No.

Department of Energy
Republic of the Philippines

The Study on Capability Enhancement on Policy and Planning for a More Effective and Comprehensive Philippine Energy Plan (PEP) Formulation

Final Report

(Appendix)

- Tools for PEP Formulation -

December 2008

Japan International Cooperation Agency

The Institute of Energy Economics, Japan

Tokyo Electric Power Company

IDD
JR
08-059

Contents of Appendix

Appendix-1

Overview of Case Studies

Appendix 1

1.1 BAU Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	438	525	582	640	690	2.7	3.7	2.1	1.9	1.5	2.4
TPE per GDP	toe/mil. PHP	27.0	24.7	24.4	22.8	21.7	20.7	-1.8	-0.3	-1.3	-1.0	-1.0	-1.1
Electricity per capita	kWh/person	530	636	781	936	1,094	1,251	3.7	4.2	3.7	3.2	2.7	3.5
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	85,090	106,750	136,680	165,180	195,170	5.7	4.6	5.1	3.9	3.4	4.5
Total Primary Energy Supply	*ktoe*	*38,498*	*46,510*	*58,665*	*68,603*	*79,242*	*89,253*	*3.9*	*4.8*	*3.2*	*2.9*	*2.4*	*3.4*
Coal	ktoe	5,190	7,458	9,975	14,688	18,789	23,903	7.5	6.0	8.0	5.0	4.9	6.3
Natural Gas	ktoe	2,504	2,858	3,608	3,793	4,529	4,615	2.7	4.8	1.0	3.6	0.4	2.5
Oil	ktoe	14,430	18,096	21,841	25,836	29,748	33,313	4.6	3.8	3.4	2.9	2.3	3.4
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	327	681	834	962	1,061	153.2	15.8	4.1	2.9	2.0	26.2
Commercial Energy	ktoe	32,731	40,727	53,074	63,243	74,148	84,435	4.5	5.4	3.6	3.2	2.6	3.9
Non-commercial Energy	*ktoe*	*5,766*	*5,783*	*5,591*	*5,360*	*5,095*	*4,818*	*0.1*	*-0.7*	*-0.8*	*-1.0*	*-1.1*	*-0.7*
Coal	%	13.5	16.0	17.0	21.4	23.7	26.8						
Natural Gas	%	6.5	6.1	6.1	5.5	5.7	5.2						
Oil	%	37.5	38.9	37.2	37.7	37.5	37.3						
Others	%	27.6	26.5	30.1	27.6	26.6	25.3						
Non-commercial Energy	%	15.0	12.4	9.5	7.8	6.4	5.4						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*22,931*	*29,531*	*36,445*	*43,253*	*49,668*	*5.7*	*5.2*	*4.3*	*3.5*	*2.8*	*4.3*
Agriculture	ktoe	313	269	324	381	435	485	-3.0	3.8	3.3	2.7	2.2	1.8
Industry	ktoe	4,084	4,822	6,125	7,562	9,109	10,717	3.4	4.9	4.3	3.8	3.3	3.9
Energy Intensive	ktoe	2,653	3,260	4,035	4,894	5,815	6,772	4.2	4.4	3.9	3.5	3.1	3.8
Other	ktoe	1,430	1,562	2,090	2,668	3,294	3,944	1.8	6.0	5.0	4.3	3.7	4.1
Commercial	ktoe	1,660	2,312	3,145	4,107	5,163	6,278	6.9	6.3	5.5	4.7	4.0	5.5
Residential	ktoe	2,405	2,908	3,870	4,988	6,208	7,463	3.9	5.9	5.2	4.5	3.8	4.6
Transport	ktoe	8,940	12,619	16,066	19,408	22,338	24,724	7.1	4.9	3.9	2.9	2.1	4.2
Energy Net Import	*ktoe*	*18,112*	*23,198*	*28,779*	*37,330*	*46,410*	*54,713*	*5.1*	*4.4*	*5.3*	*4.5*	*3.3*	*4.5*
Coal	ktoe	3,710	5,139	6,975	10,656	14,074	17,937	6.7	6.3	8.8	5.7	5.0	6.5
Natural Gas	ktoe	0	0	0	875	2,625	3,500				24.6	5.9	
Oil	ktoe	14,402	18,059	21,805	25,799	29,711	33,276	4.6	3.8	3.4	2.9	2.3	3.4
Energy Import Ratio	*%*	*55.3*	*57.0*	*54.2*	*59.0*	*62.6*	*64.8*						
Coal	%	71.5	68.9	69.9	72.5	74.9	75.0						
Natural Gas	%	0.0	0.0	0.0	23.1	58.0	75.8						
Oil	%	99.8	99.8	99.8	99.9	99.9	99.9						

1.2 Reference Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	529	567	595	1.7	3.3	1.5	1.4	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.8	19.3	17.8	-2.7	-0.7	-1.8	-1.5	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	95,640	118,020	137,160	156,210	4.3	3.7	4.3	3.1	2.6	3.6
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,366*	*71,498*	*78,545*	*3.1*	*4.4*	*2.7*	*2.4*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	12,021	14,579	17,968	7.3	3.4	6.7	3.9	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,600	3,716	4,448	4,509	2.2	5.2	0.6	3.7	0.3	2.4
Oil	ktoe	14,430	16,400	19,718	22,993	25,741	27,841	2.6	3.8	3.1	2.3	1.6	2.7
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	312	630	749	839	899	150.9	15.1	3.5	2.3	1.4	25.4
Commercial Energy	ktoe	32,731	38,871	49,614	57,571	65,727	72,761	3.5	5.0	3.0	2.7	2.1	3.2
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	19.0	20.4	22.9						
Natural Gas	%	6.5	6.2	6.5	5.9	6.2	5.7						
Oil	%	37.5	36.6	35.6	36.3	36.0	35.4						
Others	%	27.6	27.5	31.7	29.7	29.3	28.6						
Non-commercial Energy	%	15.0	13.2	10.5	9.1	8.1	7.4						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,148*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,700*	*32,353*	*38,763*	*44,341*	*3.5*	*3.6*	*4.7*	*3.7*	*2.7*	*3.6*
Coal	ktoe	3,710	5,139	6,019	8,599	10,515	13,143	6.7	3.2	7.4	4.1	4.6	5.2
Natural Gas	ktoe	0	0	0	798	2,544	3,394				26.1	5.9	
Oil	ktoe	14,402	16,363	19,682	22,957	25,705	27,804	2.6	3.8	3.1	2.3	1.6	2.7
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*56.2*	*59.0*	*60.9*						
Coal	%	71.5	69.7	69.2	71.5	72.1	73.1						
Natural Gas	%	0.0	0.0	0.0	21.5	57.2	75.3						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.3 High Grow Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,672	2,289	3,072	4,032	5,181	6.7	6.5	6.1	5.6	5.1	6.0
RGDP per capita	PHP/person	14,198	17,976	22,651	28,254	34,796	42,341	4.8	4.7	4.5	4.3	4.0	4.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	423	508	564	629	690	2.0	3.7	2.1	2.2	1.9	2.4
TPE per GDP	toe/mil. PHP	27.0	23.5	22.4	20.0	18.1	16.3	-2.7	-1.0	-2.3	-2.0	-2.1	-2.0
Electricity per capita	kWh/person	530	611	748	905	1,081	1,276	2.9	4.1	3.9	3.6	3.4	3.6
Passenger Cars	1,000 units	788	872	1,144	1,480	1,879	2,337	2.0	5.6	5.3	4.9	4.5	4.4
Utility Vehicles	1,000 units	1,792	2,473	3,378	4,239	4,919	5,327	6.7	6.4	4.6	3.0	1.6	4.5
Trucks	1,000 units	267	363	452	535	607	664	6.3	4.5	3.5	2.5	1.8	3.7
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,684	5,370	6,973	8,177	8,800	11.3	7.8	5.4	3.2	1.5	5.8
CO2 Emission	CO_2-kton	64,453	80,830	101,680	129,890	160,880	194,440	4.6	4.7	5.0	4.4	3.9	4.5
Total Primary Energy Supply	*ktoe*	*38,498*	*45,265*	*57,277*	*67,316*	*79,035*	*90,881*	*3.3*	*4.8*	*3.3*	*3.3*	*2.8*	*3.5*
Coal	ktoe	5,190	7,440	10,012	14,123	19,079	24,963	7.5	6.1	7.1	6.2	5.5	6.5
Natural Gas	ktoe	2,504	2,858	3,285	3,716	4,235	4,615	2.7	2.8	2.5	2.6	1.7	2.5
Oil	ktoe	14,430	16,739	20,443	24,611	28,550	32,318	3.0	4.1	3.8	3.0	2.5	3.3
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	317	655	801	925	1,020	151.6	15.6	4.1	2.9	2.0	26.0
Commercial Energy	ktoe	32,731	39,343	51,364	61,343	72,908	84,458	3.7	5.5	3.6	3.5	3.0	3.9
Non-commercial Energy	*ktoe*	*5,766*	*5,922*	*5,913*	*5,972*	*6,127*	*6,423*	*0.5*	*-0.0*	*0.2*	*0.5*	*0.9*	*0.4*
Coal	%	13.5	16.4	17.5	21.0	24.1	27.5						
Natural Gas	%	6.5	6.3	5.7	5.5	5.4	5.1						
Oil	%	37.5	37.0	35.7	36.6	36.1	35.6						
Others	%	27.6	27.2	30.8	28.1	26.6	24.8						
Non-commercial Energy	%	15.0	13.1	10.3	8.9	7.8	7.1						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*22,135*	*28,350*	*35,142*	*42,165*	*49,265*	*4.9*	*5.1*	*4.4*	*3.7*	*3.2*	*4.3*
Agriculture	ktoe	313	256	300	347	392	435	-3.9	3.3	2.9	2.5	2.1	1.3
Industry	ktoe	4,084	4,650	5,944	7,454	9,191	11,161	2.6	5.0	4.6	4.3	4.0	4.1
Energy Intensive	ktoe	2,653	3,164	3,953	4,874	5,922	7,105	3.6	4.6	4.3	4.0	3.7	4.0
Other	ktoe	1,430	1,486	1,990	2,580	3,270	4,056	0.8	6.0	5.3	4.9	4.4	4.3
Commercial	ktoe	1,660	2,232	3,049	4,065	5,277	6,684	6.1	6.4	5.9	5.4	4.8	5.7
Residential	ktoe	2,405	2,792	3,651	4,666	5,802	7,037	3.0	5.5	5.0	4.5	3.9	4.4
Transport	ktoe	8,940	12,205	15,406	18,610	21,503	23,948	6.4	4.8	3.9	2.9	2.2	4.0
Energy Net Import	*ktoe*	*18,112*	*21,841*	*27,381*	*35,427*	*45,207*	*54,778*	*3.8*	*4.6*	*5.3*	*5.0*	*3.9*	*4.5*
Coal	ktoe	3,710	5,139	6,975	10,054	14,363	18,997	6.7	6.3	7.6	7.4	5.8	6.8
Natural Gas	ktoe	0	0	0	798	2,330	3,500				23.9	8.5	
Oil	ktoe	14,402	16,702	20,406	24,574	28,514	32,281	3.0	4.1	3.8	3.0	2.5	3.3
Energy Import Ratio	*%*	*55.3*	*55.5*	*53.3*	*57.8*	*62.0*	*64.9*						
Coal	%	71.5	69.1	69.7	71.2	75.3	76.1						
Natural Gas	%	0.0	0.0	0.0	21.5	55.0	75.8						
Oil	%	99.8	99.8	99.8	99.9	99.9	99.9						

1.4 Low Growth Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,580	1,942	2,335	2,758	3,216	5.5	4.2	3.8	3.4	3.1	4.0
RGDP per capita	PHP/person	14,198	16,986	19,210	21,471	23,803	26,284	3.7	2.5	2.2	2.1	2.0	2.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	408	463	472	495	508	1.2	2.5	0.4	0.9	0.5	1.1
TPE per GDP	toe/mil. PHP	27.0	24.0	24.1	22.0	20.8	19.3	-2.3	0.0	-1.8	-1.1	-1.4	-1.3
Electricity per capita	kWh/person	530	579	648	716	780	843	1.8	2.3	2.0	1.7	1.6	1.9
Passenger Cars	1,000 units	788	837	988	1,145	1,306	1,469	1.2	3.4	3.0	2.7	2.4	2.5
Utility Vehicles	1,000 units	1,792	2,338	2,943	3,468	3,868	4,119	5.5	4.7	3.3	2.2	1.3	3.4
Trucks	1,000 units	267	346	405	455	494	521	5.3	3.2	2.4	1.6	1.1	2.7
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,442	4,654	5,715	6,490	6,936	9.8	6.2	4.2	2.6	1.3	4.8
CO2 Emission	CO_2-kton	64,453	77,330	88,330	96,350	108,910	119,880	3.7	2.7	1.8	2.5	1.9	2.5
Total Primary Energy Supply	*ktoe*	*38,498*	*43,827*	*52,443*	*56,889*	*62,679*	*67,399*	*2.6*	*3.7*	*1.6*	*2.0*	*1.5*	*2.3*
Coal	ktoe	5,190	7,336	8,578	8,360	10,283	12,142	7.2	3.2	-0.5	4.2	3.4	3.5
Natural Gas	ktoe	2,504	2,424	2,368	3,715	3,739	3,783	-0.6	-0.5	9.4	0.1	0.2	1.7
Oil	ktoe	14,430	15,926	18,258	20,535	22,450	23,928	2.0	2.8	2.4	1.8	1.3	2.0
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	302	580	667	733	778	149.2	13.9	2.8	1.9	1.2	24.7
Commercial Energy	ktoe	32,731	37,977	46,753	51,368	57,323	62,174	3.0	4.2	1.9	2.2	1.6	2.6
Non-commercial Energy	*ktoe*	*5,766*	*5,850*	*5,690*	*5,520*	*5,356*	*5,224*	*0.3*	*-0.6*	*-0.6*	*-0.6*	*-0.5*	*-0.4*
Coal	%	13.5	16.7	16.4	14.7	16.4	18.0						
Natural Gas	%	6.5	5.5	4.5	6.5	6.0	5.6						
Oil	%	37.5	36.3	34.8	36.1	35.8	35.5						
Others	%	27.6	28.0	33.5	33.0	33.3	33.1						
Non-commercial Energy	%	15.0	13.3	10.9	9.7	8.5	7.8						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,085*	*24,903*	*28,552*	*31,872*	*34,820*	*3.9*	*3.4*	*2.8*	*2.2*	*1.8*	*2.8*
Agriculture	ktoe	313	247	273	297	320	340	-4.6	2.0	1.7	1.4	1.2	0.3
Industry	ktoe	4,084	4,414	5,160	5,945	6,768	7,626	1.6	3.2	2.9	2.6	2.4	2.5
Energy Intensive	ktoe	2,653	3,015	3,497	4,010	4,554	5,126	2.6	3.0	2.8	2.6	2.4	2.7
Other	ktoe	1,430	1,400	1,663	1,935	2,214	2,500	-0.4	3.5	3.1	2.7	2.5	2.3
Commercial	ktoe	1,660	2,097	2,558	3,040	3,540	4,062	4.8	4.1	3.5	3.1	2.8	3.6
Residential	ktoe	2,405	2,695	3,359	4,077	4,807	5,503	2.3	4.5	4.0	3.3	2.7	3.4
Transport	ktoe	8,940	11,631	13,553	15,192	16,438	17,289	5.4	3.1	2.3	1.6	1.0	2.7
Energy Net Import	*ktoe*	*18,112*	*21,029*	*24,240*	*26,924*	*31,302*	*34,961*	*3.0*	*2.9*	*2.1*	*3.1*	*2.2*	*2.7*
Coal	ktoe	3,710	5,139	6,019	5,629	7,058	8,405	6.7	3.2	-1.3	4.6	3.6	3.3
Natural Gas	ktoe	0	0	0	797	1,831	2,665				18.1	7.8	
Oil	ktoe	14,402	15,890	18,222	20,498	22,414	23,891	2.0	2.8	2.4	1.8	1.3	2.0
Energy Import Ratio	*%*	*55.3*	*55.4*	*51.8*	*52.4*	*54.6*	*56.2*						
Coal	%	71.5	70.0	70.2	67.3	68.6	69.2						
Natural Gas	%	0.0	0.0	0.0	21.5	49.0	70.4						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.8						

1.5 High Price Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	39.5	45.2	50.8	56.5	13.7	3.1	2.7	2.4	2.1	4.7
Coal	Peso / kg	2.0	3.2	3.9	4.6	5.4	6.2	9.9	4.0	3.5	3.1	2.6	4.6
Natural Gas	Peso / mmBtu	347	642	749	856	963	1,070	13.1	3.1	2.7	2.4	2.1	4.6
LPG	Peso / litter	19.1	30.8	37.0	43.1	49.3	55.4	10.0	3.7	3.1	2.7	2.4	4.4
Gasoline	Peso / litter	30.7	53.1	61.8	71.0	80.7	91.2	11.6	3.1	2.8	2.6	2.5	4.4
Kerosene	Peso / litter	29.5	52.8	61.4	70.5	80.2	90.5	12.3	3.1	2.8	2.6	2.5	4.6
Jet Fuel	Peso / litter	32.6	59.6	69.3	79.7	90.9	102.9	12.8	3.1	2.8	2.7	2.5	4.7
Diesel	Peso / litter	28.8	50.4	58.7	67.4	76.5	86.3	11.8	3.1	2.8	2.6	2.4	4.5
Fuel Oil	Peso / litter	18.9	38.2	44.5	51.0	57.5	64.2	15.1	3.1	2.7	2.5	2.2	5.0
Electricity (Average)	Peso / kWh	6.8	12.0	13.9	15.8	17.8	19.7	12.0	3.0	2.6	2.3	2.1	4.3
Energy Indicators													
TPE per capita	kgoe/person	384	418	488	523	559	584	1.7	3.2	1.4	1.3	0.9	1.7
TPE per GDP	toe/mil. PHP	27.0	23.6	22.7	20.5	19.0	17.5	-2.7	-0.8	-2.0	-1.5	-1.6	-1.7
Electricity per capita	kWh/person	530	602	711	820	924	1,019	2.6	3.4	2.9	2.4	2.0	2.7
Passenger Cars	1,000 units	788	862	1,078	1,308	1,542	1,769	1.8	4.6	3.9	3.4	2.8	3.3
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	94,940	115,700	134,780	152,960	4.3	3.6	4.0	3.1	2.6	3.5
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,207*	*62,719*	*70,648*	*77,383*	*3.1*	*4.3*	*2.6*	*2.4*	*1.8*	*2.8*
Coal	ktoe	5,190	7,373	8,684	11,684	14,539	17,913	7.3	3.3	6.1	4.5	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,509	3,716	4,103	4,007	2.2	4.6	1.2	2.0	-0.5	1.9
Oil	ktoe	14,430	16,400	19,559	22,652	25,225	27,162	2.6	3.6	3.0	2.2	1.5	2.6
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	312	625	738	823	878	150.9	14.9	3.4	2.2	1.3	25.3
Commercial Energy	ktoe	32,731	38,871	49,347	56,881	64,809	71,503	3.5	4.9	2.9	2.6	2.0	3.2
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,860*	*5,837*	*5,839*	*5,880*	*0.5*	*-0.1*	*-0.1*	*0.0*	*0.1*	*0.1*
Coal	%	13.5	16.5	15.7	18.6	20.6	23.1						
Natural Gas	%	6.5	6.2	6.4	5.9	5.8	5.2						
Oil	%	37.5	36.6	35.4	36.1	35.7	35.1						
Others	%	27.6	27.5	31.9	30.0	29.6	29.0						
Non-commercial Energy	%	15.0	13.2	10.6	9.3	8.3	7.6						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*26,901*	*31,888*	*36,413*	*40,287*	*4.6*	*4.3*	*3.5*	*2.7*	*2.0*	*3.4*
Agriculture	ktoe	313	254	289	322	351	374	-4.0	2.6	2.2	1.7	1.3	0.7
Industry	ktoe	4,084	4,551	5,548	6,588	7,644	8,676	2.2	4.0	3.5	3.0	2.6	3.1
Energy Intensive	ktoe	2,653	3,071	3,646	4,251	4,863	5,463	3.0	3.5	3.1	2.7	2.4	2.9
Other	ktoe	1,430	1,480	1,902	2,337	2,781	3,214	0.7	5.2	4.2	3.5	2.9	3.3
Commercial	ktoe	1,660	2,187	2,856	3,589	4,349	5,104	5.7	5.5	4.7	3.9	3.3	4.6
Residential	ktoe	2,405	2,763	3,531	4,380	5,254	6,095	2.8	5.0	4.4	3.7	3.0	3.8
Transport	ktoe	8,940	12,032	14,676	17,009	18,815	20,038	6.1	4.1	3.0	2.0	1.3	3.3
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,541*	*31,744*	*37,899*	*43,158*	*3.5*	*3.5*	*4.4*	*3.6*	*2.6*	*3.5*
Coal	ktoe	3,710	5,139	6,019	8,331	10,515	13,143	6.7	3.2	6.7	4.8	4.6	5.2
Natural Gas	ktoe	0	0	0	797	2,196	2,890				22.5	5.6	
Oil	ktoe	14,402	16,363	19,523	22,615	25,188	27,125	2.6	3.6	3.0	2.2	1.5	2.6
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*55.8*	*58.5*	*60.4*						
Coal	%	71.5	69.7	69.3	71.3	72.3	73.4						
Natural Gas	%	0.0	0.0	0.0	21.5	53.5	72.1						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.6 Low Price Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	33.9	33.9	33.9	33.9	13.7	0.0	0.0	0.0	0.0	2.6
Coal	Peso / kg	2.0	3.2	3.3	3.5	3.6	3.7	9.9	0.8	0.8	0.7	0.5	2.5
Natural Gas	Peso / mmBtu	347	642	642	642	642	642	13.1	0.0	0.0	0.0	0.0	2.5
LPG	Peso / litter	19.1	30.8	30.8	30.8	30.8	30.8	10.0	0.0	0.0	0.0	0.0	1.9
Gasoline	Peso / litter	30.7	53.1	56.1	59.7	63.8	68.6	11.6	1.1	1.2	1.3	1.5	3.3
Kerosene	Peso / litter	29.5	52.8	55.8	59.2	63.3	68.0	12.3	1.1	1.2	1.3	1.4	3.4
Jet Fuel	Peso / litter	32.6	59.6	63.7	68.4	73.9	80.3	12.8	1.3	1.4	1.6	1.7	3.7
Diesel	Peso / litter	28.8	50.4	53.0	56.1	59.6	63.7	11.8	1.0	1.1	1.2	1.3	3.2
Fuel Oil	Peso / litter	18.9	38.2	38.9	39.7	40.6	41.7	15.1	0.4	0.4	0.5	0.5	3.2
Electricity (Average)	Peso / kWh	6.8	12.0	12.1	12.2	12.3	12.4	12.0	0.1	0.2	0.2	0.2	2.4
Energy Indicators													
TPE per capita	kgoe/person	384	417	493	535	576	606	1.7	3.4	1.7	1.5	1.0	1.8
TPE per GDP	toe/mil. PHP	27.0	23.5	22.9	21.0	19.5	18.2	-2.7	-0.6	-1.7	-1.4	-1.4	-1.6
Electricity per capita	kWh/person	530	600	719	839	956	1,064	2.5	3.7	3.1	2.6	2.2	2.8
Passenger Cars	1,000 units	788	862	1,111	1,389	1,679	1,964	1.8	5.2	4.6	3.9	3.2	3.7
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,380	96,180	119,820	140,630	160,740	4.3	3.9	4.5	3.3	2.7	3.7
Total Primary Energy Supply	*ktoe*	*38,498*	*44,681*	*55,627*	*63,896*	*72,402*	*79,837*	*3.0*	*4.5*	*2.8*	*2.5*	*2.0*	*3.0*
Coal	ktoe	5,190	7,368	8,703	12,238	15,164	18,567	7.3	3.4	7.1	4.4	4.1	5.2
Natural Gas	ktoe	2,504	2,767	3,608	3,772	4,331	4,590	2.0	5.5	0.9	2.8	1.2	2.5
Oil	ktoe	14,430	16,340	19,887	23,281	26,235	28,541	2.5	4.0	3.2	2.4	1.7	2.8
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	311	634	759	856	922	150.8	15.3	3.7	2.4	1.5	25.5
Commercial Energy	ktoe	32,731	38,775	49,800	58,142	66,705	74,164	3.4	5.1	3.1	2.8	2.1	3.3
Non-commercial Energy	*ktoe*	*5,766*	*5,906*	*5,826*	*5,755*	*5,697*	*5,673*	*0.5*	*-0.3*	*-0.2*	*-0.2*	*-0.1*	*-0.1*
Coal	%	13.5	16.5	15.6	19.2	20.9	23.3						
Natural Gas	%	6.5	6.2	6.5	5.9	6.0	5.7						
Oil	%	37.5	36.6	35.8	36.4	36.2	35.7						
Others	%	27.6	27.5	31.6	29.5	29.0	28.1						
Non-commercial Energy	%	15.0	13.2	10.5	9.0	7.9	7.1						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,706*	*27,249*	*32,768*	*37,866*	*42,317*	*4.5*	*4.7*	*3.8*	*2.9*	*2.2*	*3.6*
Agriculture	ktoe	313	253	303	353	400	441	-4.1	3.7	3.1	2.5	2.0	1.4
Industry	ktoe	4,084	4,535	5,616	6,756	7,929	9,088	2.1	4.4	3.8	3.3	2.8	3.3
Energy Intensive	ktoe	2,653	3,060	3,693	4,365	5,054	5,737	2.9	3.8	3.4	3.0	2.6	3.1
Other	ktoe	1,430	1,475	1,923	2,391	2,875	3,351	0.6	5.5	4.5	3.8	3.1	3.5
Commercial	ktoe	1,660	2,180	2,892	3,682	4,512	5,349	5.6	5.8	4.9	4.2	3.5	4.8
Residential	ktoe	2,405	2,756	3,573	4,485	5,435	6,361	2.8	5.3	4.7	3.9	3.2	4.0
Transport	ktoe	8,940	11,983	14,866	17,492	19,590	21,078	6.0	4.4	3.3	2.3	1.5	3.5
Energy Net Import	*ktoe*	*18,112*	*21,442*	*25,869*	*32,865*	*39,606*	*45,584*	*3.4*	*3.8*	*4.9*	*3.8*	*2.9*	*3.8*
Coal	ktoe	3,710	5,139	6,019	8,766	10,982	13,604	6.7	3.2	7.8	4.6	4.4	5.3
Natural Gas	ktoe	0	0	0	854	2,426	3,475				23.2	7.5	
Oil	ktoe	14,402	16,303	19,850	23,244	26,199	28,504	2.5	4.0	3.2	2.4	1.7	2.8
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.9*	*56.5*	*59.4*	*61.5*						
Coal	%	71.5	69.7	69.2	71.6	72.4	73.3						
Natural Gas	%	0.0	0.0	0.0	22.6	56.0	75.7						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.7 Super High Price Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	39.5	46.6	53.6	60.7	67.8	17.2	3.3	2.9	2.5	2.2	5.5
Coal	Peso / kg	2.0	3.7	4.6	5.5	6.5	7.4	13.4	4.2	3.7	3.3	2.7	5.4
Natural Gas	Peso / mmBtu	347	749	883	1,017	1,150	1,284	16.6	3.3	2.9	2.5	2.2	5.4
LPG	Peso / litter	19.1	37.0	44.7	52.4	60.1	67.8	14.1	3.9	3.2	2.8	2.4	5.2
Gasoline	Peso / litter	30.7	58.7	68.9	79.5	90.6	102.5	13.9	3.2	2.9	2.7	2.5	4.9
Kerosene	Peso / litter	29.5	58.4	68.5	79.0	90.1	101.8	14.6	3.2	2.9	2.7	2.5	5.1
Jet Fuel	Peso / litter	32.6	65.2	76.4	88.2	100.8	114.2	14.9	3.2	2.9	2.7	2.5	5.1
Diesel	Peso / litter	28.8	56.0	65.7	75.8	86.4	97.6	14.2	3.2	2.9	2.6	2.5	5.0
Fuel Oil	Peso / litter	18.9	43.8	51.6	59.4	67.4	75.5	18.3	3.3	2.9	2.6	2.3	5.7
Electricity (Average)	Peso / kWh	6.8	13.8	16.2	18.6	21.0	23.3	15.3	3.2	2.8	2.4	2.1	5.0
Energy Indicators													
TPE per capita	kgoe/person	384	413	482	514	551	574	1.5	3.1	1.3	1.4	0.8	1.6
TPE per GDP	toe/mil. PHP	27.0	23.3	22.4	20.2	18.7	17.2	-2.9	-0.8	-2.0	-1.5	-1.6	-1.8
Electricity per capita	kWh/person	530	592	699	805	907	1,001	2.3	3.4	2.9	2.4	2.0	2.6
Passenger Cars	1,000 units	788	840	1,036	1,254	1,477	1,693	1.3	4.3	3.9	3.3	2.8	3.1
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	78,440	93,220	112,440	132,230	149,320	4.0	3.5	3.8	3.3	2.5	3.4
Total Primary Energy Supply	*ktoe*	*38,498*	*44,348*	*54,592*	*61,806*	*69,741*	*76,258*	*2.9*	*4.2*	*2.5*	*2.4*	*1.8*	*2.8*
Coal	ktoe	5,190	7,349	8,654	11,212	14,494	17,557	7.2	3.3	5.3	5.3	3.9	5.0
Natural Gas	ktoe	2,504	2,637	3,290	3,715	3,739	3,783	1.0	4.5	2.5	0.1	0.2	1.7
Oil	ktoe	14,430	16,129	19,160	22,167	24,672	26,551	2.3	3.5	3.0	2.2	1.5	2.5
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	308	613	723	806	859	150.2	14.8	3.4	2.2	1.3	25.2
Commercial Energy	ktoe	32,731	38,412	48,686	55,909	63,830	70,294	3.3	4.9	2.8	2.7	1.9	3.1
Non-commercial Energy	*ktoe*	*5,766*	*5,936*	*5,906*	*5,897*	*5,911*	*5,964*	*0.6*	*-0.1*	*-0.0*	*0.1*	*0.2*	*0.1*
Coal	%	13.5	16.6	15.9	18.1	20.8	23.0						
Natural Gas	%	6.5	5.9	6.0	6.0	5.4	5.0						
Oil	%	37.5	36.4	35.1	35.9	35.4	34.8						
Others	%	27.6	27.7	32.2	30.4	30.0	29.4						
Non-commercial Energy	%	15.0	13.4	10.8	9.5	8.5	7.8						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,409*	*26,354*	*31,216*	*35,628*	*39,403*	*4.2*	*4.2*	*3.4*	*2.7*	*2.0*	*3.3*
Agriculture	ktoe	313	243	273	304	331	353	-4.9	2.4	2.2	1.7	1.3	0.5
Industry	ktoe	4,084	4,469	5,444	6,460	7,493	8,501	1.8	4.0	3.5	3.0	2.6	3.0
Energy Intensive	ktoe	2,653	3,013	3,573	4,163	4,760	5,345	2.6	3.5	3.1	2.7	2.3	2.8
Other	ktoe	1,430	1,457	1,871	2,297	2,733	3,156	0.4	5.1	4.2	3.5	2.9	3.2
Commercial	ktoe	1,660	2,149	2,805	3,522	4,266	5,005	5.3	5.5	4.7	3.9	3.2	4.5
Residential	ktoe	2,405	2,719	3,472	4,304	5,161	5,986	2.5	5.0	4.4	3.7	3.0	3.7
Transport	ktoe	8,940	11,829	14,359	16,626	18,378	19,559	5.8	4.0	3.0	2.0	1.3	3.2
Energy Net Import	*ktoe*	*18,112*	*21,231*	*25,142*	*30,886*	*36,980*	*42,061*	*3.2*	*3.4*	*4.2*	*3.7*	*2.6*	*3.4*
Coal	ktoe	3,710	5,139	6,019	7,959	10,514	12,883	6.7	3.2	5.7	5.7	4.1	5.1
Natural Gas	ktoe	0	0	0	797	1,831	2,664				18.1	7.8	
Oil	ktoe	14,402	16,092	19,123	22,130	24,635	26,514	2.2	3.5	3.0	2.2	1.5	2.5
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.6*	*55.2*	*57.9*	*59.8*						
Coal	%	71.5	69.9	69.5	71.0	72.5	73.4						
Natural Gas	%	0.0	0.0	0.0	21.5	49.0	70.4						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.8 Energy Efficiency and Conservation Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	414	478	501	527	539	1.5	2.9	0.9	1.0	0.5	1.4
TPE per GDP	toe/mil. PHP	27.0	23.4	22.2	19.6	17.9	16.2	-2.9	-1.0	-2.4	-1.8	-2.0	-2.0
Electricity per capita	kWh/person	530	593	688	777	858	927	2.3	3.0	2.5	2.0	1.6	2.3
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	78,600	92,220	107,300	122,660	134,400	4.0	3.2	3.1	2.7	1.8	3.0
Total Primary Energy Supply	*ktoe*	*38,498*	*44,403*	*54,226*	*60,436*	*67,206*	*72,316*	*2.9*	*4.1*	*2.2*	*2.1*	*1.5*	*2.6*
Coal	ktoe	5,190	7,352	8,630	10,303	12,818	14,928	7.2	3.3	3.6	4.5	3.1	4.3
Natural Gas	ktoe	2,504	2,650	3,085	3,714	3,735	3,775	1.1	3.1	3.8	0.1	0.2	1.7
Oil	ktoe	14,430	16,170	18,984	21,607	23,628	24,946	2.3	3.3	2.6	1.8	1.1	2.2
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	308	607	705	773	812	150.2	14.5	3.0	1.9	1.0	24.9
Commercial Energy	ktoe	32,731	38,469	48,275	54,421	61,074	66,004	3.3	4.6	2.4	2.3	1.6	2.8
Non-commercial Energy	*ktoe*	*5,766*	*5,934*	*5,952*	*6,015*	*6,131*	*6,312*	*0.6*	*0.1*	*0.2*	*0.4*	*0.6*	*0.4*
Coal	%	13.5	16.6	15.9	17.0	19.1	20.6						
Natural Gas	%	6.5	6.0	5.7	6.1	5.6	5.2						
Oil	%	37.5	36.4	35.0	35.8	35.2	34.5						
Others	%	27.6	27.7	32.4	31.1	31.1	30.9						
Non-commercial Energy	%	15.0	13.4	11.0	10.0	9.1	8.7						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,460*	*26,049*	*30,312*	*33,930*	*36,759*	*4.3*	*4.0*	*3.1*	*2.3*	*1.6*	*3.0*
Agriculture	ktoe	313	251	285	316	340	358	-4.3	2.6	2.1	1.5	1.0	0.5
Industry	ktoe	4,084	4,482	5,369	6,254	7,110	7,900	1.9	3.7	3.1	2.6	2.1	2.7
Energy Intensive	ktoe	2,653	3,025	3,529	4,038	4,527	4,979	2.7	3.1	2.7	2.3	1.9	2.5
Other	ktoe	1,430	1,458	1,840	2,216	2,583	2,920	0.4	4.8	3.8	3.1	2.5	2.9
Commercial	ktoe	1,660	2,154	2,764	3,407	4,045	4,647	5.3	5.1	4.3	3.5	2.8	4.2
Residential	ktoe	2,405	2,721	3,415	4,153	4,879	5,538	2.5	4.6	4.0	3.3	2.6	3.4
Transport	ktoe	8,940	11,852	14,216	16,182	17,555	18,315	5.8	3.7	2.6	1.6	0.9	2.9
Energy Net Import	*ktoe*	*18,112*	*21,273*	*24,966*	*29,599*	*34,595*	*38,349*	*3.3*	*3.3*	*3.5*	*3.2*	*2.1*	*3.0*
Coal	ktoe	3,710	5,139	6,019	7,233	9,176	10,783	6.7	3.2	3.7	4.9	3.3	4.4
Natural Gas	ktoe	0	0	0	796	1,827	2,656				18.1	7.8	
Oil	ktoe	14,402	16,134	18,947	21,570	23,592	24,910	2.3	3.3	2.6	1.8	1.1	2.2
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.7*	*54.4*	*56.6*	*58.1*						
Coal	%	71.5	69.9	69.7	70.2	71.6	72.2						
Natural Gas	%	0.0	0.0	0.0	21.4	48.9	70.4						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.9						

