,300					10		148			96	18	72		24	15
SAM Regiments	5	1,112	5,560					8		60						36		
AAA Regiments	5	529	2,645					14		104								
FROG Battalions	10	173	1,730			3	3			54		3				3		
Command and Support	1	338	338					44	30	68								
Artillery Regiments	3	735	2,205					4		75								
MRL Regiment	1	751	751		15			10		48								
AAA Regiments	2	529	1,058					14		104								
Engineering Regiment	1	1,206	1,206					9		103	23						12	33
Signal Battalion	1	299	299					5	20	37								
Decon Battalion	1	315	315					1		30								
ATGM Company	1	81	81					1		5								
Field Hospital	1	435	435					4		63								
TOTAL INDICATED LAND FORCES			936,018		15	30	30	5,400	2,542	63,575	23	30	480	90	360	210	132	108
Reported Ground Personnel	(as of 1990)		1.07E+06	*7, 23, 26*			453		7,942	63,575								1,433
TRUED-UP LAND FORCES	True-Up Factor, '90/96:		1.14		17	34	34	6,150	2,895	72,403	26	34	547	102	410	239	150	123
Equipment Totals by Category							516		9,045	72,403								1,632

Estimate of Number of Vehicles In Military Fleet					**MOTORIZED EQUIPMENT, BY TYPE, PER UNIT**													
Branch or Unit of Ground Forces	Number	Personnel per Unit	TOTAL Personnel	Notes	**GUNS, MISSILES (Cont.)**			**LIGHT VEH.**			**TRUCKS AND UTILITY VEHICLES**							
					BM-20,24 (ZIL-151,7)	FROG 3/5 (PT-76)	FROG 7 (ZIL-135)	JEEPS	Motor-Cycles	**2.5 T Truck**	Dump	Zil-135	Zil-151	KRAZ-214	GAZ-63	Zil-157V	Power Boats	Oth Hvy Equip.
Reserve Infantry Divisions	26	10,359	269,334	*1*				57	29	692								
Reserve-Infantry Brigades	18	8,296	149,328	*2*				39	29	503								
Infantry Divisions	30	10,359	310,770	*1*				57	29	692								
Truck Mobile Divisions	1	8,194	8,194	*5*				56		255								
Infantry Brigades	4	8,296	33,184	*2*				39	29	503								
Truck Mobile Brigades	20	4,781	95,620	*4*				28	8	376								
Armored Brigades	15	2,481	37,215	*3*				26		162								
Special Operations Brigades	22			*6*														
Elite Training Regiments	5	1,490	7,450					14	14	133								
Engineering River Regiments	5	1,660	8,300					10		148			96	18	72		24	15
SAM Regiments	5	1,112	5,560					8		60						36		
AAA Regiments	5	529	2,645					14		104								
FROG Battalions	10	173	1,730			3	3			54		3				3		
Command and Support	1	338	338					44	30	68								
Artillery Regiments	3	735	2,205					4		75								
MRL Regiment	1	751	751		15			10		48								
AAA Regiments	2	529	1,058					14		104								
Engineering Regiment	1	1,206	1,206					9		103	23						12	33
Signal Battalion	1	299	299					5	20	37								
Decon Battalion	1	315	315					1		30								
ATGM Company	1	81	81					1		5								
Field Hospital	1	435	435					4		63								
TOTAL INDICATED LAND FORCES			936,018		15	30	30	5,400	2,542	63,575	23	30	480	90	360	210	132	108
Reported Ground Personnel	(as of 1990)		1.07E+06	*7, 23, 26*			453		7,942	63,575								1,433
TRUED-UP LAND FORCES	True-Up Factor, '90/96:		1.14		17	34	34	6,150	2,895	72,403	26	34	547	102	410	239	150	123
Equipment Totals by Category							516		9,045	72,403								1,632

				MOTORIZED EQUIPMENT, BY TYPE, PER UNIT											
				TANKS			AMPHIBIOUS VEH. AND TANK RTVR						ARMORED FTG. VEHICLES		GUNS, MISSILES	
				Medium	Med: T62/		PT-76	PTS	K-61		AMPHI	Tank			AAG	BM-21
Fuel Use Effic. Calculations	Units		Notes	T-54/55	63/PT-76	ASLT	Lt Amph	Trk Amph	Trk Amph	GAZ-46	FERRY	Retriever	BTR-60	BRDM	ZSU-57	(URAL-375)
Reported Range	km			500	500	300	260	500	260	530	500	300	500	750	500	650
Reported Fuel Capacity (*Est*)	gal			254	240	150	67	240	67	*20*	480	148	76.6	100	254	*110*
Reported Horsepower	hp									55						180
Payload	ton							5.5	3.3	0.4	11					4.9
Fuel Used				Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Gas	Diesel	Diesel	Gas??	Gas	Diesel	Diesel??
Fuel Use Efficiency	km/gal			1.97	2.08	2.00	3.88	2.08	3.88	26.50	1.04	2.03	6.53	7.50	1.97	5.91
Notes				*8*	*8, 9*	*8*	*8*	*12*	*13*	*14*	*15*	*8*	*8*	*16*		*11*
Operating Assumptions																
Fract. Time In-Use During Maneuvers				*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*25%*	*25%*	*50%*	*50%*	*25%*	*25%*
Average Speed During Maneuvers	km/hr			*25*	*25*	*25*	*20*	*20*	*20*	*20*	*15*	*15*	*30*	*30*	*20*	*20*
Hours of Operation, 1990	hrs			50	50	50	50	50	50	50	25	25	50	50	25	25
Hours of Operation, 1996	hrs			40	40	40	40	40	40	40	20	20	40	40	20	20
Hours of Operation, 2000	hrs			30	30	30	30	30	30	30	15	15	30	30	15	15
Hours of Operation, 2005	hrs			27.5	27.5	27.5	27.5	27.5	27.5	27.5	13.75	13.75	27.5	27.5	13.75	13.75
Hours of Operation, 2008	hrs			25	25	25	25	25	25	25	12.5	12.5	25	25	12.5	12.5
Hours of Operation, 2009	hrs			25	25	25	25	25	25	25	12.5	12.5	25	25	12.5	12.5
Hours of Operation, 2010--Decline Scenario	hrs			435	435	435	435	435	435	435	217.5	217.5	435	435	217.5	217.5
Fuel Consumption Results, 1990																
TOTAL FUEL USED	gal		*22*	5.55E+05	7.45E+05	1.35E+05	1.95E+04	2.19E+03	3.76E+04	6.02E+02	4.92E+03	8.39E+03	3.3E+05	3.1E+04	1.39E+04	2.66E+03
By Vehicle Category	gal	**All Veh.** 5.50E+07	*22*			1.44E+06						7.31E+04		3.6E+05		
TOTAL FUEL USED	liters			2.11E+06	2.83E+06	5.14E+05	7.41E+04	8.31E+03	1.43E+05	2.29E+03	1.87E+04	3.19E+04	1.3E+06	1.2E+05	5.28E+04	1.01E+04
By Vehicle Category	liters	**All Veh.** 2.09E+08				5.46E+06						2.78E+05		1.4E+06		
TOTAL FUEL USED	GJ			7.93E+04	1.06E+05	1.93E+04	2.78E+03	3.12E+02	5.37E+03	7.44E+01	7.03E+02	1.20E+03	4.1E+04	3.9E+03	1.98E+03	3.80E+02
By Vehicle Category	GJ	**All Veh.** 6.85E+06				2.05E+05						1.04E+04		4.5E+04		
Fuel Consumption Results, 1996																
TOTAL FUEL USED	gal		*22*	4.44E+05	5.96E+05	1.08E+05	1.56E+04	1.75E+03	3.01E+04	4.81E+02	3.94E+03	6.71E+03	2.7E+05	2.5E+04	1.11E+04	2.13E+03
By Vehicle Category	gal	**All Veh.** 4.78E+07	*22*			1.15E+06						5.85E+04		2.9E+05		
TOTAL FUEL USED	liters			1.69E+06	2.27E+06	4.11E+05	5.92E+04	6.65E+03	1.14E+05	1.83E+03	1.50E+04	2.55E+04	1.0E+06	9.6E+04	4.22E+04	8.09E+03
By Vehicle Category	liters	**All Veh.** 1.81E+08				4.36E+06						2.22E+05		1.1E+06		
TOTAL FUEL USED	GJ			6.34E+04	8.52E+04	1.55E+04	2.23E+03	2.50E+02	4.29E+03	5.95E+01	5.62E+02	9.58E+02	3.3E+04	3.1E+03	1.59E+03	3.04E+02
By Vehicle Category	GJ	**All Veh.** 5.94E+06				1.64E+05						8.35E+03		3.6E+04		
Fuel Consumption Results, 2000																
TOTAL FUEL USED	gal		*22*	3.11E+05	4.18E+05	7.58E+04	1.09E+04	1.23E+03	2.11E+04	3.37E+02	2.76E+03	4.70E+03	1.9E+05	1.8E+04	7.78E+03	1.49E+03
By Vehicle Category	gal	**All Veh.** 3.48E+07	*22*			8.05E+05						4.10E+04		2.0E+05		
TOTAL FUEL USED	liters			1.18E+06	1.59E+06	2.88E+05	4.15E+04	4.66E+03	8.00E+04	1.28E+03	1.05E+04	1.79E+04	7.1E+05	6.7E+04	2.96E+04	5.67E+03
By Vehicle Category	liters	**All Veh.** 1.32E+08				3.06E+06						1.56E+05		7.8E+05		
TOTAL FUEL USED	GJ			4.44E+04	5.97E+04	1.08E+04	1.56E+03	1.75E+02	3.01E+03	4.17E+01	3.94E+02	6.71E+02	2.3E+04	2.2E+03	1.11E+03	2.13E+02
By Vehicle Category	GJ	**All Veh.** 4.33E+06				1.15E+05						5.85E+03		2.5E+04		

