THE DPRK ENERGY SECTOR: ESTIMATED YEAR 2000 ENERGY BALANCE AND SUGGESTED APPROACHES TO SECTORAL REDEVELOPMENT

ATTACHMENTS

WORKPAPERS, BACKGROUND DATA, AND DETAILED RESULTS

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ATTACHMENT 1

WORKPAPERS AND DETAILED RESULTS:

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

NAUTILUS INSTITUTE

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

2002 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 1990

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	1,355,949	110,742	26,604	76,641	376,250	-	(11,886)	1,934,300
Domestic Production	1,317,960	-		76,641	349,583			1,744,185
Imports	68,392	110,742	26,604		26,667			232,404
Exports	30,403						11,886	42,289
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(375,470)	(110,742)	82,809	(76,641)	(10,667)	3,520	122,184	(365,007)
Electricity Generation	(295,227)		(21,645)	(76,641)			165,600	(227,914)
Petroleum Refining		(110,742)	104,454				(593)	(6,881)
Coal Production/Preparation	(63,900)						(8,654)	(72,554)
Charcoal Production					(10,667)	3,520		(7,147)
Coke Production								-
Other Transformation								-
Own Use							(12,408)	(12,408)
Losses	(16,343)						(21,761)	(38,104)
FUELS FOR FINAL CONSUMPTION	980,479	-	109,413	-	365,583	3,520	110,298	1,569,293
ENERGY DEMAND	979,947	-	109,710	-	365,475	3,435	110,302	1,568,869
INDUSTRIAL SECTOR	660,084	-	25,110	-	1,600	-	65,439	752,233
Iron and Steel	378,717						20,286	399,003
Cement	87,059		8,610				5,504	101,174
Fertilizers	23,994						18,891	42,885
Other Chemicals	11,203						6,616	17,819
Pulp and Paper	4,026						932	4,959
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	40,000		3,900		1,600		6,000	51,500
TRANSPORT SECTOR	-	-	36,413	-	1,696	-	11,533	49,643
Road			30,288		1,696			31,984
Rail	-		1,949				10,533	12,482
Water	-		1,253					1,253
Air			1,123					1,123
Non-Specified			1,800				1,000	2,800
RESIDENTIAL SECTOR	218,440	-	7,300	-	258,562	3,435	10,718	498,456
Urban	117,956		6,441			3,435	7,420	135,253
Rural	100,484		859		258,562		3,298	363,203
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	-	-	1,947	-	-	-	100	2,047
Large Ships	-		1,747					1,747
Processing/Other	-		200				100	300
MILITARY SECTOR	38,467	-	18,812	-	-	-	9,008	66,287
Trucks and other Transport			6,585					6,585
Armaments			2,632					2,632
Air Force			2,648					2,648
Naval Forces			6,847					6,847
Military Manufacturing	887						48	935
Buildings and Other	37,580		100				8,960	46,640
PUBLIC/COMMERCIAL SECTORS	34,915		-		-		10,932	45,847
NON-SPECIFIED/OTHER SECTORS			5,700					5,700
NON-ENERGY USE	18,290		9,422		58,667			86,379
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)
2002 UPDATE
ESTIMATED ENERGY BALANCE FOR THE YEAR 1996

Prepared By David Von Hippel
Date Last Modified: 2/21/2003

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	696,725	42,503	31,159	19,160	366,811	-	(3,328)	1,153,030
Domestic Production	740,694	-		19,160	340,145			1,099,998
Imports	4,018	42,503	38,556		26,667			111,744
Exports	47,987						3,328	51,315
Inputs to International Marine Bunkers								-
Stock Changes			7,397					7,397
ENERGY TRANSFORMATION	(241,525)	(42,503)	15,395	(19,160)	(7,787)	2,570	48,994	(244,016)
Electricity Generation	(196,429)		(24,694)	(19,160)			78,981	(161,303)
Petroleum Refining		(42,503)	42,503				(227)	(227)
Coal Production/Preparation	(35,912)						(4,863)	(40,775)
Charcoal Production					(7,787)	2,570		(5,217)
Coke Production								-
Other Transformation								-
Own Use			(2,413)				(9,649)	(12,062)
Losses	(9,185)						(15,247)	(24,431)
FUELS FOR FINAL CONSUMPTION	455,200	-	46,555	-	359,025	2,570	45,666	909,015
ENERGY DEMAND	455,161	-	46,547	-	358,948	2,554	45,885	909,095
INDUSTRIAL SECTOR	242,504	-	8,505	-	528	-	21,909	273,446
Iron and Steel	148,782						7,970	156,751
Cement	31,003		3,407				1,960	36,370
Fertilizers	6,515						5,130	11,645
Other Chemicals	3,697		-				2,183	5,880
Pulp and Paper	1,329						308	1,636
Other Metals	7,828						1,362	9,189
Other Minerals	-		4,158				131	4,289
Textiles	9,697						824	10,521
Building Materials	20,453						62	20,516
Non-specified Industry	13,200		941		528		1,980	16,649
TRANSPORT SECTOR	-	-	14,910	-	814	-	4,670	20,394
Road			12,667		814			13,482
Rail	-		779				4,670	5,449
Water	-		564					564
Air			899					899
Non-Specified			-				-	-
RESIDENTIAL SECTOR	129,927	-	2,128	-	281,951	2,554	5,885	422,445
Urban	70,160		1,916			2,554	4,414	79,043
Rural	59,767		213		281,951		1,471	343,402
AGRICULTURAL SECTOR	8,775	-	1,502	-	40,455	-	2,315	53,046
Field Operations			786				816	1,602
Processing/Other	8,775		716		40,455		1,498	51,444
FISHERIES SECTOR	-	-	973	-	-	-	50	1,023
Large Ships	-		873					873
Processing/Other	-		100				50	150
MILITARY SECTOR	38,290	-	15,702	-	-	-	4,518	58,510
Trucks and other Transport			5,735					5,735
Armaments			2,290					2,290
Air Force			2,135					2,135
Naval Forces			5,443					5,443
Military Manufacturing	710		-				38	748
Buildings and Other	37,580		100				4,480	42,160
PUBLIC/COMMERCIAL SECTORS	31,151		-		-		6,539	37,690
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE	4,515		2,827		35,200			42,542
Electricity Gen. (Gross TWhe)*	15.71		0.91	5.32				21.94

**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)

2002 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 2000

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

UNITS: TERAJOULES (TJ)	COAL & COKE	CRUDE OIL	REFINED PROD.	HYDRO/ NUCLEAR	WOOD/ BIOMASS	CHARCOAL	ELECTRICITY	**TOTAL**
ENERGY SUPPLY	385,716	24,796	39,996	35,449	358,572	-	(82)	844,448
Domestic Production	384,185	-		35,449	331,906			751,540
Imports	9,318	24,796	43,005		26,667			103,786
Exports	7,788		3,009				82	10,878
Inputs to International Marine Bunkers								-
Stock Changes			-					-
ENERGY TRANSFORMATION	(54,984)	(24,796)	5,891	(35,449)	(7,680)	2,534	29,301	(85,183)
Electricity Generation	(31,593)		(16,278)	(35,449)			45,490	(37,830)
Petroleum Refining		(24,796)	23,577				(147)	(1,366)
Coal Production/Preparation	(18,627)						(2,523)	(21,149)
Charcoal Production					(7,680)	2,534		(5,146)
Coke Production								-
Other Transformation								-
Own Use			(1,408)				(1,955)	(3,363)
Losses	(4,764)						(11,565)	(16,329)
FUELS FOR FINAL CONSUMPTION	330,732	-	45,887	-	350,892	2,534	29,219	759,265
ENERGY DEMAND	330,760	-	45,883	-	350,920	2,539	29,216	759,318
INDUSTRIAL SECTOR	152,875	-	11,652	-	327	-	12,612	177,465
Iron and Steel	77,301						4,141	81,442
Cement	29,531		6,490				1,867	37,889
Fertilizers	2,906						2,288	5,194
Other Chemicals	2,287		-				1,350	3,637
Pulp and Paper	822						190	1,012
Other Metals	4,842						842	5,684
Other Minerals	-		4,274				134	4,408
Textiles	5,998						510	6,507
Building Materials	21,024						64	21,088
Non-specified Industry	8,165		888		327		1,225	10,604
TRANSPORT SECTOR	-	-	7,717	-	489	-	3,160	11,365
Road			6,044		489			6,533
Rail	-		585				3,160	3,745
Water	-		439					439
Air			650					650
Non-Specified			-				-	-
RESIDENTIAL SECTOR	107,645	-	2,582	-	280,316	2,539	2,788	395,870
Urban	58,127		1,905			2,539	2,463	65,034
Rural	49,517		677		280,316		325	330,836
AGRICULTURAL SECTOR	8,775	-	1,763	-	40,455	-	2,500	53,493
Field Operations			1,048				882	1,930
Processing/Other	8,775		716		40,455		1,618	51,564
FISHERIES SECTOR	-	-	808	-	-	-	42	849
Large Ships	-		725					725
Processing/Other	-		83				42	125
MILITARY SECTOR	38,290	-	16,606	-	-	-	4,518	59,414
Trucks and other Transport			5,894					5,894
Armaments			2,353					2,353
Air Force			1,703					1,703
Naval Forces			6,555					6,555
Military Manufacturing	710		-				38	748
Buildings and Other	37,580		100				4,480	42,160
PUBLIC/COMMERCIAL SECTORS	21,249		-		-		3,597	24,846
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE	1,926		4,755		29,333			36,015
Electricity Gen. (Gross TWhe)*	2.64		0.15	9.85				12.64

**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)

2002 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 1990: REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	110,742	5,272	12,954	6,220	2,159	-		137,346
Domestic Production	-							-
Imports	110,742	5,272	12,954	6,220	2,159			137,346
Exports								-
Inputs to International Marine Bunkers								-
Stock Changes								-
ENERGY TRANSFORMATION	(110,742)	25,314	19,344	16,932	8,843	11,627	1,080	(27,602)
Electricity Generation				(21,645)				(21,645)
Petroleum Refining	(110,742)	25,314	19,344	38,578	8,843	17,583	1,080	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
Other Transformation								-
Own Use						(5,956)		(5,956)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	30,586	32,298	23,152	11,002	11,627	1,080	109,744
ENERGY DEMAND	-	30,578	32,279	23,155	10,993	11,627	1,080	109,711
INDUSTRIAL SECTOR	-	-	3,500	21,610	-	-	-	25,110
Iron and Steel								-
Cement				8,610				8,610
Fertilizers								-
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				12,600				12,600
Textiles								-
Building Materials								
Non-specified Industry			3,500	400				3,900
TRANSPORT SECTOR	-	22,783	11,880	627	399	-	724	36,413
Road		22,783	7,505					30,288
Rail			1,949					1,949
Water			627	627				1,253
Air					399		724	1,123
Non-Specified			1,800					1,800
RESIDENTIAL SECTOR	-	-	-	-	5,096	2,204	-	7,300
Urban					4,237	2,204		6,441
Rural					859			859
AGRICULTURAL SECTOR	-	-	5,005	-	-	-	-	5,005
Field Operations			2,619					2,619
Processing/Other			2,386					2,386
FISHERIES SECTOR	-	-	1,073	873	-	-	-	1,947
Large Ships			873	873				1,747
Processing/Other			200			-		200
MILITARY SECTOR	-	7,794	8,820	45	1,798	-	356	18,813
Trucks and other Transport		6,477	109					6,586
Armaments		452	2,179					2,632
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			-					-
NON-SPECIFIED/OTHER SECTORS		-	2,000		3,700			5,700
NON-ENERGY USE						9,422		9,422

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%	462	17%	462	20%
Heavy Oil	650	0.96	624	20%	922	35%	621	26%
Kerosene/Jet Fuel	210	1.045	219	7%	211	8%	211	9%
Other Products	165	0.96	158	5%	446	17%	446	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 Carbide as Heavy" columns in this table present production as estimated in the refined products balance, which assumes that oil used in carbide production is heavy or residual oil. It is possible that crude oil is input to the carbide production process without previous refining. If this is the case, 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)

2002 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 1996: REFINED PRODUCTS BY PRODUCT TYPE

Prepared By David Von Hippel
Date Last Modified: 6/6/2002

UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	42,503	8,039	5,181	17,421	518	-	-	73,662
Domestic Production	-							-
Imports	42,503	8,039	5,181	24,818	518			81,059
Exports								-
Inputs to International Marine Bunkers								-
Stock Changes		-	-	7,397				7,397
ENERGY TRANSFORMATION	(42,503)	8,773	8,617	(8,972)	1,723	4,381	871	(27,107)
Electricity Generation				(24,694)				(24,694)
Petroleum Refining	(42,503)	8,773	8,617	15,723	1,723	6,795	871	0
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
Other Transformation								-
Own Use						(2,413)		(2,413)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	16,813	13,799	8,449	2,242	4,381	871	46,555
ENERGY DEMAND	-	16,836	13,768	8,449	2,242	4,381	871	46,547
INDUSTRIAL SECTOR	-	-	809	7,697	-	-	-	8,505
Iron and Steel								-
Cement				3,407				3,407
Fertilizers								-
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				4,158				4,158
Textiles								-
Building Materials								
Non-specified Industry			809	132				941
TRANSPORT SECTOR	-	10,013	3,715	282	320	-	579	14,910
Road		10,013	2,654					12,667
Rail			779					779
Water			282	282				564
Air					320		579	899
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	574	1,555	-	2,128
Urban					361	1,555		1,916
Rural					213			213
AGRICULTURAL SECTOR	-	-	1,502	-	-	-	-	1,502
Field Operations			786					786
Processing/Other			716					716
FISHERIES SECTOR	-	-	537	437	-	-	-	973
Large Ships			437	437				873
Processing/Other			100			-		100
MILITARY SECTOR	-	6,822	7,206	34	1,348	-	292	15,702
Trucks and other Transport		5,640	95					5,735
Armaments		394	1,896					2,290
Air Force		494			1,348		292	2,135
Naval Forces		295	5,115	34				5,443
Military Manufacturing								-
Buildings and Other			100					100
PUBLIC/COMMERCIAL SECTORS			-					-
NON-SPECIFIED/OTHER SECTORS			-		-			-
NON-ENERGY USE						2,827		2,827

NAUTILUS INSTITUTE

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

2002 UPDATE

ESTIMATED ENERGY BALANCE FOR THE YEAR 2000
REFINED PRODUCTS BY PRODUCT TYPE

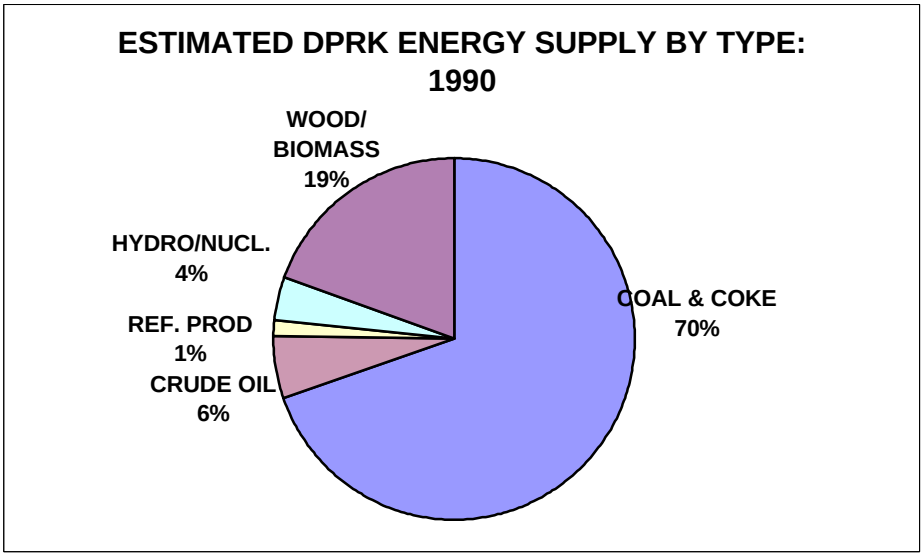
Prepared By David Von Hippel
Date Last Modified: 6/8/2002