1.9 Super Energy Efficiency and Conservation Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	409	465	473	488	489	1.3	2.6	0.4	0.6	0.0	1.0
TPE per GDP	toe/mil. PHP	27.0	23.1	21.6	18.6	16.6	14.7	-3.1	-1.4	-3.0	-2.3	-2.4	-2.4
Electricity per capita	kWh/person	530	584	660	728	783	825	2.0	2.5	2.0	1.5	1.0	1.8
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	77,570	88,920	97,210	107,010	113,090	3.8	2.8	1.8	1.9	1.1	2.3
Total Primary Energy Supply	*ktoe*	*38,498*	*44,038*	*53,040*	*57,678*	*62,969*	*66,585*	*2.7*	*3.8*	*1.7*	*1.8*	*1.1*	*2.2*
Coal	ktoe	5,190	7,331	8,566	8,686	10,261	11,403	7.2	3.2	0.3	3.4	2.1	3.2
Natural Gas	ktoe	2,504	2,503	2,588	3,712	3,731	3,765	-0.0	0.7	7.5	0.1	0.2	1.6
Oil	ktoe	14,430	15,944	18,274	20,301	21,683	22,356	2.0	2.8	2.1	1.3	0.6	1.8
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	304	584	664	713	734	149.5	14.0	2.6	1.4	0.6	24.4
Commercial Energy	ktoe	32,731	38,070	46,981	51,456	56,507	59,801	3.1	4.3	1.8	1.9	1.1	2.4
Non-commercial Energy	*ktoe*	*5,766*	*5,967*	*6,059*	*6,223*	*6,463*	*6,784*	*0.7*	*0.3*	*0.5*	*0.8*	*1.0*	*0.7*
Coal	%	13.5	16.6	16.1	15.1	16.3	17.1						
Natural Gas	%	6.5	5.7	4.9	6.4	5.9	5.7						
Oil	%	37.5	36.2	34.5	35.2	34.4	33.6						
Others	%	27.6	27.9	33.1	32.5	33.1	33.5						
Non-commercial Energy	%	15.0	13.6	11.4	10.8	10.3	10.2						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,137*	*25,016*	*28,382*	*30,975*	*32,720*	*4.0*	*3.4*	*2.6*	*1.8*	*1.1*	*2.6*
Agriculture	ktoe	313	247	274	295	311	319	-4.6	2.1	1.6	1.0	0.5	0.1
Industry	ktoe	4,084	4,415	5,156	5,855	6,491	7,031	1.6	3.2	2.6	2.1	1.6	2.2
Energy Intensive	ktoe	2,653	2,979	3,389	3,781	4,133	4,432	2.3	2.6	2.2	1.8	1.4	2.1
Other	ktoe	1,430	1,436	1,767	2,075	2,358	2,599	0.1	4.2	3.3	2.6	2.0	2.4
Commercial	ktoe	1,660	2,122	2,655	3,190	3,693	4,137	5.0	4.6	3.7	3.0	2.3	3.7
Residential	ktoe	2,405	2,680	3,280	3,888	4,454	4,930	2.2	4.1	3.5	2.8	2.1	2.9
Transport	ktoe	8,940	11,673	13,652	15,153	16,027	16,304	5.5	3.2	2.1	1.1	0.3	2.4
Energy Net Import	*ktoe*	*18,112*	*21,046*	*24,256*	*27,007*	*30,610*	*32,947*	*3.0*	*2.9*	*2.2*	*2.5*	*1.5*	*2.4*
Coal	ktoe	3,710	5,139	6,019	5,948	7,141	7,981	6.7	3.2	-0.2	3.7	2.3	3.1
Natural Gas	ktoe	0	0	0	794	1,823	2,646				18.1	7.7	
Oil	ktoe	14,402	15,907	18,238	20,265	21,646	22,320	2.0	2.8	2.1	1.3	0.6	1.8
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.6*	*52.5*	*54.2*	*55.1*						
Coal	%	71.5	70.1	70.3	68.5	69.6	70.0						
Natural Gas	%	0.0	0.0	0.0	21.4	48.9	70.3						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.8						

1.10 E20 and CNG Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	529	567	595	1.7	3.3	1.5	1.4	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.8	19.3	17.8	-2.7	-0.7	-1.8	-1.5	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,460	93,350	114,490	131,970	149,420	4.3	3.3	4.2	2.9	2.5	3.4
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,367*	*71,499*	*78,546*	*3.1*	*4.4*	*2.7*	*2.4*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	12,021	14,579	17,968	7.3	3.4	6.7	3.9	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,600	3,716	4,448	4,509	2.2	5.2	0.6	3.7	0.3	2.4
Oil	ktoe	14,430	16,343	18,951	21,824	24,032	25,614	2.5	3.0	2.9	1.9	1.3	2.3
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	370	1,398	1,919	2,549	3,126	159.5	30.5	6.5	5.8	4.2	31.8
Commercial Energy	ktoe	32,731	38,871	49,614	57,572	65,727	72,761	3.5	5.0	3.0	2.7	2.1	3.2
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,841*	*5,796*	*5,771*	*5,785*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	19.0	20.4	22.9						
Natural Gas	%	6.5	6.2	6.5	5.9	6.2	5.7						
Oil	%	37.5	36.5	34.2	34.4	33.6	32.6						
Others	%	27.6	27.6	33.1	31.6	31.7	31.4						
Non-commercial Energy	%	15.0	13.2	10.5	9.1	8.1	7.4						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,149*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,445*	*24,933*	*31,184*	*37,053*	*42,115*	*3.4*	*3.1*	*4.6*	*3.5*	*2.6*	*3.4*
Coal	ktoe	3,710	5,139	6,019	8,599	10,515	13,143	6.7	3.2	7.4	4.1	4.6	5.2
Natural Gas	ktoe	0	0	0	798	2,544	3,394				26.1	5.9	
Oil	ktoe	14,402	16,306	18,915	21,787	23,995	25,578	2.5	3.0	2.9	1.9	1.3	2.3
Energy Import Ratio	*%*	*55.3*	*55.2*	*50.3*	*54.2*	*56.4*	*57.9*						
Coal	%	71.5	69.7	69.2	71.5	72.1	73.1						
Natural Gas	%	0.0	0.0	0.0	21.5	57.2	75.3						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.9						

1.11 E85 and CNG Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	529	567	595	1.7	3.3	1.5	1.4	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.8	19.3	17.8	-2.7	-0.7	-1.8	-1.5	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,460	93,350	114,490	126,420	137,680	4.3	3.3	4.2	2.0	1.7	3.1
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,367*	*71,502*	*78,553*	*3.1*	*4.4*	*2.7*	*2.4*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	12,021	14,579	17,968	7.3	3.4	6.7	3.9	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,600	3,716	4,448	4,509	2.2	5.2	0.6	3.7	0.3	2.4
Oil	ktoe	14,430	16,343	18,951	21,824	22,120	21,569	2.5	3.0	2.9	0.3	-0.5	1.6
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	370	1,398	1,919	4,461	7,171	159.5	30.5	6.5	18.4	10.0	36.3
Commercial Energy	ktoe	32,731	38,871	49,614	57,572	65,728	72,762	3.5	5.0	3.0	2.7	2.1	3.2
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,841*	*5,796*	*5,775*	*5,792*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.1*	*0.0*
Coal	%	13.5	16.5	15.7	19.0	20.4	22.9						
Natural Gas	%	6.5	6.2	6.5	5.9	6.2	5.7						
Oil	%	37.5	36.5	34.2	34.4	30.9	27.5						
Others	%	27.6	27.6	33.1	31.6	34.4	36.6						
Non-commercial Energy	%	15.0	13.2	10.5	9.1	8.1	7.4						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,149*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,871	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,592	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,445*	*24,933*	*31,184*	*35,142*	*38,070*	*3.4*	*3.1*	*4.6*	*2.4*	*1.6*	*3.0*
Coal	ktoe	3,710	5,139	6,019	8,599	10,515	13,143	6.7	3.2	7.4	4.1	4.6	5.2
Natural Gas	ktoe	0	0	0	798	2,544	3,394				26.1	5.9	
Oil	ktoe	14,402	16,306	18,915	21,787	22,083	21,533	2.5	3.0	2.9	0.3	-0.5	1.6
Energy Import Ratio	*%*	*55.3*	*55.2*	*50.3*	*54.2*	*53.5*	*52.3*						
Coal	%	71.5	69.7	69.2	71.5	72.1	73.1						
Natural Gas	%	0.0	0.0	0.0	21.5	57.2	75.3						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.8						

1.12 Vehicle Plus Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	421	497	539	580	609	1.8	3.4	1.6	1.5	1.0	1.9
TPE per GDP	toe/mil. PHP	27.0	23.7	23.1	21.2	19.7	18.3	-2.6	-0.6	-1.7	-1.4	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,496	3,411	4,255	4,923	5,362	6.9	6.4	4.5	3.0	1.7	4.5
Trucks	1,000 units	267	368	462	548	619	671	6.6	4.7	3.5	2.5	1.6	3.8
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,800	5,699	7,555	9,049	10,015	12.0	8.4	5.8	3.7	2.0	6.3
CO2 Emission	CO_2-kton	64,453	80,340	97,430	121,060	141,390	161,390	4.5	3.9	4.4	3.2	2.7	3.7
Total Primary Energy Supply	*ktoe*	*38,498*	*45,011*	*56,076*	*64,425*	*72,969*	*80,347*	*3.2*	*4.5*	*2.8*	*2.5*	*1.9*	*3.0*
Coal	ktoe	5,190	7,373	8,696	12,021	14,579	17,968	7.3	3.4	6.7	3.9	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,600	3,716	4,449	4,511	2.2	5.2	0.6	3.7	0.3	2.4
Oil	ktoe	14,430	16,632	20,309	23,997	27,137	29,550	2.9	4.1	3.4	2.5	1.7	2.9
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	320	662	803	915	992	152.1	15.7	3.9	2.6	1.6	25.9
Commercial Energy	ktoe	32,731	39,110	50,236	58,630	67,199	74,564	3.6	5.1	3.1	2.8	2.1	3.3
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.4	15.5	18.7	20.0	22.4						
Natural Gas	%	6.5	6.2	6.4	5.8	6.1	5.6						
Oil	%	37.5	37.0	36.2	37.2	37.2	36.8						
Others	%	27.6	27.3	31.4	29.3	28.8	28.0						
Non-commercial Energy	%	15.0	13.1	10.4	9.0	7.9	7.2						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*22,026*	*27,742*	*33,421*	*38,621*	*43,076*	*4.8*	*4.7*	*3.8*	*2.9*	*2.2*	*3.7*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,272	15,422	18,335	20,692	22,367	6.5	4.7	3.5	2.4	1.6	3.7
Energy Net Import	*ktoe*	*18,112*	*21,734*	*26,291*	*33,358*	*40,159*	*46,052*	*3.7*	*3.9*	*4.9*	*3.8*	*2.8*	*3.8*
Coal	ktoe	3,710	5,139	6,019	8,599	10,515	13,143	6.7	3.2	7.4	4.1	4.6	5.2
Natural Gas	ktoe	0	0	0	798	2,545	3,396				26.1	5.9	
Oil	ktoe	14,402	16,595	20,272	23,961	27,100	29,513	2.9	4.1	3.4	2.5	1.7	2.9
Energy Import Ratio	*%*	*55.3*	*55.6*	*52.3*	*56.9*	*59.8*	*61.8*						
Coal	%	71.5	69.7	69.2	71.5	72.1	73.1						
Natural Gas	%	0.0	0.0	0.0	21.5	57.2	75.3						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.13 Nuclear and LNG Free Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	529	572	599	1.7	3.3	1.5	1.6	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.8	19.4	18.0	-2.7	-0.7	-1.8	-1.3	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	95,640	118,020	133,270	152,290	4.3	3.7	4.3	2.5	2.7	3.5
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,366*	*72,074*	*79,110*	*3.1*	*4.4*	*2.7*	*2.6*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	12,021	14,038	17,431	7.3	3.4	6.7	3.2	4.4	5.0
Natural Gas	ktoe	2,504	2,797	3,600	3,716	3,740	3,786	2.2	5.2	0.6	0.1	0.2	1.7
Oil	ktoe	14,430	16,400	19,718	22,993	25,741	27,841	2.6	3.8	3.1	2.3	1.6	2.7
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	1,826	1,826					0.0	
Renewables	ktoe	3	312	630	749	839	899	150.9	15.1	3.5	2.3	1.4	25.4
Commercial Energy	ktoe	32,731	38,871	49,614	57,571	66,304	73,327	3.5	5.0	3.0	2.9	2.0	3.3
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	19.0	19.5	22.0						
Natural Gas	%	6.5	6.2	6.5	5.9	5.2	4.8						
Oil	%	37.5	36.6	35.6	36.3	35.7	35.2						
Others	%	27.6	27.5	31.7	29.7	31.6	30.7						
Non-commercial Energy	%	15.0	13.2	10.5	9.1	8.0	7.3						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,148*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,700*	*32,353*	*37,587*	*43,153*	*3.5*	*3.6*	*4.7*	*3.0*	*2.8*	*3.5*
Coal	ktoe	3,710	5,139	6,019	8,599	10,050	12,682	6.7	3.2	7.4	3.2	4.8	5.0
Natural Gas	ktoe	0	0	0	798	1,832	2,667				18.1	7.8	
Oil	ktoe	14,402	16,363	19,682	22,957	25,705	27,804	2.6	3.8	3.1	2.3	1.6	2.7
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*56.2*	*56.7*	*58.9*						
Coal	%	71.5	69.7	69.2	71.5	71.6	72.8						
Natural Gas	%	0.0	0.0	0.0	21.5	49.0	70.4						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.14 Nuclear and LNG Fix Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	529	569	597	1.7	3.3	1.5	1.5	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.7	19.3	17.9	-2.7	-0.7	-1.9	-1.4	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	95,640	117,520	130,420	149,500	4.3	3.7	4.2	2.1	2.8	3.4
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,279*	*71,721*	*78,787*	*3.1*	*4.4*	*2.7*	*2.5*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	11,857	12,896	16,278	7.3	3.4	6.4	1.7	4.8	4.7
Natural Gas	ktoe	2,504	2,797	3,600	3,793	4,529	4,615	2.2	5.2	1.0	3.6	0.4	2.5
Oil	ktoe	14,430	16,400	19,718	22,993	25,741	27,841	2.6	3.8	3.1	2.3	1.6	2.7
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	1,826	1,826					0.0	
Renewables	ktoe	3	312	630	749	839	899	150.9	15.1	3.5	2.3	1.4	25.4
Commercial Energy	ktoe	32,731	38,871	49,614	57,485	65,951	73,003	3.5	5.0	3.0	2.8	2.1	3.3
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	18.7	18.0	20.7						
Natural Gas	%	6.5	6.2	6.5	6.0	6.3	5.9						
Oil	%	37.5	36.6	35.6	36.3	35.9	35.3						
Others	%	27.6	27.5	31.7	29.8	31.8	30.8						
Non-commercial Energy	%	15.0	13.2	10.5	9.2	8.0	7.3						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,148*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,700*	*32,290*	*37,400*	*42,997*	*3.5*	*3.6*	*4.7*	*3.0*	*2.8*	*3.5*
Coal	ktoe	3,710	5,139	6,019	8,458	9,070	11,693	6.7	3.2	7.0	1.4	5.2	4.7
Natural Gas	ktoe	0	0	0	875	2,625	3,500				24.6	5.9	
Oil	ktoe	14,402	16,363	19,682	22,957	25,705	27,804	2.6	3.8	3.1	2.3	1.6	2.7
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*56.2*	*56.7*	*58.9*						
Coal	%	71.5	69.7	69.2	71.3	70.3	71.8						
Natural Gas	%	0.0	0.0	0.0	23.1	58.0	75.8						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.15 Double Refinery Capacity Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	533	570	598	1.7	3.3	1.6	1.4	0.9	1.8
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	20.9	19.4	17.9	-2.7	-0.7	-1.7	-1.5	-1.5	-1.6
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	95,640	118,020	137,160	156,210	4.3	3.7	4.3	3.1	2.6	3.6
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*63,712*	*71,879*	*78,926*	*3.1*	*4.4*	*2.8*	*2.4*	*1.9*	*2.9*
Coal	ktoe	5,190	7,373	8,696	12,021	14,579	17,968	7.3	3.4	6.7	3.9	4.3	5.1
Natural Gas	ktoe	2,504	2,797	3,600	3,716	4,448	4,509	2.2	5.2	0.6	3.7	0.3	2.4
Oil	ktoe	14,430	16,400	19,718	23,340	26,123	28,222	2.6	3.8	3.4	2.3	1.6	2.7
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	312	630	749	839	899	150.9	15.1	3.5	2.3	1.4	25.4
Commercial Energy	ktoe	32,731	38,871	49,614	57,918	66,109	73,142	3.5	5.0	3.1	2.7	2.0	3.3
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	18.9	20.3	22.8						
Natural Gas	%	6.5	6.2	6.5	5.8	6.2	5.7						
Oil	%	37.5	36.6	35.6	36.6	36.3	35.8						
Others	%	27.6	27.5	31.7	29.6	29.2	28.4						
Non-commercial Energy	%	15.0	13.2	10.5	9.1	8.0	7.3						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,148*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,700*	*32,700*	*39,144*	*44,722*	*3.5*	*3.6*	*4.9*	*3.7*	*2.7*	*3.7*
Coal	ktoe	3,710	5,139	6,019	8,599	10,515	13,143	6.7	3.2	7.4	4.1	4.6	5.2
Natural Gas	ktoe	0	0	0	798	2,544	3,394				26.1	5.9	
Oil	ktoe	14,402	16,363	19,682	23,303	26,086	28,185	2.6	3.8	3.4	2.3	1.6	2.7
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*56.5*	*59.2*	*61.1*						
Coal	%	71.5	69.7	69.2	71.5	72.1	73.1						
Natural Gas	%	0.0	0.0	0.0	21.5	57.2	75.3						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.16 Double Renewable Energy Capacity Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	33.9	36.7	39.5	42.3	45.2	13.7	1.6	1.5	1.4	1.3	3.8
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	642	696	749	803	856	13.1	1.6	1.5	1.4	1.3	3.7
LPG	Peso / litter	19.1	30.8	33.9	37.0	40.0	43.1	10.0	1.9	1.8	1.6	1.5	3.3
Gasoline	Peso / litter	30.7	53.1	59.0	65.3	72.3	79.9	11.6	2.1	2.1	2.0	2.0	3.9
Kerosene	Peso / litter	29.5	52.8	58.6	64.9	71.8	79.3	12.3	2.1	2.1	2.0	2.0	4.0
Jet Fuel	Peso / litter	32.6	59.6	66.5	74.1	82.4	91.6	12.8	2.2	2.2	2.2	2.1	4.2
Diesel	Peso / litter	28.8	50.4	55.8	61.7	68.1	75.0	11.8	2.1	2.0	2.0	2.0	3.9
Fuel Oil	Peso / litter	18.9	38.2	41.7	45.3	49.1	53.0	15.1	1.8	1.7	1.6	1.5	4.2
Electricity (Average)	Peso / kWh	6.8	12.0	13.0	14.0	15.0	16.1	12.0	1.6	1.5	1.4	1.3	3.5
Energy Indicators													
TPE per capita	kgoe/person	384	418	491	559	605	634	1.7	3.3	2.6	1.6	0.9	2.0
TPE per GDP	toe/mil. PHP	27.0	23.6	22.8	21.9	20.5	19.0	-2.7	-0.7	-0.8	-1.3	-1.5	-1.4
Electricity per capita	kWh/person	530	602	716	830	939	1,040	2.6	3.5	3.0	2.5	2.1	2.7
Passenger Cars	1,000 units	788	862	1,094	1,346	1,605	1,857	1.8	4.9	4.2	3.6	3.0	3.5
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	79,640	95,640	112,090	131,460	148,760	4.3	3.7	3.2	3.2	2.5	3.4
Total Primary Energy Supply	*ktoe*	*38,498*	*44,771*	*55,455*	*66,551*	*75,862*	*83,307*	*3.1*	*4.4*	*3.7*	*2.7*	*1.9*	*3.1*
Coal	ktoe	5,190	7,373	8,696	10,581	13,598	16,572	7.3	3.4	4.0	5.1	4.0	4.8
Natural Gas	ktoe	2,504	2,797	3,600	3,716	3,740	3,786	2.2	5.2	0.6	0.1	0.2	1.7
Oil	ktoe	14,430	16,400	19,718	22,993	25,741	27,841	2.6	3.8	3.1	2.3	1.6	2.7
Geothermal	ktoe	8,516	9,327	13,426	18,006	20,296	21,381	1.8	7.6	6.0	2.4	1.0	3.8
Hydro	ktoe	2,088	2,661	3,543	4,690	5,836	6,983	5.0	5.9	5.8	4.5	3.7	4.9
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	312	630	769	880	961	150.9	15.1	4.1	2.7	1.8	25.7
Commercial Energy	ktoe	32,731	38,871	49,614	60,756	70,092	77,524	3.5	5.0	4.1	2.9	2.0	3.5
Non-commercial Energy	*ktoe*	*5,766*	*5,901*	*5,840*	*5,795*	*5,770*	*5,784*	*0.5*	*-0.2*	*-0.2*	*-0.1*	*0.0*	*0.0*
Coal	%	13.5	16.5	15.7	15.9	17.9	19.9						
Natural Gas	%	6.5	6.2	6.5	5.6	4.9	4.5						
Oil	%	37.5	36.6	35.6	34.6	33.9	33.4						
Others	%	27.6	27.5	31.7	35.3	35.6	35.2						
Non-commercial Energy	%	15.0	13.2	10.5	8.7	7.6	6.9						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*21,787*	*27,120*	*32,363*	*37,148*	*41,273*	*4.6*	*4.5*	*3.6*	*2.8*	*2.1*	*3.5*
Agriculture	ktoe	313	254	297	337	373	402	-4.0	3.1	2.6	2.0	1.6	1.0
Industry	ktoe	4,084	4,551	5,590	6,677	7,785	8,870	2.2	4.2	3.6	3.1	2.6	3.2
Energy Intensive	ktoe	2,653	3,071	3,674	4,311	4,957	5,591	3.0	3.7	3.2	2.8	2.4	3.0
Other	ktoe	1,430	1,480	1,916	2,366	2,828	3,279	0.7	5.3	4.3	3.6	3.0	3.4
Commercial	ktoe	1,660	2,187	2,878	3,638	4,429	5,218	5.7	5.6	4.8	4.0	3.3	4.7
Residential	ktoe	2,405	2,763	3,556	4,434	5,342	6,219	2.8	5.2	4.5	3.8	3.1	3.9
Transport	ktoe	8,940	12,032	14,800	17,277	19,220	20,563	6.1	4.2	3.1	2.2	1.4	3.4
Energy Net Import	*ktoe*	*18,112*	*21,502*	*25,700*	*31,118*	*37,209*	*42,416*	*3.5*	*3.6*	*3.9*	*3.6*	*2.7*	*3.5*
Coal	ktoe	3,710	5,139	6,019	7,363	9,672	11,945	6.7	3.2	4.1	5.6	4.3	4.8
Natural Gas	ktoe	0	0	0	798	1,832	2,667				18.1	7.8	
Oil	ktoe	14,402	16,363	19,682	22,957	25,705	27,804	2.6	3.8	3.1	2.3	1.6	2.7
Energy Import Ratio	*%*	*55.3*	*55.3*	*51.8*	*51.2*	*53.1*	*54.7*						
Coal	%	71.5	69.7	69.2	69.6	71.1	72.1						
Natural Gas	%	0.0	0.0	0.0	21.5	49.0	70.4						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.17 Revised Price Case at $70/Bbl