					MOTORIZED EQUIPMENT, BY TYPE, PER UNIT											
					TANKS			AMPHIBIOUS VEH. AND TANK RTVR						ARMORED FTG. VEHICLES		GUNS, MISSILES	
					Medium	Med: T62/		PT-76	PTS	K-61		AMPHI	Tank			AAG	BM-21
Fuel Consumption Results, 2005																	
TOTAL FUEL USED	gal			*22*	2.72E+05	3.65E+05	6.63E+04	9.55E+03	1.07E+03	1.84E+04	2.95E+02	2.41E+03	4.11E+03	1.6E+05	1.5E+04	6.81E+03	1.30E+03
By Vehicle Category	gal	**All Veh.**	3.03E+07	*22*			7.04E+05						3.59E+04		1.8E+05		
TOTAL FUEL USED	liters				1.03E+06	1.39E+06	2.52E+05	3.63E+04	4.07E+03	7.00E+04	1.12E+03	9.16E+03	1.56E+04	6.2E+05	5.9E+04	2.59E+04	4.95E+03
By Vehicle Category	liters	**All Veh.**	1.15E+08				2.67E+06						1.36E+05		6.8E+05		
TOTAL FUEL USED	GJ				3.89E+04	5.22E+04	9.47E+03	1.36E+03	1.53E+02	2.63E+03	3.65E+01	3.44E+02	5.87E+02	2.0E+04	1.9E+03	9.72E+02	1.86E+02
By Vehicle Category	GJ	**All Veh.**	3.77E+06				1.01E+05						5.11E+03		2.2E+04		
Fuel Consumption Results, 2008																	
TOTAL FUEL USED	gal			*22*	2.13E+05	2.86E+05	5.19E+04	7.48E+03	8.39E+02	1.44E+04	2.31E+02	1.89E+03	3.22E+03	1.3E+05	1.2E+04	5.33E+03	1.02E+03
By Vehicle Category	gal	**All Veh.**	2.76E+07	*22*			5.51E+05						2.81E+04		1.4E+05		
TOTAL FUEL USED	liters				8.09E+05	1.09E+06	1.97E+05	2.84E+04	3.19E+03	5.48E+04	8.77E+02	7.17E+03	1.22E+04	4.9E+05	4.6E+04	2.02E+04	3.88E+03
By Vehicle Category	liters	**All Veh.**	1.05E+08				2.09E+06						1.07E+05		5.3E+05		
TOTAL FUEL USED	GJ				3.04E+04	4.08E+04	7.41E+03	1.07E+03	1.20E+02	2.06E+03	2.85E+01	2.70E+02	4.59E+02	1.6E+04	1.5E+03	7.61E+02	1.46E+02
By Vehicle Category	GJ	**All Veh.**	3.44E+06				7.87E+04						4.00E+03		1.7E+04		
Fuel Consumption Results, 2009																	
TOTAL FUEL USED	gal			*22*	2.13E+05	2.86E+05	5.19E+04	7.48E+03	8.39E+02	1.44E+04	2.31E+02	1.89E+03	3.22E+03	1.3E+05	1.2E+04	5.33E+03	1.02E+03
By Vehicle Category	gal	**All Veh.**	2.76E+07	*22*			5.51E+05						2.81E+04		1.4E+05		
TOTAL FUEL USED	liters				8.09E+05	1.09E+06	1.97E+05	2.84E+04	3.19E+03	5.48E+04	8.77E+02	7.17E+03	1.22E+04	4.9E+05	4.6E+04	2.02E+04	3.88E+03
By Vehicle Category	liters	**All Veh.**	1.05E+08				2.09E+06						1.07E+05		5.3E+05		
TOTAL FUEL USED	GJ				3.04E+04	4.08E+04	7.41E+03	1.07E+03	1.20E+02	2.06E+03	2.85E+01	2.70E+02	4.59E+02	1.6E+04	1.5E+03	7.61E+02	1.46E+02
By Vehicle Category	GJ	**All Veh.**	3.44E+06				7.87E+04						4.00E+03		1.7E+04		

			MOTORIZED EQUIPMENT, BY TYPE, PER UNIT													
			GUNS, MISSILES (Cont.)			LIGHT VEH.			TRUCKS AND UTILITY VEHICLES							
			BM-20,24	FROG 3/5	FROG 7		Motor-	2.5 T							Power	Oth Hvy
Fuel Use Effic. Calculations	Units	Notes	(ZIL-151,7)	(PT-76)	(ZIL-135)	JEEPS	Cycles	**Truck**	Dump	Zil-135	Zil-151	Kraz-214	GAZ-63	Zil-157V	Boats	Equip.
Reported Range	km		600, 430	260	500	530		345	530	500	600	530	345	430		
Reported Fuel Capacity (*Est*)	gal			67	*130*	*20*		*40*	*130*	*130*	*80*	*130*	*40*	*80*		
Reported Horsepower	hp		92, 109		180	54		70	205	180	92	205	55	109	*28*	
Payload	ton				11			2.2	7.7	11	2.7	7.7	2.2			
Fuel Used			Diesel??	Diesel	Gas	Gas	Gas	Gas	Diesel	Gas	Diesel??	Diesel	Gas	Diesel??	Diesel??	Diesel??
Fuel Use Efficiency	km/gal		6.4375	3.88	3.85	26.50	50	8.63	4.08	3.85	7.50	4.08	8.63	5.38	0.195 l/hp-hr	5.38
Notes			*11*		*17*		*19*	*10*	*17*	*17*	*11*	*11*	*10*	*11*	*20*	*18*
Operating Assumptions																
Fract. Time In-Use During Maneuvers			*25%*	*25%*	*25%*	*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*50%*	*25%*	*25%*
Average Speed During Maneuvers	km/hr		*20*	*20*	*20*	*30*	*30*	*30*	*25*	*25*	*25*	*25*	*25*	*25*		*15*
Hours of Operation, 1990	hrs		25	25	25	500	500	500	500	500	500	500	500	500	250	250
Hours of Operation, 1996	hrs		20	20	20	435	435	435	435	435	435	435	435	435	217.5	217.5
Hours of Operation, 2000	hrs		15	15	15	340	340	340	340	340	340	340	340	340	170	170
Hours of Operation, 2005	hrs		13.75	13.75	13.75	310	310	310	310	310	310	310	310	310	155	155
Hours of Operation, 2008	hrs		12.5	12.5	12.5	330	330	330	330	330	330	330	330	330	165	165
Hours of Operation, 2009	hrs		12.5	12.5	12.5	330	330	330	330	330	330	330	330	330	165	165
Fuel Consumption Results, 1990																
TOTAL FUEL USED	gal		2.65E+02	8.80E+02	8.88E+02	1.39E+06	3.47E+05	5.04E+07	3.2E+04	4.4E+04	3.6E+05	1.3E+05	2.4E+05	2.2E+05	0.0E+00	1.7E+04
By Vehicle Category	gal	**All Veh.** 5.50E+07			1.86E+04		1.74E+06	5.04E+07								1.0E+06
TOTAL FUEL USED	liters		1.01E+03	3.35E+03	3.38E+03	5.29E+06	1.32E+06	1.91E+08	1.2E+05	1.7E+05	1.4E+06	4.8E+05	9.0E+05	8.5E+05	0.0E+00	6.5E+04
By Vehicle Category	liters	**All Veh.** 2.09E+08			7.06E+04		6.61E+06	1.91E+08								4.0E+06
TOTAL FUEL USED	GJ		3.79E+01	1.26E+02	1.10E+02	1.72E+05	4.29E+04	6.23E+06	4.6E+03	5.5E+03	5.2E+04	1.8E+04	2.9E+04	3.2E+04	0.0E+00	2.5E+03
By Vehicle Category	GJ	**All Veh.** 6.85E+06			2.64E+03		2.15E+05	6.23E+06								1.4E+05
Fuel Consumption Results, 1996																
TOTAL FUEL USED	gal		2.12E+02	7.04E+02	7.11E+02	1.21E+06	3.02E+05	4.38E+07	2.8E+04	3.9E+04	3.2E+05	1.1E+05	2.1E+05	1.9E+05	0.0E+00	1.5E+04
By Vehicle Category	gal	**All Veh.** 4.78E+07			1.49E+04		1.51E+06	4.38E+07								9.1E+05
TOTAL FUEL USED	liters		8.07E+02	2.68E+03	2.70E+03	4.60E+06	1.15E+06	1.67E+08	1.1E+05	1.5E+05	1.2E+06	4.2E+05	7.9E+05	7.4E+05	0.0E+00	5.7E+04
By Vehicle Category	liters	**All Veh.** 1.81E+08			5.65E+04		5.75E+06	1.67E+08								3.5E+06
TOTAL FUEL USED	GJ		3.03E+01	1.01E+02	1.01E+02	1.50E+05	3.74E+04	5.42E+06	4.0E+03	5.5E+03	4.5E+04	1.6E+04	3.0E+04	2.8E+04	0.0E+00	2.1E+03
By Vehicle Category	GJ	**All Veh.** 5.94E+06			2.12E+03		1.87E+05	5.42E+06								1.3E+05
Fuel Consumption Results, 2000																
TOTAL FUEL USED	gal		1.49E+02	4.94E+02	4.98E+02	8.85E+05	2.21E+05	3.20E+07	2.0E+04	2.8E+04	2.3E+05	8.0E+04	1.5E+05	1.4E+05	0.0E+00	1.1E+04
By Vehicle Category	gal	**All Veh.** 3.48E+07			1.04E+04		1.11E+06	3.20E+07								6.6E+05
TOTAL FUEL USED	liters		5.65E+02	1.88E+03	1.89E+03	3.36E+06	8.39E+05	1.22E+08	7.8E+04	1.1E+05	8.8E+05	3.0E+05	5.7E+05	5.4E+05	0.0E+00	4.1E+04
By Vehicle Category	liters	**All Veh.** 1.32E+08			3.96E+04		4.20E+06	1.22E+08								2.5E+06
TOTAL FUEL USED	GJ		2.12E+01	7.05E+01	7.11E+01	1.09E+05	2.73E+04	3.96E+06	2.9E+03	4.0E+03	3.3E+04	1.1E+04	2.2E+04	2.0E+04	0.0E+00	1.6E+03
By Vehicle Category	GJ	**All Veh.** 4.33E+06			1.49E+03		1.37E+05	3.96E+06								9.5E+04