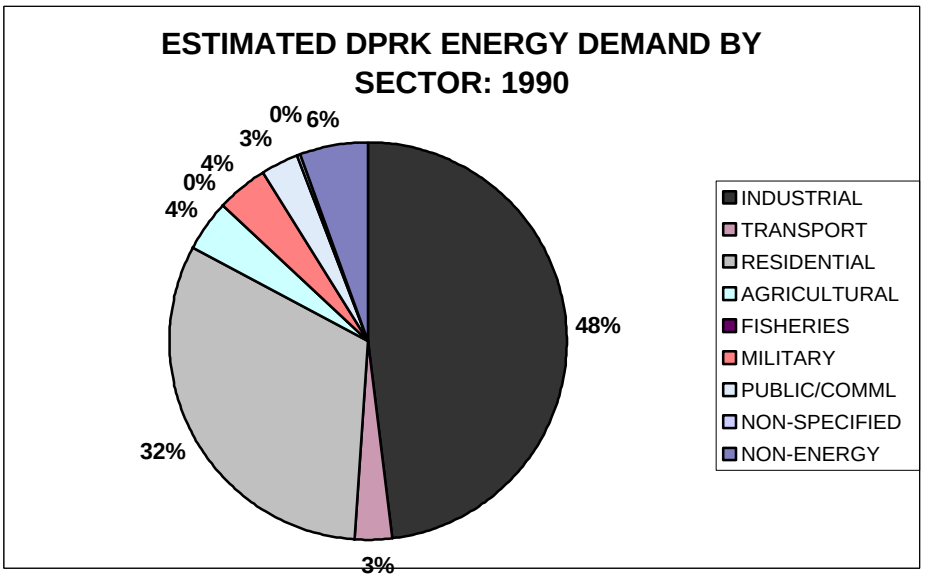
UNITS: TERAJOULES (TJ)	CRUDE OIL	GASOLINE	DIESEL	HEAVY OIL	KEROSENE & JET FUEL	LPG, REF. FUEL, NON-E.	AVIATION GAS	**TOTAL**
ENERGY SUPPLY	24,796	6,276	9,138	18,751	2,421	3,411	-	64,792
Domestic Production	-							-
Imports	24,796	6,276	9,138	21,576	2,421	3,594		67,801
Exports				2,825		183		3,009
Inputs to International Marine Bunkers								-
Stock Changes		-		-	-			-
ENERGY TRANSFORMATION	(24,796)	4,433	5,240	(7,128)	1,183	1,577	585	(18,905)
Electricity Generation				(15,407)		(870)		(16,278)
Petroleum Refining	(24,796)	4,433	5,240	8,279	1,183	3,856	585	(1,219)
Coal Production/Preparation								-
Charcoal Production								-
Coke Production								-
Other Transformation								-
Own Use						(1,408)		(1,408)
Losses								-
FUELS FOR FINAL CONSUMPTION	-	10,709	14,378	11,623	3,604	4,988	585	45,887
ENERGY DEMAND	-	10,678	14,379	11,630	3,622	4,988	585	45,883
INDUSTRIAL SECTOR	-	-	643	11,009	-	-	-	11,652
Iron and Steel								-
Cement				6,490				6,490
Fertilizers								-
Other Chemicals								-
Pulp and Paper								-
Other Metals								-
Other Minerals				4,274				4,274
Textiles								-
Building Materials								
Non-specified Industry			643	245				888
TRANSPORT SECTOR	-	3,628	3,220	219	300	-	350	7,717
Road		3,628	2,416					6,044
Rail			585					585
Water			219	219				439
Air					300		350	650
Non-Specified			-					-
RESIDENTIAL SECTOR	-	-	-	-	2,349	233	-	2,582
Urban					1,672	233		1,905
Rural					677			677
AGRICULTURAL SECTOR	-	-	1,763	-	-	-	-	1,763
Field Operations			1,048					1,048
Processing/Other			716					716
FISHERIES SECTOR	-	-	445	362	-	-	-	808
Large Ships			362	362				725
Processing/Other			83			-		83
MILITARY SECTOR	-	7,050	8,307	39	974	-	235	16,606
Trucks and other Transport		5,797	97					5,894
Armaments		404	1,949					2,353
Air Force		494			974		235	1,703
Naval Forces		355	6,161	39				6,555
Military Manufacturing								-
Buildings and Other			100					100
PUBLIC/COMMERCIAL SECTORS			-					-
NON-SPECIFIED/OTHER SECTORS			-					-
NON-ENERGY USE						4,755		4,755

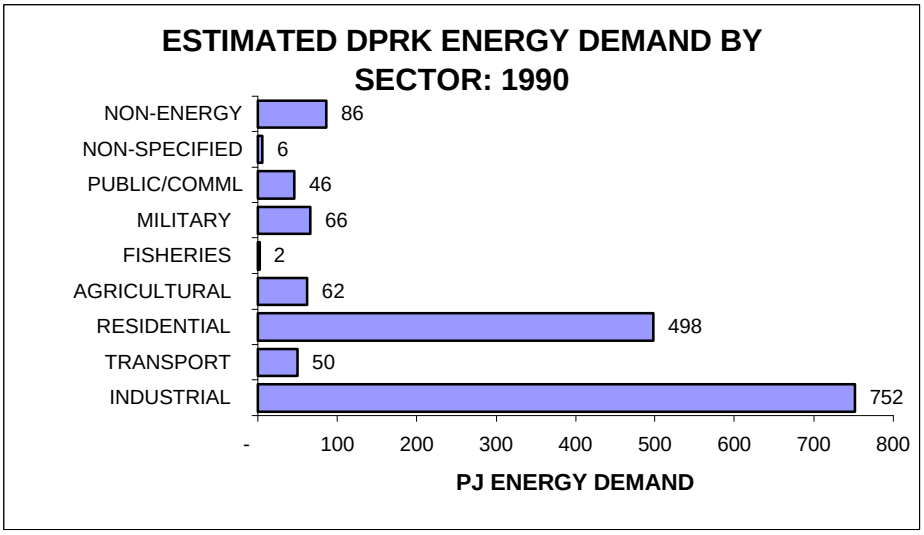
NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 1990

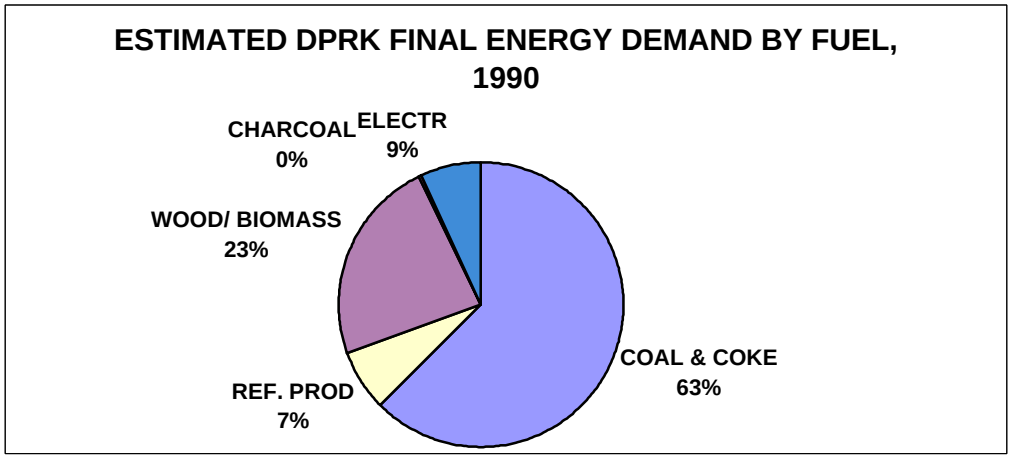
Prepared By David Von Hippel
Date Last Modified: 6/8/2002

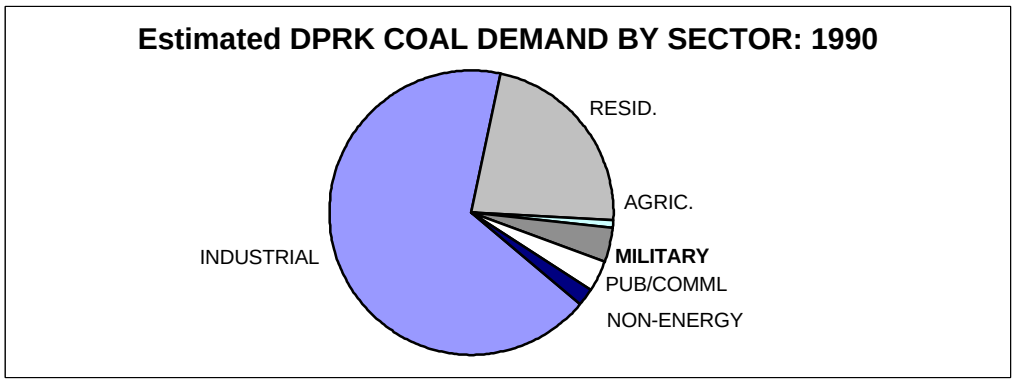
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/NUCL.	WOOD/ BIOMASS	CHAR-COAL	ELEC.	**TOTAL**
ENERGY SUPPLY	1,356	111	27	77	376	-	(12)	1,934
Domestic Production	1,318	-		77	350			1,744
Imports	68	111	27		27			232
Exports	30						12	42
Stock Changes								
ENERGY TRANSF.	(381)	(111)	89	(77)	(11)	4	111	(376)
Electricity Generation	(301)		(16)	(77)			166	(228)
Petroleum Refining		(111)	104					(6)
Coal Prod./Prep.							(9)	(9)
Charcoal Production					(11)	4		(7)
Own Use	(64)						(12)	(76)
Losses	(16)						(34)	(50)
FUELS FOR FINAL CONS.	974	-	115	-	366	4	99	1,558
ENERGY DEMAND	980	-	110	-	365	3	110	1,569
INDUSTRIAL	660	-	25	-	2	-	65	752
TRANSPORT	-	-	36	-	2	-	12	50
RESIDENTIAL	218	-	7	-	259	3	11	498
AGRICULTURAL	10	-	5	-	45	-	3	62
FISHERIES	-	-	2	-	-	-	0	2
MILITARY	38	-	19	-	-	-	9	66
PUBLIC/COMML	35	-	-	-	-	-	11	46
NON-SPECIFIED			6					6
NON-ENERGY	18		9		59			86
Elect. Gen. (Gr. TWhe)	23.43		1.28	21.29				46.00

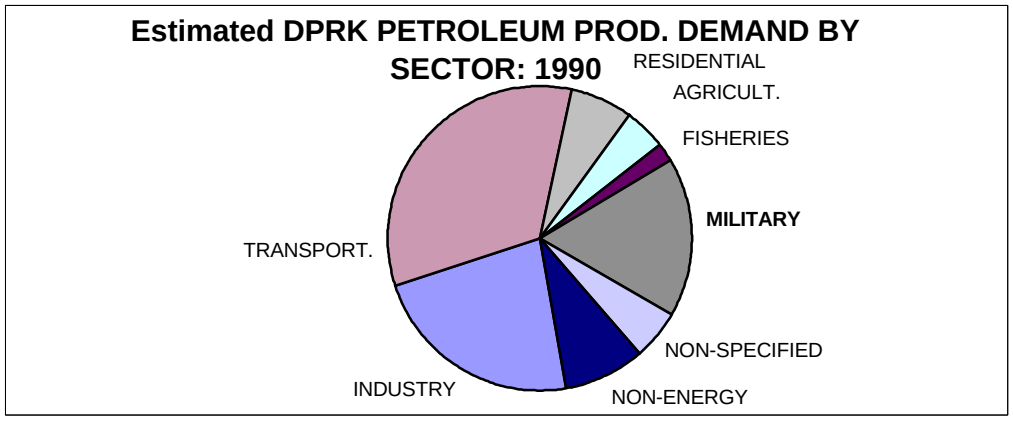

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1990
WOOD/ BIOMASS 19%
HYDRO/NUCL. 4%
REF. PROD 1%
CRUDE OIL 6%
COAL & COKE 70%

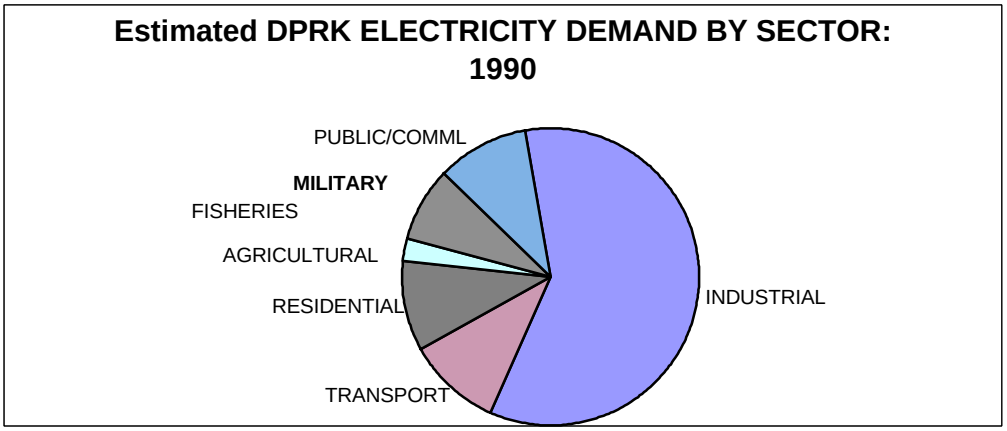

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
0%
6%
3%
4%
0%
4%
48%
32%
3%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1990
NON-ENERGY 86
NON-SPECIFIED 6
PUBLIC/COMML 46
MILITARY 66
FISHERIES 2
AGRICULTURAL 62
RESIDENTIAL 498
TRANSPORT 50
INDUSTRIAL 752
- 100 200 300 400 500 600 700 800
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 1990
CHARCOAL 0%
ELECTR 9%
WOOD/ BIOMASS 23%
COAL & COKE 63%
REF. PROD 7%


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
TRANSPORT.
NON-SPECIFIED
INDUSTRY
NON-ENERGY


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

NAUTILUS INSTITUTE
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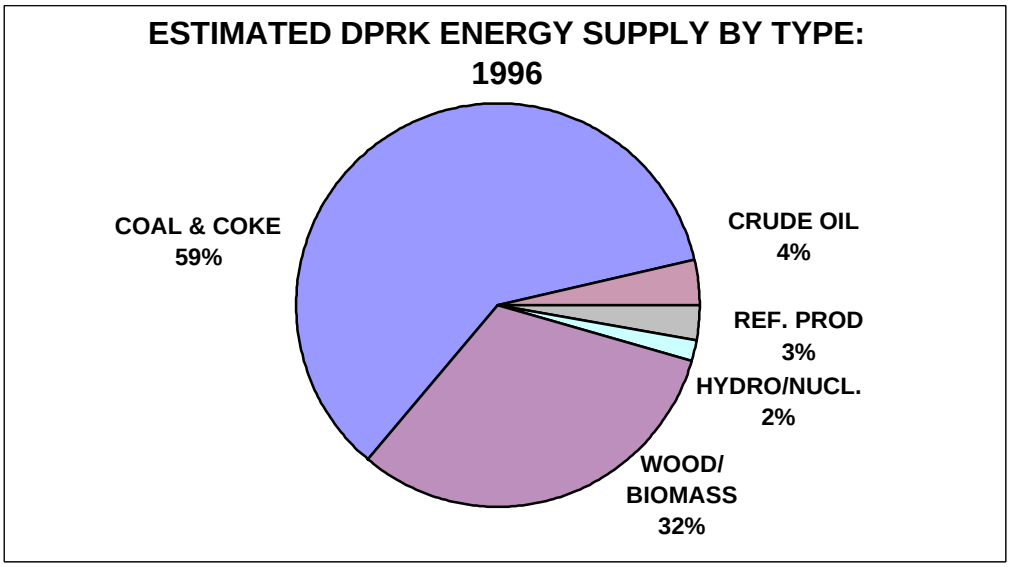
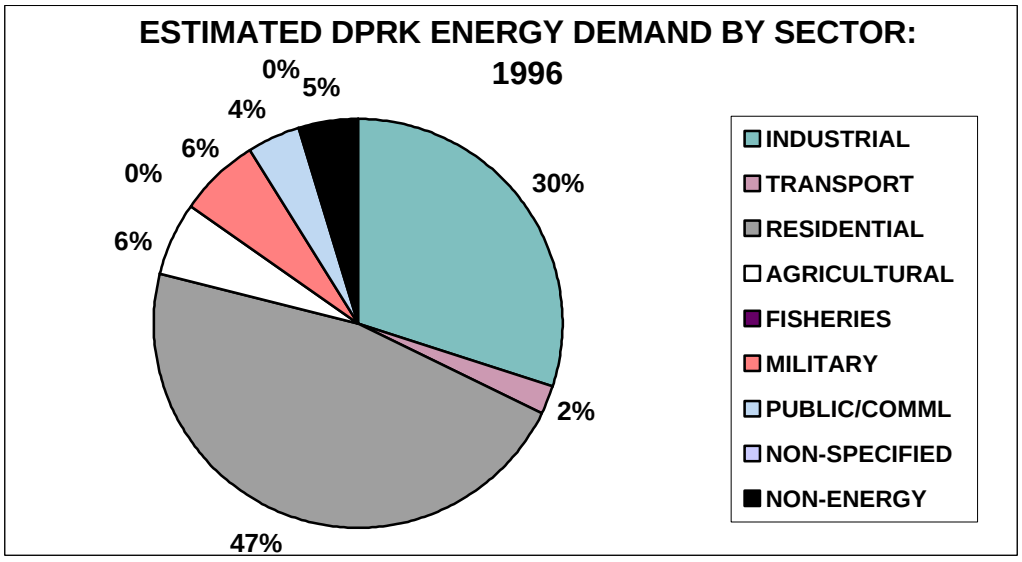
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 1996