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,647	2,177	2,772	3,413	4,079	6.3	5.7	5.0	4.3	3.6	5.0
RGDP per capita	PHP/person	14,198	17,708	21,536	25,491	29,456	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Prices													
Crude oil	Peso / litter	17.8	19.8	21.9	24.0	26.1	28.2	2.1	2.1	1.9	1.7	1.6	1.9
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	440	477	523	569	615	4.9	1.6	1.9	1.7	1.6	2.3
LPG	Peso / litter	19.1	18.5	21.6	24.6	27.7	30.8	-0.7	3.1	2.7	2.4	2.1	1.9
Gasoline	Peso / litter	30.7	39.0	44.2	49.8	56.0	62.9	4.9	2.5	2.4	2.4	2.3	2.9
Kerosene	Peso / litter	29.5	38.6	43.8	49.4	55.5	62.3	5.5	2.5	2.4	2.4	2.3	3.0
Jet Fuel	Peso / litter	32.6	45.5	51.7	58.6	66.2	74.7	6.9	2.6	2.5	2.5	2.4	3.4
Diesel	Peso / litter	28.8	36.3	41.0	46.2	51.8	58.1	4.7	2.5	2.4	2.3	2.3	2.8
Fuel Oil	Peso / litter	18.9	24.1	26.9	29.8	32.8	36.0	5.0	2.2	2.1	2.0	1.9	2.6
Electricity (Average)	Peso / kWh	6.8	8.2	9.0	9.9	10.8	11.7	3.8	1.9	1.9	1.7	1.6	2.2
Energy Indicators													
TPE per capita	kgoe/person	384	436	509	548	586	614	2.6	3.1	1.5	1.3	0.9	1.9
TPE per GDP	toe/mil. PHP	27.0	24.6	23.6	21.5	19.9	18.4	-1.9	-0.8	-1.9	-1.5	-1.5	-1.5
Electricity per capita	kWh/person	530	627	743	860	971	1,074	3.4	3.5	3.0	2.5	2.0	2.9
Passenger Cars	1,000 units	788	951	1,220	1,492	1,768	2,034	3.8	5.1	4.1	3.5	2.8	3.9
Utility Vehicles	1,000 units	1,792	2,434	3,238	3,944	4,470	4,784	6.3	5.9	4.0	2.5	1.4	4.0
Trucks	1,000 units	267	358	437	505	558	595	6.0	4.1	2.9	2.0	1.3	3.3
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,610	5,134	6,497	7,479	8,010	10.8	7.3	4.8	2.9	1.4	5.4
CO2 Emission	CO_2-kton	64,453	84,520	101,470	124,710	144,100	163,540	5.6	3.7	4.2	2.9	2.6	3.8
Total Primary Energy Supply	*ktoe*	*38,498*	*46,320*	*57,150*	*65,281*	*73,551*	*80,728*	*3.8*	*4.3*	*2.7*	*2.4*	*1.9*	*3.0*
Coal	ktoe	5,190	7,416	9,304	12,824	15,187	18,575	7.4	4.6	6.6	3.4	4.1	5.2
Natural Gas	ktoe	2,504	2,858	3,608	3,729	4,529	4,615	2.7	4.8	0.7	4.0	0.4	2.5
Oil	ktoe	14,430	17,922	20,872	24,177	27,204	29,420	4.4	3.1	3.0	2.4	1.6	2.9
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	329	666	789	881	942	153.5	15.2	3.4	2.2	1.3	25.6
Commercial Energy	ktoe	32,731	40,513	51,419	59,611	67,920	75,095	4.4	4.9	3.0	2.6	2.0	3.4
Non-commercial Energy	*ktoe*	*5,766*	*5,807*	*5,731*	*5,670*	*5,631*	*5,633*	*0.1*	*-0.3*	*-0.2*	*-0.1*	*0.0*	*-0.1*
Coal	%	13.5	16.0	16.3	19.6	20.6	23.0						
Natural Gas	%	6.5	6.2	6.3	5.7	6.2	5.7						
Oil	%	37.5	38.7	36.5	37.0	37.0	36.4						
Others	%	27.6	26.6	30.9	28.9	28.6	27.9						
Non-commercial Energy	%	15.0	12.5	10.0	8.7	7.7	7.0						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*22,933*	*28,528*	*33,925*	*38,825*	*43,027*	*5.7*	*4.5*	*3.5*	*2.7*	*2.1*	*3.7*
Agriculture	ktoe	313	307	360	405	444	476	-0.3	3.2	2.4	1.9	1.4	1.7
Industry	ktoe	4,084	4,729	5,797	6,912	8,045	9,153	3.0	4.2	3.6	3.1	2.6	3.3
Energy Intensive	ktoe	2,653	3,183	3,802	4,454	5,114	5,762	3.7	3.6	3.2	2.8	2.4	3.1
Other	ktoe	1,430	1,546	1,995	2,457	2,931	3,391	1.6	5.2	4.3	3.6	3.0	3.5
Commercial	ktoe	1,660	2,291	3,005	3,788	4,601	5,409	6.7	5.6	4.7	4.0	3.3	4.8
Residential	ktoe	2,405	2,879	3,693	4,593	5,520	6,413	3.7	5.1	4.5	3.7	3.0	4.0
Transport	ktoe	8,940	12,727	15,673	18,228	20,216	21,576	7.3	4.3	3.1	2.1	1.3	3.6
Energy Net Import	*ktoe*	*18,112*	*23,024*	*27,332*	*34,190*	*40,774*	*46,487*	*4.9*	*3.5*	*4.6*	*3.6*	*2.7*	*3.8*
Coal	ktoe	3,710	5,139	6,497	9,239	10,982	13,604	6.7	4.8	7.3	3.5	4.4	5.3
Natural Gas	ktoe	0	0	0	811	2,625	3,500				26.5	5.9	
Oil	ktoe	14,402	17,885	20,835	24,141	27,167	29,383	4.4	3.1	3.0	2.4	1.6	2.9
Energy Import Ratio	*%*	*55.3*	*56.8*	*53.2*	*57.4*	*60.0*	*61.9*						
Coal	%	71.5	69.3	69.8	72.0	72.3	73.2						
Natural Gas	%	0.0	0.0	0.0	21.7	58.0	75.8						
Oil	%	99.8	99.8	99.8	99.8	99.9	99.9						

1.18 Revised Price ($70/Bbl) and Economic Growth (4%) Case

	Unit	2005	2010	2015	2020	2025	2030	Growth Rate (%) 05-10	10-15	15-20	20-25	25-30	05-30
Economic Indicators													
Population	Million	85.3	93.0	101.1	108.7	115.9	122.4	1.8	1.7	1.5	1.3	1.1	1.5
Real GDP in 1985 price	Billion PHP	1,210	1,498	1,872	2,286	2,736	3,222	4.4	4.6	4.1	3.7	3.3	4.0
RGDP per capita	PHP/person	14,198	16,110	18,523	21,021	23,612	26,331	2.6	2.8	2.6	2.4	2.2	2.5
Energy Prices													
Crude oil	Peso / litter	17.8	19.8	21.9	24.0	26.1	28.2	2.1	2.1	1.9	1.7	1.6	1.9
Coal	Peso / kg	2.0	3.2	3.6	4.1	4.5	4.9	9.9	2.4	2.3	2.1	1.8	3.7
Natural Gas	Peso / mmBtu	347	440	477	523	569	615	4.9	1.6	1.9	1.7	1.6	2.3
LPG	Peso / litter	19.1	18.5	21.6	24.6	27.7	30.8	-0.7	3.1	2.7	2.4	2.1	1.9
Gasoline	Peso / litter	30.7	39.0	44.2	49.8	56.0	62.9	4.9	2.5	2.4	2.4	2.3	2.9
Kerosene	Peso / litter	29.5	38.6	43.8	49.4	55.5	62.3	5.5	2.5	2.4	2.4	2.3	3.0
Jet Fuel	Peso / litter	32.6	45.5	51.7	58.6	66.2	74.7	6.9	2.6	2.5	2.5	2.4	3.4
Diesel	Peso / litter	28.8	36.3	41.0	46.2	51.8	58.1	4.7	2.5	2.4	2.3	2.3	2.8
Fuel Oil	Peso / litter	18.9	24.1	26.9	29.8	32.8	36.0	5.0	2.2	2.1	2.0	1.9	2.6
Electricity (Average)	Peso / kWh	6.8	8.2	9.0	9.9	10.8	11.7	3.8	1.9	1.9	1.7	1.6	2.2
Energy Indicators													
TPE per capita	kgoe/person	384	421	480	499	525	540	1.9	2.7	0.8	1.0	0.6	1.4
TPE per GDP	toe/mil. PHP	27.0	26.1	25.9	23.7	22.2	20.5	-0.7	-0.2	-1.7	-1.3	-1.6	-1.1
Electricity per capita	kWh/person	530	604	686	766	842	914	2.7	2.6	2.2	1.9	1.6	2.2
Passenger Cars	1,000 units	788	887	1,059	1,238	1,422	1,608	2.4	3.6	3.2	2.8	2.5	2.9
Utility Vehicles	1,000 units	1,792	2,293	2,921	3,466	3,878	4,131	5.1	5.0	3.5	2.3	1.3	3.4
Trucks	1,000 units	267	355	422	478	520	549	5.9	3.5	2.5	1.7	1.1	2.9
Buses	1,000 units	31	31	32	34	35	37	-0.2	1.1	0.9	0.8	0.7	0.7
Motorcycles/Tricycles	1,000 units	2,158	3,622	4,979	6,163	7,016	7,497	10.9	6.6	4.4	2.6	1.3	5.1
CO2 Emission	CO_2-kton	64,453	80,620	93,140	106,540	121,520	134,440	4.6	2.9	2.7	2.7	2.0	3.0
Total Primary Energy Supply	*ktoe*	*38,498*	*44,946*	*54,183*	*59,749*	*66,194*	*71,416*	*3.1*	*3.8*	*2.0*	*2.1*	*1.5*	*2.5*
Coal	ktoe	5,190	7,303	8,548	9,855	12,216	14,436	7.1	3.2	2.9	4.4	3.4	4.2
Natural Gas	ktoe	2,504	2,832	3,055	3,716	3,741	3,787	2.5	1.5	4.0	0.1	0.2	1.7
Oil	ktoe	14,430	16,692	19,308	21,827	23,924	25,520	3.0	3.0	2.5	1.9	1.3	2.3
Geothermal	ktoe	8,516	9,327	13,426	13,667	14,812	15,354	1.8	7.6	0.4	1.6	0.7	2.4
Hydro	ktoe	2,088	2,661	3,543	4,425	5,307	6,189	5.0	5.9	4.5	3.7	3.1	4.4
Nuclear	ktoe	0	0	0	0	0	0						
Renewables	ktoe	3	320	625	722	794	842	152.2	14.3	2.9	1.9	1.2	25.1
Commercial Energy	ktoe	32,731	39,136	48,506	54,212	60,794	66,128	3.6	4.4	2.2	2.3	1.7	2.9
Non-commercial Energy	*ktoe*	*5,766*	*5,810*	*5,677*	*5,537*	*5,399*	*5,288*	*0.2*	*-0.5*	*-0.5*	*-0.5*	*-0.4*	*-0.3*
Coal	%	13.5	16.2	15.8	16.5	18.5	20.2						
Natural Gas	%	6.5	6.3	5.6	6.2	5.7	5.3						
Oil	%	37.5	37.1	35.6	36.5	36.1	35.7						
Others	%	27.6	27.4	32.5	31.5	31.6	31.3						
Non-commercial Energy	%	15.0	12.9	10.5	9.3	8.2	7.4						
Final Demand (excl. Non-Con	*ktoe*	*17,402*	*22,034*	*26,297*	*30,342*	*33,997*	*37,176*	*4.8*	*3.6*	*2.9*	*2.3*	*1.8*	*3.1*
Agriculture	ktoe	313	348	393	431	465	496	2.2	2.4	1.9	1.6	1.3	1.9
Industry	ktoe	4,084	4,451	5,257	6,094	6,958	7,835	1.7	3.4	3.0	2.7	2.4	2.6
Energy Intensive	ktoe	2,653	3,034	3,531	4,056	4,595	5,140	2.7	3.1	2.8	2.5	2.3	2.7
Other	ktoe	1,430	1,417	1,726	2,038	2,363	2,695	-0.2	4.0	3.4	3.0	2.7	2.6
Commercial	ktoe	1,660	2,101	2,600	3,139	3,707	4,298	4.8	4.4	3.8	3.4	3.0	3.9
Residential	ktoe	2,405	2,884	3,620	4,413	5,211	5,957	3.7	4.7	4.0	3.4	2.7	3.7
Transport	ktoe	8,940	12,250	14,427	16,264	17,656	18,590	6.5	3.3	2.4	1.7	1.0	3.0
Energy Net Import	*ktoe*	*18,112*	*21,794*	*25,290*	*29,526*	*34,470*	*38,579*	*3.8*	*3.0*	*3.1*	*3.1*	*2.3*	*3.1*
Coal	ktoe	3,710	5,139	6,019	6,938	8,750	10,428	6.7	3.2	2.9	4.8	3.6	4.2
Natural Gas	ktoe	0	0	0	798	1,833	2,668				18.1	7.8	
Oil	ktoe	14,402	16,655	19,272	21,790	23,887	25,483	3.0	3.0	2.5	1.9	1.3	2.3
Energy Import Ratio	*%*	*55.3*	*55.7*	*52.1*	*54.5*	*56.7*	*58.3*						
Coal	%	71.5	70.4	70.4	70.4	71.6	72.2						
Natural Gas	%	0.0	0.0	0.0	21.5	49.0	70.5						
Oil	%	99.8	99.8	99.8	99.8	99.8	99.9						

Appendix-2

Sample of Summary Sheet

This summary sheet is produced for each case to state summary of the supply/demand optimization for all years from 2005 through 2030. However, because of limited paper size, only several sample years are printed in this Appendix-2. Please refer to the excel sheet on PC for detail annual figures.

Reference Case

(Economic and Energy Indicators)

Reference	Summary sheet			Acctual			Forecast			G R O W T H R A T E (%)					
TERM 1	TERM 2	TERM 3	Unit	2005	2006	2007	2008	2009	2030	05 -> 10	10 -> 15	15 -> 20	20 -> 25	25 -> 30	05 -> 30
Economic Indicators	Population		Million	85.26	86.97	88.45	89.95	91.46	122.37	1.8	1.7	1.5	1.3	1.1	1.5
	GDP at 1985 price on PHP base		Billion PHP	1,210.5	1,276.4	1,364.6	1,450.6	1,543.8	4,078.8	6.3	5.7	5.0	4.3	3.6	5.0
	GDP per capita on 1985 PHP base		PHP/person	14,198	14,676	15,428	16,127	16,880	33,332	4.5	4.0	3.4	2.9	2.5	3.5
Energy Indicators	TPE per capita		kgoe/person	383.9	377.5	372.8	407.9	416.5	689.9	2.7	3.7	2.1	1.9	1.5	2.4
	TPE per GDP		TOE/million PHI	27.0	25.7	24.2	25.3	24.7	20.7	-1.8	-0.3	-1.3	-1.0	-1.0	-1.1
	Electricity per capita		kWh / person	530	525	543	575	604	1,251	3.7	4.2	3.7	3.2	2.7	3.5
	Vehicle number	Total	1000Unit	5,036	5,308	5,777	6,213	6,723	15,283	7.7	6.4	4.4	2.8	1.6	4.5
		Passenger Cars	1000Unit	788	792	812	801	823	1,857	1.8	4.9	4.2	3.6	3.0	3.5
		Utility Vehicles	1000Unit	1,792	1,791	1,946	2,098	2,260	4,784	6.3	5.9	4.0	2.5	1.4	4.0
		Trucks	1000Unit	267	286	303	320	338	595	6.0	4.1	2.9	2.0	1.3	3.3
		Buses	1000Unit	31	29	30	30	30	37	-0.2	1.1	0.9	0.8	0.7	0.7
		Motorcycles/Tricycles	1000Unit	2,158	2,409	2,685	2,964	3,271	8,010	10.8	7.3	4.8	2.9	1.4	5.4
		Total No. of vehicle per perso	unit/1000psn	59.1	61.0	65.3	69.1	73.5	124.9	5.8	4.6	2.9	1.5	0.5	3.0
		Passenger Cars	unit/1000psn	9.2	9.1	9.2	8.9	9.0	15.2	0.0	3.2	2.7	2.3	1.8	2.0
		Utility Vehicles	unit/1000psn	21.0	20.6	22.0	23.3	24.7	39.1	4.5	4.1	2.5	1.2	0.3	2.5
		Trucks	unit/1000psn	3.1	3.3	3.4	3.6	3.7	4.9	4.2	2.3	1.5	0.7	0.2	1.8
		Buses	unit/1000psn	0.4	0.3	0.3	0.3	0.3	0.3	-1.9	-0.6	-0.5	-0.4	-0.3	-0.8
		Motorcycles/Tricycles	unit/1000psn	25.3	27.7	30.4	33.0	35.8	65.5	8.9	5.5	3.3	1.6	0.3	3.9
	CO2 Emission		CO2-kton	64,453	59,619	65,892	77,100	79,480	195,130	5.7	4.6	5.1	3.9	3.4	4.5
	Total Primary Energy	Commercial Total	**kTOE**	32,731	32,830	32,975	36,685	38,094	84,428	4	5.4	3.6	3.2	2.6	3.9
	Domestic Requirement	Coal	**kTOE**	5,190	4,889	5,210	7,350	7,401	23,903	7.5	6.0	8.0	5.0	4.9	6.3
	excluding Stockpiling	Natural Gas	**kTOE**	2,504	2,363	2,821	2,322	2,842	4,632	2.7	4.8	1.0	3.6	0.4	2.5
		Oil	**kTOE**	14,430	14,096	13,992	15,858	16,279	33,288	4.6	3.8	3.4	2.9	2.3	3.4
		Crude Oil Processing	**kTOE**	10,493	10,543	10,022	14,621	14,621	14,621	6.9	0.0	0.0	0.0	0.0	1.3
		Petroleum Products Import	**kTOE**	3,937	3,554	3,970	1,236	1,658	18,666	-2.5	15.8	9.2	6.2	4.3	6.4
		Fossil total	**kTOE**	22,124	21,349	22,022	25,529	26,521	61,823	5.1	4.5	4.6	3.7	3.1	4.2
		Fossil ratio	**%**	67.6	65.0	66.8	69.6	69.6	73.2	0.6	-0.9	1.0	0.4	0.5	0.3
		Geothermal	**kTOE**	8,516	9,000	8,785	8,785	8,785	15,354	1.8	7.6	0.4	1.6	0.7	2.4
		Hydro	**kTOE**	2,088	2,475	2,132	2,309	2,485	6,189	5.0	5.9	4.5	3.7	3.1	4.4
		Nuclear	**kTOE**	0	0	0	0	0	0						
		Renewables	**kTOE**	3	7	35	62	303	1,061	153.2	15.8	4.1	2.9	2.0	26.2
		Non-Commercials	**kTOE**	5,766	5,652	5,561	5,829	5,804	4,818	0.1	-0.7	-0.8	-1.0	-1.1	-0.7
		Total	**kTOE**	38,498	38,483	38,535	42,514	43,898	89,245	*3.9*	*4.8*	*3.2*	*2.9*	*2.4*	*3.4*
	Final Energy Demand	Total	**kTOE**	17,402	16,814	18,494	20,570	21,600	49,668	5.7	5.2	4.3	3.5	2.8	4.3
		Agricluture	**kTOE**	313	281	134	256	259	485	-3.0	3.8	3.3	2.7	2.2	1.8
		Industry (Energy Insentive)	**kTOE**	2,653	2,753	2,645	2,970	3,109	6,772	4.2	4.4	3.9	3.5	3.1	3.8
		Industry (Other)	**kTOE**	1,430	1,385	1,282	1,364	1,458	3,944	1.8	6.0	5.0	4.3	3.7	4.1
		Commercial	**kTOE**	1,660	1,749	1,689	2,010	2,153	6,278	6.9	6.3	5.5	4.7	4.0	5.5
		Residential	**kTOE**	2,405	2,277	2,338	2,546	2,718	7,463	3.9	5.9	5.2	4.5	3.8	4.6
		Transport	**kTOE**	8,940	8,369	10,406	11,422	11,903	24,724	7.1	4.9	3.9	2.9	2.1	4.2
	Energy Net Import	Total	**kTOE**	18,112	18,145	18,046	21,095	21,567	54,688	5.1	4.4	5.3	4.4	3.3	4.5
		Coal	**kTOE**	3,710	4,073	4,079	5,274	5,324	17,937	6.7	6.3	8.8	5.7	5.0	6.5
		Natural Gas	**kTOE**	0	0	0	0	0	3,500				24.6	5.9	
		Oil	**kTOE**	14,402	14,072	13,967	15,821	16,242	33,251	4.6	3.8	3.4	2.9	2.3	3.4
	Import Ratio	Total	%	55	55	55	58	57	65	0.6	-1.0	1.7	1.2	0.7	0.6
	(excl. oil stockpiling)	Coal	%	71.5	83.3	78.3	71.8	71.9	75.0	-0.7	0.3	0.7	0.6	0.0	0.2
		Natural Gas	%	0.0	0.0	0.0	0.0	0.0	75.6				20.2	5.5	
		Oil	%	99.8	99.8	99.8	99.8	99.8	99.9	0.0	0.0	0.0	0.0	0.0	0.0