					MOTORIZED EQUIPMENT, BY TYPE, PER UNIT												
					GUNS, MISSILES (Cont.)			LIGHT VEH.			TRUCKS AND UTILITY VEHICLES						
Fuel Consumption Results, 2005																	
TOTAL FUEL USED	gal			22	1.30E+02	4.32E+02	4.35E+02	7.69E+05	1.92E+05	2.78E+07	1.8E+04	2.5E+04	2.0E+05	6.9E+04	1.3E+05	1.2E+05	0.0E+00	9.5E+03
By Vehicle Category	gal	**All Veh.**	3.03E+07	22			9.11E+03		9.61E+05	2.78E+07							5.8E+05
TOTAL FUEL USED	liters				4.94E+02	1.64E+03	1.65E+03	2.92E+06	7.29E+05	1.06E+08	6.7E+04	9.3E+04	7.7E+05	2.6E+05	5.0E+05	4.7E+05	0.0E+00	3.6E+04
By Vehicle Category	liters	**All Veh.**	1.15E+08				3.46E+04		3.65E+06	1.06E+08								2.2E+06
TOTAL FUEL USED	GJ				1.86E+01	6.16E+01	6.22E+01	9.51E+04	2.37E+04	3.44E+06	2.5E+03	3.5E+03	2.9E+04	9.9E+03	1.9E+04	1.8E+04	0.0E+00	1.4E+03
By Vehicle Category	GJ	**All Veh.**	3.77E+06				1.30E+03		1.19E+05	3.44E+06								8.2E+04
Fuel Consumption Results, 2008																	
TOTAL FUEL USED	gal			22	1.02E+02	3.38E+02	3.41E+02	7.05E+05	1.76E+05	2.55E+07	1.6E+04	2.2E+04	1.8E+05	6.4E+04	1.2E+05	1.1E+05	0.0E+00	8.7E+03
By Vehicle Category	gal	**All Veh.**	2.76E+07	22			7.13E+03		8.81E+05	2.55E+07								5.3E+05
TOTAL FUEL USED	liters				3.87E+02	1.28E+03	1.30E+03	2.68E+06	6.69E+05	9.69E+07	6.2E+04	8.5E+04	7.0E+05	2.4E+05	4.6E+05	4.3E+05	0.0E+00	3.3E+04
By Vehicle Category	liters	**All Veh.**	1.05E+08				2.71E+04		3.35E+06	9.69E+07								2.0E+06
TOTAL FUEL USED	GJ				1.45E+01	4.82E+01	4.87E+01	8.72E+04	2.17E+04	3.15E+06	2.3E+03	3.2E+03	2.6E+04	9.1E+03	1.7E+04	1.6E+04	0.0E+00	1.2E+03
By Vehicle Category	GJ	**All Veh.**	3.44E+06				1.02E+03		1.09E+05	3.15E+06								7.6E+04
Fuel Consumption Results, 2009																	
TOTAL FUEL USED	gal			22	1.02E+02	3.38E+02	3.41E+02	7.05E+05	1.76E+05	2.55E+07	1.6E+04	2.2E+04	1.8E+05	6.4E+04	1.2E+05	1.1E+05	0.0E+00	8.7E+03
By Vehicle Category	gal	**All Veh.**	2.76E+07	22			7.13E+03		8.81E+05	2.55E+07								5.3E+05
TOTAL FUEL USED	liters				3.87E+02	1.28E+03	1.30E+03	2.68E+06	6.69E+05	9.69E+07	6.2E+04	8.5E+04	7.0E+05	2.4E+05	4.6E+05	4.3E+05	0.0E+00	3.3E+04
By Vehicle Category	liters	**All Veh.**	1.05E+08				2.71E+04		3.35E+06	9.69E+07								2.0E+06
TOTAL FUEL USED	GJ				1.45E+01	4.82E+01	4.87E+01	8.72E+04	2.17E+04	3.15E+06	2.3E+03	3.2E+03	2.6E+04	9.1E+03	1.7E+04	1.6E+04	0.0E+00	1.2E+03
By Vehicle Category	GJ	**All Veh.**	3.44E+06				1.02E+03		1.09E+05	3.15E+06								7.6E+04

NOTES:

1 "Infantry Division" from North Korea Handbook, page 5-5

2 "Basic Corps Independent Infantry Brigade" from Opposing Force Training Module, p. 11-13

3 "Tank Brigade" from North Korea Handbook, page 5-31

4 "Mechanized Infantry Brigade" from North Korea Handbook, page 5-37

5 "Mechanized Infantry Division--Strategic Forces Command" from Opposing Force Training Module, p. 11-3

6 "Special Operations Brigades" are assumed to be those units listed in the Opposing Force Training Module as being under either the Strategic Forces Command or the Basic Army Corps, but which are not obviously included in the force units accounted for separately here.

7 From "Military Balance: North vs. South" Unclassified DOD document, September 27, 1993.

8 From Opposing Force Training Module, pp. 13-16 - 13-22.

9 For T-62. Pt-76 is a lighter, amphibious tank with a range of 260 km and a fuel load of 67 gal, but the ratio of the two types is not known.

10 Engine size and range are as listed for the older but similar Sungni-58, which is reported to be very fuel-inefficient. Fuel tank capacity is a guess. Data from reference 8, page 13-29.

11 Estimates based on measurements of drawings in reference 8.

12 Carriage, size seem similar to T-62 tank.

13 Carriage, size seem similar to PT-76 tank.

14 Built on Jeep chassis--assumed to have similar performance

15 Ferry consists of two tracked vehicles, each of which is assumed to have performance like T-62 tank.

16 Carriage seems similar to GAZ-66 2.2 ton truck. Fuel capacity for latter estimated based on measurement of drawings in reference 8.

17 Assumed similar to KRAZ-214.

18 Assumed similar to Zil-157V on average. Reference 8 lists the lighter Zil-151 as one of the prime movers used for cranes.

19 Rough Estimate

20 Assumes boats will have similar engines to tractors, with similar fuel consumption.

21 Unusable equipment includes equipment rendered unusable by age, rust, or lack of spare parts.

22 Energy use as calculated here excludes fuel that would have been used by equipment considered unusable.

23 Republic of Korea National Intelligence Service, "North Korea Military. The KPA: Troops & Equipment", from http://www.fas.org/irp/world/rok/nis-docs/defense08.htm, visited 5/21/02, lists the total ground forces for the DPRK at a total of 996,000 *troops in 20 corps units. Assuming that this estimate holds for the year 2000, a "true-up factor" for the equipment estimates above of* 1.06408 *is implied.*

24 It has not been possible to obtain unclassified information that provides any specific information on recent fuel use by the DPRK military. Analysts contacted regarding the "tempo" of recent DPRK military exercises, and reports in the media (for example, "NK Ground Exercises Up as Navy and Air Force Decline", Yoo Yong-won, www.chosun.com, 2001- 9-10) suggest that the DPRK military exercise tempo for ground forces has increased somewhat in recent years, but not substantially, and that some of the apparent increase in exercises may be an increase in the number of soldiers involved, but not necessarily the number of fuel-using vehicles and armaments. Accordingly, we assume that the average hours of annual use by ground vehicles in 2000 was slightly lower than in 1996 by 2000, and somewhat lower still, in part due to fuel supply restrictions, in 2005.

25 Observers of DPRK and other countries' military activity suggest that the active (mobile) hours for tanks, mobile armaments, armoured vehicles, amphibious vehicles, and similar equipment are typically, under routine (non-wartime) use, likely to be quite limited. Trucks and other utility vehicles that are used both for training/exercise use and also (especially in the DPRK) for other goods and human transport uses, are assumed likely to be used significantly more than tanks and other armaments. See also Note 27.

26 There are a range of different estimates for the number of ground troops in the DPRK military in the years since 2000, though the range of estimates is not great. The document The Asian Military Balance: An Analytic Overview--A Comparative Summary of Military Expenditures; Manpower; Land, Air, and Naval, Forces; and Arms Sales, by Anthony H. Cordesman and G. Ryan Faith of the Center for Strategic and International Studies, Washington, D.C., (available as http://www.csis.org/media/csis/pubs/asia_ro_asian_mb_comp%5B1%5D.pdf), published May, 2003, lists the manpower of DPRK ground forces in 2003 at 950,000 troops. *Assuming that this estimate holds for 2005 and beyond, a "true-up factor" for the equipment estimates above of* 1.0149 *is implied.*

27 *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", and 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 includes a quote from Chin that suggests typical training for heavy equipment was minimal: "Due to the fuel shortage, the North Korean Army's training exercises for heavily armed vehicles such as tanks is said to involve 'an annual travel distance of 30 kilometers'". This quote would appear to pertain to the time period around 2000, and the interviewee claims to have been based near Wonsan, in the "rear area".*

If this information can be taken at face value, it would imply that a true estimate for training use for tanks (and other heavy armaments) might be just a few tens of km, as opposed to the 200 - 700 km/yr we estimate. Although it seems likely that training with heavy armaments is limited, and has been decreasing over the years, we will, until additional information becomes available, stay with our higher estimates of average usage. In so doing, we discount somewhat Chin Yon-kyu's account, in part because A) Chin appears to have been stationed well North of the DMZ, where training (and concentration of operable equipment, as well as fuel supplies) would be expected to be far less than in areas closer to the DMZ, and B) because it is only one, anecdotal account. Additional information on this topic would, however, be very welcome.

In the same interview, the interviewee reported that starting in "…1992, the North Korean Army has begun to gradually use fuel oil (incluidng benzene, gasoline, and diesel) stored for combat emergencies. Fuel oil tanks for use in combat are all empty."