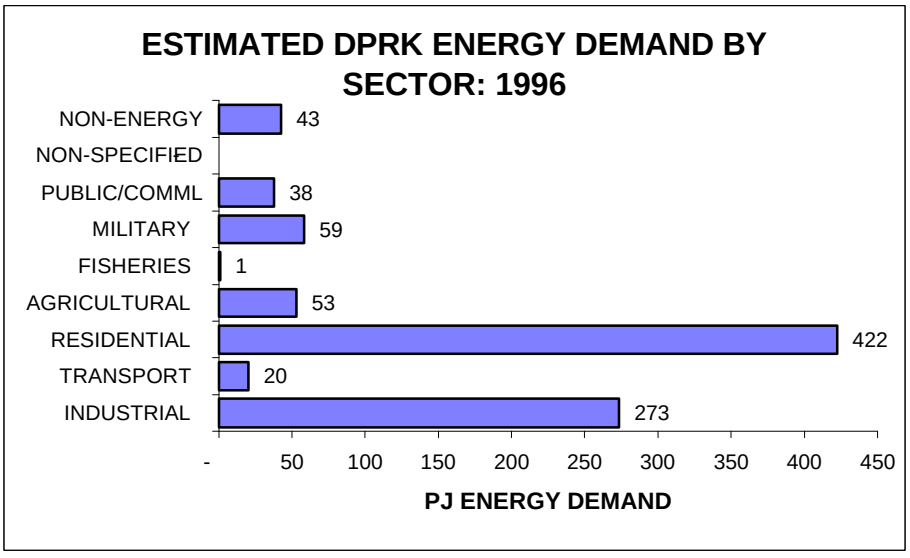
Prepared By David Von Hippel
Date Last Modified: 2/24/2003

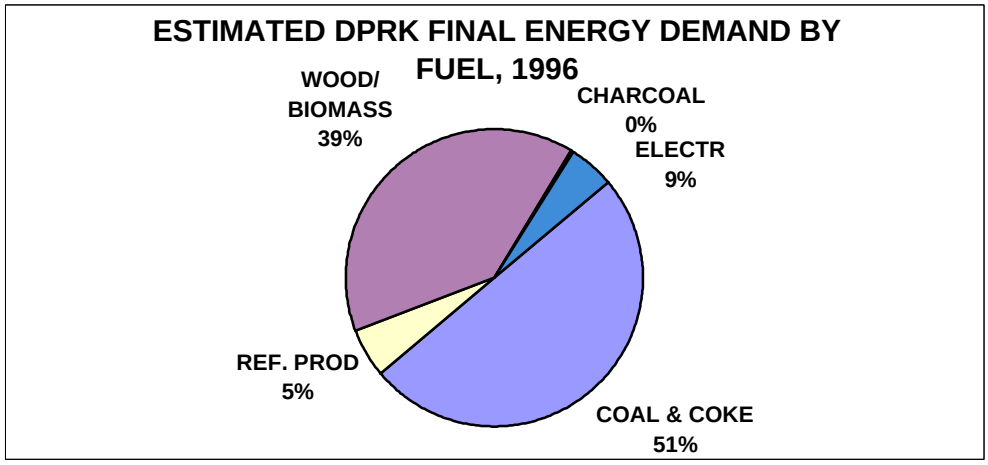
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	ELEC.	**TOTAL**
ENERGY SUPPLY	697	43	31	19	367	-	(3)	1,153
Domestic Production	741	-	-	19	340	-	-	1,100
Imports	4	43	39	-	27	-	-	112
Exports	48	-	-	-	-	-	3	51
Stock Changes	-	-	7	-	-	-	-	7
ENERGY TRANSF.	(242)	(43)	15	(19)	(8)	3	49	(244)
Electricity Generation	(196)	-	(25)	(19)	-	-	79	(161)
Petroleum Refining	-	(43)	43	-	-	-	(0)	(0)
Coal Prod./Prep.	(36)	-	-	-	-	-	(5)	(41)
Charcoal Production	-	-	-	-	(8)	3	-	(5)
Own Use	-	-	(2)	-	-	-	(10)	(12)
Losses	(9)	-	-	-	-	-	(15)	(24)
FUELS FOR FINAL CONS.	455	-	47	-	359	3	46	909
ENERGY DEMAND	455	-	47	-	359	3	46	909
INDUSTRIAL	243	-	9	-	1	-	22	273
TRANSPORT	-	-	15	-	1	-	5	20
RESIDENTIAL	130	-	2	-	282	3	6	422
AGRICULTURAL	9	-	2	-	40	-	2	53
FISHERIES	-	-	1	-	-	-	0	1
MILITARY	38	-	16	-	-	-	5	59
PUBLIC/COMML	31	-	-	-	-	-	7	38
NON-SPECIFIED			-					-
NON-ENERGY	5		3		35			43
								-
Elect. Gen. (Gr. TWhe)*	15.71	-	0.91	5.32	-	-	-	21.94

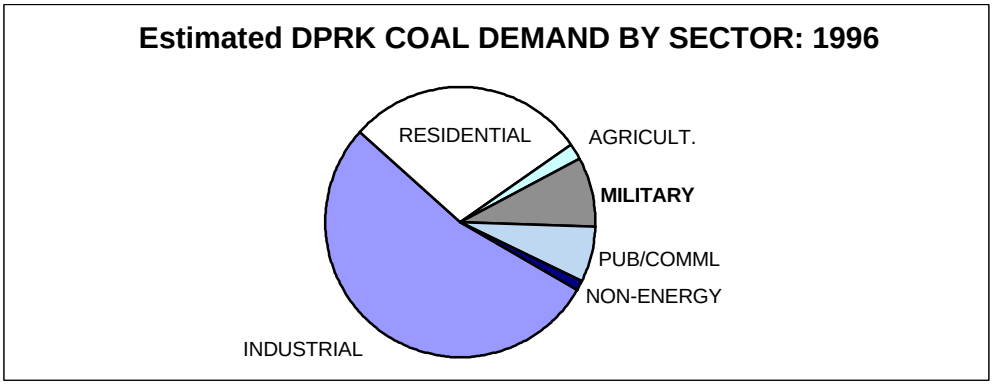
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

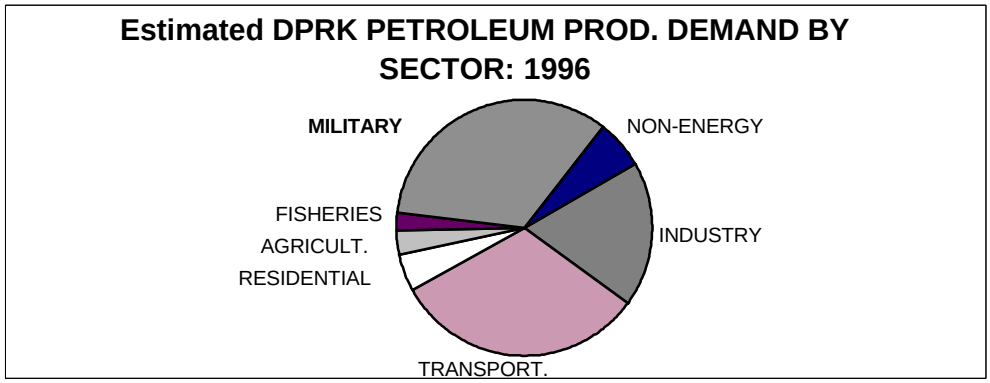

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 1996
COAL & COKE 59%
CRUDE OIL 4%
REF. PROD 3%
HYDRO/NUCL. 2%
WOOD/ BIOMASS 32%

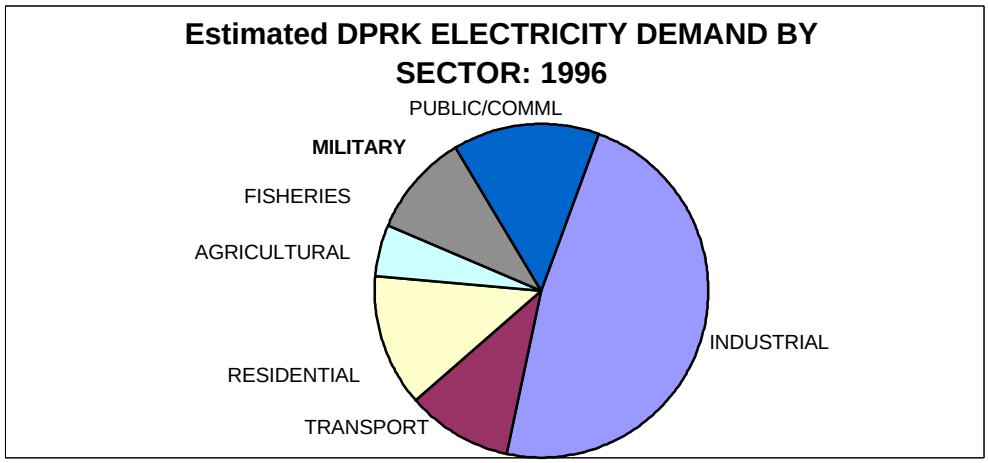

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
0%
5%
4%
6%
0%
6%
30%
2%
47%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 1996
NON-ENERGY 43
NON-SPECIFIED
PUBLIC/COMML 38
MILITARY 59
FISHERIES 1
AGRICULTURAL 53
RESIDENTIAL 422
TRANSPORT 20
INDUSTRIAL 273
- 50 100 150 200 250 300 350 400 450
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 1996
WOOD/ BIOMASS 39%
CHARCOAL 0%
ELECTR 9%
REF. PROD 5%
COAL & COKE 51%


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


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

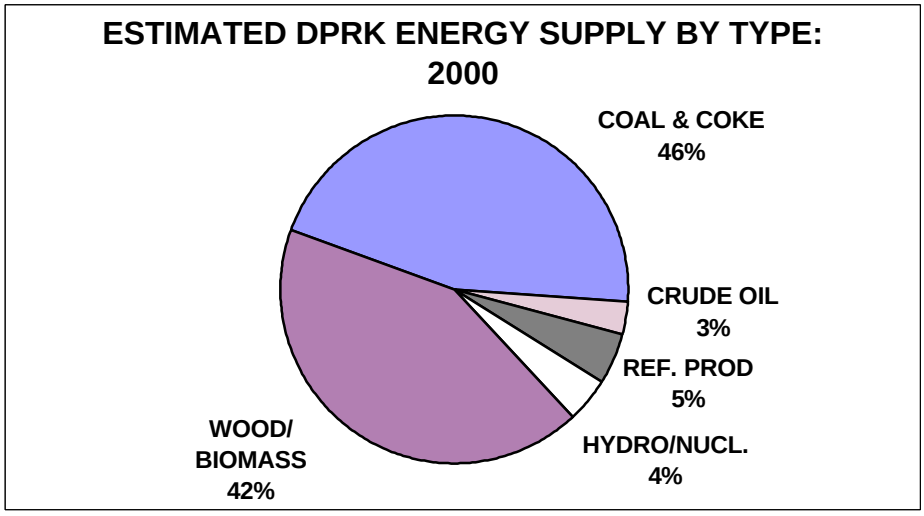

Estimated DPRK ELECTRICITY DEMAND BY SECTOR: 1996
PUBLIC/COMML
MILITARY
FISHERIES
AGRICULTURAL
RESIDENTIAL
TRANSPORT
INDUSTRIAL

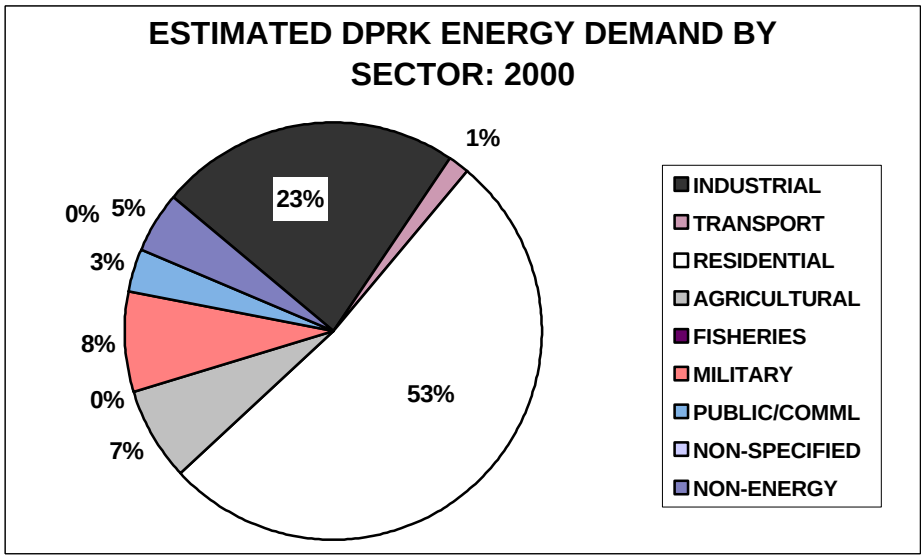
NAUTILUS INSTITUTE
ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ESTIMATED SUMMARY ENERGY BALANCE FOR 2000

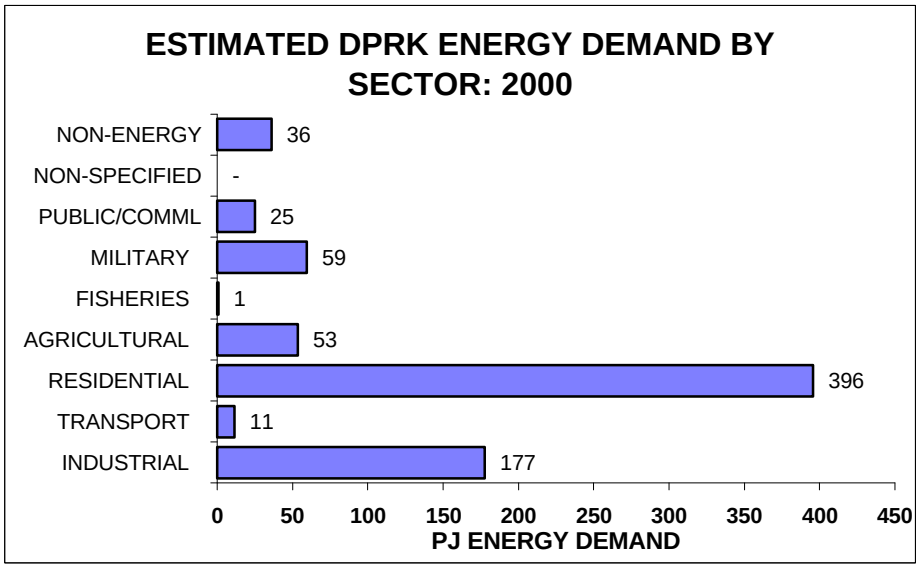
Prepared By David Von Hippel
Date Last Modified: 2/24/2003

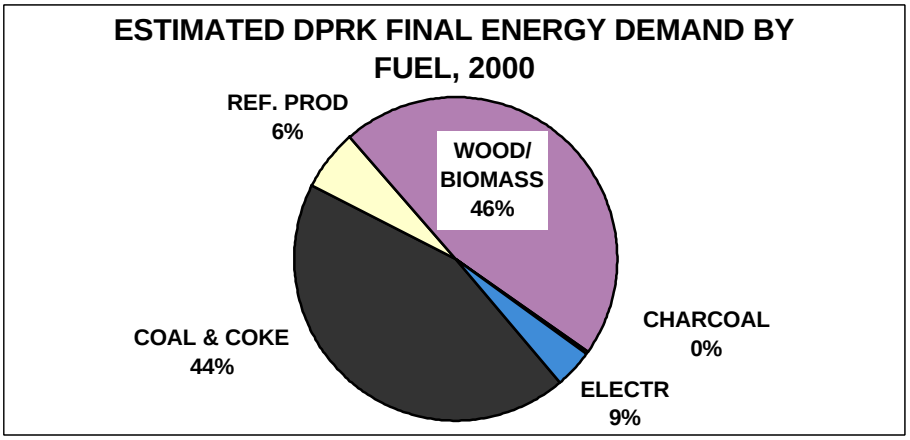
UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL.	WOOD/ BIOMASS	CHAR-COAL	ELEC.	**TOTAL**
ENERGY SUPPLY	386	25	40	35	359	-	(0)	844
Domestic Production	384	-	-	35	332	-	-	752
Imports	9	25	43	-	27	-	-	104
Exports	8	-	3	-	-	-	0	11
Stock Changes	-	-	-	-	-	-	-	-
ENERGY TRANSF.	(55)	(25)	6	(35)	(8)	3	29	(85)
Electricity Generation	(32)	-	(16)	(35)	-	-	45	(38)
Petroleum Refining	-	(25)	24	-	-	-	(0)	(1)
Coal Prod./Prep.	(19)	-	-	-	-	-	(3)	(21)
Charcoal Production	-	-	-	-	(8)	3	-	(5)
Own Use	-	-	(1)	-	-	-	(2)	(3)
Losses	(5)	-	-	-	-	-	(12)	(16)
FUELS FOR FINAL CONS.	331	-	46	-	351	3	29	759
ENERGY DEMAND	331	-	46	-	351	3	29	759
INDUSTRIAL	153	-	12	-	0	-	13	177
TRANSPORT	-	-	8	-	0	-	3	11
RESIDENTIAL	108	-	3	-	280	3	3	396
AGRICULTURAL	9	-	2	-	40	-	2	53
FISHERIES	-	-	1	-	-	-	0	1
MILITARY	38	-	17	-	-	-	5	59
PUBLIC/COMML	21	-	-	-	-	-	4	25
NON-SPECIFIED			-					-
NON-ENERGY	2		5		29			36
Elect. Gen. (Gr. TWhe)*	2.64	-	0.15	9.85	-	-	-	12.64