Reference Case

(Oil & Gas Sector)

Acctual → ← Forecast →

Reference	Oil and Gas Sector									G R O W T H R A T E (%)					
TERM 1	TERM 2	TERM 3	Unit	2005	2006	2007	2008	2009	2030	05 -> 10	10 -> 15	15 -> 20	20 -> 25	25 -> 30	05 -> 30
Oil & Gas sector	Primary Energy Supply	Total	kTOE	16,376	15,062	16,925	17,790	18,968	38,587	4.9	4.3	3.2	3.0	2.1	3.5
		Natural gas	kTOE	2,504	2,363	2,821	2,322	2,842	4,632	2.7	4.8	1.0	3.6	0.4	2.5
		Final demand	kTOE	12	53	77	78	80	199	46.6	3.0	3.2	4.8	7.0	11.8
		For electricity	kTOE	2,492	2,310	2,743	2,243	2,762	4,434	2.2	4.8	1.0	3.6	0.1	2.3
	including Biofuel	Petroleum Products Total	kTOE	13,872	12,699	14,104	15,468	16,127	33,955	5.3	4.2	3.5	2.9	2.3	3.6
		LPG	kTOE	1,063	1,008	1,074	1,385	1,520	3,218	9.4	8.0	4.8	0.4	0.4	4.5
		LPG substitute	kTOE	0	0	0	0	0	2,025				37.1	12.7	
	including Bio-ethanol	Gasoline	kTOE	2,928	2,737	2,795	3,280	3,478	7,318	4.9	5.3	3.9	2.7	1.8	3.7
		Ethanol	kTOE	1	1	2	0	177	748	167.0	21.0	3.9	2.8	1.8	28.6
		Gasoline	kTOE	2,926	2,736	2,793	3,280	3,301	6,570	3.8	4.2	3.9	2.7	1.8	3.3
		Jet fuel	kTOE	1,000	1,003	1,125	1,168	1,228	2,989	5.3	4.8	4.5	4.1	3.7	4.5
		Kerosene	kTOE	285	222	200	193	185	90	-9.0	-3.9	-3.5	-3.2	-2.8	-4.5
	including Bio-diesel	Diesel	kTOE	5,582	5,230	5,553	6,295	6,616	13,066	5.0	4.6	3.5	2.6	1.7	3.5
		Final demand	kTOE	5,377	5,082	5,404	6,174	6,494	12,940	5.1	4.9	3.7	2.6	1.7	3.6
		Bio-Diesel	kTOE	0	1	28	53	113	214	304.3	4.8	3.4	2.3	1.3	35.3
		Diesel	kTOE	5,377	5,082	5,376	6,121	6,382	12,726	4.7	4.9	3.7	2.6	1.7	3.5
		For electricity	kTOE	205	148	149	121	121	126	2.2	-6.9	-5.4	0.4	0.4	-1.9
		Fuel oil	kTOE	3,014	2,499	3,358	3,147	3,099	5,249	5.8	0.6	0.8	1.9	2.3	2.2
		Final demand	kTOE	1,796	1,606	2,453	2,519	2,471	4,506	7.2	3.4	3.2	2.7	2.2	3.7
		For electricity	kTOE	1,218	893	905	627	628	743	3.4	-5.5	-7.2	-2.8	2.7	-2.0
	Crude oil	Production (crude oil)	kTOE	28	24	25	37	37	37	5.6	0.0	0.0	0.0	0.0	1.1
		Production (condensate)	kTOE	582	535	601	777	951	379	10.4	4.8	-4.1	-8.1	-10.0	-1.7
		Import	kTOE	10,465	10,518	9,997	14,584	14,584	14,584	6.9	0.0	0.0	0.0	0.0	1.3
		Export	kTOE	0	0	0	0	0	0						
		Processing	kTOE	10,116	10,054	9,694	14,621	14,621	14,621	7.6	0.0	0.0	0.0	0.0	1.5
		Net Balance (export)	KTOE	582	535	601	777	951	379	10.4	4.8	-4.1	-8.1	-10.0	-1.7
	Natural gas	Production	kTOE	2,701	2,529	3,033	2,322	2,842	1,132	1.1	4.8	-4.1	-8.1	-10.0	-3.4
		Import	kTOE	0	0	0	0	0	3,500				24.6	5.9	
		Export	kTOE	0	0	0	0	0	0						
		Consumption	kTOE	2,504	2,363	2,821	2,322	2,842	4,632	2.7	4.8	1.0	3.6	0.4	2.5
		Net Balance (export)	KTOE	197	166	212	0	0	0	-91.8	31.7	14.8	-25.2	-232.7	-165.8
	Oil & Gas product net imp	Total	KTOE	13,819	13,537	13,366	15,044	15,291	36,372	4.4	3.8	4.5	4.3	2.8	3.9
		Natural gas	KTOE	0	0	0	0	0	3,500		31.7	-1346.2	24.6	5.9	
		Crude oil	KTOE	10,465	10,518	9,997	14,584	14,584	14,584	6.9	0.0	0.0	0.0	0.0	1.3
		Condensate	KTOE	-582	-535	-601	-777	-951	-379	10.4	4.8	-4.1	-8.1	-10.0	-1.7
		LPG	KTOE	695	665	820	675	809	2,360	6.6	12.6	6.4	0.0	0.0	5.0
		LPG substitute	KTOE	0	0	0	0	0	2,025				37.1	12.7	
		Gasoline	KTOE	1,150	1,140	1,333	556	577	3,846	-6.9	14.8	9.5	5.4	3.2	4.9
		Jet fuel	KTOE	259	291	359	-38	0	1,589	-100.0		21.7	11.2	7.7	7.5
		Kerosene	KTOE	94	79	52	0	14	90	-4.8	14.6	-3.5	-3.2	-2.8	-0.2
		Diesel	KTOE	2,024	1,873	2,128	756	1,017	7,366	-5.6	16.5	8.5	5.2	3.1	5.3
		Fuel oil	KTOE	-286	-495	-720	-712	-760	1,390	-184.4	14.0	12.2	14.6	10.8	-206.5

Reference Case

(Electric Power Sector)

Reference	Electric Power Sector			Acctual			Forecast			G R O W T H R A T E (%)					
TERM 1	TERM 2	TERM 3	Unit	2005	2006	2007	2008	2009	2030	05 -> 10	10 -> 15	15 -> 20	20 -> 25	25 -> 30	05 -> 30
Electric Power Secto	Power Generation		GWh	56,477	56,545	60,430	63,600	67,916	187,741	5.2	5.9	5.2	4.5	3.8	4.9
	Electricity Tariff	Average	PHP/kWh	6.8	7.4	8.0	11.5	11.9	16.1	12.0	1.6	1.5	1.4	1.3	3.5
		Residential	PHP/kWh	7.0	7.8	8.5	12.2	12.7	16.8	12.8	1.5	1.4	1.3	1.2	3.6
		Commercial	PHP/kWh	7.2	7.7	8.2	11.8	12.3	16.5	11.4	1.6	1.5	1.4	1.3	3.4
		Industrial	PHP/kWh	6.2	6.6	7.4	10.7	11.1	14.9	12.5	1.6	1.5	1.4	1.3	3.6
	Electricity per capita		kWh/person	662	650	683	707	743	1,534	3.4	4.2	3.7	3.2	2.7	3.4
	Sectoral Demand	Total	GWh	45,159	45,672	48,009	51,697	55,214	153,135	5.5	6.0	5.2	4.5	3.8	5.0
		Agriculture	GWh	491	480	493	533	572	1,298	4.4	5.0	4.1	3.5	2.9	4.0
		Industry (Energy Insentive)	GWh	8,008	8,119	8,456	8,744	9,071	17,751	3.3	3.7	3.4	3.1	2.7	3.2
		Industry (Other)	GWh	7,404	7,505	7,783	8,332	8,954	26,486	5.4	6.5	5.5	4.7	4.0	5.2
		Commercial	GWh	13,134	13,642	14,795	15,761	16,926	51,950	6.8	6.6	5.7	4.9	4.2	5.7
		Residential	GWh	16,031	15,830	16,376	18,218	19,580	55,494	5.7	6.1	5.3	4.5	3.8	5.1
		Transport	GWh	91	97	107	109	111	156	4.5	1.9	1.7	1.5	1.3	2.2
	Power Supply	Total	GWh	56,568	56,784	59,613	63,600	67,916	187,741	5.2	5.9	5.2	4.5	3.8	4.9
		Coal	GWh	15,257	15,294	16,837	25,613	25,613	111,461	10.9	8.1	10.5	6.1	5.9	8.3
		Natural Gas	GWh	16,951	16,605	19,442	15,807	19,363	29,323	2.7	4.7	0.6	3.3	-0.2	2.2
		Oil	GWh	6,051	4,426	4,495	2,586	2,589	3,096	-0.1	-5.4	-7.3	-2.9	2.8	-2.6
		Geothermal	GWh	9,902	10,465	10,215	10,215	10,215	17,854	1.8	7.6	0.4	1.6	0.7	2.4
		Hydro	GWh	8,387	9,939	8,564	9,272	9,981	24,858	5.0	5.9	4.5	3.7	3.1	4.4
		Nuclear	GWh	0	0	0	0	0	0						
		Renewables	GWh	19	55	59	107	154	1,150	60.4	16.8	9.0	6.2	4.7	17.8
	Power Capacity	Total	MW				15,803	15,803	37,353		4.3	4.6	5.0	3.7	
		Coal	MW				4,177	4,177	18,177		8.1	10.5	6.1	5.9	
		Natural Gas	MW				2,763	2,763	5,763		6.4	2.5	4.3	1.8	
		Oil	MW				3,602	3,602	3,152		0.0	0.0	0.5	-3.2	
		Geothermal	MW				1,978	1,978	3,078		2.9	1.7	1.6	2.8	
		Hydro	MW				3,257	3,257	5,757		2.3	1.0	3.8	3.9	
		Nuclear	MW				0	0	1,000					0.0	
		Renewables	MW				26	26	426		0.0	0.0	37.1	27.6	

Reference Case

(Coal Sector, Non-Commercial)

				Acctual			Forecast			G R O W T H R A T E (%)					
Reference	Coal & Renewable Energy Sector														
TERM 1	TERM 2	TERM 3	Unit	2005	2006	2007	2008	2009	2030	05 -> 10	10 -> 15	15 -> 20	20 -> 25	25 -> 30	05 -> 30
Coal sector	Demand	Total	kTOE	5,190	4,889	5,210	7,350	7,401	23,903	7.5	6.0	8.0	5.0	4.9	6.3
		General	kTOE	1,056	1,175	1,238	1,326	1,394	3,213	6.8	4.7	4.2	3.7	3.3	4.5
		For electricity	kTOE	4,134	3,714	3,972	6,024	6,006	20,690	7.7	6.3	8.8	5.3	5.2	6.7
		Export	kTOE	0	0	0	0	0	0						
	Supply	Total	kTOE	5,230	5,317	5,874	7,350	7,401	23,903	7.4	6.0	8.0	5.0	4.9	6.3
		Production	kTOE	1,520	1,243	1,795	2,076	2,076	5,966	8.8	5.3	6.1	3.2	4.8	5.6
		Import	kTOE	3,710	4,073	4,079	5,274	5,324	17,937	6.7	6.3	8.8	5.7	5.0	6.5
Reference	Non-commercial Energy Sector														
Non-commercial Ene	Supply & Demand	Total	kTOE	5,766	5,652	5,561	5,829	5,804	4,818	0.1	-0.7	-0.8	-1.0	-1.1	-0.7
		Rice hull	kTOE	48	48	48	51	53	111	2.7	4.1	3.8	3.4	3.0	3.4
		Charcoal	kTOE	677	684	691	670	648	32	-1.6	-4.5	-6.7	-11.3	-30.1	-11.5
		Fuel wood	kTOE	3,669	3,527	3,404	3,324	3,229	608	-3.1	-3.8	-5.4	-8.1	-13.9	-6.9
		Bagasse	kTOE	711	740	769	1,132	1,212	3,105	12.8	5.6	4.8	4.0	3.3	6.1
		Agriculture waste	kTOE	646	638	632	646	655	946	0.6	1.8	1.8	1.8	1.7	1.5
		Animal waste	kTOE	15	16	16	6	6	16	-15.5	5.5	4.8	4.2	3.6	0.1

Appendix-3

Sample of Energy Balance Table

This energy balance table is produced for each case to state summary of the supply/demand optimization for all years from 2008 through 2030. However, because of limited paper size, only several sample years are printed in this Appendix-3. Please refer to the excel sheet on PC for detail annual figures.

Reference Case

2008

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	2,076	1,986	488	37	0	0	0	0	0	0	0	2,309	8,785	0	9	0	0	0	5,900	21,590
Import	5,218	0	0	14,584	440	0	548	0	609	0	4	0	0	0	0	0	0	0	0	21,403
Export	0	0	-488	0	0	0	0	-756	0	-75	0	0	0	0	0	0	0	0	0	-1,318
Total Primary Energy Supply	7,294	1,986	0	14,621	440	0	548	-756	609	-75	4	2,309	8,785	0	9	0	0	0	5,900	41,674
Transformation Sector	-6,024	-1,907	0	-14,621	2,724	193	5,365	3,231	711	1,207	0	-2,309	-8,785	0	-9	0	51	4,281	0	-15,894
Electricity Plants	-6,024	-1,907	0	0	0	0	-121	-627	0	0	0	-2,309	-8,785	0	-9	0	0	5,266	0	-14,517
Petroleum Refineries	0	0	0	-14,036	2,724	193	5,486	3,859	711	1,207	0	0	0	0	0	0	0	0	0	143
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	0	0	51
Energy Sector	0	0	0	-585	0	0	0	0	0	0	0	0	0	0	0	0	0	-986	0	-1,570
Petroleum Refineries	0	0	0	-585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-585
LNG Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-392	0	-392
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-593	0	-593
Total Final Consumption	1,270	78	0	0	3,164	193	5,913	2,475	1,319	1,132	4	0	0	0	0	0	51	4,281	5,900	25,780
Total Industry	1,270	77	0	0	0	16	326	997	61	0	0	0	0	0	0	0	0	1,410	1,697	5,854
Energy Intensive Industry	1,242	0	0	0	0	16	221	613	33	0	0	0	0	0	0	0	0	720	1,481	4,325
Other Industry	28	77	0	0	0	0	105	384	29	0	0	0	0	0	0	0	0	690	216	1,529
Total Transport	0	1	0	0	3,164	0	5,357	1,300	65	1,132	4	0	0	0	0	0	51	9	0	11,084
Road	0	1	0	0	3,164	0	5,057	0	65	0	0	0	0	0	0	0	51	0	0	8,338
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	9
Water	0	0	0	0	0	0	300	1,300	0	0	0	0	0	0	0	0	0	0	0	1,600
Air	0	0	0	0	0	0	0	0	0	1,132	4	0	0	0	0	0	0	0	0	1,136
Total Other Sectors	0	0	0	0	0	177	229	179	1,193	0	0	0	0	0	0	0	0	2,862	4,203	8,843
Residential	0	0	0	0	0	172	0	0	775	0	0	0	0	0	0	0	0	1,514	3,904	6,365
Commercial	0	0	0	0	0	0	70	141	419	0	0	0	0	0	0	0	0	1,304	299	2,233
Agriculture	0	0	0	0	0	5	159	37	0	0	0	0	0	0	0	0	0	44	0	246
Electricity Output in ktoe	2,203	1,156	0	0	0	0	222	0	0	0	0	797	879	0	9	0	0	0	0	5,266
Installed Capacity of Power Plant in MW	4,177	2,763	0	0	0	0	2,952	650	0	0	0	3,257	1,978	0	26	0	0	0	0	15,803

Reference Case

2010

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	2,234	2,797	687	37	0	0	0	0	0	0	0	2,661	9,327	0	17	0	0	0	5,901	23,662
Import	5,139	0	0	14,584	638	17	1,081	0	846	0	4	0	0	0	0	0	0	0	0	22,310
Export	0	0	−687	0	0	0	0	−808	0	0	0	0	0	0	0	0	0	0	0	−1,495
Total Primary Energy Supply	7,373	2,797	0	14,621	638	17	1,081	−808	846	0	4	2,661	9,327	0	17	0	0	0	5,901	44,476
Transformation Sector	−5,988	−2,715	0	−14,621	2,724	159	5,365	3,231	711	1,240	0	−2,661	−9,327	0	−17	181	114	4,816	0	−16,789
Electricity Plants	−5,988	−2,715	0	0	0	0	−121	−627	0	0	0	−2,661	−9,327	0	−17	0	0	5,923	0	−15,535
Petroleum Refineries	0	0	0	−14,036	2,724	159	5,486	3,859	711	1,240	0	0	0	0	0	0	0	0	0	143
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181	0	0	0	181
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114	0	0	114
Energy Sector	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,107	0	−1,692
Petroleum Refineries	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−585
LNG Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−439	0	−439
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−668	0	−668
Total Final Consumption	1,384	82	0	0	3,362	177	6,445	2,424	1,556	1,240	4	0	0	0	0	181	114	4,816	5,901	27,687
Total Industry	1,384	77	0	0	0	16	362	1,067	94	0	0	0	0	0	0	0	0	1,550	1,929	6,480
Energy Intensive Industry	1,353	0	0	0	0	16	244	654	40	0	0	0	0	0	0	0	0	763	1,681	4,752
Other Industry	31	77	0	0	0	0	117	413	55	0	0	0	0	0	0	0	0	786	248	1,728
Total Transport	0	5	0	0	3,362	0	5,852	1,191	72	1,240	4	0	0	0	0	181	114	10	0	12,032
Road	0	5	0	0	3,362	0	5,594	0	72	0	0	0	0	0	0	181	114	0	0	9,329
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10
Water	0	0	0	0	0	0	258	1,191	0	0	0	0	0	0	0	0	0	0	0	1,449
Air	0	0	0	0	0	0	0	0	0	1,240	4	0	0	0	0	0	0	0	0	1,245
Total Other Sectors	0	0	0	0	0	160	232	165	1,390	0	0	0	0	0	0	0	0	3,257	3,971	9,176
Residential	0	0	0	0	0	155	0	0	882	0	0	0	0	0	0	0	0	1,725	3,689	6,451
Commercial	0	0	0	0	0	0	70	127	507	0	0	0	0	0	0	0	0	1,482	283	2,470
Agriculture	0	0	0	0	0	5	162	38	0	0	0	0	0	0	0	0	0	50	0	254
Electricity Output in ktoe	2,203	1,629	0	0	0	0	222	0	0	0	0	919	933	0	17	0	0	0	0	5,923
Installed Capacity of Power Plant in MW	4,177	2,763	0	0	0	0	2,952	650	0	0	0	3,357	1,978	0	26	0	0	0	0	15,903

Reference Case

2015

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	2,678	3,600	884	37	0	0	0	0	0	0	0	3,543	13,426	0	38	0	0	0	5,840	30,046
Import	6,019	0	0	14,584	1,260	144	2,526	0	1,498	117	4	0	0	0	0	0	0	0	0	26,152
Export	0	0	−884	0	0	0	0	−451	0	0	0	0	0	0	0	0	0	0	0	−1,336
Total Primary Energy Supply	8,696	3,600	0	14,621	1,260	144	2,526	−451	1,498	117	4	3,543	13,426	0	38	0	0	0	5,840	54,862
Transformation Sector	−7,013	−3,506	0	−14,621	2,724	0	5,365	3,231	711	1,400	0	−3,543	−13,426	0	−38	453	140	6,222	0	−21,902
Electricity Plants	−7,013	−3,506	0	0	0	0	−121	−627	0	0	0	−3,543	−13,426	0	−38	0	0	7,647	0	−20,628
Petroleum Refineries	0	0	0	−14,036	2,724	0	5,486	3,859	711	1,400	0	0	0	0	0	0	0	0	0	143
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	453	0	0	0	453
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	140
Energy Sector	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,424	0	−2,009
Petroleum Refineries	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−585
LNG Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−561	0	−561
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−863	0	−863
Total Final Consumption	1,683	94	0	0	3,984	144	7,891	2,780	2,208	1,517	4	0	0	0	0	453	140	6,222	5,840	32,960
Total Industry	1,683	77	0	0	0	18	452	1,237	194	0	0	0	0	0	0	0	0	1,929	2,531	8,121
Energy Intensive Industry	1,644	0	0	0	0	18	305	761	61	0	0	0	0	0	0	0	0	885	2,205	5,880
Other Industry	39	77	0	0	0	0	147	476	132	0	0	0	0	0	0	0	0	1,044	326	2,241
Total Transport	0	17	0	0	3,984	0	7,183	1,401	91	1,517	4	0	0	0	0	453	140	11	0	14,800
Road	0	17	0	0	3,984	0	6,825	0	91	0	0	0	0	0	0	453	140	0	0	11,509
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	11
Water	0	0	0	0	0	0	358	1,401	0	0	0	0	0	0	0	0	0	0	0	1,759
Air	0	0	0	0	0	0	0	0	0	1,517	4	0	0	0	0	0	0	0	0	1,521
Total Other Sectors	0	0	0	0	0	126	256	142	1,924	0	0	0	0	0	0	0	0	4,282	3,309	10,040
Residential	0	0	0	0	0	120	0	0	1,190	0	0	0	0	0	0	0	0	2,246	3,074	6,629
Commercial	0	0	0	0	0	0	70	99	734	0	0	0	0	0	0	0	0	1,976	236	3,114
Agriculture	0	0	0	0	0	6	186	44	0	0	0	0	0	0	0	0	0	61	0	297
Electricity Output in ktoe	2,730	2,090	0	0	0	0	222	0	0	0	0	1,224	1,343	0	38	0	0	0	0	7,647
Installed Capacity of Power Plant in MW	5,177	3,763	0	0	0	0	2,952	650	0	0	0	3,757	2,278	0	26	0	0	0	0	18,603

Reference Case

2020

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	3,422	2,922	718	37	0	0	0	0	0	0	0	4,425	13,667	0	58	0	0	0	5,795	31,044
Import	8,599	798	0	14,584	1,945	118	3,757	0	2,198	424	4	0	0	0	0	0	0	0	0	32,428
Export	0	0	−718	0	0	0	0	−74	0	0	0	0	0	0	0	0	0	0	0	−792
Total Primary Energy Supply	12,021	3,720	0	14,621	1,945	118	3,757	−74	2,198	424	4	4,425	13,667	0	58	0	0	0	5,795	62,679
Transformation Sector	−10,020	−3,612	0	−14,621	2,724	0	5,365	3,231	711	1,400	0	−4,425	−13,667	0	−58	531	160	7,760	0	−24,522
Electricity Plants	−10,020	−3,608	0	0	0	0	−121	−627	0	0	0	−4,425	−13,667	0	−58	0	0	9,528	0	−22,998
Petroleum Refineries	0	0	0	−14,036	2,724	0	5,486	3,859	711	1,400	0	0	0	0	0	0	0	0	0	143
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	531	0	0	0	531
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	0	0	160
Energy Sector	0	−4	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,768	0	−2,357
Petroleum Refineries	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−585
LNG Plants	0	−4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−4
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−693	0	−693
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,076	0	−1,076
Total Final Consumption	2,001	108	0	0	4,669	118	9,122	3,157	2,909	1,824	4	0	0	0	0	531	160	7,760	5,795	38,157
Total Industry	2,001	77	0	0	0	19	546	1,388	316	0	0	0	0	0	0	0	0	2,330	3,203	9,880
Energy Intensive Industry	1,954	0	0	0	0	19	369	869	89	0	0	0	0	0	0	0	0	1,012	2,790	7,101
Other Industry	47	77	0	0	0	0	177	520	227	0	0	0	0	0	0	0	0	1,318	412	2,778
Total Transport	0	31	0	0	4,669	0	8,297	1,643	106	1,824	4	0	0	0	0	531	160	12	0	17,277
Road	0	31	0	0	4,669	0	7,797	0	106	0	0	0	0	0	0	531	160	0	0	13,294
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	12
Water	0	0	0	0	0	0	500	1,643	0	0	0	0	0	0	0	0	0	0	0	2,143
Air	0	0	0	0	0	0	0	0	0	1,824	4	0	0	0	0	0	0	0	0	1,828
Total Other Sectors	0	0	0	0	0	99	279	125	2,486	0	0	0	0	0	0	0	0	5,418	2,592	11,001
Residential	0	0	0	0	0	93	0	0	1,523	0	0	0	0	0	0	0	0	2,818	2,408	6,842
Commercial	0	0	0	0	0	0	70	76	964	0	0	0	0	0	0	0	0	2,528	185	3,822
Agriculture	0	0	0	0	0	7	209	49	0	0	0	0	0	0	0	0	0	72	0	337
Electricity Output in ktoe	4,238	2,115	0	0	0	0	222	0	0	0	0	1,529	1,367	0	58	0	0	0	0	9,528
Installed Capacity of Power Plant in MW	8,177	4,263	0	0	0	0	2,952	650	0	0	0	3,957	2,478	0	26	0	0	0	0	22,503