28 *Several recent estimates based on the 2008 DPRK Census, including "[North Korea Census 2008] Korean People's Army estimated to number 700 thousand troops" (The Hankyoreh, dated 3/19/2010, and available as http://english.hani.co.kr/arti/english_edition/e_northkorea/411106.html) have estimated that the current number of people in the DPRK military is approximately* 700,000 *As this reduction of troops from previous estimates may not necessarily mean a proportionate reduction in movements by energy-using vehicles, we adopt a true-up factor for 2008 and 2009 that assumes a reduction in energy use equal to about half of the proportional reduction in troop levels from previous years, or* 0.874

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK

MILITARY AIRCRAFT UPDATE 2010/2011

Detailed Data and Results	
Prepared By:	David Von Hippel
Date Last Modified:	**3/2/2011**

COMMON ASSUMPTIONS & PARAMETERS--AIRCRAFT USE

(See Notes 22 and 23)

Mission Hours Per Year:	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**
Fighters/Bombers (*Note 13*)	**24**	**16**	**11**	**19**	**20**	**15.5**
Transport Aircraft	**50**	**42**	**32**	**38**	**39**	**39**
Helicopters	**32**	**24**	**18**	**24**	**24**	**24**
Ave. airspeed--Fract. of Maximum	**80%**	**80%**	**80%**	**80%**	**80%**	**80%**
Use of Service Vehicles Relative to 1990	**100%**	**80%**	**65%**	**70%**	**75%**	**75%**
Kerosene/Jet Fuel Energy Cont. (GJ/ltr)	**0.035**	*Note 15*				
Aviation Gasoline Energy Cont. (GJ/ltr)	**0.0321**	*Note 15*				

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			Number in Air Force Estimates from Sources												1990	1996	2000	2005	2008	2009
Type of Aircraft	**Class**		*1*	*2*	*3*	*4*	*17*	*18*	Number in Air Force Assumed	Range km	Fuel Capacity liters	Max. Speed km/hr	Cruise Speed km/hr	Ave. Fuel Consumpt l/hr	Total Fuel Consumpt liters	Total Fuel Consumpt GJ	Total Fuel Consumpt GJ	Total Fuel Consumpt GJ	Total Fuel Consumpt GJ	Total Fuel Consumpt GJ	Total Fuel Consumpt GJ
		Notes:							*19*	*14*	*14*	*14*	*14*								
Fixed Wing																					
F-5 (MIG-17) Fresco	Fighter		130			140		120	130	1270	2365	1145		1706	5.32E+06	1.86E+05	1.24E+05	8.54E+04	1.47E+05	1.55E+05	1.20E+05
F-6 (MIG-19) Farmer	Fighter/Bomber		160	160		110	>100	160	160	1390	2170	1590		1986	7.63E+06	2.67E+05	1.78E+05	1.22E+05	2.11E+05	2.22E+05	1.72E+05
MIG-21 Fishbed D/F/J	Fighter		160	120		130	120	160	160	971	2340	2230		4299	1.65E+07	5.78E+05	3.85E+05	2.65E+05	4.57E+05	4.81E+05	3.73E+05
F-7 (Fishbed C)	Fighter		40						40	1203	2340	2230		3470	3.33E+06	1.17E+05	7.77E+04	5.34E+04	9.23E+04	9.71E+04	7.53E+04
MIG-23 Flogger B/C/E/G/K	Fighter		46				46	45	46	1800	5750	2440		6236	6.88E+06	2.41E+05	1.61E+05	1.10E+05	1.91E+05	2.01E+05	1.56E+05
MIG-29 Fulcrum A/B	Fighter		10	"2 reg"	13			15	13	2100	4365	2440		4057	1.27E+06	4.43E+04	2.95E+04	2.03E+04	3.51E+04	3.69E+04	2.86E+04
MIG-15 Fagot	Fighter	*5*				180		190	144	1368	2365	1017		1407	4.86E+06	1.70E+05	1.13E+05	7.80E+04	1.35E+05	1.42E+05	1.10E+05
SU-7B Fitter A	Fighter		20	20		20	20	20	20	1450	5275	1696	850	4936	2.37E+06	8.29E+04	5.53E+04	3.80E+04	6.56E+04	6.91E+04	5.35E+04
SU-25 Frogfoot A	Fighter	*9*	35	>20	36		36	35	35	1250	4568	848		2479	2.08E+06	7.29E+04	4.86E+04	3.34E+04	5.77E+04	6.07E+04	4.71E+04
IL-28 Beagle	Bomber		80	82		85	82	80	82	2180	1740	900		575	1.13E+06	3.96E+04	2.64E+04	1.81E+04	3.13E+04	3.30E+04	2.56E+04
Y-5 (AN-2 Colt)	Transport	*20*	270	>250		205	270	>300	270	900	1200	220		235	3.17E+06	1.02E+05	8.54E+04	6.51E+04	7.73E+04	7.93E+04	7.93E+04
AN-24 (Coke)	Transport		6	10			10		6	600	5550	484		3582	1.07E+06	3.45E+04	2.90E+04	2.21E+04	2.62E+04	2.69E+04	2.69E+04
IL-18 Coot	Transport		2						2	6500	30000	675	625	2885	2.88E+05	9.26E+03	7.78E+03	5.92E+03	7.04E+03	7.22E+03	7.22E+03
IL-12 Coach (Civil)	Transport	*6,10,11*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.78E+04	3.30E+04	3.39E+04	3.39E+04
LI-2 Cab (Civil)	Transport	*6,10,11*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.78E+04	3.30E+04	3.39E+04	3.39E+04
IL-14 Crate (Civil)	Transport	*6, 10*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.78E+04	3.30E+04	3.39E+04	3.39E+04
Fighters (All)			601	748	748	580			748						5.03E+07	1.76E+06	1.17E+06	8.06E+05	1.39E+06	1.47E+06	1.14E+06
Bombers (All)			80	82	82	85			82						1.13E+06	3.96E+04	2.64E+04	1.81E+04	3.13E+04	3.30E+04	2.56E+04
Transport (All)			278	310	310	205			308						8.59E+06	2.76E+05	2.32E+05	1.76E+05	2.10E+05	2.15E+05	2.15E+05
Helicopters																					
MI-2 Hoplite		*7*		"Most"			188		113	715	846	210		199	7.19E+05	2.31E+04	1.73E+04	1.30E+04	1.73E+04	1.73E+04	1.73E+04
MI-4 Hound		*8, 12*				75			45	325	846	210	160	416	6.00E+05	1.92E+04	1.44E+04	1.08E+04	1.44E+04	1.44E+04	1.44E+04
MI-8 Hip		*8*							30	475	1870	250	225	886	8.50E+05	2.73E+04	2.05E+04	1.53E+04	2.05E+04	2.05E+04	2.05E+04
MI-17 Hip										475	1870	250	240	945							
Hughes 500 D/E				87		>75	87		87	480	240	250	240	120	3.34E+05	1.07E+04	8.04E+03	6.03E+03	8.04E+03	8.04E+03	8.04E+03
All				275	275				275						2.50E+06	8.03E+04	6.02E+04	4.52E+04	6.02E+04	6.02E+04	6.02E+04
												Kerosene/Jet Fuel			5.14E+07	1.80E+06	1.20E+06	8.24E+05	1.42E+06	1.50E+06	1.16E+06
												Aviation Gasoline			1.11E+07	3.56E+05	2.92E+05	2.22E+05	2.70E+05	2.75E+05	2.75E+05
ALL AIRCRAFT									1413			**TOTAL ALL FUELS**			6.25E+07	2.15E+06	1.49E+06	1.05E+06	1.69E+06	1.77E+06	1.44E+06
Air Force Personnel		80,000	*3, 21*																		
Service Vehicles		6,235	*16*												1.52E+07	4.94E+05	3.95E+05	3.21E+05	3.46E+05	3.71E+05	3.71E+05
TOTAL: AIRCRAFT PLUS GROUND SUPPORT VEHICLES												**TOTAL ALL FUELS**			7.76E+07	2.65E+06	1.89E+06	1.37E+06	2.04E+06	2.14E+06	1.81E+06

Notes:

1 *North Korea Handbook, US Department of Defense, 1994. (PC-2600-6421-94). Pages 6-165 - 6-178.*

2 *North Korea, The Foundations for Military Strength. US Defense Intelligence Agency (1990?). Pp. 47-48.*

3 *Point Paper, Republic of Korea/North Korea: Military Capabilities (with Military Balance). JICPAC (ONK), Sept. 1993.*

4 *From Opposing Force Training Module, North Korean Military Forces. Field Manual No. 34-21. Headquarters Department of the Army (US). February, 1982. Chapter 14.*

5 *Not given in source 1. Number assumed brings total of fighters up to that listed in sources 2 and 3.*

6 *Not given in source 1. Numbers assumed are guesses to bring total of transports to figures listed in sources 2 and 3.*

7 *Not given in source 1. Number assumed brings total of helicopters up to that listed in sources 2 and 3.*

8 *No breakdown between MI-4 and MI-8 available. Breakdown assumed is a guess. MI-8 and MI-17 are similar aircraft.*

9 *Fuel capacity estimated based on (max weight - empty weight - weapons weight).*

10 *No information available (1940's vintage aircraft). Range and fuel capacity assumed similar to IL-14.*

11 *Speed assumed similar to IL-18.*

12 *Fuel capacity assumed similar to the MI-2.*

13 *Translates to approximately two 1-hr missions per month per aircraft.*

14 *Fuel Capacity data are from the following sources: A) Jane's All the World's Aircraft, 1990/91, 1981/82, 1972/73, and 1968/69 editions. Jane's Publishing Co., N.Y., NY; B) Air Forces of the World, C.Chant, Brian Trodd Publishing House, Ltd (1990); C) Military Aircraft of the World, J.W.R. Taylor and G/ Swanborough, Ian Allen Ltd., UK (1979). Range and airspeed data are from a mixture of these sources and sources 1 and 4, above.*

15 *All jet aircraft are assumed to use Kerosene/Jet Fuel, while all propeller-driven craft and helicopters are assumed to use Aviation Gasoline.*

16 *Ground support vehicles for Air Force assumed to include light vehicles, 2 1/2 ton trucks, and larger trucks and utility vehicles in the same proportions as are used in the ground forces. The number of these vehicles per person in the Air Force is assumed to be the same as in the DPRK Army.*