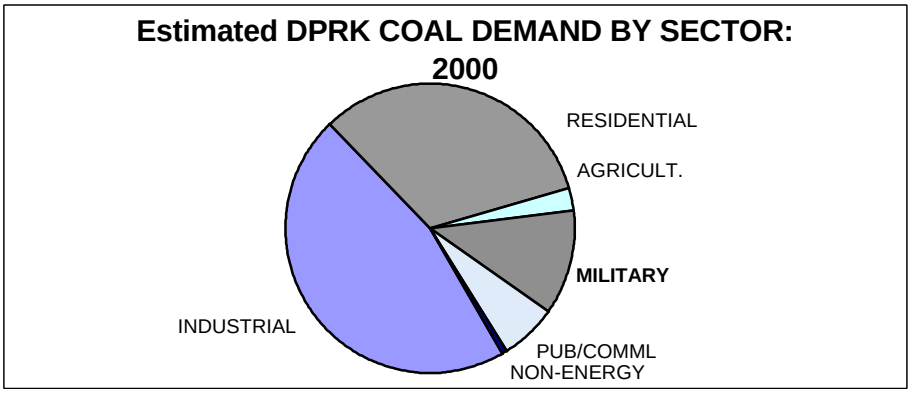
**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

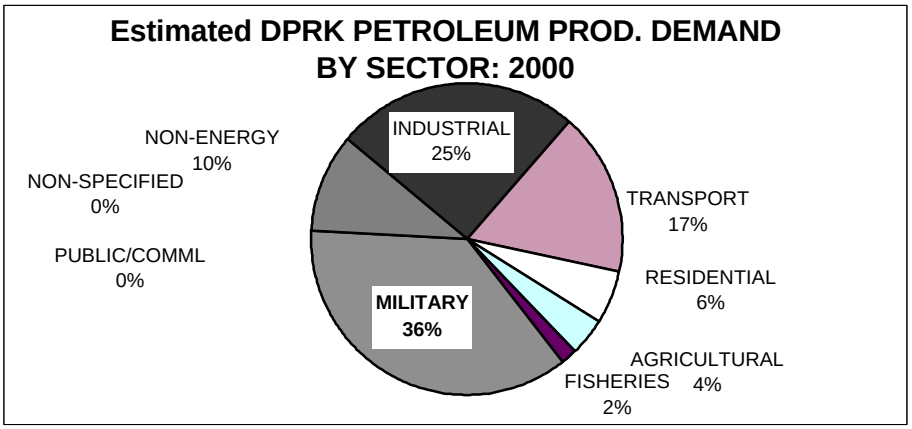

ESTIMATED DPRK ENERGY SUPPLY BY TYPE: 2000
COAL & COKE 46%
CRUDE OIL 3%
REF. PROD 5%
HYDRO/NUCL. 4%
WOOD/ BIOMASS 42%

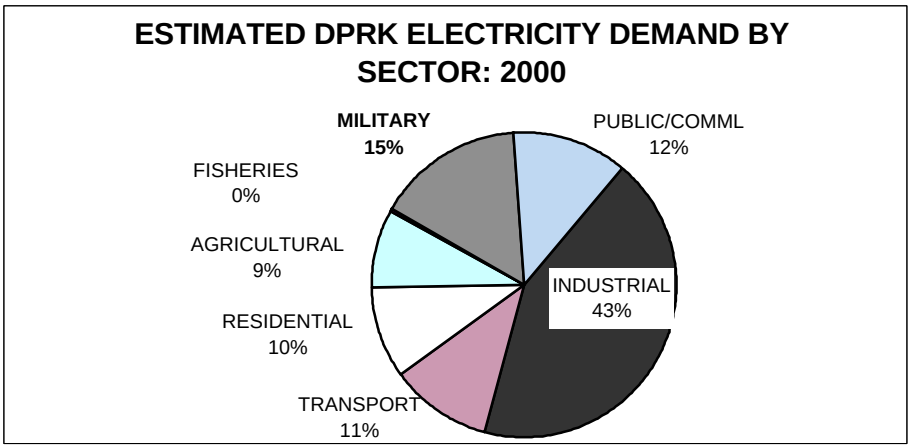

ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
1%
23%
0%
5%
3%
8%
0%
7%
53%
INDUSTRIAL
TRANSPORT
RESIDENTIAL
AGRICULTURAL
FISHERIES
MILITARY
PUBLIC/COMML
NON-SPECIFIED
NON-ENERGY


ESTIMATED DPRK ENERGY DEMAND BY SECTOR: 2000
NON-ENERGY 36
NON-SPECIFIED -
PUBLIC/COMML 25
MILITARY 59
FISHERIES 1
AGRICULTURAL 53
RESIDENTIAL 396
TRANSPORT 11
INDUSTRIAL 177
0 50 100 150 200 250 300 350 400 450
PJ ENERGY DEMAND


ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2000
REF. PROD 6%
WOOD/ BIOMASS 46%
CHARCOAL 0%
COAL & COKE 44%
ELECTR 9%


Estimated DPRK COAL DEMAND BY SECTOR: 2000
RESIDENTIAL
AGRICULT.
MILITARY
INDUSTRIAL
PUB/COMML
NON-ENERGY


Estimated DPRK PETROLEUM PROD. DEMAND BY SECTOR: 2000
NON-ENERGY 10%
NON-SPECIFIED 0%
PUBLIC/COMML 0%
INDUSTRIAL 25%
TRANSPORT 17%
RESIDENTIAL 6%
MILITARY 36%
AGRICULTURAL 4%
FISHERIES 2%


ESTIMATED DPRK ELECTRICITY DEMAND BY SECTOR: 2000
MILITARY 15%
PUBLIC/COMML 12%
FISHERIES 0%
AGRICULTURAL 9%
INDUSTRIAL 43%
RESIDENTIAL 10%
TRANSPORT 11%

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
COAL EXTRACTION AND PROCESSING, IMPORTS

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Source/Note:
Domestic Coal Production (official)			
Anthracite Coal	4.90E+07	te	*1*
Brown Coal	2.10E+07	te	*1*
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	100%		*Assumption*
Total Coal Production (revised)	1317960000	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	
Total Coal and Coke Imports	6.84E+07	GJ	
Coal Exports			
Total Coal Exports (Anthracite)	1.17E+06	te	*5*
Heat Content, Anthracite	6200	kcal/kg	*8*
Conversion Factor	4.184	kJ/kcal	
	3.04E+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	6.39E+07	GJ	
Coal Transport Losses			
Coal Loss Rate	1%	of mined	*Guess*
Mass of Coal Lost	7.00E+05	te	
Energy content of Coal Lost	1.63E+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	8.65E+06	GJ	

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	2				
Coal Imports to the DPRK relative to 1993	100%	15%					*17*
Coke Imports to the DPRK relative to 1990	36%	18%					*12*
Total Estimated Coal+Coke Imports (GJ)	4.80E+07	7.79E+06					*Calculated*
Coal Exp. from DPRK rel. to 1993 Exp. to China	100%	232%					*18*
Total Estimated Coal Exports (GJ)	4.02E+06	9.32E+06					*Calculated*
Domestic Coal Production relative to 1990	56.20%	29.15%					*13*
Total Estimated Domestic Coal Production (GJ)	7.41E+08	3.84E+08					*Calculated*
Estimated Coal Use in Coal Mining (GJ)	3.59E+07	1.86E+07					*Calculated*
Estimated Coal Losses (GJ)	9.18E+06	4.76E+06					*Calculated*
Estimated Electricity Use in Coal Mining (GJ)	4.86E+06	2.52E+06					*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 minerals	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 Note 14)*** 31,127 tonnes

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 estimates are even lower.

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 Assumed to scale with iron and steel production.

13 Set so as to balance demand+exports-imports

*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.*

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

16 From Japan customs statistics, http://www.customs.go.jp/toukei/info/index_e.htm.

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

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

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

2002 UPDATE

BACK-UP CALCULATIONS AND DATA: OIL IMPORTS, EXPORTS, AND REFINING

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

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			4.18E+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			4.18E+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
Extrapolated Crude Oil Imports from China, 1996			9.98E+05	tonnes	
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			4.25E+07	GJ	
Official Refined Prod. Imports from China, 1st - 3rd Q., 1996			4.27E+04	tonnes	5,6
Extrapolated Official Refined Prod. Imports from China, 1996			5.70E+04	tonnes	
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			3.86E+07	GJ	
Estimated HFO placed in storage, 1996			180,294	tonnes	8
			7.48E+06	GJ	8

Input Data for the Year 2000					
DPRK Crude Oil Production		0.00E+00	tonnes		*27*
Reported Crude Oil Imports from China, 2000		3.89E+05	tonnes		*18*
Other Imports of Crude Oil from not Reported		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)		1.93E+05	tonnes		*See below*
Conversion Factor		4.26E+01	GJ/te		
Total Estimated Crude Oil Imports to DPRK, 2000		2.48E+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	1.43E+05	1.050	6.28E+06	*Sum of*	
Kerosene	5.61E+04	1.032	2.42E+06	*Imports from*	
Diesel	2.12E+05	1.032	9.14E+06	*all nations*	
HFO	5.20E+05	0.991	2.16E+07	*(see below,*	
LPG/Refinery Gas/Non-Energy	6.43E+04	1.013	2.72E+06	*and note 15)*	
Total Estimated Refined Product Imports to DPRK, 2000		4.21E+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		-	tonnes		*26*
		0.00E+00	GJ		*26*

		2000	**2**		
Crude Oil Imports from China relative to 1996		39%			
Other Crude Oil Imports (tonnes)		1.93E+05			
Official Refined Products Imports from China relative to 1996		206%			*9*
HFO Supplied by KEDO (tonnes)		3.95E+05			
Other Imports of Refined Products (tonnes)	Gasoline	1.43E+05			*15*
	Kerosene	5.61E+04			*15*
	Diesel	2.12E+05			*15*
	HFO	5.20E+05			*15*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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	1.013		
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	36.82%		
Gasoline	1.12E+07	1.52E+07	25.19%		
Diesel Oil	1.00E+07	9.33E+06	18.46%		
Kerosene	2.00E+06	6.84E+06	8.44%		
LPG/Refinery Gas/Non-Energy	5.09E+06	6.53E+06	11.10%		*10*
TOTAL	4.66E+07	5.82E+07	100.00%		
Estimated Net Refinery Output, 1990 (tonnes)	1,094,488	1,363,647	2,458,134		
Refinery use of electricity, kWh/tonne output	67.04				*28*
Estimated 1990 Refinery use of electricity	165	GWh or	5.93E+05	GJ	

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)	9.98E+05	0			
Estimated Refinery Output, 1996 (tonnes)			Toe/Te		
Heavy Fuel Oil	379,193	-	0.991		
Gasoline	219,533	-	1.050		
Diesel Oil	199,575	-	1.032		
Kerosene	39,915	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	119,745	-	1.013		
Estimated Refinery Fuel Use (toe)	57,677	-			
Estimated Net Refinery Output, 1996 (GJ)			% of Net		
Heavy Fuel Oil	1.57E+07	0.00E+00	39.22%		
Gasoline	9.64E+06	0.00E+00	24.06%		
Diesel Oil	8.62E+06	0.00E+00	21.50%		
Kerosene	1.72E+06	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	4.38E+06	0.00E+00	10.93%		*10*
TOTAL	4.01E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 1996 (tonnes)	941,521				
Refinery use of electricity, kWh/tonne output	67.04				*28*
Estimated 1996 Refinery use of electricity	63	GWh or	2.27E+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)	3.89E+05	0.00E+00			
Estimated Refinery Output, 2000 (tonnes)			Toe/Te		
Heavy Fuel Oil	147,910	-	0.991		
Gasoline	85,632	-	1.050		
Diesel Oil	77,847	-	1.032		
Kerosene	15,569	-	1.032		
LPG/Refinery Gas/Non-energy (gross)	46,708	-	1.013		
Estimated Refinery Fuel Use (toe)	22,498	-			
Estimated Net Refinery Output, 2000 (GJ)			% of Net		
Heavy Fuel Oil	6.13E+06	0.00E+00	39.22%		
Gasoline	3.76E+06	0.00E+00	24.06%		
Diesel Oil	3.36E+06	0.00E+00	21.50%		
Kerosene	6.72E+05	0.00E+00	4.30%		
LPG/Refinery Gas/Non-Energy	1.71E+06	0.00E+00	10.93%		*10*
TOTAL	1.56E+07	0.00E+00	100.00%		
Estimated Net Refinery Output, 2000 (tonnes)	367,254				
Refinery use of electricity, kWh/tonne output	67.04				*28*
Estimated 2000 Refinery use of electricity	37.03	GWh or	1.33E+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

Estimate of 2000 Imports of Petroleum Products from Russia

Total Imports 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
Assume that		80%	of these imports are diesel/gas oil, and	
		20%	are heavy oil or the equivalent, then total	
import from Russia were			6.05E+04	of diesel and
			1.51E+04	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 kerosene: 99.51%
- Fraction as non-energy (mostly solvents): 0.49%
- Total imports of kerosene from Japan: 4.41E+04 *tonnes*
- Total imports of non-energy petrol. products from Japan: 2.15E+02 *tonnes*

Oil products from Singapore:
- Rough estimate of value: $14,000,000 — *See Note 22*
- Rough estimate of price: $ 0.70 per gallon — *See Note 23*
- Assume that imports are 80% gasoline and 20% diesel, and thus having
- an average density of 0.74 kg/liter for gasoline and
- and 0.87 kg/liter for diesel and
- then at 3.78 liters per gallon,
- implied oil imports are 20,000,000 gallons, or 4.48E+04 tonnes of gasoline and 1.32E+04 tonnes of diesel.

Oil Products from the ROK:
- Rough estimate of maximum rate of imports from ROK: 10,000 Bbl/day for 10% of the year, or an average of 1000 Bbl/day. — *See Note 24*
- 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

If the output of the refinery is roughly:

Output (Energy fraction of input)	Assumptions	Implied Output toe	Implied Output GJ
Heavy Fuel Oil	41%	50,076	2.15E+06
Gasoline	24%	29,313	1.26E+06
Diesel Oil	21%	43,816	1.88E+06
Kerosene/Jet Fuel	5%	11,923	5.11E+05
LPG/Refinery Gas/Non-Energy	5%	50,076	2.15E+06
TOTAL	96%	185,204	7.94E+06

Implied required crude oil input to refinery: 192,920 toe or 8.08E+06 GJ

Consider 100% of these inputs to be crude oil imports not accounted for elsewhere.

Input of refinery fuel to refinery (own use) at 0.0578 toe/te of input
- is 11,151 toe or 4.67E+05 GJ

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 barrells 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 last 2 years--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 Assumes that the capacity of the Sonbong refinery is increased to 2.5 times its original capacity, and that "cracking" capacity is added so that the relative fractions of refined products are as shown.

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.

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 (based on Singapore codes) "Kerosene and Vapourising Oil (Power Kerosene)".

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 are available, but could not be obtained by the time of this writing.

23 Data from the US DOE Energy Information Administration (table http://www.eia.doe.gov/pub/oil_gas/petroleum /data_publications/weekly_petroleum_status_report/current/txt/table13f.txt) suggests that spot prices for diesel fuel and gasoline in Singapore were in the range of $0.70 per gallon as of January, 2001. This figure is used to roughly calculate oil quantities purchased from Singapore.

24 An industry source suggests that the ROK sent to the DPRK 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.

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 very little KEDO HFO remained in storage at the end of 2000.

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. We assume based on conversations with experts in the industry, that any production from DPRK wells was minimal.