Reference Case

2025

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	4,064	1,917	471	37	0	0	0	0	0	0	0	5,307	14,812	0	78	0	0	0	5,770	32,457
Import	10,515	2,544	0	14,584	2,442	99	4,654	292	2,878	752	4	0	0	0	0	0	0	0	0	38,763
Export	0	0	−471	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−471
Total Primary Energy Supply	14,579	4,461	0	14,621	2,442	99	4,654	292	2,878	752	4	5,307	14,812	0	78	0	0	0	5,770	70,750
Transformation Sector	−12,252	−4,328	0	−14,621	2,724	0	5,362	3,212	748	1,400	0	−5,307	−14,812	0	−78	588	173	9,362	0	−27,831
Electricity Plants	−12,252	−4,315	0	0	0	0	−124	−647	0	0	0	−5,307	−14,812	0	−78	0	0	11,486	0	−26,050
Petroleum Refineries	0	0	0	−14,036	2,724	0	5,486	3,859	748	1,400	0	0	0	0	0	0	0	0	0	180
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	588	0	0	0	588
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	173	0	0	173
Energy Sector	0	−13	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	−2,125	0	−2,722
Petroleum Refineries	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−585
LNG Plants	0	−13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−13
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−827	0	−827
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,298	0	−1,298
Total Final Consumption	2,327	133	0	0	5,166	99	10,016	3,504	3,626	2,151	4	0	0	0	0	588	173	9,362	5,770	42,919
Total Industry	2,327	77	0	0	0	20	639	1,517	460	0	0	0	0	0	0	0	0	2,745	3,911	11,696
Energy Intensive Industry	2,272	0	0	0	0	20	433	973	121	0	0	0	0	0	0	0	0	1,139	3,409	8,365
Other Industry	55	77	0	0	0	0	207	545	339	0	0	0	0	0	0	0	0	1,606	503	3,331
Total Transport	0	55	0	0	5,166	0	9,078	1,874	118	2,151	4	0	0	0	0	588	173	13	0	19,220
Road	0	55	0	0	5,166	0	8,411	0	118	0	0	0	0	0	0	588	173	0	0	14,511
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13
Water	0	0	0	0	0	0	667	1,874	0	0	0	0	0	0	0	0	0	0	0	2,541
Air	0	0	0	0	0	0	0	0	0	2,151	4	0	0	0	0	0	0	0	0	2,156
Total Other Sectors	0	0	0	0	0	79	299	113	3,048	0	0	0	0	0	0	0	0	6,605	1,859	12,003
Residential	0	0	0	0	0	72	0	0	1,863	0	0	0	0	0	0	0	0	3,407	1,726	7,068
Commercial	0	0	0	0	0	0	70	59	1,185	0	0	0	0	0	0	0	0	3,115	132	4,562
Agriculture	0	0	0	0	0	7	229	54	0	0	0	0	0	0	0	0	0	83	0	373
Electricity Output in ktoe	5,367	2,497	0	0	0	0	230	0	0	0	0	1,833	1,481	0	78	0	0	0	0	11,486
Installed Capacity of Power Plant in MW	10,177	5,263	0	0	0	0	3,052	650	0	0	0	4,757	2,678	0	126	0	0	0	0	26,703

Reference Case

2030

ktoe

	Coal	Natural Gas	Condensate	Crude	Gasoline	Kerosene	Diesel	Fuel Oil	LPG	Jet Fuel	Aviation Gasoline	Hydro	Geothermal	Nuclear	Renewables	Bioethanol	Biodiesel	Electricity	Biomass	Total
Indigenous production	4,825	1,132	278	37	0	0	0	0	0	0	0	6,189	15,354	0	99	0	0	0	5,784	33,698
Import	13,143	3,394	0	14,584	2,739	84	5,175	602	3,525	1,090	4	0	0	0	0	0	0	0	0	44,341
Export	0	0	−278	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−278
Total Primary Energy Supply	17,968	4,526	0	14,621	2,739	84	5,175	602	3,525	1,090	4	6,189	15,354	0	99	0	0	0	5,784	77,761
Transformation Sector	−15,315	−4,348	0	−14,621	2,724	0	5,360	3,193	795	1,400	0	−6,189	−15,354	0	−99	622	178	10,950	0	−30,705
Electricity Plants	−15,315	−4,331	0	0	0	0	−126	−666	0	0	0	−6,189	−15,354	0	−99	0	0	13,425	0	−28,656
Petroleum Refineries	0	0	0	−14,036	2,724	0	5,486	3,859	795	1,400	0	0	0	0	0	0	0	0	0	227
Bioethanol Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	622	0	0	0	622
Biodiesel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	178	0	0	178
Energy Sector	0	−17	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	−2,475	0	−3,076
Petroleum Refineries	0	0	0	−585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−585
LNG Plants	0	−17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−17
Own Use in Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−957	0	−957
Distribution Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−1,518	0	−1,518
Total Final Consumption	2,653	178	0	0	5,463	84	10,535	3,795	4,321	2,490	4	0	0	0	0	622	178	10,950	5,784	47,056
Total Industry	2,653	77	0	0	0	21	728	1,617	620	0	0	0	0	0	0	0	0	3,154	4,620	13,490
Energy Intensive Industry	2,591	0	0	0	0	21	494	1,068	157	0	0	0	0	0	0	0	0	1,260	4,029	9,620
Other Industry	62	77	0	0	0	0	234	548	464	0	0	0	0	0	0	0	0	1,894	591	3,871
Total Transport	0	101	0	0	5,463	0	9,492	2,075	124	2,490	4	0	0	0	0	622	178	13	0	20,563
Road	0	101	0	0	5,463	0	8,647	0	124	0	0	0	0	0	0	622	178	0	0	15,136
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13
Water	0	0	0	0	0	0	845	2,075	0	0	0	0	0	0	0	0	0	0	0	2,920
Air	0	0	0	0	0	0	0	0	0	2,490	4	0	0	0	0	0	0	0	0	2,494
Total Other Sectors	0	0	0	0	0	63	315	103	3,576	0	0	0	0	0	0	0	0	7,783	1,163	13,003
Residential	0	0	0	0	0	56	0	0	2,186	0	0	0	0	0	0	0	0	3,977	1,080	7,299
Commercial	0	0	0	0	0	0	70	46	1,389	0	0	0	0	0	0	0	0	3,713	83	5,301
Agriculture	0	0	0	0	0	8	245	57	0	0	0	0	0	0	0	0	0	93	0	402
Electricity Output in ktoe	6,949	2,466	0	0	0	0	237	0	0	0	0	2,138	1,535	0	99	0	0	0	0	13,425
Installed Capacity of Power Plant in MW	13,177	5,763	0	0	0	0	3,152	650	0	0	0	5,757	3,078	0	426	0	0	0	0	32,003

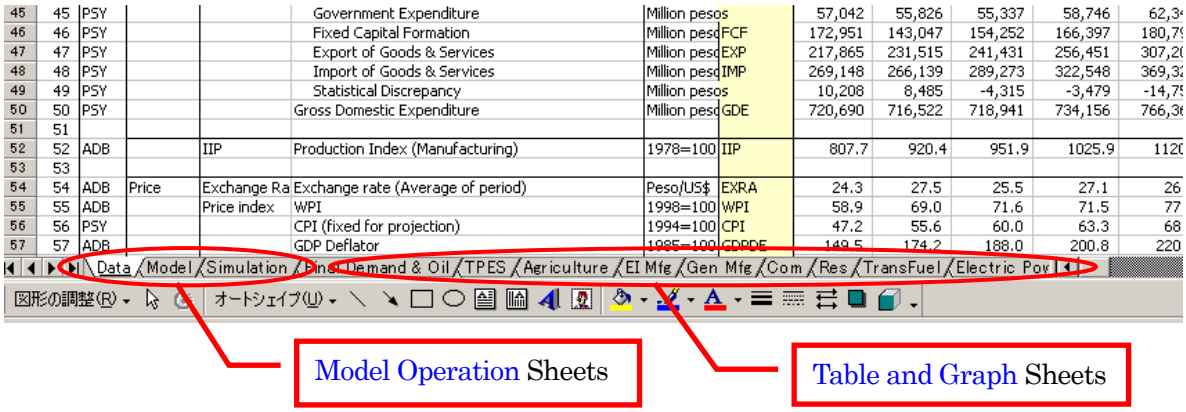
Appendix-4

Operation Manual for Demand Forecasting Model

Appendix-4 Operation Manual for Demand Forecasting Model

1. Model Configuration

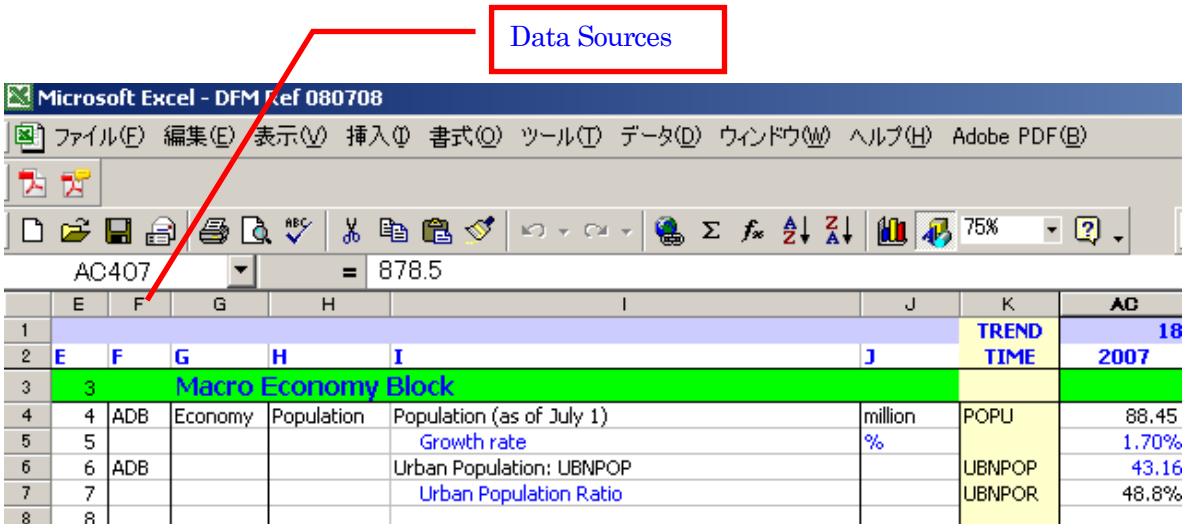
Demand forecasting model was developed on Microsoft Excel using Simple.E (regression tool) as Add-in soft developed by the Institute of Energy Economics, Japan (IEEJ). Demand forecasting model consists of 3 model operation sheets and 13 table and graph sheets. Three model operation sheets are composed of "Data", "Model", and "Simulation" sheets. "Data" sheet contains many necessary data for the model. Model equations are in "Model" sheet. "Simulation" sheet shows the results of demand forecasting model. Other 13 sheets show the table and graph of each sector for analysis.



2. Data Entry

(1) Data sources

There are many data such as ADB (Asian Development Bank), PSY (Philippine Statistical Yearbook), IEA (International Energy Agency), EPPB (Energy Policy and Planning Bureau, DOE), etc. in "Data" sheet. Data sources are shown in column F in "Data" sheet. When you update future data, refer to these data sources.



(2) Data update

This "Data" sheet contains actual data up to 2007. To use this model in the future, some data should be

updated every year. The followings are data to be updated.

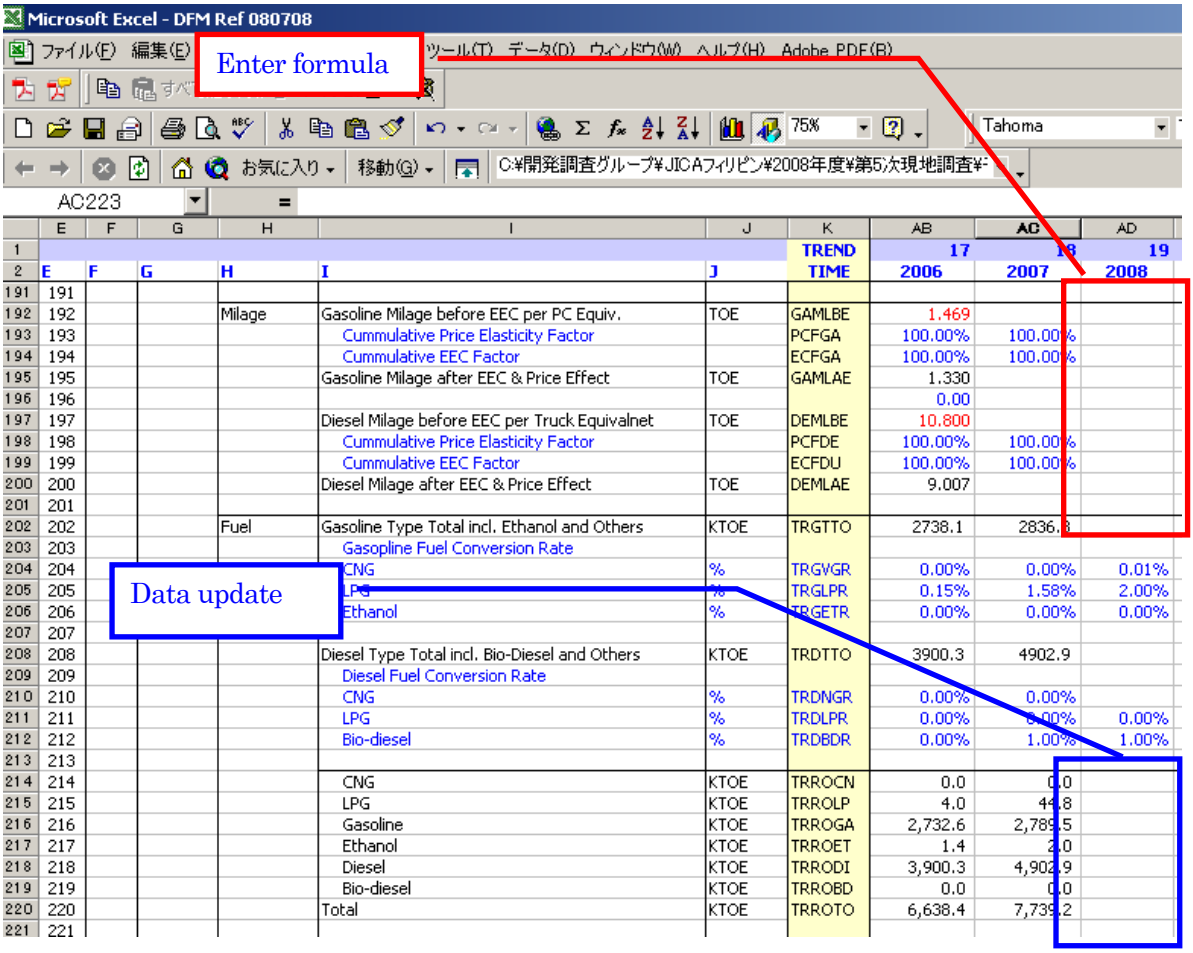
- Population (Row 4/ADB)
- Labor force (Row 9-14/ADB)
- Average income per family (Row 18/PSY)
- Average expenditure per family (Row 19/PSY)
- GDP (Row 22-32 and 38/PSY)
- GDE (Row 44-50/PSY)
- IIP (Row 52/ADB)
- Exchange rate and price index (Row 54-58/ADB, PSY)
- Energy prices (Row 68-79/EPPB)
- Sectroral data of energy intensive industries (Row 125-157 except Row 135, 137, and 139/PSY, ADB, www.psma.com)
- Household energy use (Row 160-165/EPPB)
- Number of vehicles (Row 169-183 except Row 175/PSY)
- Fuel consumption for transport (Row 214-220/EPPB)
- Data for railway (Row 222-227/PSY, EPPB)
- Data for marine (Row 229-237 except Row 233-234/PSY, EPPB)
- Data for air (Row 239-246/PSY, EPPB)
- Energy data for Agriculture (Row 256 and 265-271/EPPB)
- Energy data for Energy Intensive Industry (Row 275 and 291-297/EPPB)
- Energy data for Other Industry (Row 301 and 310-316/EPPB)
- Energy data for Commercial (Row 320 and 329-335/EPPB)
- Energy data for Residential (Row 339 and 349-355/EPPB)
- Energy data for Transport (Row 359-369/EPPB)
- Losses of power sector (Row 395 and 398/EPPB)
- Generation mix (Row 402-408/EPPB)
- Primary energy for power (Row 427-436/EPPB)
- Traditional non-commercial energy (Row 442-480/EPPB)
- Energy for Energy Intensive Industries (Row 529-641/EPPB)

(3) Enter formula

In addition to actual data, some formulas should be entered every year. These formulas are same as previous year. The followings are formulas to be entered every year.

- Energy Indicators (Row 105-122)
- Real price for major industries (Row 135, 137, and 139)
- Passenger car and truck equivalent (Row 175 and 184)
- Diffusion rate and mileage (Row 186-200) Note: Only row 192 and 197 in 2006 are exogenous variables because something is wrong with actual data.
- Gasoline and diesel consumption for transport (Row 202 and 208)
- Electricity ratio and Price mix factor of commercial energy (Row 257, 259, 276, 285, 302, 304, 321,

- After EEC and Price Effect for transport (Row 359-373)
- Final Energy Consumption (Row 376-391)
- Composition of power generation mix and thermal efficiency (Row 411-424)
- Total Primary Energy Supply (Row 491-527)



(4) Assumptions

To estimate future energy demand, it is necessary to set up some assumptions such as GDP, population, energy prices, etc. The followings are some assumptions to be entered up to 2030.

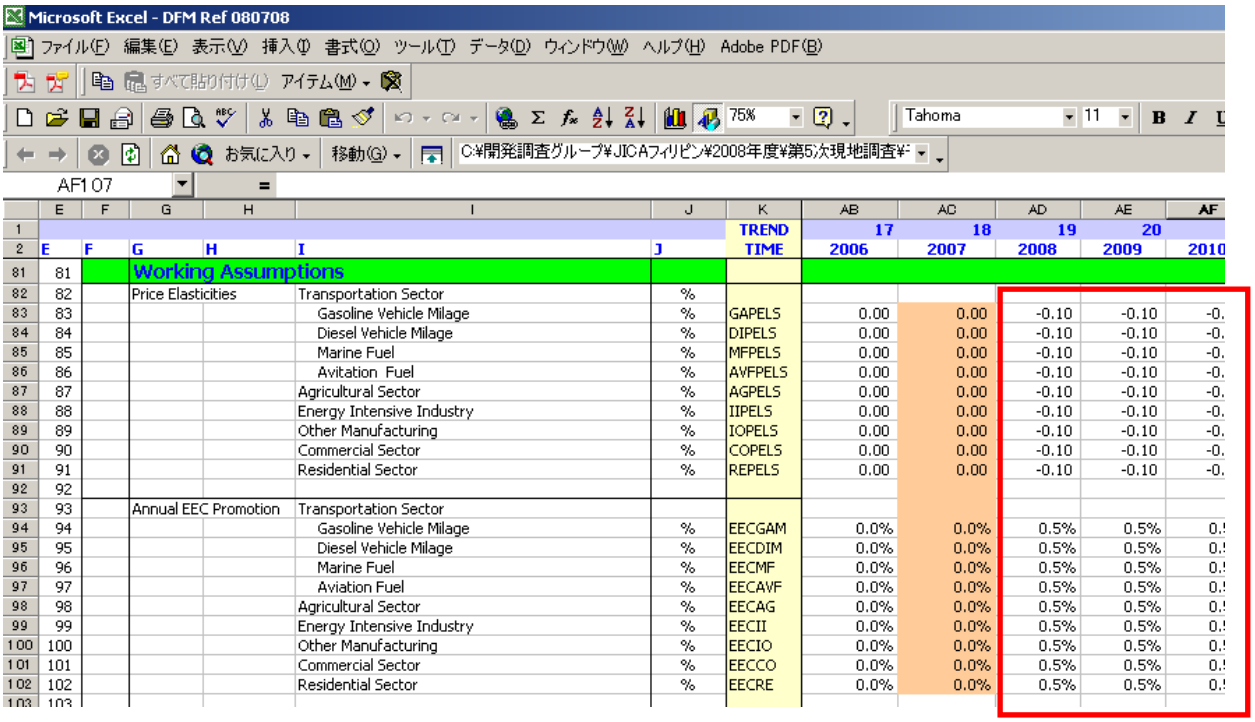
- Population (Row 4,7 and 17)
- GDP (Row 22-32 and 38)
- GDE (Row 44-50)
- Exchange rate and price index (Row 54-58)
- Energy prices (Row 68-79)
- Household energy use (Row 160-165)
- Gasoline and diesel conversion rate (Row 204-206 and 210-212)
- Losses of power sector (Row 395 and 398)
- Generation mix (Row 402-408/EPPB)

- Energy for power plants (Row 435-436)

JICA team set up these assumptions on the "Data" sheet by each case study. However, if you want to change these assumptions, you should enter your assumptions on the above rows.

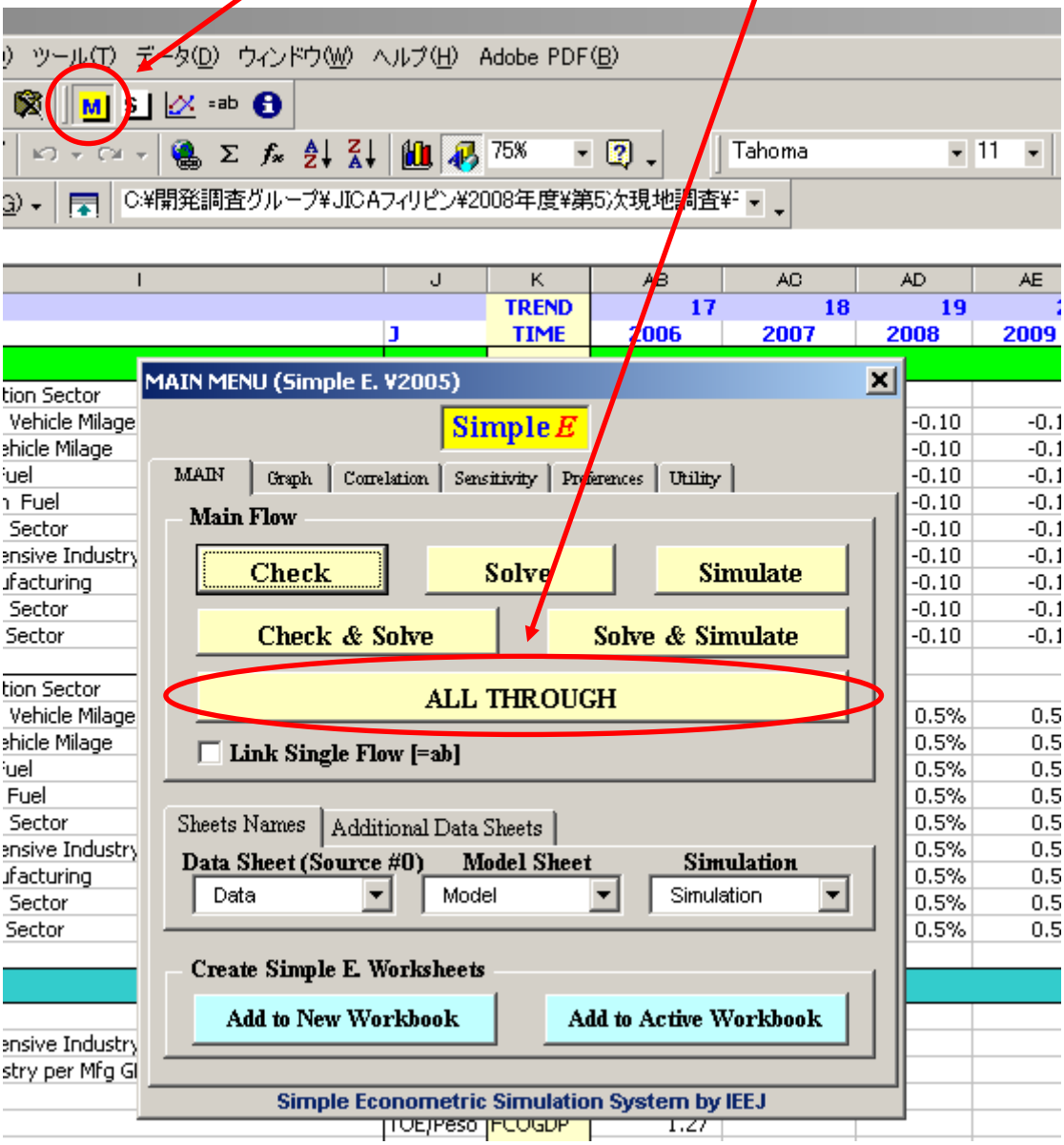
(5) Working Assumptions

This forecasting model can evaluate impacts of energy prices and energy conservation. In this case, you can change working assumptions such as price elasticity and annual EEC (Energy Efficiency and Conservation) promotion on row 83 to 102.