17 *North Korea Country Handbook ,Marine Corps Intelligence Activity, 1997. (MCIA-2630-NK-016-97). File Nkor.pdf, obtained from Federation of American Scientists WWW site, 5/21/02, and dated May, 1997. Data on aircraft are mostly from pages 36 to 38 of this document.*

18 *North Korea, The Foundations for Military Strength -- Update 1995. US Defense Intelligence Agency (1995). Obtained from Federation of American Scientists WWW site, 5/21/02, and dated December, 1995.*

19 *As estimates of the numbers of aircraft from newer information sources (17 and 18) are not significantly different from those in earlier documents, we will continue to use the composite estimates of total aircraft shown here for 1996 and 2000 aircraft fuel use estimates.*

20 *Republic of Korea National Intelligence Service (1999), North Korea Military. The KPA: Troops & Equipment http://www.fas.org/irp/world/rok/nis-docs/defense08.htm, visited 5/21/02. This cource lists the DPRK Air Force as having "a whopping 820 support aircraft and helicopters", but does not indicate of what types are the approximately 200-plus aircraft beyond those listed in other sources (that is, apart from the AN-2 units and helicopters, the totals of which are similar to the listings above).*

21 *Republic of Korea National Intelligence Service, "North Korea Military. The KPA: Troops & Equipment", from http://www.fas.org/irp/world/rok/nis-docs/defense08.htm, visited 5/21/02, lists the total air force personnel for the DPRK at a total of 103,000, somewhat above the figure used here, but as the personnel totals do not directly affect fuel use estimates for this branch of the service, the figure from source 3 is used.*

22 *Unclassified informaiton on fuel use in the DPRK military was not available, but the informal opinion or analysts familiar with the DPRK military situation suggests that air force activity in the DPRK is, if anything, declining slowly, perhaps due to lack of fuel, probably due to lack of spare parts, and probably due to a recognition on the part of the DPRK military command that in a real conflict, the DPRK Air Force is unlikely, given the age and condition of its equipment, to play a substantial role. Accordingly, we have assumed that DPRK Air Force training exercises have continued to decrease slowly since 1996, as reflected in the flight-hours estimates shown.*

23 *The article "Korean People's Army Air Force" (http://www.globalsecurity.org/military/world/dprk/airforce.htm) on the Global Security website includes the following passage on the topic of training time for DPRK flight crews:*

> "Pilot proficiency is difficult to evaluate because it is crudely proportionate to hours and quality of flight time. Although the Republic of Korea Ministry of National Defense's Defense White Paper, 1990 states that flight training levels are 60 percent of South Korea's, other sources believe the figure is closer to 20 to 30 percent. Lower flight times are attributed to fuel shortages, a more conservative training philosophy, and perhaps a concern for older airframe life expectancies or maintenance infrastructure capacity. The training of pilots on the NKAF's most modern aircraft is much more significant than "seven flying hours per year" sometimes claimed in the West. But air crew are being trained in accordance with outdated procedures and, with lack of fuel, have very little experience."

Although this article does not provide definitive information on aircraft use in training, it would seem to be consistent with the assumptions of limited, and slowly decreasing, training levels made in this analysis. The same article also inicates that "Kazakhstan had transferred lethal military equipment, specifically about 40 MiG-21 fighter aircraft, to North Korea" in the late 1990s. We assume that this transfer has had little impact on overall usable stocks of that aircraft, or on training levels (and thus energy use).

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK

MILITARY SHIPS AND BOATS UPDATE 2010/2011

Detailed Data and Results

Prepared By: David Von Hippel

Date Last Modified: **10/26/2010**

True-Up Factors (*see Note 14*)	
Missile Attack Boats:	1.50
Amphibious:	1.46
Other Sm. Surface Vessels:	1.04

COMMON ASSUMPTIONS & PARAMETERS--NAVAL ENERGY USE

(Note 30)

Active Hours Per Year in:	**1990**	**1996**	**2000**	**2005**	**2008**	**2009**	**2010**
Amphibious	**50**	**50**	**45**	**45**	**40**	**40**	**0**
Submarines	**100**	**100**	**90**	**90**	**80**	**80**	**0**
Other Vessels	**800**	**570**	**535**	**560**	**480**	**400**	**0**
Ave. power use--Fract. of Max.	**50%**	**50%**	**50%**	**50%**	**50%**	**50%**	**50%**

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Marine Diesel Fuel Cons. (*15*)	0.38	lb/hp-hr
Sub Diesel Fuel Cons. (*16*)	0.5	lb/hp-hr
Diesel Energy Content:	0.04	GJ/liter
Conversion Factor	2.2	lb/kg
Diesel Fuel Density	0.87	kg/liter

Liters per gallon: 3.78

Type of Vessel	**Class**		Number in DPRK Navy Estimates from Sources								Number in Navy Assumed	Displcmt Tons	Range n.miles	Speed knots	Engine Power (b/s/hp)
			1	*2*	*3*	*4*	*5*	*22*	*23*	*24*					
		Notes:												*6*	*5*
Nanjin Class	Frigate	*21*				4	2		2	2	1	1800	4000	14	15000
T (Tral) Class	Lg Patrol					2					2	475		18	3000
Sariwon Class	Lg Patrol					3	4			4	4	450		21	3000
SO 1 Class	Lg Patrol					15	15			18	16	250	1100	13	7500
Artillerist Class	Lg Patrol	*17*				2					2	240		25	7500
Hainan Class	Lg Patrol					4	6			6	6	400	1000	10	8800
Taechong Class	Lg Patrol					2	7			13	7	*400*			7500
OSA 1 Class	Missile Att.					8	16	12		26	24	200	800	25	12000
Komar Class	Missile Att.					10	8		39?	6	15	80	400	30	4800
Shanghi Class--Gun	Fast Att.					8	12			14	13	155	800	17	4800
Swatow Class--Gun	Fast Att.					8	8				8	80	500	28	3000
Chodo Class--Gun	Fast Att.					4	4				4	130	2000	10	6000
K-48 Class--Gun	Fast Att.					4	4				4	100		24	5000
MO IV Class--Gun	Fast Att.	*13*				20					21	56		25	3000
Chongjin Class--Gun	Fast Att.	*7*				30	45	31		51	47	*80*		*40*	4800
P 6--Torpedo	Fast Att.	*26*				62				30	65	75	450	30	4800
P 4--Torpedo	Fast Att.					12	60				13	25		50	4800
Iwon--Torpedo	Fast Att.	*10*				15	15				16	40			3600
An Ju--Torpedo	Fast Att.					6	6				6	35	1300	20	4800
Chaho Class--Torpedo	Fast Att.			>60		60	66	62		52	69	80		40	4800
Sin Hung/Kosong--Torp.	Fast Att.	*8*				60	72			98	75	35			2400
Shersen Class--Torpedo	Fast Att.					4	3				4	160		41	12000
KM 4--Torpedo	Fast Att.					10	10				10	10			146
Torpedo Boats	Patrol			150		229		200	320						
Light Patrol	Patrol	*19*				20					21	*2*			146
Hantae	Landing	*12, 18*		8			8	8		10	12	*150*			5000
Nampo	Landing			>100		70	100	100	130	95	146	82	375	40	4800
Hanchon	Landing	*9, 18*				5	25			7	36	*150*		10	5000
Kong Bang (Hovercraft)	Landing	*24,27*						125	130	135	130			52	8000
Whiskey	Submarine			4		4	15			4	4	1030	13,000	8	4000
Romeo, Chinese	Submarine			4							4	1100	16,000	10	4000
Romeo, NK	Submarine			16		11			26	22	16	1100	16,000	10	4000
YUGO mini-sub	Submarine	*25*							48+	40+	48	25		4	160
Sang-O coastal infiltration	Submarine	*29*							3	22	12	277		8.8	*800*
Frigates				1	1					1	1				
Corvettes				2	2					2	2				
Missile Attack Boats				39	39	18					39				
Coastal Patrol Craft				388	388										
Mine Warfare Craft		*11*		23	23	42				23	56				
Amphibious Craft				194	194	75					324				
Submarines				24	24	15					84				
Trawlers						105									
TOTAL, ALL VESSELS				671	671	568					801	89,216			
Those Using Heavy Fuel Oil											1	1,800			
Naval Personnel	60,000	*3, 28*													
Service Vehicles	4,077	*20*													
TOTAL: VESSELS PLUS SERVICE VEHICLES															