28 Calculated based on 1990 data for China from J.E. Sinton, ed (1992). China Energy Databook.

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

2002 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), whose web site I visited, 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." At another asphalt-related site, I saw 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 I 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 I'm assuming 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 my 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)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
BIOMASS AND WOOD PRODUCTION AND IMPORTS

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Fuelwood Consumption (Residential and Industrial)			
Residential Fuelwood	1.00E+07	cu.m.	*1*
Industrial Fuelwood	1.50E+05	cu.m.	*1*
Conversion Factor	1.50	cu.m./te	*2*
Conversion Factor	16.00	GJ/te	*2*
Total Fuelwood Production	1.08E+08	GJ	
Charcoal Production			
Wood Input	1.00E+06	cu.m.	*1*
Conversion Factor	1.50	cu.m./te	*2*
Conversion Factor	16.00	GJ/te	*2*
Process Efficiency	33%		*Rough Estimate*
Total Wood used for Charcoal	1.07E+07	GJ	
Total Charcoal Production	3.52E+06	GJ	
Wood for Non-Energy Products			
Building Materials	5.00E+06	cu.m.	*1*
Pulp and Paper	5.00E+05	cu.m.	*1*
Conversion Factor	1.50	cu.m./te	*2*
Conversion Factor	16.00	GJ/te	*2*
Total Wood, Non-Energy Products	5.87E+07	GJ	
Wood Imports			
Imports of wood from USSR	2.50E+06	cu.m.	*3*
Conversion Factor	1.50	cu.m./te	
Conversion Factor	16.00	GJ/te	
Wood Imports, Total	2.67E+07	GJ	
Total Domestic Wood Production	1.51E+08	GJ	
Other Biomass/Crop Wastes Production for Fuel			
Crop Wastes Used in Agriculture:	3.10E+06	te	*4*
Crop Wastes for Other Uses	1.06E+07	te	*Est. based on needs*
Conversion Factor	14.5	GJ/te	*2*
Total Biomass/Crop Wastes Production	1.99E+08	GJ	
TOTAL WOOD/BIOMASS PRODUCTION	3.50E+08	GJ	

ESTIMATE OF CURRENT AND FUTURE WOOD/BIOMASS SUPPLY

Category	**1996**	**2000**					
Domestic wood production relative to 1990	97%	95%				%	*6*
Domestic wood production (GJ)	1.47E+08	1.43E+08				8	
Wood used to make charcoal relative to 1990	73%	72%				%	*6*
Wood Used to make charcoal (GJ)	7.79E+06	7.68E+06				6	
Charcoal production (GJ)	2.57E+06	2.53E+06				6	
Wood imports relative to 1990	100%	100%				%	*5*
Wood imports (GJ)	2.67E+07	2.67E+07				7	
Biomass/crop wastes production relative to 1990	97.3%	95%				%	*6*
Biomass/crop wastes production (GJ)	1.93E+08	1.89E+08				8	

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

Notes:

1 From document in authors' files [TO1, p. 22]. Upper ends of ranges.
2 From document in authors' files [FC1, p. 7].
3 Annual imports from Russia. From document in authors' files [TP1, p. 4].
Note: other sources list these imports at 230kcu.m./yr.
4 Use of straw and bran in Agriculture from document in authors' files [HT1, p. 10].
5 Assumption
6 Adjusted to meet demand.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION IN 1990

Prepared By David Von Hippel
Date Last Modified: 10/14/1997

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%		*9*
	Own Use Rate, Coal Plants	9.00%		*9*
	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 used by China	700	MW	*11*
	Fraction of hydro generation exported in 1990	16%		*12*
	Exports of electricity to China	3.30E+03	GWhe	
	Exports of electricity to China	1.19E+07	GJ	
	"Emergency Losses" Rate, Coal Plants	5%		*6*
	"Emergency Losses", Coal Plants	1.17E+03	GWhe	
	"Emergency Losses", Coal Plants	4.22E+06	GJ	
	Total Net Generation, 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	3.32E+04	GWhe	
	Delivered Electricity	1.20E+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	2.0%		*Assumption*
	Oil input to coal plants	6.03E+06	GJ	
	Total Input Energy, Electricity Generation	3.94E+08	GJ	

Sources/Notes:

1 Choi Su Young, Study of the Present State of Energy Supply in North Korea, RINU, 1993. P. 49. "Official NK Figures"

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 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*
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

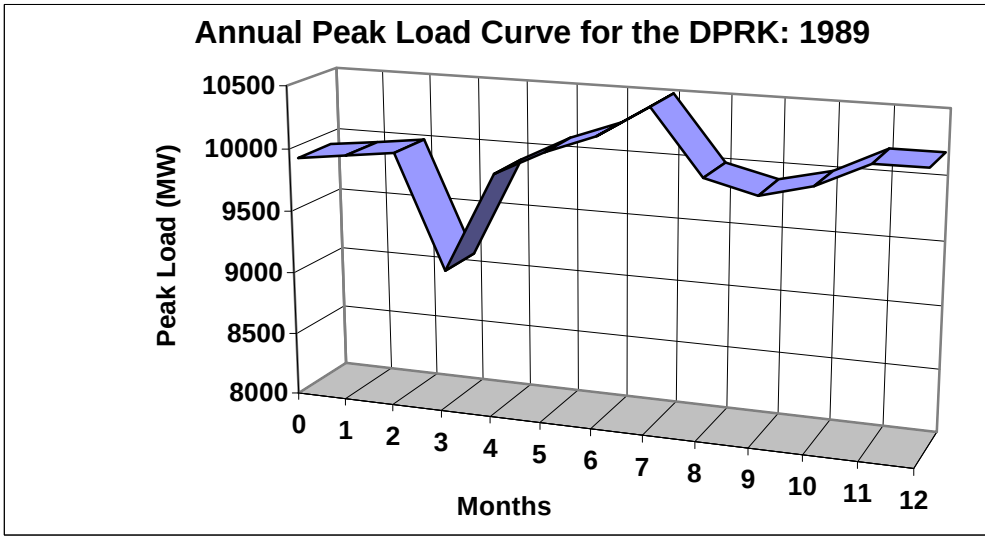
#	Name	Location (city)
1	North Kamgyong	Chongzin
2	Ryanggang	Hyesan
3	Chagang	Kanggye
4	South Hamgyong	Hamhung
5	South Pyongan	Pyongsong
6	Kangwon	Wonsan
7	North Hwanghae	Sariwon
8	Nampo	Nampo
9	South Hwanghae	Haeju
10	Kaesong	Kaesong
11	North Pyongan	Siniju

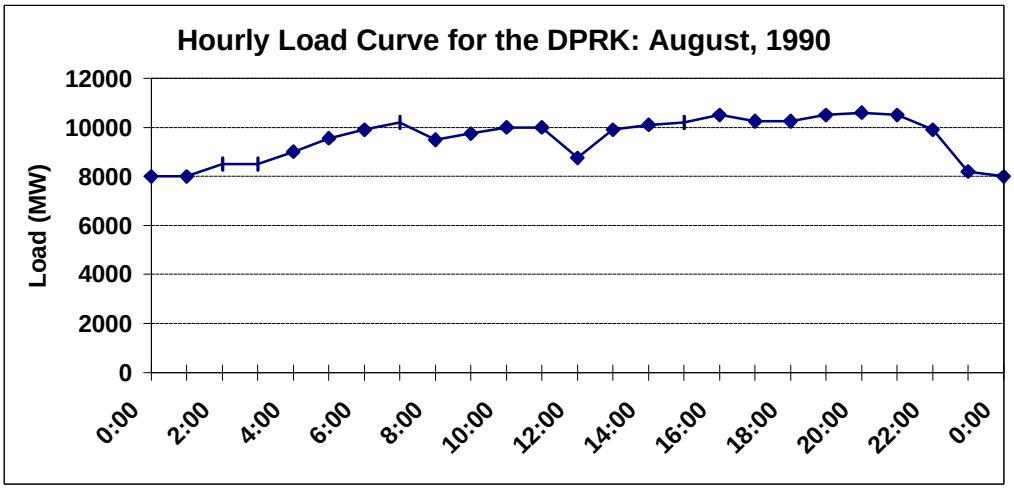
Annual Load Curve for 1989
(Source 1)

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.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
ELECTRICITY GENERATION AND FUEL REQUIREMENTS IN 1996 AND 2000

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%	84%	73%		
Changes in Capacity, 1990 to 1996 (MW):	-3250	50	0		*5*
Average 1996 Capacity Factor Relative to 1990 Est.	90%	66.00%	71.2%		*3*
Estimated Gross Generation in 1996 (GWHe)	5.32E+03	1.57E+04	9.11E+02		
Estimated Power Exports to China, 1990 (GJ)	1.19E+07				
Fraction of 1990 Exports to China in 1996	28%				
Estimated Power Exports to China, 1996 (GJ)	3.33E+06				
Gross Generation Efficiency, 1996	100%	27.0%	28.00%		*2*
Fuel Input to generation, 1996 (GJ)	1.92E+07	2.09E+08	1.17E+07		
Fraction of fuel input as HFO	N/A	6.20%	100%		*1*
HFO Input to generation, 1996 (GJ)	N/A	1.30E+07	1.17E+07		
Own Use Fractions, 1996	0.30%	9.00%	8.00%	*Based on 1990 est.*	
Own Use of Electricity (GJ)	5.75E+04	5.09E+06	2.62E+05		
"Emergency Loss" Fractions, 1996	0%	7.5%	0%	*50% higher than 1990*	
Emergency Losses, 1996 (GJ)	0	4.24E+06	0		
Transmission and Distribution Loss rate (overall), 1996	23.10%			*50% higher than 1990*	
Transmission and Distribution Losses, 1996 (GJ)	1.52E+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.	67%	11%	9%	*CF based on total capacity*
Estimated Gross Generation in 2000 (GWHe)	9.85E+03	2.64E+03	1.48E+02	
Gross Generation Efficiency, 2000	100%	21.0%	20.54%	
Fuel Input to generation, 2000 (GJ)	3.54E+07	4.53E+07	2.59E+06	
Fraction of fuel input as HFO	N/A	28.30%	100%	
HFO Input to generation, 2000 (GJ)	N/A	1.28E+07	2.59E+06	
Other Petrol Products (tires) input to gen., 2000 (GJ)	N/A	8.70E+05		
Estimated Power Exports to China, 1990 (GJ)	1.19E+07			
Fraction of 1990 Exports to China in 2000	0.7%			*Based on reported exports*
Estimated Power Exports to China, 2000 (GJ)	8.16E+04			
Own Use Fractions, 2000	0.30%	9.00%	8.00%	*Same as in 1990*
Own Use of Electricity (GJ)	1.06E+05	8.56E+05	4.26E+04	
"Emergency Loss" Fractions, 2000	0%	10.0%	0%	*One-third higher than in 1996*
Emergency Losses, 2000 (GJ)	0	9.51E+05	0	
Transmission and Distribution Loss rate (overall), 2000	26.57%			*15% higher than 1996*
Transmission and Distribution Losses, 2000 (GJ)	1.16E+07			

Conversion Factor:	1.000	toe/te
Conversion Factor:	41.84	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	14.62%	*1*
Ch'ongjin	150	27.0%	1.46E+06	10,000	28.66%	*1*
Pukchang	1600	27.0%	1.56E+07	20,000	5.37%	*1*
Sunchon	200	27.0%	1.95E+06	2,000	4.30%	*1*
East-Pyongyang	150	30%	1.31E+06	3,000	9.55%	*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 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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA: ELECTRICITY GENERATION IN 2000

Prepared by David Von Hippel
Date Last Modified: 2/24/2003

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	
East Pyongyang	Coal	100	40	*45%*	158	
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	34%	8,774	Assumes about 75% of non-border-region capacity is operable (or that the average available capacity is 75% of nameplate), and capacity factor is 70% of 1996 estimate.
Total Estimated Operable Hydro Capacity		4,625	3,644	31%	9,847	Excludes portion of capacity at Chinese border used exclusively by China.
TOTAL IMPLIED DPRK ELECTRICITY OUTPUT, 2000					**12,636**	GWH ***(see Note 4)***

Recorded Electricity Exports to China 22.66 GWh ***(see Note 5)***

Input of used tires as fuel for electricity generation 8.70E+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.*

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.*

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCE
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
INDUSTRIAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 10/1/1997

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	5.47E+08			
All Coal Consumption: Iron and Steel				
Annual Steel Production:	7.00E+06	Te		*4*
Coal Use intensity:	1.64	tce/Te Steel		*6*
Total Coal Use:	3.79E+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:	1.78E+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:	2.00E+08	GJ coal		
Coal Consumption: Cement				
Annual Cement Production:	1.39E+07	Te		*1*
Coal Use intensity:	6.9	GJ/te clinker		*2*
Fraction of fuel needs by coal	91%			*46*
Total Coal Use:	8.71E+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	2.85E+05	te/yr		
Estimated Urea Production	6.63E+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 Use, Ammonia Production	1.83E+07	GJ/yr as feedstock		
Annual Superphosphate product.	2.47E+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 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:	0.001061	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			
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 "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	8.63E+09	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	4.00E+07	GJ/yr	*26*

Oil Consumption, Cement:				
Fraction of heat input provided by oil	9%			*46*
Heavy Fuel oil use, cement product.	8.61E+06	GJ/yr		
Oil Consumption, Other Minerals:				
Magnesia Production	1.00E+06	Te		*40*
Magnesia Coal Use intensity:	12.6	GJ/te		*41*
Hvy Fuel Oil Use, Magnesia Prod.	1.26E+07	GJ		
Oil Consumption: Non-specified Ind. (Diesel):	3.50E+06	GJ		*Placeholder value*
Oil Consumption: Non-specified Ind. (Hvy Oil):	4.00E+05	GJ		*Placeholder value*
Oil Consumption, All Industries	2.51E+07	GJ		
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	6.54E+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:	2.03E+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:	5.50E+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			6.00E+06	GJ *25*

Notes/Sources:

1 National Report of DPRK to UNCED, 1992.

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 Assumes figure (1989) is for crude steel. Source: document in authors' files [IF1].

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 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 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).

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA:
INDUSTRIAL SECTOR ENERGY DEMAND IN 1996, 2000, and 2005

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

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

	Production Relative to 1990						Energy Intensity Relative to 1990					
Subsector	**1996**	**2000**					**1996**	**2000**				
Iron and Steel ***(See Note 1)***	36%	18%					110%	115%				
Cement ***(See Note 2)***	32%	29%					110%	115%				
---- fraction of heat from heavy oil	10%	20%										
Fertilizers ***(See Note 3)***	25%	11%					110%	115%				
Other Chemicals	30%	18%					110%	115%				
Pulp and Paper	30%	18%					110%	115%				
Other Metals	30%	18%					110%	115%				
Other Minerals	30%	29%					110%	115%				
Textiles	30%	18%					110%	115%				
Building Materials	30%	29%					110%	115%				
Non-Specified Industry--non-oil fuels	30%	18%					110%	115%				
Non-Specified Industry--diesel oil	21%	16%					110%	115%				
Non-Specified Industry--heavy oil	30%	53%					110%	115%				

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THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

(See Note 4)

Subsector	**1996 Production Relative to 1990**
Iron and Steel (See Note 1)	36%
Cement (See Note 2)	32%
---- fraction of heat from heavy oil	10%
Fertilizers (See Note 3)	25%
Other Chemicals	30%
Pulp and Paper	30%
Other Metals	30%
Other Minerals	30%
Textiles	30%
Building Materials	30%
Non-Specified Industry--non-oil fuels	30%
Non-Specified Industry--diesel oil	21%
Non-Specified Industry--heavy oil	30%

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), and was used for the year 2000.

2 The source noted above, in the "Economic and Social…" page, lists a DPRK cement production of 4.1 million tonnes, or about 29 percent of year 1990 production, which again seems plausible.

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.*

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
TRANSPORTATION SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 6/6/2002

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	70	km	Guess	
Energy Intensity, Diesel Trucks	3.08	MJ/te-km		19
Fract Freight on Diesel Trucks	23.8%		Guess	
Diesel Use, Road Freight	2.15E+06	GJ		
Energy Intensity, Gasoline Trucks	5.77	MJ/te-km		19
Fract Freight on Gasoline Trucks	71.3%		Guess	
Gasoline Use, Road Freight	1.21E+07	GJ		
Total Road Freight Oil Use	1.71E+07	GJ		
Number of Civilian Autos in Use	15,500			11
Average km traveled/yr	4,000		Guess	
Efficiency, Civilian Autos	1.10E+01	km/liter gasoline		11
Conversion factor	0.0325	GJ/liter		
Gasoline Use, Civilian Autos	1.83E+05	GJ		
Economically Active Population	1.38E+07			3
Per capita Trips/yr	300		Guess	
Average Trip Distance	15	km	Guess	
Fract. Trips by Motor Transport	25%		Guess	
Fraction of Trips by Road	30%			10
Fraction of km in Diesel Veh.	40%		Guess	
Energy Intensity, Diesel Oil Transport	75	kgce/kpass-km		4
Conversion Factor	0.0293	GJ/kgce		
Total Passenger Road Diesel Use	4.10E+06	GJ		
Fraction of km in Gasoline Veh.	60%		Guess	
Energy Intensity, Gasoline Transport	98.2	kgce/kpass-km		4
Total Passenger Road Gas Use	8.06E+06	GJ		
Total Oil Use, Pass Vehicles	1.32E+07	GJ		
Total Oil Use, Road Vehicles	3.03E+07	GJ		
Biomass Use, Road Vehicles				
Fract Freight on Biomass-fueled Trucks	5%			14
Efficiency of biomass trucks relative to gasoline		50%		13
Biomass use, road freight	1.70E+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	1.80E+06	GJ		
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	5.06E+06	GJ		
Total Electricity Use, Rail Transp.	1.05E+07	GJ		
Coal Use: Rail Transport	0	GJ		
Coal Use: Water Transport	0	GJ		
Electricity Use, Non-specified Transport	1.00E+06	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.

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)
2002 UPDATE
ASSUMPTIONS, BACK-UP CALCULATIONS AND DATA: TRANSPORT SECTOR ENERGY DEMAND IN 1996 AND 2000

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

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

Sources/Notes:

(See Note 5 for Assumptions for 2000)

Population Growth Rate through 2000:	**-0.14%**	/yr	***(See Note 20 in "Residential" worksheet)***				
Econ. Active. Population Growth Rate 2000-on:	**0.60%**	/yr					*(See Note 22 in "Residential" worksheet)*
			1996	2000	2005	2010	
Economically Active population relative to 1990:			99%	99%	102%	105%	*Calculated*

	1996	2000					
Total Road Freight rel. to 1990	30%	18%					
Fraction Road Freight, biomass truck	8%	8.0%					*Assumption*
Fraction Road Freight, diesel truck	10.1%	30.4%					*Assumption*
Fraction Road Freight, gasoline truck	82%	61.6%					*Calculated*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

	Activity Relative to 1990						Energy Intensity Relative to 1990						
Subsector--End Use	**1996**	**2000**					**1996**	**2000**					
Road--Freight--Gasoline	34%	16%					105%	105.0%					*2*
Road--Freight--Diesel	13%	23%					105%	100.0%					*2*
Road--Freight--Biomass	48%	29%					100%	100%					
Road--Civilian Auto Pass-km	100%	95%					105%	100.0%					*Assumption*
Road--Passenger Bus, Diesel	45%	37%					105%	100.0%					*3*
Road--Passenger Bus, Gasoline	54%	13%					105%	100.0%					*3*
Rail--Freight, Diesel	40%	30%					100%	100%					*2*
Rail--Freight, Electric	40%	30%					105%	100%					*2*
Rail--Passenger, Electric	45%	30%					105%	100%					*3*
Water--Freight, Diesel and HFO	45%	35%					100%	100%					*2*
Air--Passenger: Activity levels	80%	75%					100%	100%					*Assumption*
Air--Passenger: Fraction as Jet Fuel	36%	36%											*4*
Non-Specified Transport (Oil/Elect.)	0%	0%					100%	100%					

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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 45 to 54 percent of 1990 due to austerity measures, increasing to 100 to 135 percent of 1990 by 2005 in the recovery scenario, and decreasing to 40 to 45 percent in the Decline scenario.