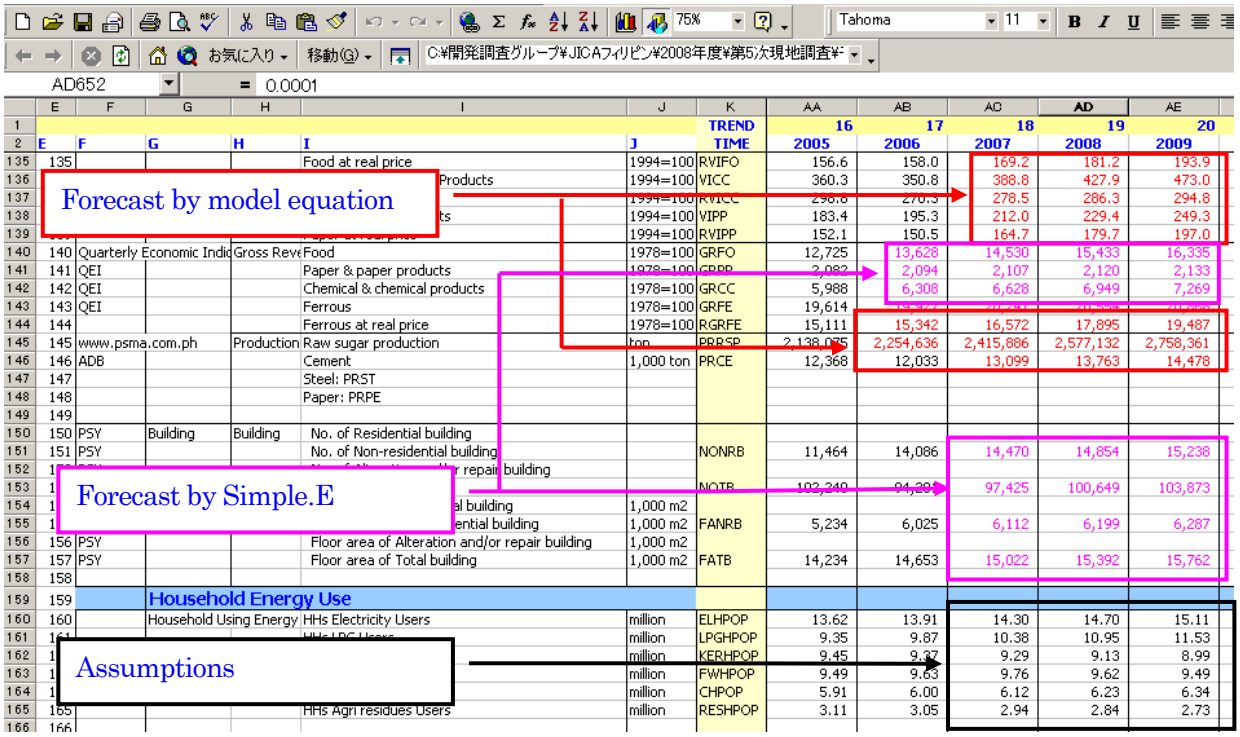
3. Model running

After enter necessary data, click  , then click **ALL THROUGH**

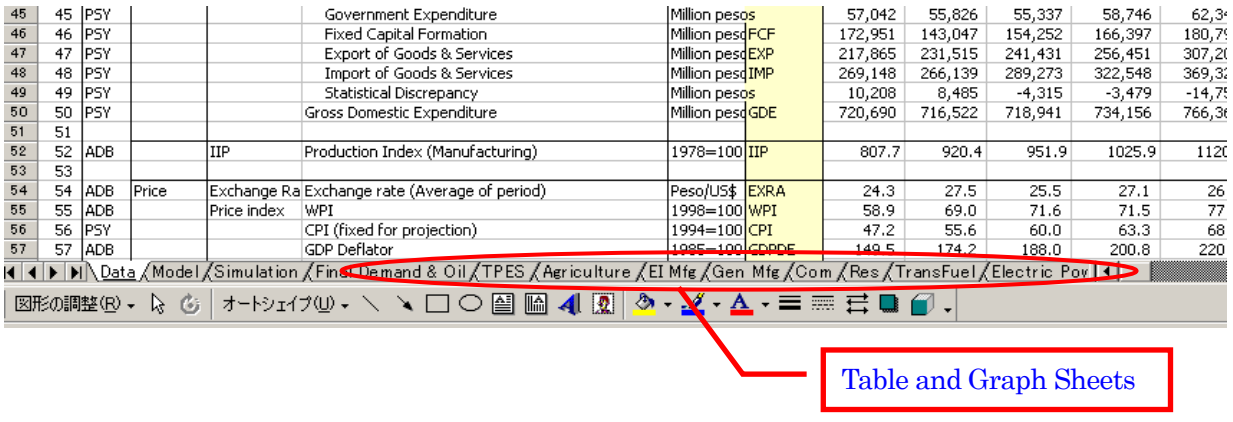


4. Result of simulation

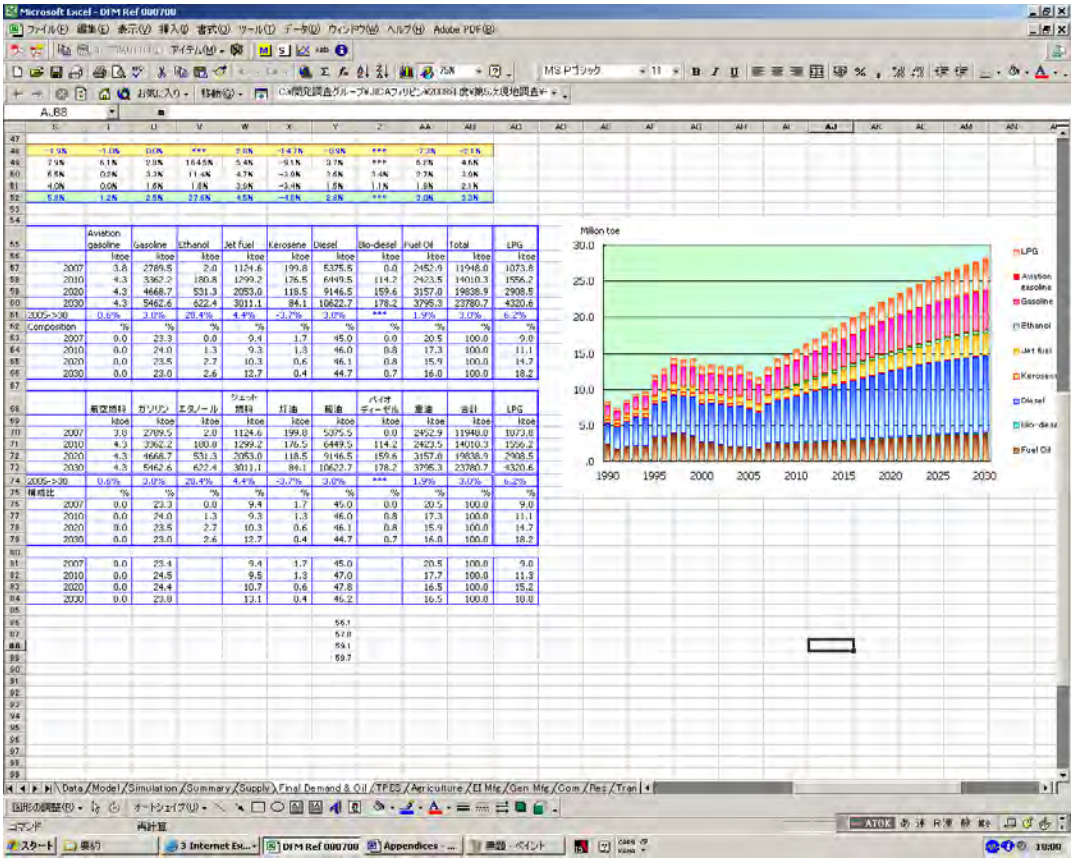
After running the model, you can see the results of model simulation on “Simulation” sheet. Red figures show the results of model equation. Pink figures show the figures that are estimated by Simple.E using linear trend automatically. Black figures show the figures defined in “Data” sheet.

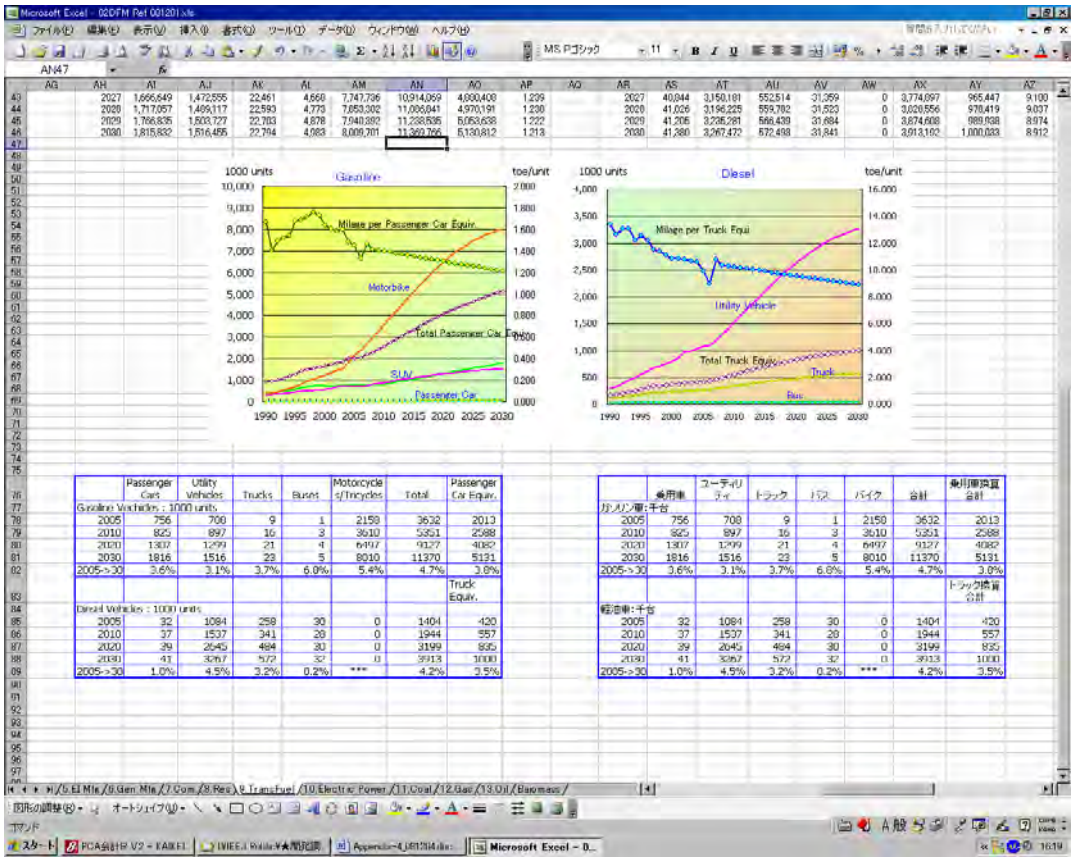


However, it is very difficult to check the model results from “Simulation” sheet only. So, we added 13 table and graph sheets for analysis.



When you open these table and graph sheet, it is easy for you to check the simulation results on each sector. These table and graph sheets are linked to the “Simulation” sheet.


Million toe
30.0
25.0
20.0
15.0
10.0
5.0
.0
1990
1995
2000
2005
2010
2015
2020
2025
2030
LPG
Aviation gasoline
Gasoline
Ethanol
Jet fuel
Kerosene
Diesel
Bio-diesel
Fuel Oil


1000 units
toe/unit
Gasoline
Milage per Passenger Car Equiv.
Motorbike
Total Passenger Car Equiv.
SUV
Passenger Car
Diesel
Milage per Truck Equi.
Utility Vehicle
Total Truck Equiv.
Truck
Bus

Appendix-5-1

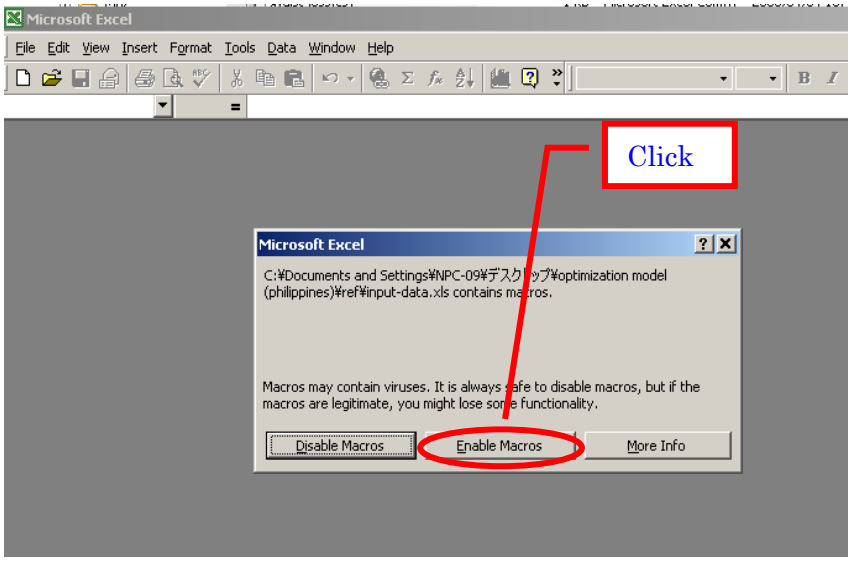
Operation Manual for Supply/Demand Optimization Model

Appendix-5-1 Operation Manual of Optimization Model

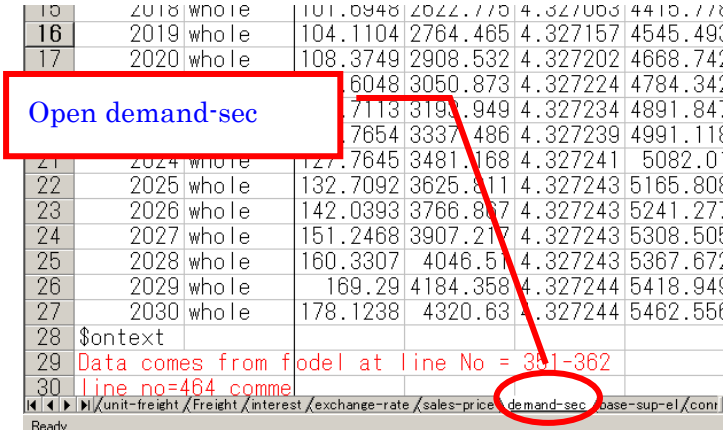
1. Import Demand Data into Optimization Model

There are many case studies in Holder of “optimization model (philippines) as following figure. After you open “ref” Holder, you can find “input-data.xls”. Then, double-click for open.

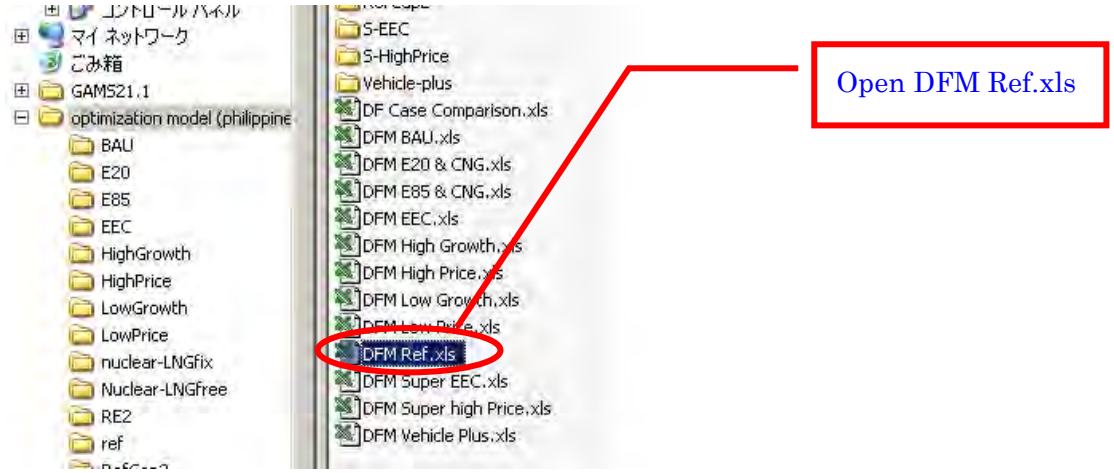
Next, click Enable Macro



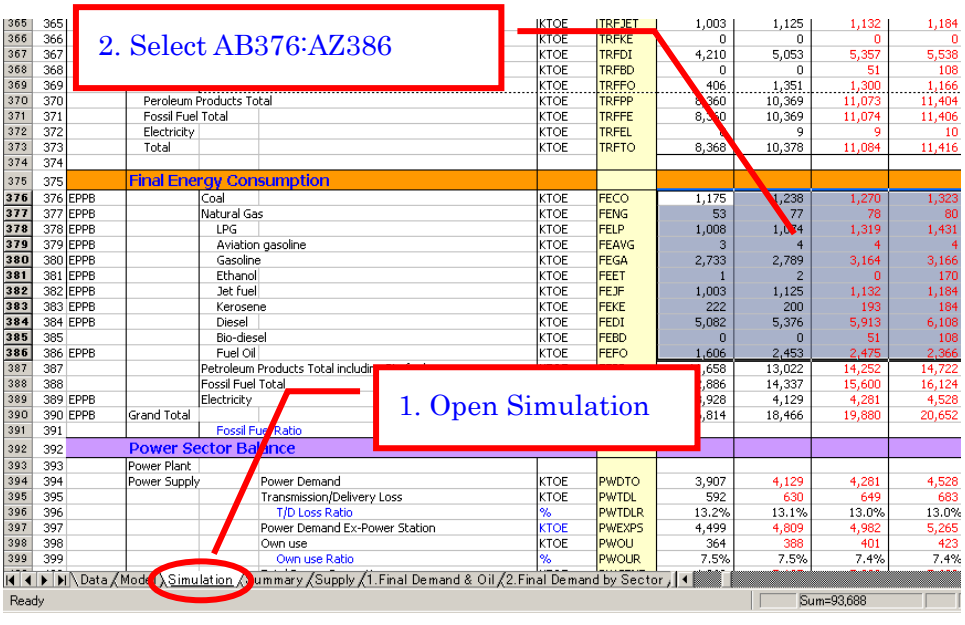
Then, open “demand-sec” sheet. This sheet contains energy demand data.



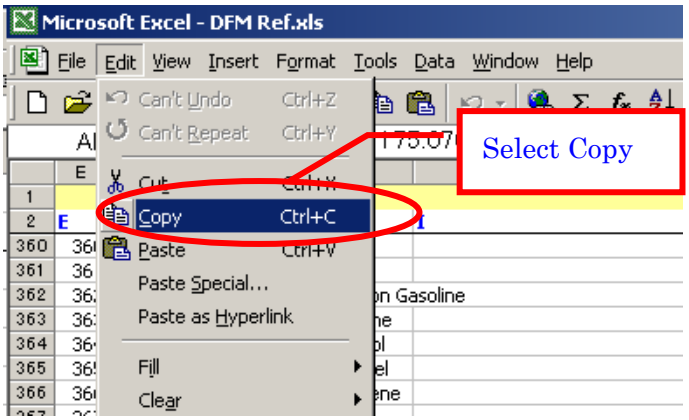
Next, open Reference Case of Energy Demand Forecasting Model, DFM Ref.xls.



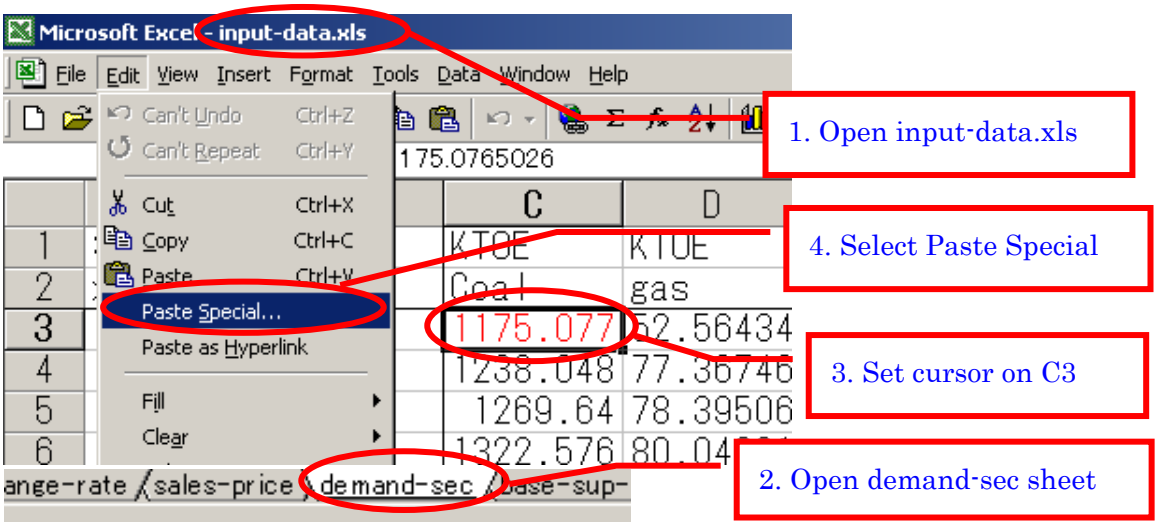
Open “Simulation” sheet and select final energy consumption from Coal to Fuel Oil from 2006 to 2030, AB376:AZ386.



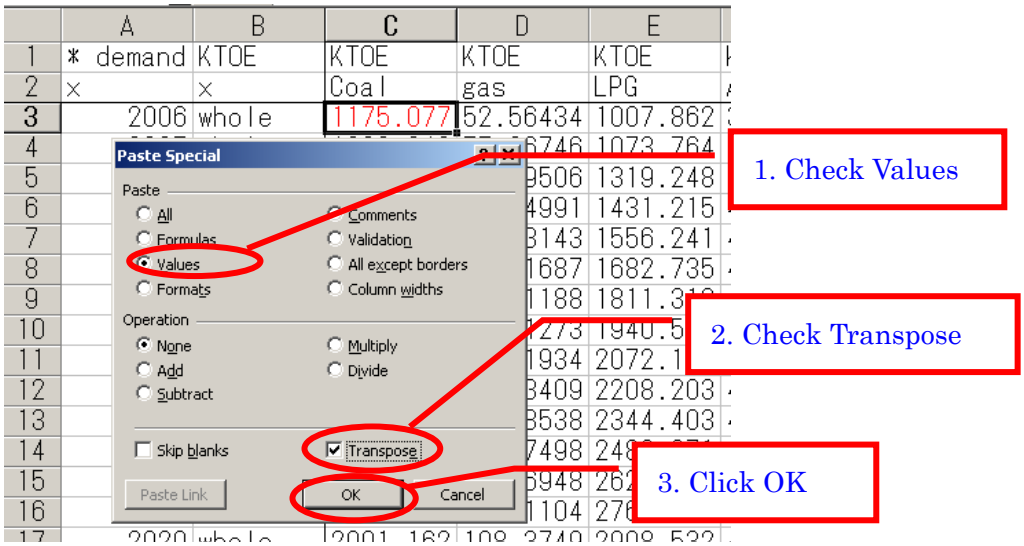
Then, click “Edit” on menu bar and select “Copy”.



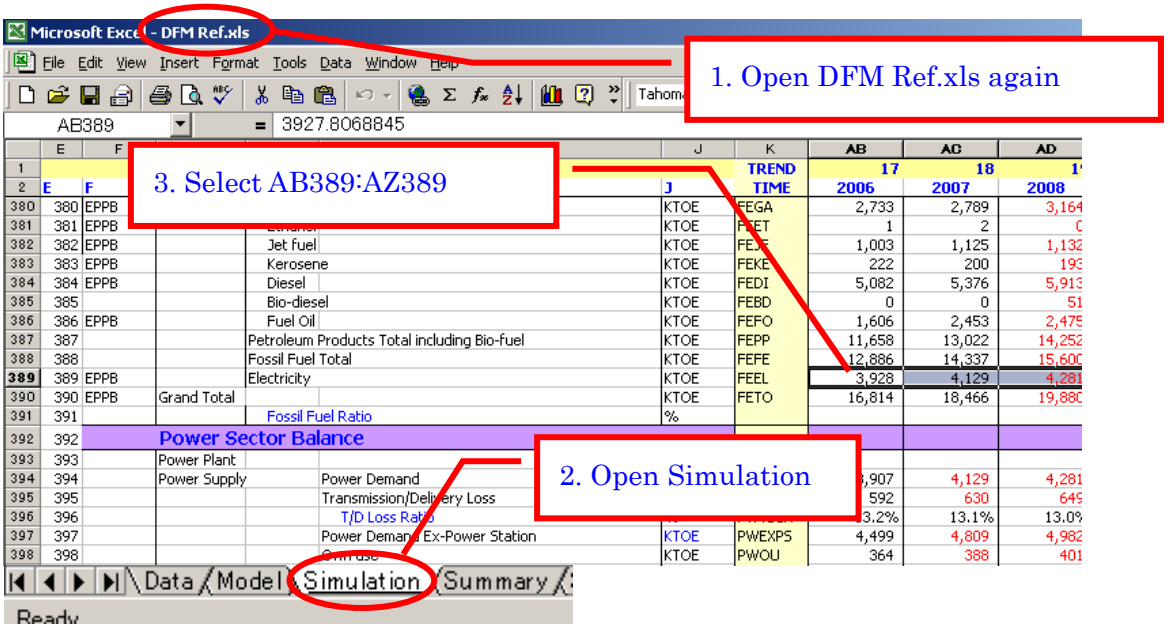
Next, open “input-data.xls” file again and click “demand-sec” sheet. After that, set cursor on Cell C3, then, select “Paste Special” on “Edit” menu.

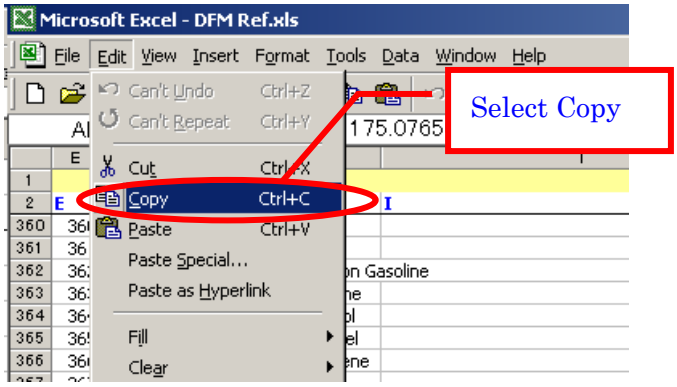


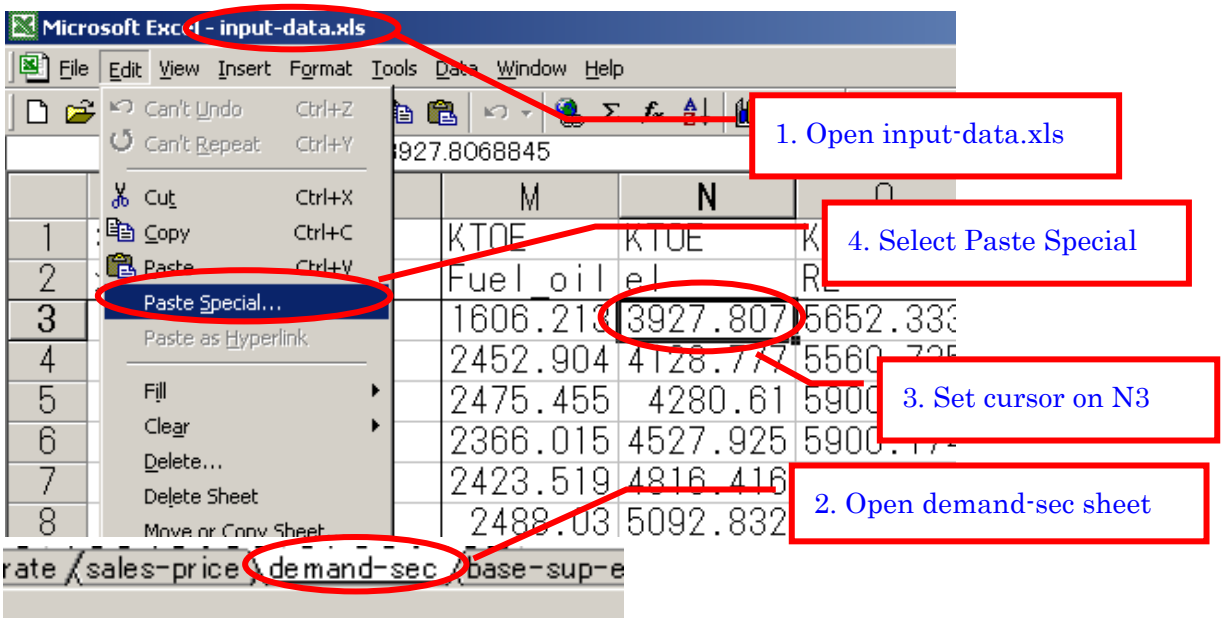
Check “Values” and “Transpose”. Then, click “OK”. Fossil energy data is copied into “input-data.xls”.