		FUEL CONSUMPTION RESULTS: MILITARY VESSELS																	
		1990			**1996**			**2000**			**2005**			**2008**			**2009**		
Type of Vessel	**Class**	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year	Per Vessel Fuel Cons. liters/year	Per Class Fuel Cons. liters/year	Per Class Fuel Cons. GJ/year
Nanjin Class	Frigate	1,191,223	1.19E+06	4.48E+04	848,746	8.49E+05	3.19E+04	796,630	7.97E+05	2.99E+04	833,856	8.34E+05	31,340	714,734	7.15E+05	2.69E+04	595,611	5.96E+05	2.24E+04
T (Tral) Class	Lg Patrol	238,245	4.76E+05	1.79E+04	169,749	3.39E+05	1.28E+04	159,326	3.19E+05	1.20E+04	166,771	333,542	12,536	142,947	2.86E+05	1.07E+04	119,122	2.38E+05	8.95E+03
Sariwon Class	Lg Patrol	238,245	9.53E+05	3.58E+04	169,749	6.79E+05	2.55E+04	159,326	6.37E+05	2.40E+04	166,771	6.67E+05	2.51E+04	142,947	5.72E+05	2.15E+04	119,122	4.76E+05	1.79E+04
SO 1 Class	Lg Patrol	595,611	9.53E+06	3.58E+05	424,373	6.79E+06	2.55E+05	398,315	6.37E+06	2.40E+05	416,928	6.67E+06	2.51E+05	357,367	5.72E+06	2.15E+05	297,806	4.76E+06	1.79E+05
Artillerist Class	Lg Patrol	595,611	1.19E+06	4.48E+04	424,373	8.49E+05	3.19E+04	398,315	7.97E+05	2.99E+04	416,928	8.34E+05	3.13E+04	357,367	7.15E+05	2.69E+04	297,806	5.96E+05	2.24E+04
Hainan Class	Lg Patrol	698,851	4.19E+06	1.58E+05	497,931	2.99E+06	1.12E+05	467,356	2.80E+06	1.05E+05	489,195	2.94E+06	1.10E+05	419,310	2.52E+06	9.46E+04	349,425	2.10E+06	7.88E+04
Taechong Class	Lg Patrol	595,611	4.17E+06	1.57E+05	424,373	2.97E+06	1.12E+05	398,315	2.79E+06	1.05E+05	416,928	2.92E+06	1.10E+05	357,367	2.50E+06	9.40E+04	297,806	2.08E+06	7.83E+04
OSA 1 Class	Missile Att.	952,978	2.29E+07	8.60E+05	678,997	1.63E+07	6.12E+05	637,304	1.53E+07	5.75E+05	667,085	1.60E+07	601,721	571,787	1.37E+07	5.16E+05	476,489	1.14E+07	4.30E+05
Komar Class	Missile Att.	381,191	5.72E+06	2.15E+05	271,599	4.07E+06	1.53E+05	254,922	3.82E+06	1.44E+05	266,834	4.00E+06	150,430	228,715	3.43E+06	1.29E+05	190,596	2.86E+06	1.07E+05
Shanghi Class--Gun	Fast Att.	381,191	4.96E+06	1.86E+05	271,599	3.53E+06	1.33E+05	254,922	3.31E+06	1.25E+05	266,834	3.47E+06	1.30E+05	228,715	2.97E+06	1.12E+05	190,596	2.48E+06	9.31E+04
Swatow Class--Gun	Fast Att.	238,245	1.91E+06	7.16E+04	169,749	1.36E+06	5.10E+04	159,326	1.27E+06	4.79E+04	166,771	1.33E+06	5.01E+04	142,947	1.14E+06	4.30E+04	119,122	9.53E+05	3.58E+04
Chodo Class--Gun	Fast Att.	476,489	1.91E+06	7.16E+04	339,498	1.36E+06	5.10E+04	318,652	1.27E+06	4.79E+04	333,542	1.33E+06	5.01E+04	285,893	1.14E+06	4.30E+04	238,245	9.53E+05	3.58E+04
K-48 Class--Gun	Fast Att.	397,074	1.59E+06	5.97E+04	282,915	1.13E+06	4.25E+04	265,543	1.06E+06	3.99E+04	277,952	1.11E+06	4.18E+04	238,245	9.53E+05	3.58E+04	198,537	7.94E+05	2.98E+04
MO IV Class--Gun	Fast Att.	238,245	5.00E+06	1.88E+05	169,749	3.56E+06	1.34E+05	159,326	3.35E+06	1.26E+05	166,771	3.50E+06	1.32E+05	142,947	3.00E+06	1.13E+05	119,122	2.50E+06	9.40E+04
Chongjin Class--Gun	Fast Att.	381,191	1.79E+07	6.73E+05	271,599	1.28E+07	4.80E+05	254,922	1.20E+07	4.50E+05	266,834	1.25E+07	4.71E+05	228,715	1.07E+07	4.04E+05	190,596	8.96E+06	3.37E+05
P 6--Torpedo	Fast Att.	381,191	2.48E+07	9.31E+05	271,599	1.77E+07	6.64E+05	254,922	1.66E+07	6.23E+05	266,834	1.73E+07	6.52E+05	228,715	1.49E+07	5.59E+05	190,596	1.24E+07	4.66E+05
P 4--Torpedo	Fast Att.	381,191	4.96E+06	1.86E+05	271,599	3.53E+06	1.33E+05	254,922	3.31E+06	1.25E+05	266,834	3.47E+06	1.30E+05	228,715	2.97E+06	1.12E+05	190,596	2.48E+06	9.31E+04
Iwon--Torpedo	Fast Att.	285,893	4.57E+06	1.72E+05	203,699	3.26E+06	1.22E+05	191,191	3.06E+06	1.15E+05	200,125	3.20E+06	1.20E+05	171,536	2.74E+06	1.03E+05	142,947	2.29E+06	8.60E+04
An Ju--Torpedo	Fast Att.	381,191	2.29E+06	8.60E+04	271,599	1.63E+06	6.12E+04	254,922	1.53E+06	5.75E+04	266,834	1.60E+06	6.02E+04	228,715	1.37E+06	5.16E+04	190,596	1.14E+06	4.30E+04
Chaho Class--Torpedo	Fast Att.	381,191	2.63E+07	9.89E+05	271,599	1.87E+07	7.04E+05	254,922	1.76E+07	6.61E+05	266,834	1.84E+07	6.92E+05	228,715	1.58E+07	5.93E+05	190,596	1.32E+07	4.94E+05
Sin Hung/Kosong--Torp.	Fast Att.	190,596	1.43E+07	5.37E+05	135,799	1.02E+07	3.83E+05	127,461	9.56E+06	3.59E+05	133,417	1.00E+07	3.76E+05	114,357	8.58E+06	3.22E+05	95,298	7.15E+06	2.69E+05
Shersen Class--Torpedo	Fast Att.	952,978	3.81E+06	1.43E+05	678,997	2.72E+06	1.02E+05	637,304	2.55E+06	9.58E+04	667,085	2.67E+06	1.00E+05	571,787	2.29E+06	8.60E+04	476,489	1.91E+06	7.16E+04
KM 4--Torpedo	Fast Att.	11,595	1.16E+05	4.36E+03	8,261	8.26E+04	3.10E+03	7,754	7.75E+04	2.91E+03	8,116	8.12E+04	3.05E+03	6,957	6.96E+04	2.61E+03	5,797	5.80E+04	2.18E+03
Torpedo Boats	Patrol																		
Light Patrol	Patrol	11,595	2.43E+05	9.15E+03	8,261	1.73E+05	6.52E+03	7,754	1.63E+05	6.12E+03	8,116	1.70E+05	6.41E+03	6,957	1.46E+05	5.49E+03	5,797	1.22E+05	4.58E+03
Hantae	Landing	24,817	2.98E+05	1.12E+04	24,817	2.98E+05	1.12E+04	22,335	2.68E+05	1.01E+04	22,335	2.68E+05	1.01E+04	19,854	2.38E+05	8.95E+03	19,854	2.38E+05	8.95E+03
Nampo	Landing	23,824	3.48E+06	1.31E+05	23,824	3.48E+06	1.31E+05	21,442	3.13E+06	1.18E+05	21,442	3.13E+06	1.18E+05	19,060	2.78E+06	1.05E+05	19,060	2.78E+06	1.05E+05
Hanchon	Landing	24,817	8.93E+05	3.36E+04	24,817	8.93E+05	3.36E+04	22,335	8.04E+05	3.02E+04	22,335	8.04E+05	3.02E+04	19,854	7.15E+05	2.69E+04	19,854	7.15E+05	2.69E+04
Kong Bang (Hovercraft)	Landing	113,400	1.47E+06	5.54E+04	113,400	7.37E+06	2.77E+05	102,060	1.33E+07	4.99E+05	102,060	1.33E+07	4.99E+05	90,720	1.18E+07	4.43E+05	90,720	1.18E+07	4.43E+05
Whiskey	Submarine	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03	47,022	1.88E+05	7.07E+03	47,022	1.88E+05	7.07E+03	41,797	1.67E+05	6.28E+03	41,797	1.67E+05	6.28E+03
Romeo, Chinese	Submarine	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03	47,022	1.88E+05	7.07E+03	47,022	1.88E+05	7.07E+03	41,797	1.67E+05	6.28E+03	41,797	1.67E+05	6.28E+03
Romeo, NK	Submarine	52,247	8.36E+05	3.14E+04	52,247	8.36E+05	3.14E+04	47,022	7.52E+05	2.83E+04	47,022	7.52E+05	2.83E+04	41,797	6.69E+05	2.51E+04	41,797	6.69E+05	2.51E+04
YUGO mini-sub	Submarine	2,090	1.00E+05	3.77E+03	2,090	1.00E+05	3.77E+03	1,881	9.03E+04	3.39E+03	1,881	9.03E+04	3.39E+03	1,672	8.03E+04	3.02E+03	1,672	8.03E+04	3.02E+03
Sang-O coastal infiltratior	Submarine	10,449	1.25E+05	4.71E+03	10,449	1.25E+05	4.71E+03	9,404	1.13E+05	4.24E+03	9,404	1.13E+05	4.24E+03	8,359	1.00E+05	3.77E+03	8,359	1.00E+05	3.77E+03
Frigates			1.19E+06	4.48E+04		8.49E+05	3.19E+04		7.97E+05	2.99E+04		8.34E+05	3.13E+04		7.15E+05	2.69E+04		5.96E+05	2.24E+04
Corvettes			4.76E+05	1.79E+04		3.39E+05	1.28E+04		3.19E+05	1.20E+04		3.34E+05	1.25E+04		2.86E+05	1.07E+04		2.38E+05	8.95E+03
Missile Attack Boats			2.86E+07	1.07E+06		2.04E+07	7.66E+05		1.91E+07	7.19E+05		2.00E+07	7.52E+05		1.72E+07	6.45E+05		1.43E+07	5.37E+05
Coastal Patrol Craft																			
Mine Warfare Craft																			
Amphibious Craft			6.14E+06	2.31E+05		1.20E+07	4.53E+05		1.75E+07	6.57E+05		1.75E+07	6.57E+05		1.55E+07	5.84E+05		1.55E+07	5.84E+05
Submarines			1.48E+06	5.56E+04		1.48E+06	5.56E+04		1.33E+06	5.00E+04		1.33E+06	5.00E+04		1.18E+06	4.45E+04		1.18E+06	4.45E+04
Trawlers																			
TOTAL, VESSELS			1.72E+08	6.48E+06		1.31E+08	4.92E+06		1.29E+08	4.84E+06		1.34E+08	5.04E+06		1.15E+08	4.34E+06		9.90E+07	3.72E+06
Those Using Heavy Fuel Oil			1.19E+06	4.48E+04		8.49E+05	3.19E+04		7.97E+05	2.99E+04		8.34E+05	3.13E+04		7.15E+05	2.69E+04		5.96E+05	2.24E+04
Service Vehicles			1.14E+07	3.71E+05		8.63E+06	2.81E+05		8.50E+06	2.77E+05		8.84E+06	2.88E+05		7.62E+06	2.48E+05		6.53E+06	2.13E+05
TOTAL: VESSELS PLUS SERVICE VEHICLES			1.84E+08	6.85E+06		1.39E+08	5.20E+06		1.37E+08	5.12E+06		1.43E+08	5.33E+06		1.23E+08	4.59E+06		1.06E+08	3.93E+06

Notes:

1 North Korea Handbook , US Department of Defense, 1994. (PC-2600-6421-94). Pages 6-165 - 6-178.

2 North Korea, The Foundations for Military Strength . US Defense Intelligence Agency (1990?). Pp. 44-46.

3 Point Paper, Republic of Korea/North Korea: Military Capabilities (with Military Balance). JICPAC (ONK), Sept. 1993.

4 From Opposing Force Training Module, North Korean Military Forces. Field Manual No. 34-21 . Headquarters Department of the Army (US). February, 1982. Chapter 15.