4 Assumes that any substantial recovery would require a substantial increase in air transport, which would be use new (to the DPRK) jet aircraft to augment the existing fleet of (mostly) aging propeller-driven planes. These planes would be needed to move visitors and investors from place to place within the country.

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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
RESIDENTIAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 6/8/2002

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:	100%				*5*
Average HH Dwelling Size	50	sq. meters			*19*
Te coal per HH/yr	1.83125				*19*
GJ/Te Coal	24				
GJ Coal Use/HH	43.95				
Total Coal Use, Urban HH			1.18E+08	GJ/yr	
Coal Use: Rural Households					
Fraction Using Coal:	26%				*6*
Te coal per HH/yr	9				*2*
GJ/Te Coal	24				*7*
GJ Coal Use/HH	216				
Total Coal Use, Rural HH			1.00E+08	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	0.22				*12*
GJ/te	44.4				*13*
GJ LPG/Kero Use/HH	9.6				
Total LPG/Kero Use, Urban HH			6.44E+06	GJ/yr	
Oil Use: Rural Households					
Fraction using LPG:	5%	(for Cooking)			
te per HH/yr	0.22				
GJ/te	44.4				
GJ LPG Use/HH	9.6				
Total LPG Use, Rural HH			8.59E+05	GJ/yr	
Charcoal Use: Urban Households					
Fraction Using Charcoal:	10%	(for Cooking)			*16*
Te Charcoal per HH/yr	0.44				*17*
GJ/Te Charcoal	28.8				*18*
GJ Charcoal Use/HH	12.8				
Total Charcoal Use, Rural HH			3.44E+06	GJ/yr	
Wood/Biomass Use: Rural Households					
Fraction Using Wood:	69%	(all End Uses)			*6*
Te Wood/Biomass per HH/yr	13.7				*14*
GJ/Te Wood/Biomass	15.25				*15*
GJ Wood/Biomass Use/HH	209.4				
Total Wood/Biomass Use, Rural HH			2.59E+08	GJ/yr	

1996 AND 2000 ENERGY USE IN RESIDENTIAL SECTOR

Growth in total number of households	-0.14%	/yr (1990 to 2000 Estimate)		*20*
	0.60%	/yr 2000-on		*22*
Fraction of Households as:	**1996**	**2000**		
Urban	60%	60%		*21*
Rural	40%	40%		*21*
Number of Households				
Urban	2,660,581	2,645,161		
Rural	1,773,721	1,763,441		
Coal Use per Household relative to 1990:	**1996**	**2000**		
Urban	60%	50%		
Rural	60%	50%		
Electricity Use per Household relative to 1990:	**1996**	**2000**		
Urban ***(See Note 23)***	60%	34%		
Rural ***(See Note 24)***	45%	10%		
Wood/Biomass Use per Household rel. to 1990:	**1996**	**2000**		
Rural	110%	110%		
Charcoal Use per Household rel. to 1990:	**1996**	**2000**		
Urban	75%	75%		
Kero/LPG Use per Household rel. to 1990:	**1996**	**2000**		
Urban	30.0%	30%		
Rural ***(See Note 25)***	25.0%	80%		

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

Sources/Notes:

1 from document in authors' files [HT1].

2 From document in authors' files [FC1]. Average figure based on figure for use in a central area of DPRK.

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. Urban households also, except in Pyongyang, use coal for cooking. From document in authors' files [R1].

6 Rough est. based on fractions cited for three different areas of DPRK, which vary from 8 to 50% coal use.

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 Based on est. 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 Placeholder estimate.

17 Assumes heat energy requirements as for wood-fired rural cooking, but assumes fuel input per unit heat supplied to the cooking vessel is two-thirds that for wood stoves.

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.)

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 lists 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) suggests 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 USDOE EIA as the year 2000 population. This suggests a modest decrease 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.

21 Assumption. There have been reports of forced migration from the cities to the rural areas, but none have been confirmed. World Bank projections suggest continued rural-to-urban migration. The overall pattern of migration remains unclear. 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.

22 This lower population growth assumption represents an attempt on our part to take into account the effects of the food shortages of the 1990's on future population growth in the DPRK, but assumes that there would be at least a modest improvement in the food situation. Historical (pre-1990) population growth rates had been near 2 percent annually.

23 Visitors to the DPRK in 2000 describe 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* 20% *of 2000, and further assuming that residents of cities other than Pyongyang had power only* 16% *of the time, we estimate that the average consumption of power per household was about* 34% *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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
AGRICULTURAL SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

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		*2*
Conversion Factor	1149	l/te		
Conversion Factor	43.17888	GJ/te		
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		*2*
Conversion Factor	0.0036	GJ/kWh		
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*
Processing/Other Coal Use	9.75E+06	GJ		
Oil Use: Processing/Other				
Total Agr. Oil Use	7.70E+00	GJ/ha rice		*7*
Oil Use in Agric. Machinery	2.62E+06			
Net Oil Use, Processing/Other	2.39E+06	GJ		
Electricity Use: Processing/Other				
Total Agr. Electricity Use	4.44E+02	kgce/ha rice		*7*
Conversion Factor	4.04E+02	kgce/MWhe		
Conversion Factor	3.60E+00	GJ/MWHe		
Electricity Use: Agric./Fields	9.07E+05	GJ		
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		*5*
Conversion Factor	14.5	GJ/te		*6*
Grain brans used in crop drying	1.00E+05	te		*5*
Conversion Factor	14.5	GJ/te		*6*
Wood used in Agricultural Sector	0		*No data*	
Conversion Factor	16	GJ/te		*6*
Total Wood/Biomass Use:	4.50E+07	GJ		

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN AGRICULTURAL SECTOR

(Note 10)

	1996	2000		
Area Cropped Relative to 1990:	100%	100%		*Assumption*
Use of Tractors, etc. Relative to 1990:	30%	40%		*8*
Use of Electricity in Fields Relative to 1990:	90%	97%		*Assumption*
Coal Use, Processing/Other, Rel. to 1990:	90%	90%		*8*
Oil Use, Processing/Other, Rel. to 1990:	30%	30%		*8*
Elect. Use, Processing/Other, Rel. to 1990:	90%	97%		*8*
Biomass Use, Processing/Other, Rel. to 1990:	90%	90%		*8*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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 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).

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
FISHERIES SECTOR ENERGY DEMAND

Prepared By David Von Hippel
Date Last Modified: 6/6/2002

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Oil Use: Large Ships			
Total Tonnage of Larger Ships	7.00E+05		*1*
Fraction in service	75%		*Guess*
Average days at sea	200		*Guess*
Operating hours/day	12		*Guess*
Average speed at sea	10	km/hr	*Guess*
Total ship travel	1.26E+10	gross te-km	
Conversion Factor	1.6	km/mile	
Oil Use efficiency	7.57	kgce/kte-mile	*2*
Conversion Factor	0.0293	GJ/kgce	
Total Oil Use, Larger Ships	1.75E+06	GJ	
Fraction of Oil Use as Diesel	50%		*Guess*
Fraction of Oil Use as Heavy Fuel Oil	50%		
Diesel Oil Use in Large Ships	8.73E+05	GJ	
Heavy Fuel Oil Use in Large Ships	8.73E+05	GJ	
Oil Use: Fishing Collectives	1.00E+05	GJ	*Placeholder estimate*
Oil Use: Processing/Other	1.00E+05	GJ	*no data*
Total Oil Use, Fisheries Sector	1.95E+06	GJ	
Coal Use: Ships	0.00E+00	GJ	*no data*
Coal Use: Processing/Other	0.00E+00	GJ	*no data*
Total Coal Use, Fisheries Sector	0.00E+00	GJ	*no data*
Electricity Use: Processing/Other	1.00E+05	GJ	*Placeholder estimate*
Total Electricity Use, Fisheries Sector	1.00E+05	GJ	

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN FISHERIES SECTOR

(See Note 3)

	1996	2000	2				
Large Ships Fishing Effort Relative to 1990:	50%	42%					*Assumption*
Fishing Collectives Fishing Effort Relative to 1990:	50%	42%					*Assumption*
Oil Use, Processing/Other Relative to 1990:	50%	42%					*Assumption*
Elect. Use, Processing/Other Relative to 1990:	50%	42%					*Assumption*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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 has increased somewhat since then. 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.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
PUBLIC/COMMERCIAL SECTOR

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

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	3.97E+07	sq.m.	4
Coal Use intensity	30	kgce/sq.m.	2
Conversion Factor	0.0293	GJ/kgce	
Total Coal Use, Public/Commercial Sectors	3.49E+07	GJ/yr	
Oil Use: Public/Commercial Sectors	0.00E+00	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	0.00E+00	GJ/yr	No data

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN PUBLIC/COMMERCIAL SECTORS

(See Note 8)

	1996	2000						
Public/Commercial Floor space per unit residential floor space relative to 1990:	100%	95%						7
Public/Commercial Floor space (sq.m.)	3.94E+07	3.72E+07					7	
Coal use per square meter relative to 1990:	90%	65%						Assumption
Elect. use per square meter relative to 1990:	60%	34%						
Other Public/Comm'l elect use rel to 1990.	60%	34%						

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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. 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.

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

2002 UPDATE

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

Prepared By David Von Hippel
Date Last Modified: 2/24/2003

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	30	kgce/sq.m.	*2*
	Conversion Factor	0.0293	GJ/kgce	
	Total Coal Use, Military Buildings	1.76E+07	GJ	
	Coal Use, Military Manufacturing	8.87E+05	GJ	*5*
	Other Coal Use: Military Sector	2.00E+07	GJ	*1*
	Total Coal Use, Buildings and Other	3.85E+07	GJ	
Oil Use: Military Sector				
	Oil Use, Military Transport Vehicles	6.58E+06	GJ	*5*
	Oil Use, Heavy Armaments	2.63E+06	GJ	*5*
	Oil Use in Air Force	2.65E+06	GJ	*5*
	Oil Use in Navy	6.85E+06	GJ	*5*
	Oil Use, Buildings and Other	1.00E+05	GJ	*1*
	Total Oil Use, Military Sector	1.88E+07	GJ	
Electricity Use: Military Buildings and Other				
	Electricity Use intensity, Buildings	55	kWh/sq.m.	*4*
	Conversion Factor	0.0036	GJ/kWh	
	Other Electricity Use	5.00E+06		*1*
	Total Electricity Use, Buildings and Other:	8.96E+06	GJ	
	Electricity Use, Military Manufacturing	4.75E+04	GJ	*5*
	Total Electricity Use, Military:	9.01E+06	GJ	

Energy Use in 1996 and 2000 Relative to 1990 for Subsectors/End-Uses Not Covered in Military Workbook		
1996 Coal Use, Buildings and Other, relative to 1990	100%	*Assumption*
2000 Coal Use, Buildings and Other, relative to 1990	100%	*Assumption*
1996 Oil Use, Buildings and Other, relative to 1990	100%	*Assumption*
2000 Oil Use, Buildings and Other, relative to 1990	100%	*Assumption*
1996 Elect. Use, Buildings and Other, relative to 1990	50%	*Assumption*
2000 Elect. Use, Buildings and Other, relative to 1990 *(See Note 6)*	50%	*Assumption*

Sources/Notes:

1 Placeholder Estimate

2 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 twice the level in public and commercial buildings.

5 As estimated in other Military Energy Consumption sections.

6 Rough assumption, but as the electricity situation in the country has continued to worsen, it.seems unlikely that electricity use in military buildings in the DPRK is larger than in 1996, even considering the importance of the military sector in the DPRK

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

2002 UPDATE

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

Prepared By David Von Hippel
Date Last Modified: 6/6/2002

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Coal Use: Other/Non-Specified Sectors			
Diesel Oil Use: Other/Non-Specified Sectors	2.00E+06	GJ	*1*
Kerosene/Jet Fuel Use: Other/Non-Specified Sect.	3.70E+06	GJ	*1*
Electricity Use: Other/Non-Specified Sectors			
Wood/Biomass Use: Other/Non-Specified Sectors			

ESTIMATE OF CURRENT AND FUTURE ENERGY USE IN NON-SPECIFIED SECTORS

Values Relative to 1990	**1996**	**2000**	THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS	
Oil used in unspecified/other sectors	0%	0%		*Assumption*

Sources/Notes:

1 Included to account for remainder of refined products production in balance sheet, 1990.

ESTIMATED/PROJECTED ENERGY SUPPLY/DEMAND BALANCES
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (DPRK)
2002 UPDATE
BACK-UP CALCULATIONS AND DATA:
NON-ENERGY RESOURCE USES

Prepared By David Von Hippel
Date Last Modified: 6/6/2002

DERIVATION OF INFORMATION PASSED TO ENERGY BALANCE SHEET, 1990

			Sources/Notes:
Coal Use as feedstock: Fertilizer (Ammonia) production	1.83E+07	GJ/yr	*1*
Total Coal Use: Non-Energy Applications:	1.83E+07	GJ/yr	
Oil Use: Non-Energy Products	9.42E+06	GJ/yr	*4*
Wood/Biomass Use: Roundwood for Wood Products:	5.87E+07	GJ/yr	*2*
Wood/Biomass Use: Non-Energy Applications	5.87E+07	GJ/yr	

ESTIMATE OF CURRENT AND FUTURE NON-ENERGY USE OF FUELS

Values Relative to 1990	**1996**	**2000**	**2...**	**...**	**...**	**...ec.**	
Coal used as feedstock for ammonia production	25%	11%				%	*3*
Oil Use: Non-Energy Products	30%	30%				%	*Assumption*
Wood/biomass used as roundwood:	60%	50%				%	*Assumption*

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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).

ATTACHMENT 2

WORKPAPERS AND DETAILED RESULTS:

ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN DPRK UPDATE FOR THE YEAR 2000

ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK UPDATE 2002

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

		1990			1996	2000
MILITARY BRANCH **Equipment**	Est. Number in Service	Fuel Cons GJ	Fraction of Branch	Fraction of Total	Fuel Cons GJ	Fuel Cons GJ
GROUND FORCES						
Tanks	5,832	2.05E+06	22.2%	10.4%	1.78E+06	1.83E+06
Amphibious Vehicles	900	1.04E+05	1.1%	0.5%	9.08E+04	9.33E+04
Armored Fighting Vehicles	4,015	4.50E+05	4.9%	2.3%	3.92E+05	4.03E+05
Truck/Tank-Mounted Guns, Missiles	516	2.64E+04	0.3%	0.1%	2.31E+04	2.37E+04
Jeeps and Motorcycles	9,045	2.15E+05	2.3%	1.1%	1.87E+05	1.92E+05
2 1/2 Ton Trucks	72,403	6.23E+06	67.6%	31.7%	5.42E+06	5.57E+06
Other Trucks and Utility Equipment	1,632	1.44E+05	1.6%	0.7%	1.30E+05	1.33E+05
TOTAL: Ground Forces	94,343	9.22E+06	100.0%	46.9%	8.02E+06	8.25E+06
AIR FORCE						
Fighters	748	1.76E+06	66.4%	8.9%	1.32E+06	9.52E+05
Bombers	82	3.96E+04	1.5%	0.2%	2.97E+04	2.14E+04
Transport	308	2.76E+05	10.4%	1.4%	2.32E+05	1.88E+05
Helicopters	275	8.03E+04	3.0%	0.4%	6.02E+04	4.77E+04
TOTAL: Aircraft	1,413	2.15E+06	81.3%	11.0%	1.64E+06	1.21E+06
Service (Ground) Vehicles	6,235	4.94E+05	18.7%	2.5%	4.94E+05	4.94E+05
TOTAL: Air Force		2.65E+06	100.0%	13.5%	2.13E+06	1.70E+06
NAVY						
Frigates	1	4.48E+04	0.7%	0.2%	3.36E+04	3.92E+04
Corvettes	2	1.79E+04	0.3%	0.1%	1.34E+04	1.57E+04
Missile Attack Boats	39	1.07E+06	15.7%	5.5%	8.06E+05	9.40E+05
Patrol and Mine Craft	351	5.05E+06	73.8%	25.7%	3.79E+06	4.42E+06
Amphibious Craft	324	2.31E+05	3.4%	1.2%	4.53E+05	7.30E+05
Submarines	84	5.56E+04	0.8%	0.3%	5.56E+04	5.56E+04
TOTAL: Naval Vessels	801	6.48E+06	94.6%	33.0%	5.15E+06	6.20E+06
Service (Land) Vehicles	4,077	3.71E+05	5.4%	1.9%	2.95E+05	3.55E+05
TOTAL: Naval Forces		6.85E+06	100.0%	34.9%	5.44E+06	6.56E+06
MILITARY MANUFACTURING: Coal Use		8.87E+05	GJ/yr	4.5%	7.10E+05	7.10E+05
MILITARY MANUFACTURING: Electricity Use		4.75E+04	GJ/yr	0.2%	3.80E+04	3.80E+04
TOTAL, ALL MILITARY ENERGY USES ABOVE		**1.96E+07**	GJ/yr	**100%**	**1.63E+07**	**1.73E+07**