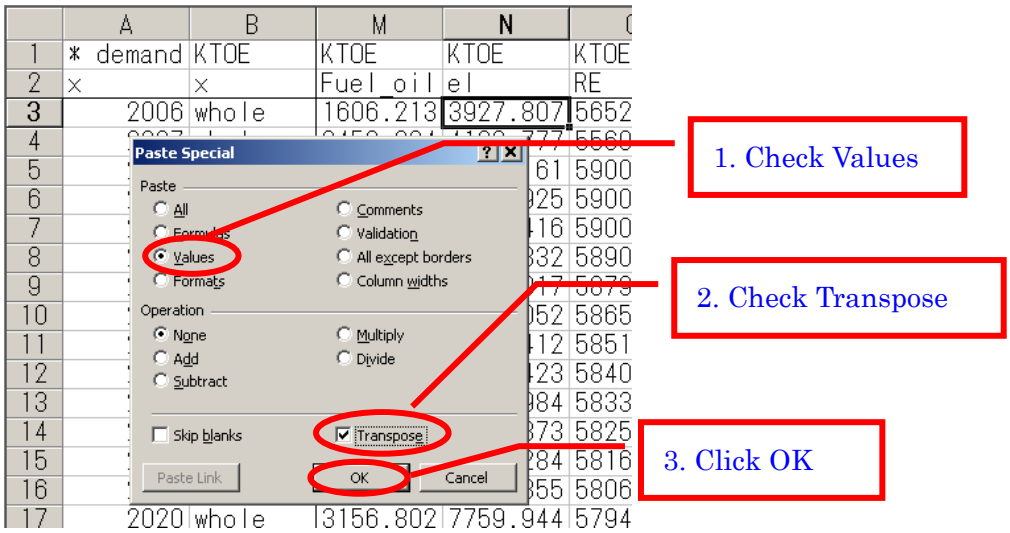


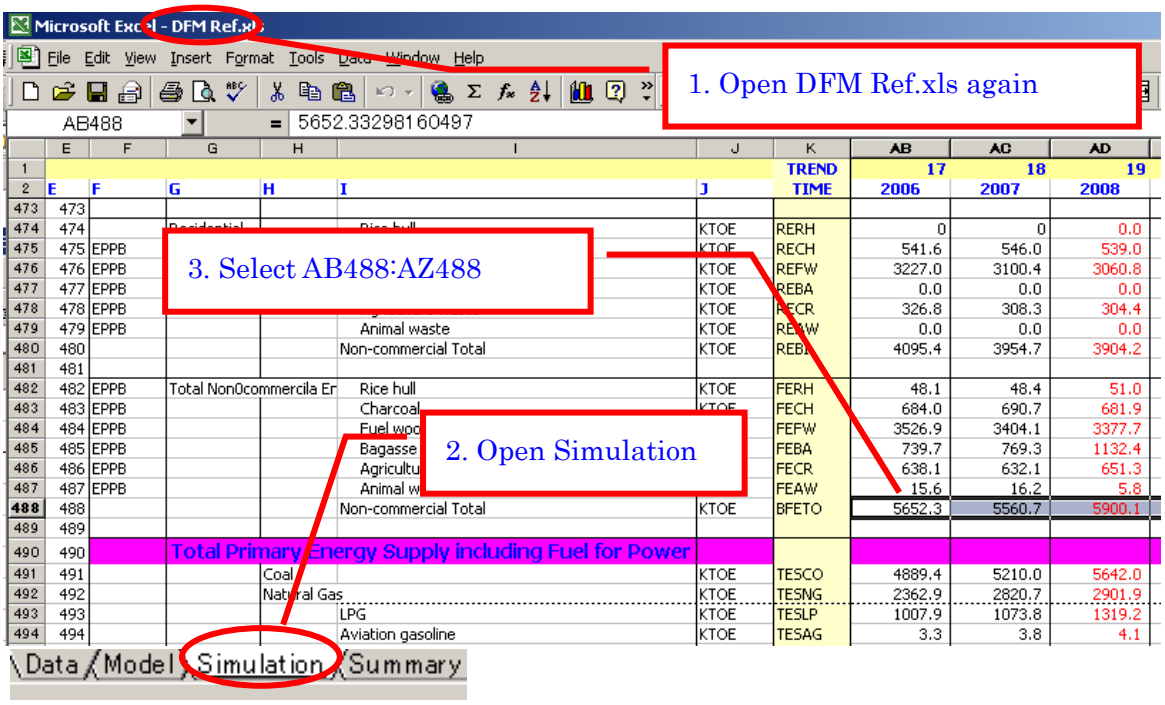
Next, you should import electricity data and non-commercial energy data from “Energy Demand Forecasting Model” same as fossil energy before as follows.

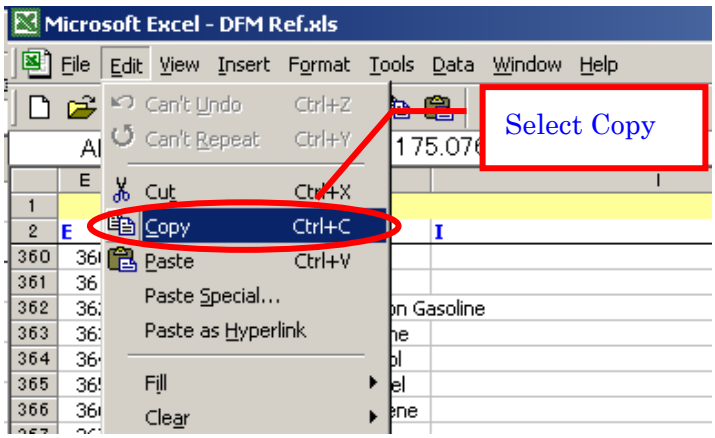


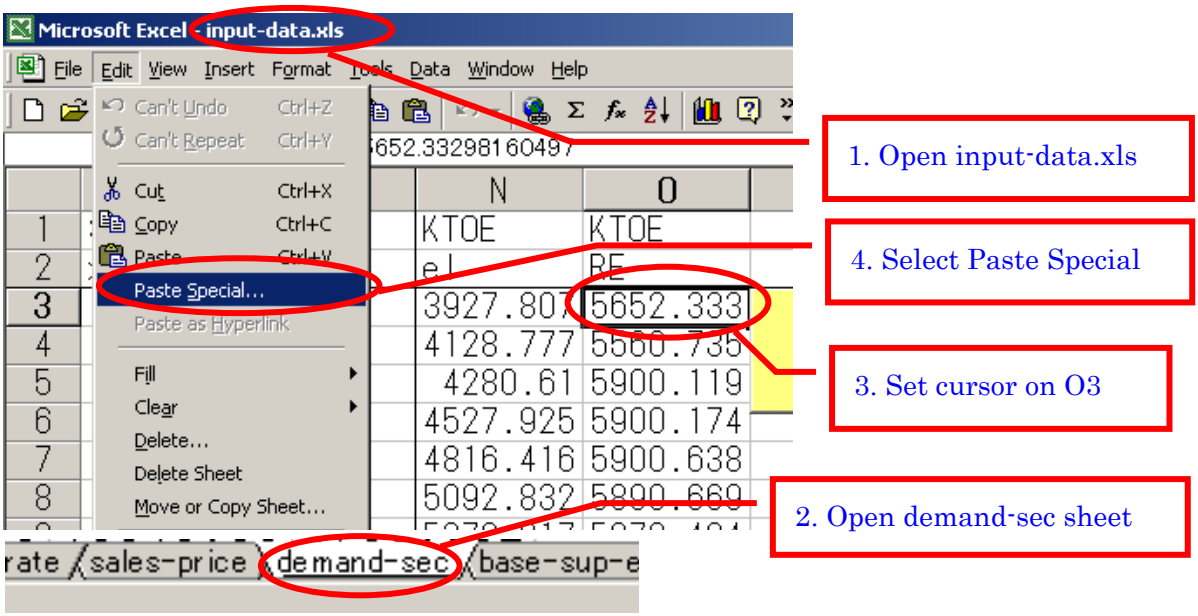


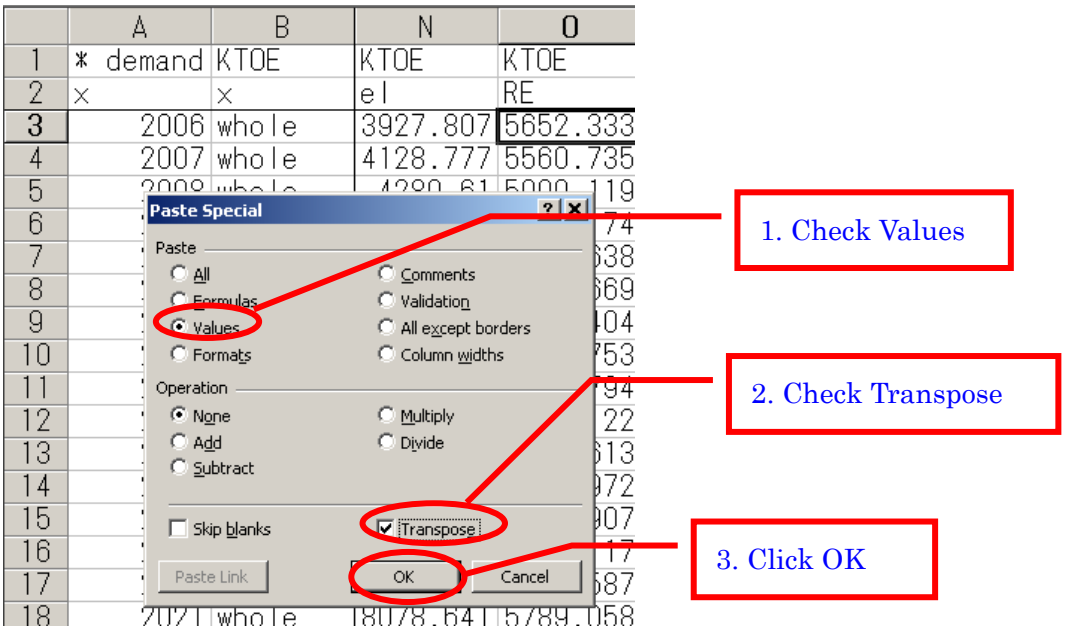



Paste Special
Paste
All
Comments
Formulas
Validation
Values
All except borders
Formats
Column widths
Operation
None
Multiply
Add
Divide
Subtract
Skip blanks
Transpose
Paste Link
OK
Cancel
1. Check Values
2. Check Transpose
3. Click OK


1. Open DFM Ref.xls again
3. Select AB488:AZ488
2. Open Simulation
Data
Model
Simulation
Summary


Microsoft Excel - DFM Ref.xls
File
Edit
View
Insert
Format
Tools
Data
Window
Help
Can't Undo Ctrl+Z
Can't Repeat Ctrl+Y
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Paste Special...
Paste as Hyperlink
Fill
Clear
Select Copy

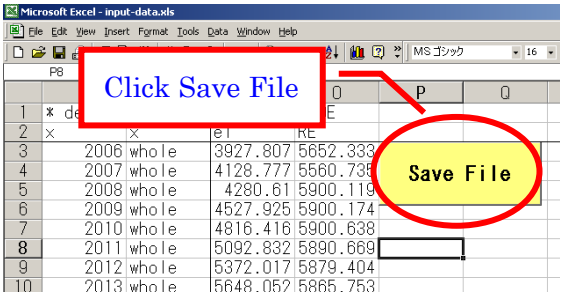


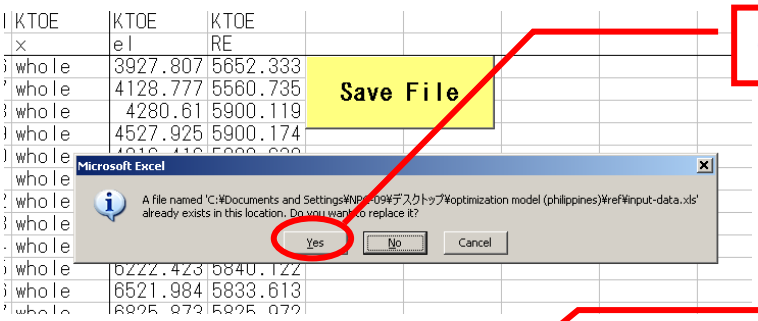


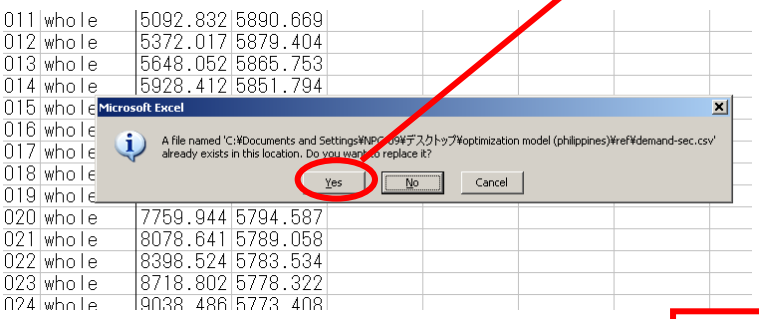
Now, you have imported energy demand data of Reference Case from “Energy Demand Forecasting Model” into “Optimization Model”. The above procedure is the same in cases of BAU, High Growth, Low Growth, EEC, S-EEC, Vehicle-plus, E20, and E85. However, in cases of High Price, Low Price, and S-High Price, you need to import price data from “Energy Demand Forecasting Model” into “sale-price” sheet in “Optimization Model” in addition to energy demand.

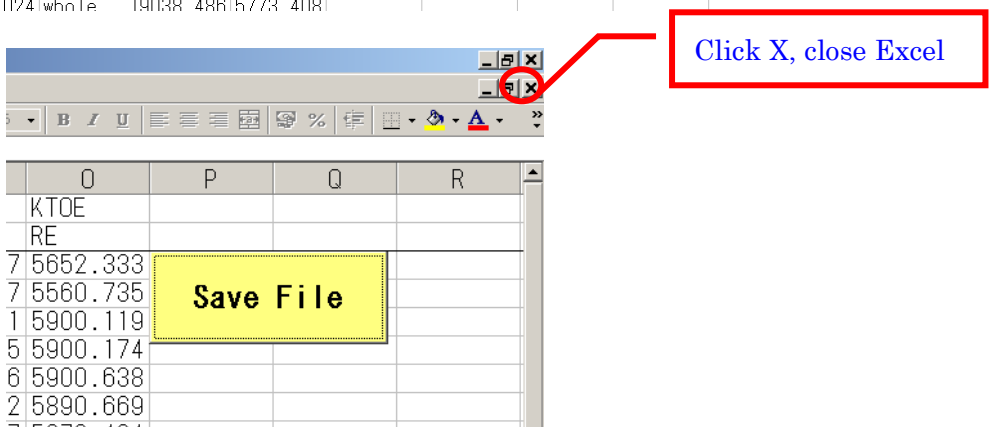
Moreover, in case of nuclear-LNGfree, nuclear-LNGfix, RE2, and RefCap2, you have to change assumption of “base-sup-el”, “capacity”, and “merge-cons-max” sheets. Specialized experience is needed for this assumption setting.

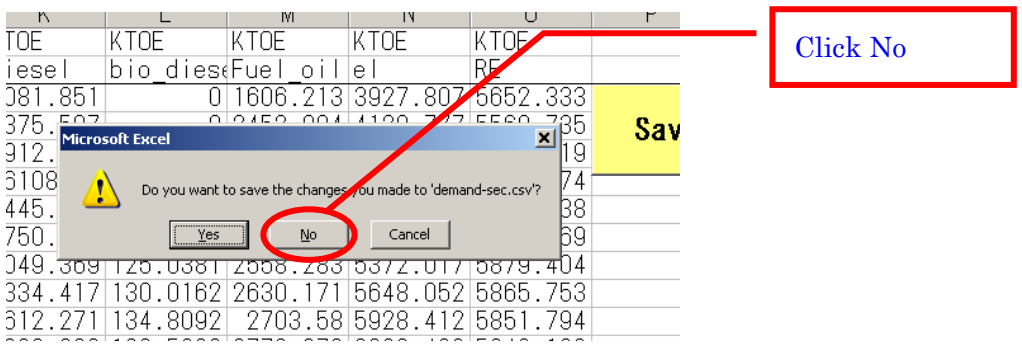
After you finish importing necessary data into “input-data.xls”, click “Save File”. Then, close “input-data.xls” as follows.







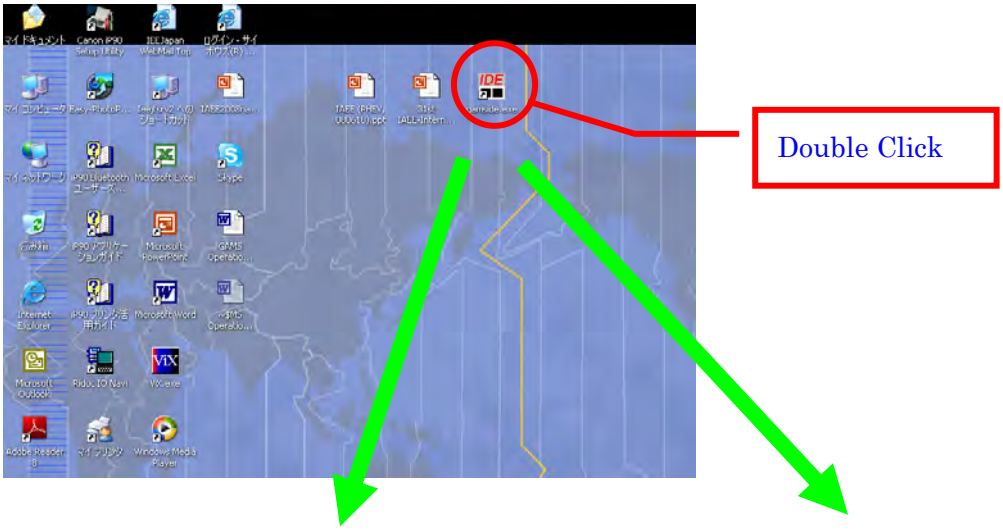


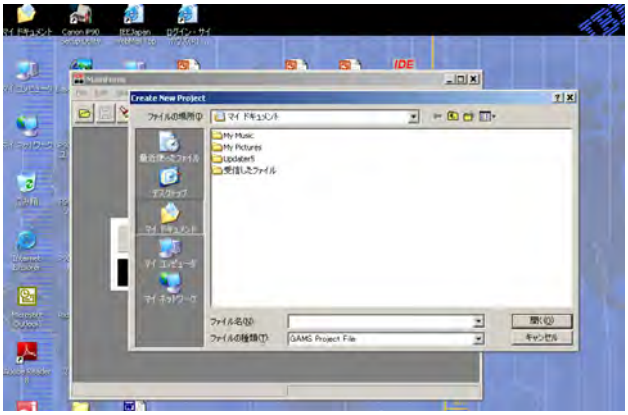


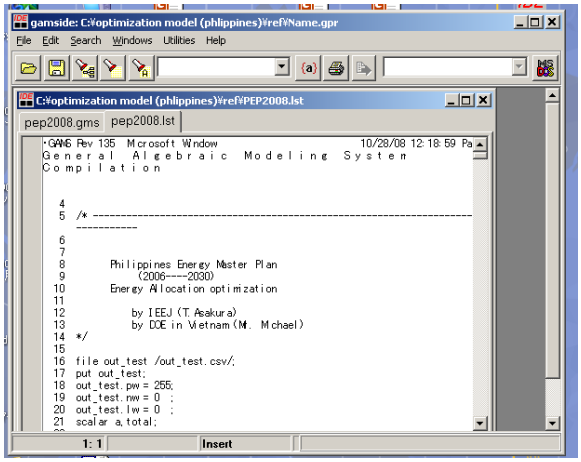
2. Run Optimization Model (GAMS)

After setting input-data, you can run “Optimization Model” as follows.

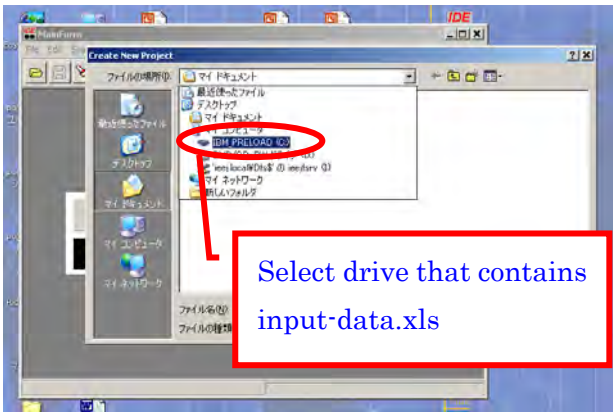
Double-click IDE icon  to open GAMS.

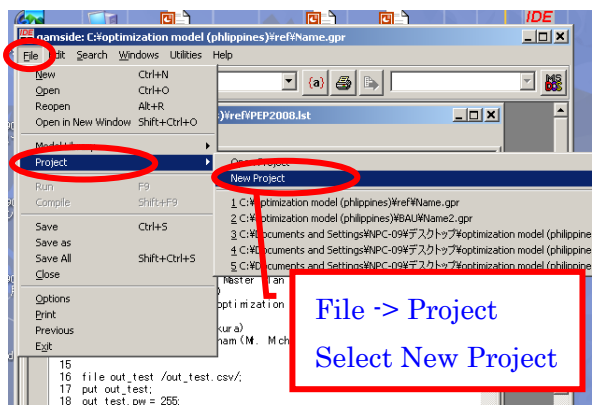


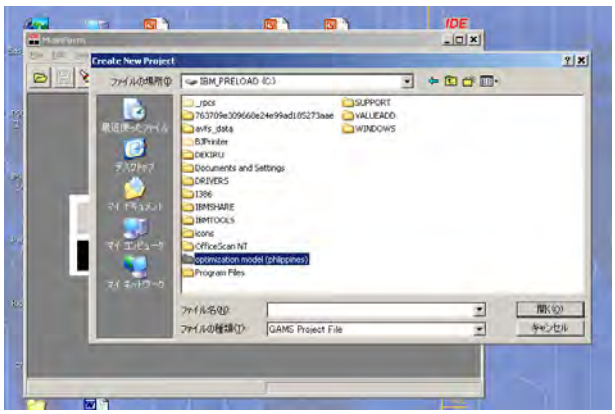


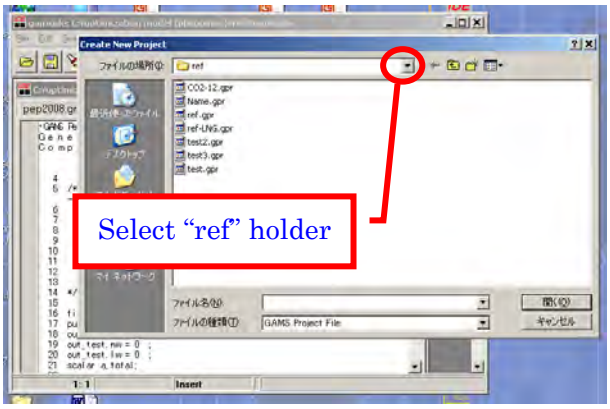


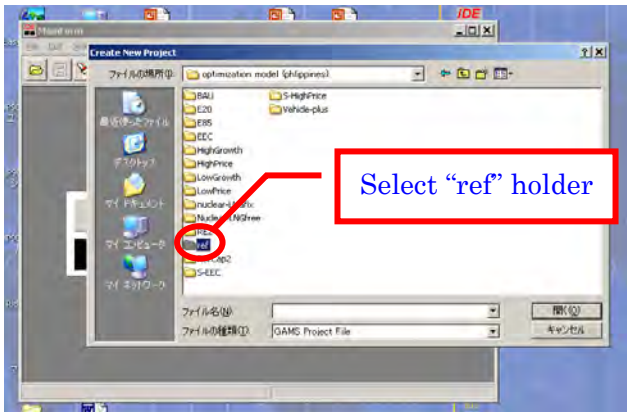
Two patterns will appear according to model condition as follows. Final destination of both patterns is the same to specify the holder. In this case, specified holder is “ref”.