5 Jane's Fighting Ships, 1987-88 . Edited by J. Moore, Jane's Publishing Co., NY, NY. P. 329-222.

6 Speed shown is that given with the range of the vessel, if specified.

7 Assumed similar to Chaho Class based on information in source 4.

8 Similar to Soviet "D3" class.

9 Source 4 shows this vessel as approximately twice as long and 10% wider than the Nampo.

10 Similar to Soviet "P 2" class.

11 Total shown for source 4 are vessels listed in source 1 as mine-capable.

12 Source 1 shows this vessel to be about 30% longer, 10% narrower than the Hanchon

13 Assumed similar to Swatow class (engine size)

14 "True-up" factors are used to inflate numbers of vessels by individual class (from 4 and 5) to the aggregate values presented in sources 2 and 3. True-up factors are not applied to Kong Bang hovercraft or mini-subs.

15 Generic value for fuel consumption by marine diesel engines from The Marine Power Plant, L.B.Chapman McGraw-Hill, 1942. This figure may (or may not) be slightly high for the DPRK Navy. Figure judged to be reasonable by a representative of a US distributor of marine diesel engines, who gave a range of 0.32 lb/hp-hr for best modern diesels, to 0.40+ for older diesels, with 20 hp-hr/gallon (0.364 lb/hp-hr) as a modern rule of thumb. Same representative also indicated that a range of 0.4 to 0.6 of maximum power use was a reasonable range for a ship cruising at sea.

16 *Generic value for fuel consumption by submarine diesel engines from Submarine Design and Development, N.Freedman, Naval Institute Press, Annapolis, MD, 1984. P. 131.*

17 *Assumed similar to SO 1 class (engine size)*

18 *Assumed similar to K-48 class (engine size)*

19 *Assumed similar to KM-4 torpedo class (engine size)*

20 *Service vehicles for Navy assumed to include light vehicles, 2 1/2 ton trucks, and larger trucks and utility vehicles in the same proportions as are used in the ground forces. The number of these vehicles per person in the Navy is assumed to be the same as in the DPRK Army.*

21 *Frigate is assumed to be fueled with heavy oil. All other vessels are assumed to be diesel-fueled.*

22 *North Korea Country Handbook ,Marine Corps Intelligence Activity, 1997. (MCIA-2630-NK-016-97). File Nkor.pdf, obtained from Federation of American Scientists WWW site, 5/21/02, and dated May, 1997. Data on naval vessels are mostly from pages 39 and 40 of this document.*

23 *North Korea, The Foundations for Military Strength -- Update 1995. US Defense Intelligence Agency (1995). Obtained from Federation of American Scientists WWW site, 5/21/02, and dated December, 1995.*

24 *World Navies Today: North Korea, from www.hazegray.org/worldnav/ (visited 5/22/02) suggests that the DPRK has "135 Kongbang class assault hovercraft, carrying 35-55 troops". Source 22 lists three types of these craft, with sizes ranging from 23 x 60.7 feet to 29.5 x 75.5 feet. Source 22 lists the speed of these vessels as 52 knots. No specific information on the propulsion systems used in these craft was included in either of these sources, but a somewhat larger troop landing hovercraft (47 x 88 feet) used by the US Navy, and with a slightly lower speed, is listed as having 16,000 hp (total?) in four turbine engines. http://www.fas.org/man/dod-101/sys/ship/lcac.htm (visited 5/22/02) lists the US "LCAC" as having 12,280 bhp, and "Fuel capacity is 5000 gallons. The LCAC uses an average of 1000 gallons per hour." Assume that the somewhat smaller DPRK vessels would have lower fuel consumption and power ratings perhaps [600] gallons per hour. According to source 23, production of the Kong Bang type II and III craft began in 1988, suggesting that the major portion of the Kong Bang fleet was produced after 1990. Assume that [10%] of the fleet shown was in service by 1990, and [50%] was in service by 1996.*

25 Source 23 suggests that there are "over 48" YUGO submarines and 3 SANGO coastal submarines in the DPRK fleet.

26 Source 24 lists 18 "Sinpo class" small patrol boats, with 66.5 tons full load displacement, and 4800 hp diesels, and "up to 12" P-6 class small torpedo boats.

27 Estimate of 8000 bhp shown here for the Kong Bang hovercraft is a rough figure based on the specifications for the larger US vessel described in note 24. Fuel consumption, however, is based on the estimate given in note 24, not on the horsepower estimate. See also notes 31 and 32.

28 Republic of Korea National Intelligence Service, "North Korea Military. The KPA: Troops & Equipment", from http://www.fas.org/irp/world/rok/nis-docs/defense08.htm, visited 5/21/02, lists the total naval force personnel for the DPRK at a total of 48,000, somewhat above the figure used here, but as the personnel totals do not directly affect fuel use estimates for this branch of the service, the figure from source 3 is used.

29 Engine size for the Sang-O submarines is a rough estimate based on reported engine size for other DPRK subs and the relative size of the different submarine models.

30 There does not appear to be any available definitive intormation of an unclassified nature that could be used to even quailitatively estimate the level of activity in the DPRK naval forces as of 2000 or 2005. Analysts contacted in researching this update, however, indicate that the DPRK Navy did not, as of about 2002 seem to be operating under any particular fuel restrictions, and that the level of incursions (from DPRK vessels) experienced in ROK waters seems to be fairly consistent with prior years. As a result, we have assumed that DPRK naval activity was about the same (in terms of activity per vessel) as in 1996 for vessels other than submarines and amphibious craft. We have assumed that submarine and amphibious craft activity in the DPRK navy declined slightly in the period after 1996, in part, in the case of amphibious craft, in keeping with our assumption of reduced training levels for ground forces, as well as taking into account reported restrictions on fuel availability in the general economy.

31 http://www.globalsecurity.org/military/world/dprk/navy.htm states "[t]he North Korean navy has built over 140 hovercraft capable of carrying platoon-size units ashore…" which is on the same order as the estimates of the number of these craft provided in other sources, but slightly higher.

32 Two recent ROK media reports--"North Korea Deploys Air Cushion Warships", Seoul, The Korea Times (Internet Version-WWW) in English, by Cho'ng Su'ng-ki, dated April 1, 2007 (and quoting the 2006 ROK Defense White Paper); and "N.Korea Develops High-Speed Military Hovercraft", Seoul. Chosun Ilbo WWW-Text in English, dated April 2, 2007--report the development of DPRK hovercraft, but these appear to be the same as the Kong Bang hovercraft developed deployed during the 1990s, with no apparent change in the number of such vessels (both of the 2007 articles give a number of 130 hovercraft) since about 2000.

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK
ENERGY USE IN MANUFACTURING MILITARY EQUIPMENT UPDATE 2010/2011

Detailed Data and Results	
Prepared By:	David Von Hippel
Date Last Modified:	**2/28/2011**

COMMON ASSUMPTIONS & PARAMETERS, MILITARY MANUFACTURING	
Lifetime of Ground Forces Equipment (yrs):	20
Lifetime of Small Armaments (yrs):	10
Lifetime of Naval Vessels (yrs):	30
Fract. of Weight of Equipment as Iron & Steel	90%

GROUND FORCES: VEHICLES		Estimated Number in Service	Average Weight Each (t)	Made in DPRK?	Equip. Lifetime (years)	Total Weight (t)	Estimated Iron&Steel Needed (t)
	Notes:		*1*				
Tanks							
T-54/55		2,185	36	Yes?	20	7.87E+04	3.54E+03
T62/63/PT-76		3,106	36.4	Yes?	20	1.13E+05	5.09E+03
Assault		541	30	Yes?	20	1.62E+04	7.30E+02
Amphibious Vehicles +							
PT-76		189	14	Yes?	20	2.65E+03	1.19E+02
PTS		11	*20*	Yes?	20	2.28E+02	1.02E+01
K-61		364	*15*	Yes?	20	5.47E+03	2.46E+02
GAZ-46		40	*2*	Yes	20	7.97E+01	3.59E+00
Amphibious Ferry		68	50	Yes?	20	3.42E+03	1.54E+02
Tank Retriever		227	29	Yes?	20	6.57E+03	2.96E+02
Armored Fighting Vehicles							
BTR-60		3,622	10	Yes?	20	3.62E+04	1.63E+03
BRDM		393	*5*	Yes?	20	1.96E+03	8.84E+01
Truck/Tank Mtd Guns & Missiles							
AAG		273	31	Yes?	20	8.47E+03	3.81E+02
BM-21	*2*	157	13	Yes?	20	2.04E+03	9.19E+01
BM-20,24		17	9	Yes?	20	1.54E+02	6.92E+00
FROG 3/5		34	16	Yes?	20	5.47E+02	2.46E+01
FROG 7		34	20	Yes?	20	6.83E+02	3.07E+01
Light Vehicles							
Jeeps		6,150	1.5	Yes	20	9.22E+03	4.15E+02
Motorcycles		2,895	0.2	Yes	20	5.79E+02	2.61E+01
2 1/2 T Trucks		72,403	2.9	Yes	20	2.10E+05	9.45E+03
Trucks and Utility Vehicles					20		
Dump		26	13.5	Yes	20	3.54E+02	1.59E+01
Zil-135		34	12.4	No	20	4.24E+02	0.00E+00
Zil-151		547	6.1	No	20	3.33E+03	0.00E+00
KRAZ-214		102	13.5	Yes	20	1.38E+03	6.23E+01
GAZ-63		410	2.9	Yes	20	1.19E+03	5.35E+01
Zil-157V		239	6.6	No	20	1.58E+03	0.00E+00
Power Boats		150	*1*	Yes	20	1.50E+02	6.76E+00
Other Heavy Equipment		123	6.6	Yes	20	8.12E+02	3.65E+01
TOTAL--GROUND FORCES VEHICLES		94,343				5.05E+05	2.25E+04