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

Detailed Data and Results	
Prepared By:	David Von Hippel
Date Last Modified:	**6/6/2002**

UPDATE 2002

GROUND FORCES	
Hours of Maneuvers Per Year, 1990:	1000
Hours of Maneuvers Per Year, 1996:	870
Hours of Maneuvers Per Year, 2000:	957

AIRCRAFT				
Mission Hours Per Year:	1990	1996	2000	
Fighters/Bombers	24	18	13	
Transport Aircraft	50	42	34	
Helicopters	32	24	19	
Ave. airspeed--Fract. of Maximum	80%	80%	80%	

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

MILITARY SHIPS AND BOATS				
Active Hours Per Year in:	1990	1996	2000	
Amphibious	50	50	50	
Submarines	100	100	100	
Other Vessels	800	600	700	
Ave. power use--Fract. of Maximum	50%	50%	50%	

PROJECTION OF ENERGY REQUIRMENTS FOR MILITARY PRODUCT MANUFACTURING	
Ratio of Military Equipment Output in 1996 versus 1990:	0.8
Ratio of Military Equipment Output in 2000 versus 1990:	0.8

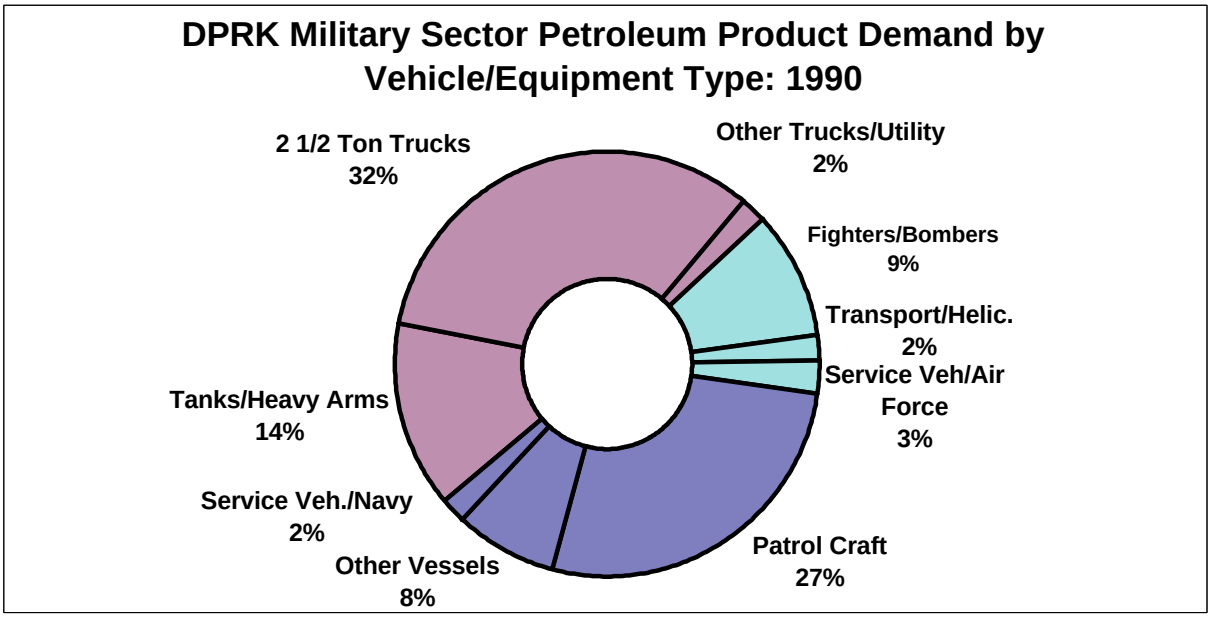
ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN DPRK
SUMMARY: FUEL USE IN EQUIPMENT, ALL MILITARY BRANCHES--1990

Summary Graphics	
Prepared By:	David Von Hippel
Date Last Modified:	**6/6/2002**

UPDATE 2002

MILITARY BRANCH **Equipment**	Fuel Cons GJ	Fraction of Branch	Fraction of Total
GROUND FORCES			
Tanks/Heavy Arms	2.63E+06	28.6%	14.1%
2 1/2 Ton Trucks	6.23E+06	67.6%	33.3%
Oth Trucks/Utility	3.59E+05	3.9%	1.9%
TOTAL: Ground Forces	9.22E+06	100.0%	49.3%
AIR FORCE			
Fighters/Bombers	1.80E+06	67.9%	9.6%
Transport/Helic.	3.56E+05	13.4%	1.9%
Service (Grnd) Veh.	4.94E+05	18.7%	2.6%
TOTAL: Air Force	2.65E+06	100.0%	14.2%
NAVY			
Patrol Craft	5.05E+06	73.8%	27.0%
Other Vessels	1.42E+06	20.8%	7.6%
Service (Land) Veh.	3.71E+05	5.4%	2.0%
TOTAL: Naval Forces	6.85E+06	100.0%	36.6%
TOTAL MILITARY EQUIP ENERGY USE	**1.87E+07**	**GJ/yr**	**100%**

Figure 3-16:



ESTIMATES AND PROJECTIONS OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK: MILITARY GROUND VEHICLES AND ARMAMENTS UPDATE 2002

Prepared By:	David Von Hippel
Date Last Modified:	**6/8/2002**

Summary Input Data and Results

Hours of Ground Maneuvers Per Year, 1990:	**1000**
Hours of Ground Maneuvers Per Year, 1996:	**870**
Hours of Ground Maneuvers Per Year, 2000:	**957**

						1990			
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
Notes				*1*	*2*				
Tanks	5,832	1.97	2.08	50%	25	500	5.46E+07	2.05E+06	22.2%
Amphibious Vehicles	900	1.04	26.50	50%	20	500	2.78E+06	1.04E+05	1.1%
Armored Fighting Vehicles	4,015	6.53	7.50	50%	30	500	1.38E+07	4.50E+05	4.9%
Truck/Tank-Mounted Guns, Missiles	516	1.97	6.44	25%	20	250	7.06E+05	2.64E+04	0.3%
Jeeps and Motorcycles	9,045	26.50	50	50%	30	500	6.61E+06	2.15E+05	2.3%
2 1/2 Ton Trucks	72,403	8.63		50%	30	500	1.91E+08	6.23E+06	67.6%
Other Trucks and Utility Equipment	1,632	3.85	8.63	50%	25	500	3.97E+06	1.44E+05	1.6%
TOTALS	94,343						2.74E+08	9.22E+06	100.0%
Diesel Consumption							6.09E+07	2.29E+06	24.8%
Gasoline Consumption							2.13E+08	6.93E+06	75.2%

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.

						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	Annual Hrs Use	Fuel Cons (liters)	Fuel Cons GJ
Notes				*1*	*2*						
Tanks	5,832	1.97	2.08	50%	25	435	4.75E+07	1.78E+06	478.5	4.88E+07	1.83E+06
Amphibious Vehicles	900	1.04	26.50	50%	20	435	2.42E+06	9.08E+04	478.5	2.49E+06	9.33E+04
Armored Fighting Vehicles	4,015	6.53	7.50	50%	30	435	1.20E+07	3.92E+05	478.5	1.24E+07	4.03E+05
Truck/Tank-Mounted Guns, Missiles	516	1.97	6.44	25%	20	217.5	6.14E+05	2.31E+04	239.25	6.31E+05	2.37E+04
Jeeps and Motorcycles	9,045	26.50	50	50%	30	435	5.75E+06	1.87E+05	478.5	5.91E+06	1.92E+05
2 1/2 Ton Trucks	72,403	8.63		50%	30	435	1.67E+08	5.42E+06	478.5	1.71E+08	5.57E+06
Other Trucks and Utility Equipment	1,632	3.85	8.63	50%	25	435	3.45E+06	1.30E+05	478.5	3.55E+06	1.33E+05
TOTALS	94,343						2.38E+08	8.02E+06		2.45E+08	8.25E+06
Diesel Consumption							5.30E+07	1.99E+06		5.44E+07	2.05E+06
Gasoline Consumption							1.85E+08	6.03E+06		1.90E+08	6.20E+06

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK
MILITARY GROUND VEHICLES AND ARMAMENTS UPDATE 2002

Detailed Data and Results

Prepared By:	David Von Hippel
Date Last Modified:	**6/3/2002**

COMMON ASSUMPTIONS & PARAMETERS GROUND FORCES			
Hours of Maneuvers Per Year, 1990:		**1000**	
Hours of Maneuvers Per Year, 1996:		**870**	
Hours of Maneuvers Per Year, 2000:		**957**	***Note 24***
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											
					TANKS			AMPHIBIOUS VEH. AND TANK RTVR						ARMORED FTG. VEHICLES		GUNS, MISSILES	
Branch or Unit of Ground Forces	Number	Personnel per Unit	TOTAL Personnel	Notes	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*			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

Branch or Unit of Ground Forces	Number	Personnel per Unit	TOTAL Personnel	Notes	MOTORIZED EQUIPMENT, BY TYPE, PER UNIT: GUNS, MISSILES (Cont.) BM-20,24 (ZIL-151,7)	FROG 3/5 (PT-76)	FROG 7 (ZIL-135)	LIGHT VEH. JEEPS	Motor-Cycles	**2.5 T Truck**	TRUCKS AND UTILITY VEHICLES: 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*			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	
Fuel Use Effic. Calculations	Units		Notes	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)
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			500	500	500	500	500	500	500	250	250	500	500	250	250
Hours of Operation, 1996	hrs			425	425	425	425	425	425	425	212.5	212.5	425	425	212.5	212.5
Hours of Operation, 2000--Recovery Scenario	hrs			550	550	550	550	550	550	550	275	275	550	550	275	275
Hours of Operation, 2000--Decline Scenario	hrs			375	375	375	375	375	375	375	187.5	187.5	375	375	187.5	187.5
Hours of Operation, 2005--Recovery Scenario	hrs			580	580	580	580	580	580	580	290	290	580	580	290	290
Hours of Operation, 2005--Decline Scenario	hrs			425	425	425	425	425	425	425	212.5	212.5	425	425	212.5	212.5
Fuel Consumption Results, 1990																
TOTAL FUEL USED	gal		*22*	5.55E+06	7.45E+06	1.35E+06	1.95E+05	2.19E+04	3.76E+05	6.02E+03	4.92E+04	8.39E+04	3.3E+06	3.1E+05	1.39E+05	2.66E+04
By Vehicle Category	gal	**All Veh.** 7.21E+07	*22*			1.44E+07						7.31E+05		3.6E+06		
TOTAL FUEL USED	liters			2.11E+07	2.83E+07	5.14E+06	7.41E+05	8.31E+04	1.43E+06	2.29E+04	1.87E+05	3.19E+05	1.3E+07	1.2E+06	5.28E+05	1.01E+05
By Vehicle Category	liters	**All Veh.** 2.74E+08				5.46E+07						2.78E+06		1.4E+07		
TOTAL FUEL USED	GJ			7.93E+05	1.06E+06	1.93E+05	2.78E+04	3.12E+03	5.37E+04	7.44E+02	7.03E+03	1.20E+04	4.1E+05	3.9E+04	1.98E+04	3.80E+03
By Vehicle Category	GJ	**All Veh.** 9.22E+06				2.05E+06						1.04E+05		4.5E+05		

				MOTORIZED EQUIPMENT, BY TYPE, PER UNIT													
				TANKS			AMPHIBIOUS VEH. AND TANK RTVR						FTG.		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			500	500	500	500	500	500	500	250	250	500	500	250	250
Hours of Operation, 1996	hrs			435	435	435	435	435	435	435	217.5	217.5	435	435	217.5	217.5
Hours of Operation, 2000	hrs			478.5	478.5	478.5	478.5	478.5	478.5	478.5	239.25	239.25	478.5	478.5	239.25	239.25
Hours of Operation, 2005--Recovery Scenario	hrs			550	550	550	550	550	550	550	275	275	550	550	275	275
Hours of Operation, 2005--Decline Scenario	hrs			375	375	375	375	375	375	375	187.5	187.5	375	375	187.5	187.5
Hours of Operation, 2010--Recovery Scenario	hrs			580	580	580	580	580	580	580	290	290	580	580	290	290
Hours of Operation, 2010--Decline Scenario	hrs			425	425	425	425	425	425	425	212.5	212.5	425	425	212.5	212.5
Fuel Consumption Results, 1990																
TOTAL FUEL USED	gal		*22*	5.55E+06	7.45E+06	1.35E+06	1.95E+05	2.19E+04	3.76E+05	6.02E+03	4.92E+04	8.39E+04	3.3E+06	3.1E+05	1.39E+05	2.66E+04
By Vehicle Category	gal	**All Veh.** 7.21E+07	*22*			1.44E+07						7.31E+05		3.6E+06		
TOTAL FUEL USED	liters			2.11E+07	2.83E+07	5.14E+06	7.41E+05	8.31E+04	1.43E+06	2.29E+04	1.87E+05	3.19E+05	1.3E+07	1.2E+06	5.28E+05	1.01E+05
By Vehicle Category	liters	**All Veh.** 2.74E+08				5.46E+07						2.78E+06		1.4E+07		
TOTAL FUEL USED	GJ			7.93E+05	1.06E+06	1.93E+05	2.78E+04	3.12E+03	5.37E+04	7.44E+02	7.03E+03	1.20E+04	4.1E+05	3.9E+04	1.98E+04	3.80E+03
By Vehicle Category	GJ	**All Veh.** 9.22E+06				2.05E+06						1.04E+05		4.5E+05		
Fuel Consumption Results, 1996																
TOTAL FUEL USED	gal		*22*	4.83E+06	6.48E+06	1.18E+06	1.70E+05	1.90E+04	3.27E+05	5.23E+03	4.28E+04	7.30E+04	2.9E+06	2.7E+05	1.21E+05	2.31E+04
By Vehicle Category	gal	**All Veh.** 6.27E+07	*22*			1.25E+07						6.36E+05		3.2E+06		
TOTAL FUEL USED	liters			1.84E+07	2.46E+07	4.47E+06	6.44E+05	7.23E+04	1.24E+06	1.99E+04	1.63E+05	2.77E+05	1.1E+07	1.0E+06	4.59E+05	8.79E+04
By Vehicle Category	liters	**All Veh.** 2.38E+08				4.75E+07						2.42E+06		1.2E+07		
TOTAL FUEL USED	GJ			6.90E+05	9.26E+05	1.68E+05	2.42E+04	2.72E+03	4.67E+04	6.47E+02	6.11E+03	1.04E+04	3.6E+05	3.4E+04	1.73E+04	3.30E+03
By Vehicle Category	GJ	**All Veh.** 8.02E+06				1.78E+06						9.08E+04		3.9E+05		
Fuel Consumption Results, 2000																
TOTAL FUEL USED	gal		*22*	4.96E+06	6.66E+06	1.21E+06	1.74E+05	1.96E+04	3.36E+05	5.38E+03	4.40E+04	7.50E+04	3.0E+06	2.8E+05	1.24E+05	2.38E+04
By Vehicle Category	gal	**All Veh.** 6.44E+07	*22*			1.28E+07						6.54E+05		3.3E+06		
TOTAL FUEL USED	liters			1.89E+07	2.53E+07	4.60E+06	6.62E+05	7.43E+04	1.28E+06	2.04E+04	1.67E+05	2.85E+05	1.1E+07	1.1E+06	4.72E+05	9.04E+04
By Vehicle Category	liters	**All Veh.** 2.45E+08				4.88E+07						2.49E+06		1.2E+07		
TOTAL FUEL USED	GJ			7.09E+05	9.52E+05	1.73E+05	2.49E+04	2.79E+03	4.80E+04	6.65E+02	6.28E+03	1.07E+04	3.7E+05	3.5E+04	1.77E+04	3.40E+03
By Vehicle Category	GJ	**All Veh.** 8.25E+06				1.83E+06						9.33E+04		4.0E+05		

				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			250	250	250	500	500	500	500	500	500	500	500	500	250	250
Hours of Operation, 1996	hrs			217.5	217.5	217.5	435	435	435	435	435	435	435	435	435	217.5	217.5
Hours of Operation, 2000	hrs			239.25	239.25	239.25	478.5	478.5	478.5	478.5	478.5	478.5	478.5	478.5	478.5	239.25	239.25
Hours of Operation, 2005--Recovery Scenario	hrs			275	275	275	550	550	550	550	550	550	550	550	550	275	275
Hours of Operation, 2005--Decline Scenario	hrs			187.5	187.5	187.5	375	375	375	375	375	375	375	375	375	187.5	187.5
Hours of Operation, 2010--Recovery Scenario	hrs			290	290	290	580	580	580	580	580	580	580	580	580	290	290
Hours of Operation, 2010--Decline Scenario	hrs			212.5	212.5	212.5	425	425	425	425	425	425	425	425	425	212.5	212.5
Fuel Consumption Results, 1990																	
TOTAL FUEL USED	gal		*22*	2.65E+03	8.80E+03	8.88E+03	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.** 7.21E+07	*22*			1.86E+05		1.74E+06	5.04E+07								1.0E+06
TOTAL FUEL USED	liters			1.01E+04	3.35E+04	3.38E+04	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.** 2.74E+08				7.06E+05		6.61E+06	1.91E+08								4.0E+06
TOTAL FUEL USED	GJ			3.79E+02	1.26E+03	1.10E+03	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.** 9.22E+06				2.64E+04		2.15E+05	6.23E+06								1.4E+05
Fuel Consumption Results, 1996																	
TOTAL FUEL USED	gal		*22*	2.31E+03	7.66E+03	7.73E+03	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.** 6.27E+07	*22*			1.62E+05		1.51E+06	4.38E+07								9.1E+05
TOTAL FUEL USED	liters			8.77E+03	2.91E+04	2.94E+04	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.** 2.38E+08				6.14E+05		5.75E+06	1.67E+08								3.5E+06
TOTAL FUEL USED	GJ			3.30E+02	1.09E+03	1.10E+03	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.** 8.02E+06				2.31E+04		1.87E+05	5.42E+06								1.3E+05
Fuel Consumption Results, 2000																	
TOTAL FUEL USED	gal		*22*	2.37E+03	7.87E+03	7.94E+03	1.25E+06	3.11E+05	4.50E+07	2.9E+04	4.0E+04	3.3E+05	1.1E+05	2.1E+05	2.0E+05	0.0E+00	1.5E+04
By Vehicle Category	gal	**All Veh.** 6.44E+07	*22*			1.66E+05		1.56E+06	4.50E+07								9.3E+05
TOTAL FUEL USED	liters			9.02E+03	2.99E+04	3.02E+04	4.73E+06	1.18E+06	1.71E+08	1.1E+05	1.5E+05	1.2E+06	4.3E+05	8.1E+05	7.6E+05	0.0E+00	5.8E+04
By Vehicle Category	liters	**All Veh.** 2.45E+08				6.31E+05		5.91E+06	1.71E+08								3.5E+06
TOTAL FUEL USED	GJ			3.39E+02	1.12E+03	1.13E+03	1.54E+05	3.84E+04	5.57E+06	4.1E+03	5.7E+03	4.7E+04	1.6E+04	3.0E+04	2.8E+04	0.0E+00	2.2E+03
By Vehicle Category	GJ	**All Veh.** 8.25E+06				2.37E+04		1.92E+05	5.57E+06								1.3E+05

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 be 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 10 percent higher than in 1996.

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

MILITARY AIRCRAFT UPDATE 2002

Detailed Data and Results	
Prepared By:	David Von Hippel
Date Last Modified:	**6/8/2002**

COMMON ASSUMPTIONS & PARAMETERS--AIRCRAFT USE

(See Note 22)

Mission Hours Per Year:	**1990**	**1996**	**2000**
Fighters/Bombers (*Note 13*)	**24**	**18**	**13**
Transport Aircraft	**50**	**42**	**34**
Helicopters	**32**	**24**	**19**
Ave. airspeed--Fract. of Maximum	**80%**	**80%**	**80%**

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

Kerosene/Jet Fuel Energy Cont. (GJ/ltr)	**0.0350**	*Note 15*
Aviation Gasoline Energy Cont. (GJ/ltr)	**0.03209**	*Note 15*

Type of Aircraft	**Class**		Number in Air Force Estimates from Sources *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	**1990** Total Fuel Consumpt liters	**1990** Total Fuel Consumpt GJ	**1996** Total Fuel Consumpt GJ	**2000** 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	1.40E+05	1.01E+05
F-6 (MIG-19) Farmer	Fighter/Bomber		160	160		110	>100	160	160	1390	2170	1590		1986	7.63E+06	2.67E+05	2.00E+05	1.45E+05
MIG-21 Fishbed D/F/J	Fighter		160	120		130	120	160	160	971	2340	2230		4299	1.65E+07	5.78E+05	4.33E+05	3.13E+05
F-7 (Fishbed C)	Fighter		40						40	1203	2340	2230		3470	3.33E+06	1.17E+05	8.74E+04	6.31E+04
MIG-23 Flogger B/C/E/G/K	Fighter		46				46	45	46	1800	5750	2440		6236	6.88E+06	2.41E+05	1.81E+05	1.30E+05
MIG-29 Fulcrum A/B	Fighter		10	"2 reg"	13			15	13	2100	4365	2440		4057	1.27E+06	4.43E+04	3.32E+04	2.40E+04
MIG-15 Fagot	Fighter	*5*				180		190	144	1368	2365	1017		1407	4.86E+06	1.70E+05	1.28E+05	9.21E+04
SU-7B Fitter A	Fighter		20	20		20	20	20	20	1450	5275	1696	850	4936	2.37E+06	8.29E+04	6.22E+04	4.49E+04
SU-25 Frogfoot A	Fighter	*9*	35	>20	36		36	35	35	1250	4568	848		2479	2.08E+06	7.29E+04	5.47E+04	3.95E+04
IL-28 Beagle	Bomber		80	82		85	82	80	82	2180	1740	900		575	1.13E+06	3.96E+04	2.97E+04	2.14E+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	6.91E+04
AN-24 (Coke)	Transport		6	10			10		6	600	5550	484		3582	1.07E+06	3.45E+04	2.90E+04	2.34E+04
IL-18 Coot	Transport		2						2	6500	30000	675	625	2885	2.88E+05	9.26E+03	7.78E+03	6.29E+03
IL-12 Coach (Civil)	Transport	*6,10,11*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.96E+04
LI-2 Cab (Civil)	Transport	*6,10,11*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.96E+04
IL-14 Crate (Civil)	Transport	*6, 10*							10	1500	6500	675	625	2708	1.35E+06	4.35E+04	3.65E+04	2.96E+04
Fighters (All)			601	748	748	580			748						5.03E+07	1.76E+06	1.32E+06	9.52E+05
Bombers (All)			80	82	82	85			82						1.13E+06	3.96E+04	2.97E+04	2.14E+04
Transport (All)			278	310	310	205			308						8.59E+06	2.76E+05	2.32E+05	1.88E+05
Helicopters																		
MI-2 Hoplite		*7*		"Most"			188		113	715	846	210		199	7.19E+05	2.31E+04	1.73E+04	1.37E+04
MI-4 Hound		*8, 12*				75			45	325	846	210	160	416	6.00E+05	1.92E+04	1.44E+04	1.14E+04
MI-8 Hip		*8*							30	475	1870	250	225	886	8.50E+05	2.73E+04	2.05E+04	1.62E+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	6.37E+03
All				275	275				275						2.50E+06	8.03E+04	6.02E+04	4.77E+04
														Kerosene/Jet Fuel	5.14E+07	1.80E+06	1.35E+06	9.74E+05
														Aviation Gasoline	1.11E+07	3.56E+05	2.92E+05	2.35E+05
ALL AIRCRAFT									1413					**TOTAL ALL FUELS**	6.25E+07	2.15E+06	1.64E+06	1.21E+06
Air Force Personnel		80,000	*3, 21*															
Service Vehicles		6,235	*16*												1.52E+07	4.94E+05	4.94E+05	4.94E+05
TOTAL: AIRCRAFT PLUS GROUND SUPPORT VEHICLES														**TOTAL ALL FUELS**	7.76E+07	2.65E+06	2.13E+06	1.70E+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.

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK
MILITARY SHIPS AND BOATS UPDATE 2002

Detailed Data and Results

Prepared By: David Von Hippel
Date Last Modified: **6/3/2002**

COMMON ASSUMPTIONS & PARAMETERS--NAVAL ENERGY USE *(Note 30)*

Active Hours Per Year in:	**1990**	**1996**	**2000**
Amphibious	**50**	**50**	**50**
Submarines	**100**	**100**	**100**
Other Vessels	**800**	**600**	**700**
Ave. power use--Fract. of Max.	**50%**	**50%**	**50%**

THIS SECTION OF THIS WORKSHEET NOT USED FOR THIS ANALYSIS

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

True-Up Factors (*see Note 14*)

Missile Attack Boats:	1.50
Amphibious:	1.46
Other Sm. Surface Vessels:	1.04

Type of Vessel	**Class**		Number in DPRK Navy Estimates from Sources *1*	*2*	*3*	*4*	*5*	*22*	*23*	*24*	Number in Navy Assumed	Displcmt Tons	Range n.miles	Speed knots	Engine Power (b/s/hp)
		Notes:												*6*	*5*
Nanjin Class	Frigate	*21*				4	2		2	2	1	1800	4000	14	15000
T (Tral) Class	Lg Patrol					2				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		
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
Nanjin Class	Frigate	1,191,223	1.19E+06	4.48E+04	893,417	8.93E+05	3.36E+04	1,042,320	1.04E+06	3.92E+04
T (Tral) Class	Lg Patrol	238,245	4.76E+05	1.79E+04	178,683	3.57E+05	1.34E+04	208,464	4.17E+05	1.57E+04
Sariwon Class	Lg Patrol	238,245	9.53E+05	3.58E+04	178,683	7.15E+05	2.69E+04	208,464	8.34E+05	3.13E+04
SO 1 Class	Lg Patrol	595,611	9.53E+06	3.58E+05	446,708	7.15E+06	2.69E+05	521,160	8.34E+06	3.13E+05
Artillerist Class	Lg Patrol	595,611	1.19E+06	4.48E+04	446,708	8.93E+05	3.36E+04	521,160	1.04E+06	3.92E+04
Hainan Class	Lg Patrol	698,851	4.19E+06	1.58E+05	524,138	3.14E+06	1.18E+05	611,494	3.67E+06	1.38E+05
Taechong Class	Lg Patrol	595,611	4.17E+06	1.57E+05	446,708	3.13E+06	1.18E+05	521,160	3.65E+06	1.37E+05
OSA 1 Class	Missile Att.	952,978	2.29E+07	8.60E+05	714,734	1.72E+07	6.45E+05	833,856	2.00E+07	7.52E+05
Komar Class	Missile Att.	381,191	5.72E+06	2.15E+05	285,893	4.29E+06	1.61E+05	333,542	5.00E+06	1.88E+05
Shanghi Class--Gun	Fast Att.	381,191	4.96E+06	1.86E+05	285,893	3.72E+06	1.40E+05	333,542	4.34E+06	1.63E+05
Swatow Class--Gun	Fast Att.	238,245	1.91E+06	7.16E+04	178,683	1.43E+06	5.37E+04	208,464	1.67E+06	6.27E+04
Chodo Class--Gun	Fast Att.	476,489	1.91E+06	7.16E+04	357,367	1.43E+06	5.37E+04	416,928	1.67E+06	6.27E+04
K-48 Class--Gun	Fast Att.	397,074	1.59E+06	5.97E+04	297,806	1.19E+06	4.48E+04	347,440	1.39E+06	5.22E+04
MO IV Class--Gun	Fast Att.	238,245	5.00E+06	1.88E+05	178,683	3.75E+06	1.41E+05	208,464	4.38E+06	1.65E+05
Chongjin Class--Gun	Fast Att.	381,191	1.79E+07	6.73E+05	285,893	1.34E+07	5.05E+05	333,542	1.57E+07	5.89E+05
P 6--Torpedo	Fast Att.	381,191	2.48E+07	9.31E+05	285,893	1.86E+07	6.98E+05	333,542	2.17E+07	8.15E+05
P 4--Torpedo	Fast Att.	381,191	4.96E+06	1.86E+05	285,893	3.72E+06	1.40E+05	333,542	4.34E+06	1.63E+05
Iwon--Torpedo	Fast Att.	285,893	4.57E+06	1.72E+05	214,420	3.43E+06	1.29E+05	250,157	4.00E+06	1.50E+05
An Ju--Torpedo	Fast Att.	381,191	2.29E+06	8.60E+04	285,893	1.72E+06	6.45E+04	333,542	2.00E+06	7.52E+04
Chaho Class--Torpedo	Fast Att.	381,191	2.63E+07	9.89E+05	285,893	1.97E+07	7.41E+05	333,542	2.30E+07	8.65E+05
Sin Hung/Kosong--Torp.	Fast Att.	190,596	1.43E+07	5.37E+05	142,947	1.07E+07	4.03E+05	166,771	1.25E+07	4.70E+05
Shersen Class--Torpedo	Fast Att.	952,978	3.81E+06	1.43E+05	714,734	2.86E+06	1.07E+05	833,856	3.34E+06	1.25E+05
KM 4--Torpedo	Fast Att.	11,595	1.16E+05	4.36E+03	8,696	8.70E+04	3.27E+03	10,145	1.01E+05	3.81E+03
Torpedo Boats	Patrol									
Light Patrol	Patrol	11,595	2.43E+05	9.15E+03	8,696	1.83E+05	6.86E+03	10,145	2.13E+05	8.01E+03
Hantae	Landing	24,817	2.98E+05	1.12E+04	24,817	2.98E+05	1.12E+04	24,817	2.98E+05	1.12E+04
Nampo	Landing	23,824	3.48E+06	1.31E+05	23,824	3.48E+06	1.31E+05	23,824	3.48E+06	1.31E+05
Hanchon	Landing	24,817	8.93E+05	3.36E+04	24,817	8.93E+05	3.36E+04	24,817	8.93E+05	3.36E+04
		113,400	1.47E+06	5.54E+04	113,400	7.37E+06	2.77E+05	113,400	1.47E+07	5.54E+05
Whiskey	Submarine	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03
Romeo, Chinese	Submarine	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03	52,247	2.09E+05	7.85E+03
Romeo, NK	Submarine	52,247	8.36E+05	3.14E+04	52,247	8.36E+05	3.14E+04	52,247	8.36E+05	3.14E+04
		2,090	1.00E+05	3.77E+03	2,090	1.00E+05	3.77E+03	2,090	1.00E+05	3.77E+03
		10,449	1.25E+05	4.71E+03	10,449	1.25E+05	4.71E+03	10,449	1.25E+05	4.71E+03
Frigates			1.19E+06	4.48E+04		8.93E+05	3.36E+04		1.04E+06	3.92E+04
Corvettes			4.76E+05	1.79E+04		3.57E+05	1.34E+04		4.17E+05	1.57E+04
Missile Attack Boats			2.86E+07	1.07E+06		2.14E+07	8.06E+05		2.50E+07	9.40E+05
Coastal Patrol Craft										
Mine Warfare Craft										
Amphibious Craft			6.14E+06	2.31E+05		1.20E+07	4.53E+05		1.94E+07	7.30E+05
Submarines			1.48E+06	5.56E+04		1.48E+06	5.56E+04		1.48E+06	5.56E+04
Trawlers										
TOTAL, VESSELS			1.72E+08	6.48E+06		1.37E+08	5.15E+06		1.65E+08	6.20E+06
Those Using Heavy Fuel Oil			1.19E+06	4.48E+04		8.93E+05	3.36E+04		1.04E+06	3.92E+04
Service Vehicles			1.14E+07	3.71E+05		9.04E+06	2.95E+05		1.09E+07	3.55E+05
TOTAL: VESSELS PLUS SERVICE VEHICLES			1.84E+08	6.85E+06		1.46E+08	5.44E+06		1.76E+08	6.56E+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.

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 definitive intormation of an unclassified nature that could be used to quailitatively estimate the level of activity in the DPRK naval forces as of 2000. Analysts contacted in researching this update, however, indicate that the DPRK Navy does not 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 somewhat more (in terms of activity per vessel) than in 1996.

ESTIMATE OF ANNUAL FUEL USE BY THE MILITARY SECTOR IN THE DPRK
ENERGY USE IN MANUFACTURING MILITARY EQUIPMENT UPDATE 2002

Detailed Data and Results

Prepared By: David Von Hippel
Date Last Modified: **6/6/2002**

COMMON ASSUMPTIONS & PARAMETERS	
Lifetime of Ground Forces Equipment (yrs):	20
Lifetime of Small Armaments (yrs):	10
Lifetime of Naval Vessels (yrs):	30
Fract. of Weight of Equip. 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

GROUND FORCES: OTHER ARMAMENTS		Estimated Number in Service	Average Weight Each (t)	Made in DPRK?	Equip. Lifetime (years)	Total Weight (t)	Estimated Iron&Steel Needed (t)
	Notes:		*1*				
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:	**0.8**	
Ratio of Military Equipment Output in 2000 versus 1990:	**0.8**	***(See Note 11)***

	1996	**2000**	**2005--R**
Projection of Coal Use in Military Manufacturing (GJ)	**7.10E+05**	**7.10E+05**	**1.06E+06**
Projection of Electricity Use in Military Manufacturing (GJ)	**3.80E+04**	**3.80E+04**	**5.70E+04**
	2005--D	**2010--R**	**2010--D**
Projection of Coal Use in Military Manufacturing (GJ)	**7.10E+05**	**1.06E+06**	**7.54E+05**
Projection of Electricity Use in Military Manufacturing (GJ)	**3.80E+04**	**5.70E+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 is no direct information available on the intensity of military manufacturing in the DPRK in recent years. There have been reports of missile exports from the DPRK, but quantities exported are difficult to obtain, and 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.*