		Estimated Number in Service	Average Weight Each (t)	Made in DPRK?	Equip. Lifetime (years)	Total Weight (t)	Estimated Iron&Steel Needed (t)
	Notes:		*1*				
GROUND FORCES: OTHER ARMAMENTS							
Towed Guns and Missile Launchers	*3*	10,000	6	Yes?	20	6.00E+04	2.70E+03
Light Arms, Various	*4*			Yes?	10	*42,640*	3.84E+03
TOTAL--GROUND FORCES OTHER						1.03E+05	6.54E+03

NAVAL FORCES						
Total Tonnage of Naval Vessels	*5*		Yes	30	8.92E+04	2.68E+03
Service Vehicles	7	4,077	(varies)	20	1.29E+04	5.66E+02
TOTAL--NAVAL FORCES					1.02E+05	3.24E+03
AIR FORCES						
AIRCRAFT	*6*		No			0
Service Vehicles	*7*	6,235	(varies)	20	1.72E+04	7.55E+02
TOTAL--AIR FORCES					1.72E+04	7.55E+02
TOTAL IRON&STEEL REQUIRED/YR FOR MILITARY EQUIPMENT						3.30E+04

CALCULATION OF ENERGY REQUIRMENTS FOR MILITARY PRODUCT MANUFACTURING, 1990

Energy Required to melt iron for steel	**250**	kgce/te crude steel	*Note 8*
Average number of melts to produce military products	**2**		*Note 9*
DPRK Steelmaking processes assumed to be	**10%**	more energy intensive than in China	
Conversion Factor:	29.3	GJ/tce	

ESTIMATED COAL TO MANUFACTURE IRON AND STEEL MILITARY EQUIPMENT	5.32E+05	GJ
Fract. Energy Use in Production of Military Equipment Represented by Iron and Steel	**60%**	*Note 9*
ESTIMATED TOTAL COAL USED IN MILITARY EQUIPMENT MANUFACTURE	**8.87E+05**	GJ
Ratio of Electricity Use to Coal Use in DPRK (Non-Military) Iron and Steel Industry	0.054	*Note 10*
ESTIMATED TOTAL ELECTRICITY USED IN MILITARY EQUIPMENT MANUFACTURE	**4.75E+04**	GJ

PROJECTION OF ENERGY REQUIRMENTS FOR MILITARY PRODUCT MANUFACTURING

Ratio of Military Equipment Output in 1996 versus 1990:	**0.7**	
Ratio of Military Equipment Output in 2000 versus 1990:	**0.45**	***(See Notes 11 - 13)***
Ratio of Military Equipment Output in 2005 versus 1990:	**0.45**	***(See Notes 11 - 13)***
Ratio of Military Equipment Output in 2008 versus 1990:	**0.45**	
Ratio of Military Equipment Output in 2009 versus 1990:	**0.45**	

	1996	2000	2005
Projection of Coal Use in Military Manufacturing (GJ)	**6.21E+05**	**3.99E+05**	**3.99E+05**
Projection of Electricity Use in Military Manufacturing (GJ)	**3.33E+04**	**2.14E+04**	**2.14E+04**

	2008	2009	2010--D
Projection of Coal Use in Military Manufacturing (GJ)	**3.99E+05**	**3.99E+05**	**7.54E+05**
Projection of Electricity Use in Military Manufacturing (GJ)	**2.14E+04**	**2.14E+04**	**4.04E+04**

Notes:

1 *From Opposing Force Training Module, North Korean Military Forces. Field Manual No. 34-21. Figures in* ***italics*** *are guesses--no data available.*

2 *Weight of launcher only--prime mover assumed to be imported..*

3 *Point Paper, Republic of Korea/North Korea: Military Capabilities (with Military Balance). JICPAC (ONK), Sept. 1993. This source reports roughly 10,800 artillery pieces and rocket launchers. Figure shown nets out roughly guns and missiles included in the accounting of ground forces vehicles. Weight per unit is a rough estimate, and is probably more likely to be high than low.*

4 *Assumes an average of 40 kg of light arms per person in the Army.*

5 *Sum of displacement of Naval vessels. Actual weight of vessels may be different.*

6 *All aircraft assumed to be imported.*

7 *Based on service/ground support vehicle totals calculated in the Aircraft and Navy sheets, and the vehicle tonnages shown in the Ground Forces section of this sheet.*

8 *"The Energy Efficiency of the Steel Industry of China", M.Ross and L.Feng. Energy, Volume 16, no. 5 (1991), pp. 833-848.*

9 *Peter Zimmerman, personal communication.*

10 *Assumes that the ratio of electricity to coal use in military manufacturing will be similar to that in the iron and steel subsector of the DPRK's (assumed) non-military industries. Ratio calculated from figures in estimated energy balance for DPRK.*

11 *There has been little direct or quantitative information available on the intensity of military manufacturing in the DPRK in recent years. There have been some reports of missile exports from the DPRK. The Seoul T'ongil Kyongje article referenced below (13) suggests that exports of SCUD-C missles in the "early 1990s" were on the order of 100-150 per year. The same article also suggests that "weapons exports at the 15 to 20 percent [presumably of total national exports] in the Cold War…dropped to less than 5 percent after the mid 1990s". It seems unlikely that such exports of relatively high-value armaments would have a substantial effect on overall military sector manufacturing. We assume that the level of military manufacturing is approximately the same as in 1996, though even that level may be difficult for the DPRK to sustain given the reported difficulties in the DPRK coal sector.*

12 *A description of SCUD missles ("Weapons of Mass Destruction (WMD): R-11 / SS-1B SCUD-A R-300 9K72 Elbrus / SS-1C SCUD-B") from http://www.globalsecurity.org/wmd/world/russia/r-11.htm suggests that the typical weight of a SCUD missile is about 6.5 tonnes, of which "3,500 kilograms (7,700 pounds) of IRFNA [inhibited red fuming nitric acid, a fuel oxidant] and about 1,000 kilograms (2,200 pounds) of fuel". An article in Janes.com, "SS-1 `Scud' (R-11/8K11, R-11FM (SS-N-1B) and R-17/8K14)", dated April 26, 2001, lists the SCUD-C as having a launch weight of 6.4 tonnes and a warhead weight of 600 kg (http://www.janes.com/security/international_security/news/misc/sws_scud010426.shtml). these figures together suggest that the weight of the missile hardware itself is about 1.3 tonnes. Assuming that most or all of this mass is steel, exports of SCUD-C missiles in the early-1990s imply a use of iron/steel of about 130-200 tonnes--which amounts to on the order of half of 1 percent of the iron/steel needed for routine replacement of DPRK equipment (as of 1990), as calculated above. Thus, exports of these missiles, at least, would seem to have little impact on overall DPRK Military manufacturing energy use.*

13 *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. This general description, together with the information in notes 11 and 12, leads us to believe that military manufacturing has fallen fairly substantially since 1996, in part due to further loss of exports since then, but also due to fuels, material, and parts shortages. We assume that military manufacturing activity was 45 percent of (estimated) 1990 levels in 2005. This would mean that miltary-sector manufacturing, while substantially less than in 1990, has not fallen by as much as average industrial sector output in the DPRK.*

ESTIMATES OIL FUEL USE IN A CONFLICT BY THE MILITARY SECTOR IN THE DPRK

Prepared by: D. Von Hippel, 6/3/04 **(Updated 4/12/07, 10/16/2011, and 8/22/12)**

Based on our estimates of 1990 Fuel Use (from this workbook), total use of fuel per hour of exercise-level activity are as follows:

Conversions from GJ to tonnes assume	43	GJ/tonne fuel

Service	GJ/hr	Tonnes/hr	Notes
Ground Forces	7,638	178	Per hour overall ground forces activity*
Air Forces	110,342	2,566	Per hour fighter/bomber activity
Naval Forces	8,559	199	Per hour "other vessels" activity

*Assumes armaments (including tanks) move 4 times as much as during routine exercises.

Assuming a 30 -day conflict in which:
50% of ground forces are destroyed/rendered inoperable by the end of the period,
and ground forces are moving about 50% of the time,
100% of air forces are destroyed/rendered inoperable or placed in deep storage within
24 hours of the start of the conflict, and
90% of naval forces are destroyed/rendered inoperable/placed in deep storage within
120 hours of the start of the conflict.

Total fuel use during a 30-day conflict would be: 129,387 tonnes

Based on our preliminary estimates of year 2009 diesel plus gasoline production plus imports in the DPRK, it would take on the order of 3.6 months to replenish the stocks consumed in the conflict, even if A) all domestic production and imports were diverted to the war effort, and B) all supply lines remained intact.
Running the two operating refineries at full capacity (only possible if sufficient imported crude oil supplies are available) would increase the total output of gasoline plus diesel by about 3.70E+04 tonnes per month, meaning that the stocks consumed could be replenished in about 1.8 months

The rate of fuel use by the forces remaining after a 30-day war as above would be 108.71 tonnes/hr
This is about 215% of the total average year 2009 rate of diesel plus gasoline production and imports, or
about 107% of the total rate of diesel plus gasoline production and imports with refineries running to full capacity.