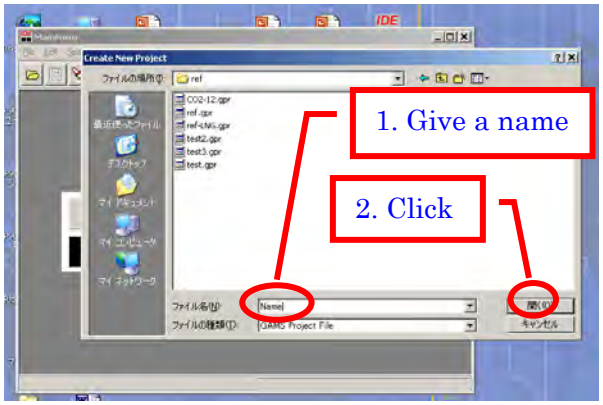


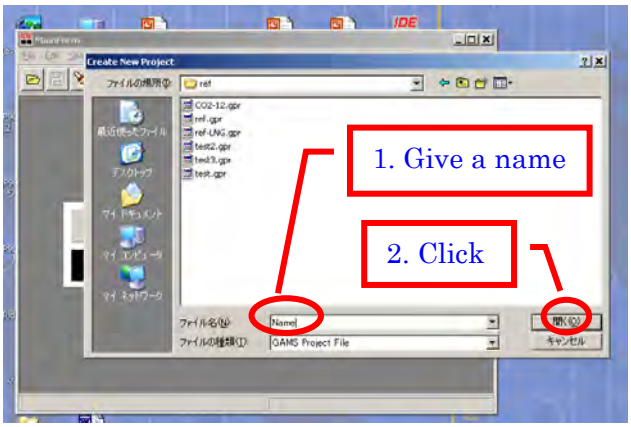




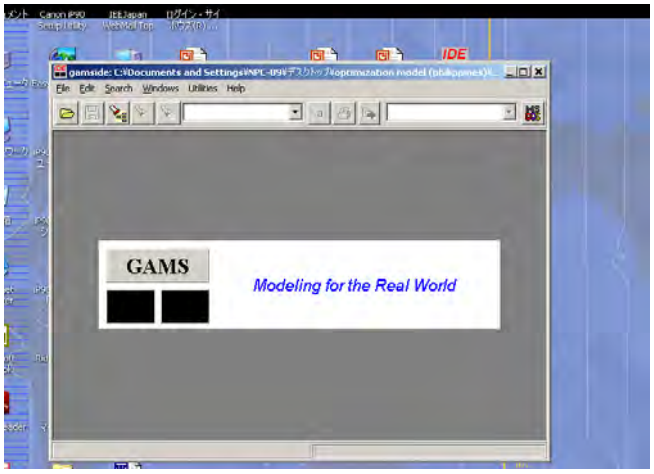

Select “ref” holder

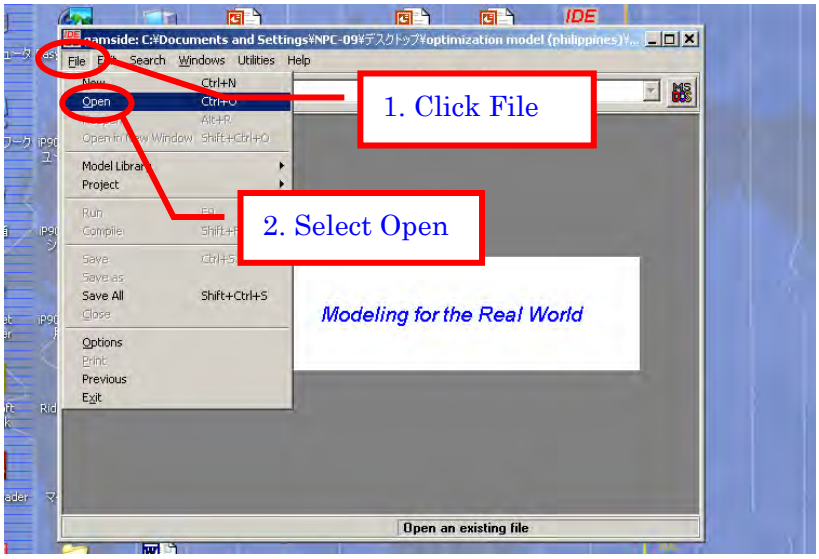

Select “ref” holder

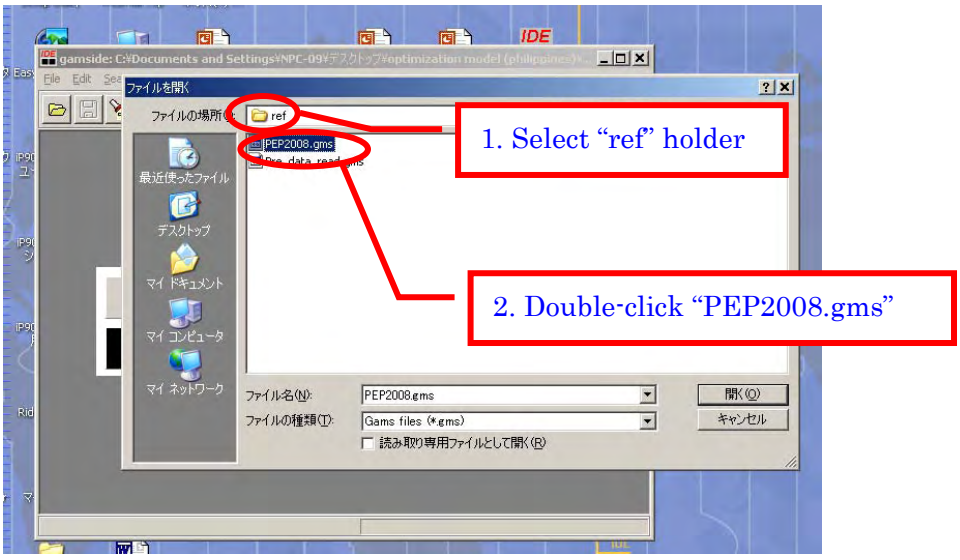

1. Give a name
2. Click


1. Give a name
2. Click

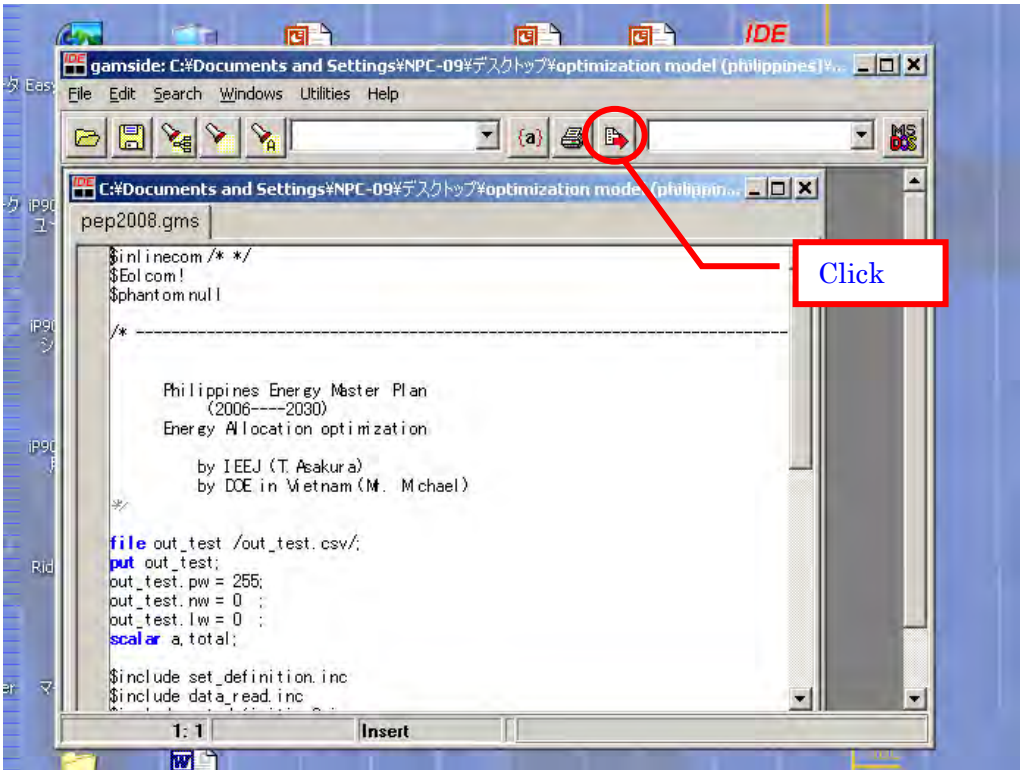
After previous operation, you can find the below screen.



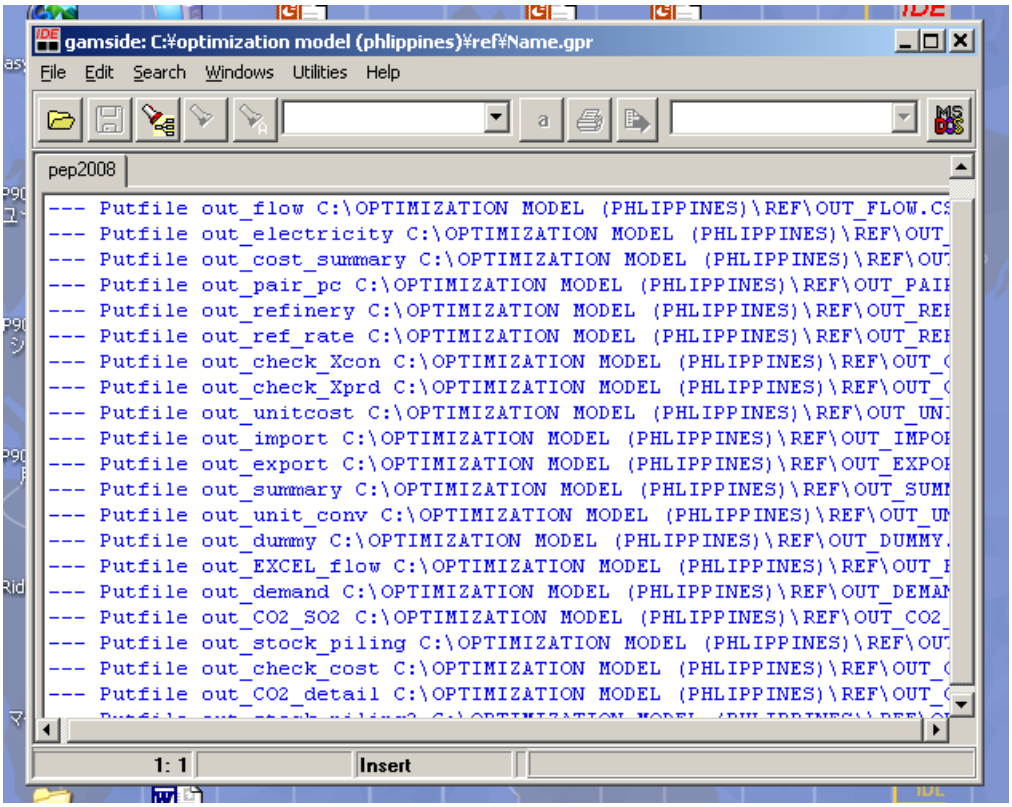




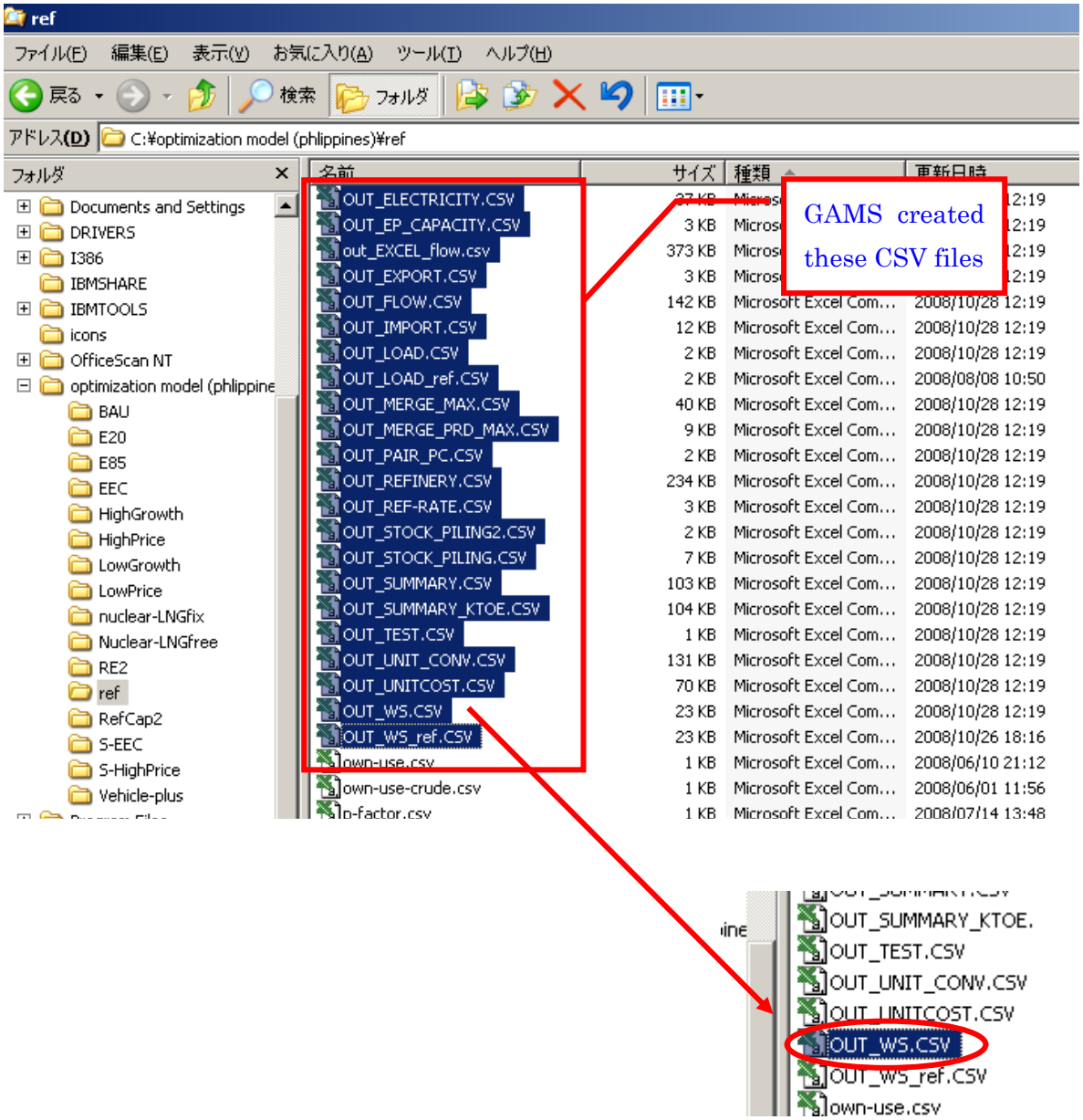
When you click  , “Optimization Model” is running.



The below figure is the result after Model run.

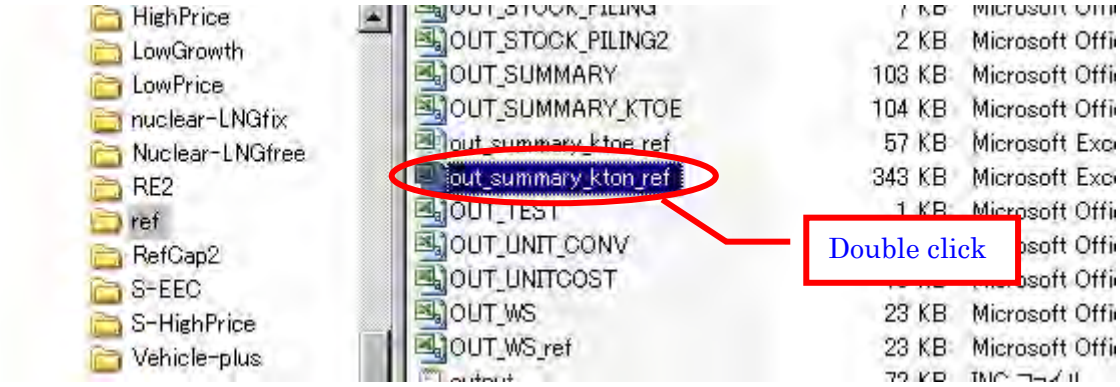


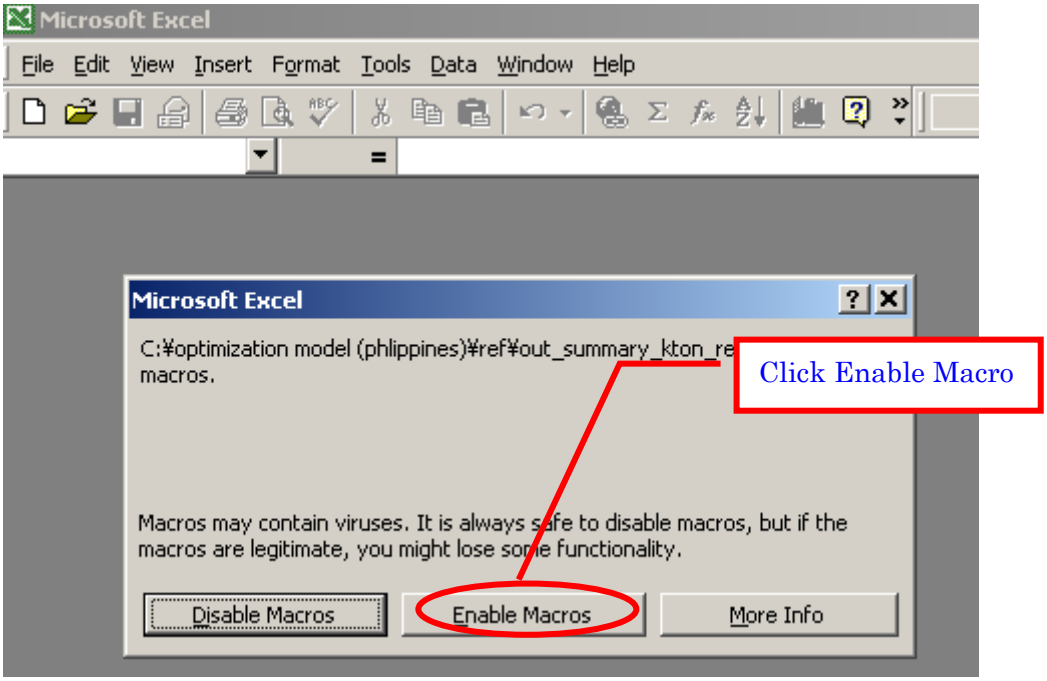
After running model, Optimization Model (GAMS) created many CSV files, “OUT_*******.CSV” as follows. Of which, “OUT_WS.CSV” file is used by “Outlook Summary Model” described in “Attachment-6”.

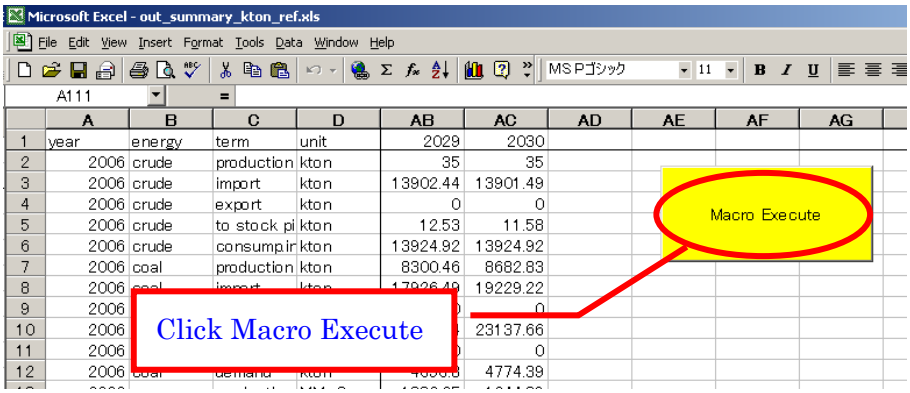


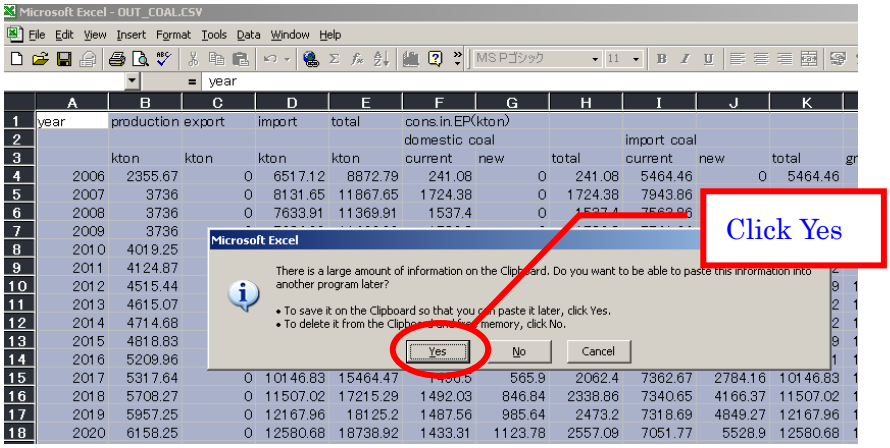
3. Out_Summary Sheet for Energy Balance

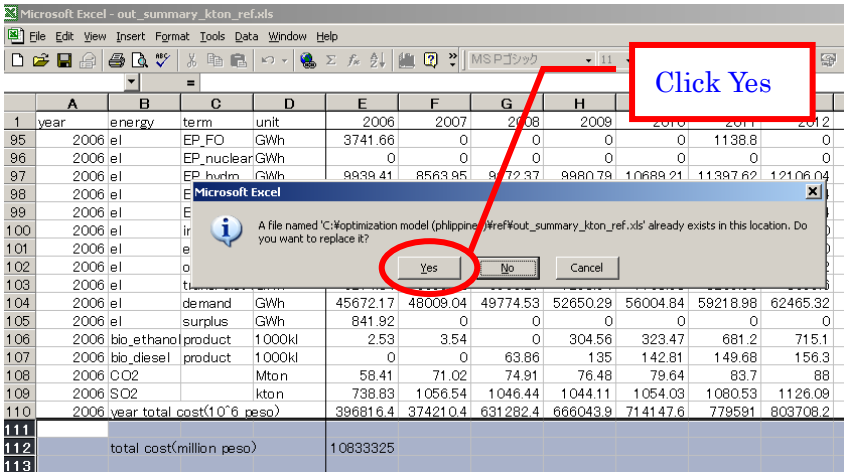
CSV file only is not enough to check the results of the model. So, “out_summary_kton_***.xls” is prepared. This file is very useful to check energy balance.

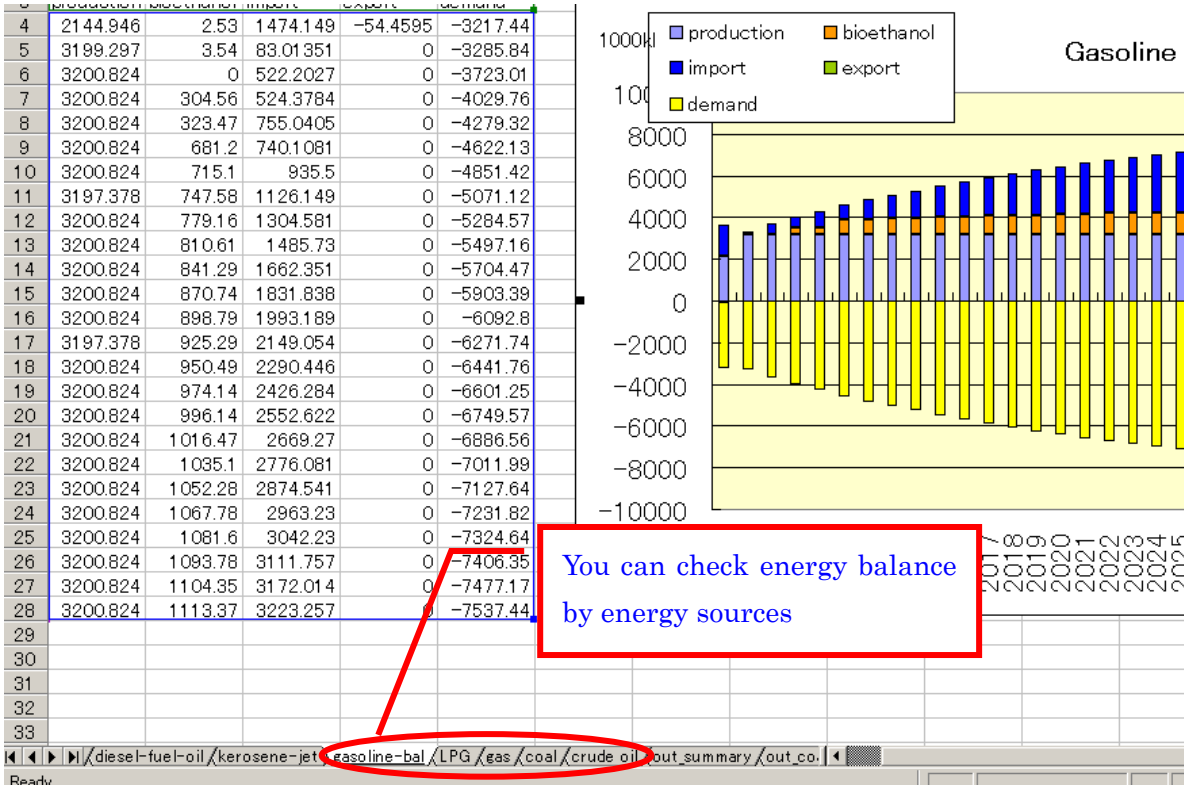







Microsoft Excel - OUT_COAL.CSV
Click Yes
Microsoft Excel
There is a large amount of information on the Clipboard. Do you want to be able to paste this information into another program later?
• To save it on the Clipboard so that you can paste it later, click Yes.
• To delete it from the Clipboard and free memory, click No.
Yes
No
Cancel


Microsoft Excel - out_summary_kton_ref.xls
Click Yes
Microsoft Excel
A file named 'C:¥optimization model (philippine)¥ref¥out_summary_kton_ref.xls' already exists in this location. Do you want to replace it?
Yes
No
Cancel


Gasoline
production
bioethanol
import
export
demand
You can check energy balance by energy sources
diesel-fuel-oil
kerosene-jet
gasoline-bal
LPG
gas
coal
crude oil
out_summary
Ready

Appendix-5-2

Guidance for Supply/Demand Optimization Model

Appendix-5-2 Guidance for Supply/Demand Optimization Model

1 Summary of Supply and Demand Optimization Model

1.1 Objective

The objective of the energy demand and supply optimization model (hereinafter called as "optimization model") is to calculate a logically correct and consistent supply and demand balance of various energies. Demand is forecasted by the demand forecasting model and given to this model as input data. This optimization model decides the amount of each energy supply with minimum total cost under the condition that the given demand should be satisfied. Linear Programming theory is used as the optimization method.

Furthermore, this optimization model can be used as a tool to examine how the energy balance would change under various conditions. In order to facilitate easy comparison study, the program is designed to produce summary sheets of the calculation results.

1.2 Objectives of Optimization Model

1.2.1 Objective Energies

Since the objective of developing the optimization model is to provide basis for formulating the Energy Plan of Philippines, any energy to be used in the country in principle becomes the objective of this optimization model. Thus, 38 types of energy are incorporated in this model, which are as follows.

- Crude oil : Domestic crude oil 1, Import crude oil for distillate and for oil stockpiling
- Coal: Domestic, Import (import coal)
- Gas: domestic (raw gas) and import (PNG, LNG)
- Petroleum products : LPG, LPG substitute, gasoline, kerosene, jet fuel, gas oil, heavy oil
- By product at refinery : off gas, whole range naphtha, light naphtha, heavy naphtha, condensate ,raw kerosene, fine kerosene, raw gas oil, fine gas oil, atmosphere residue from topper, vacuum gas oil, vacuum residue, light cycle oil
- Electricity
- Biofuel (bio-ethanol, bio diesel)

1.2.2 Objective Facilities (Energy Transforming Facilities)

Three kinds of energy transforming facilities are incorporated in the model; they are oil refinery, power plant, and gas processing plant.

- Oil refinery

  An oil refinery composes of topper (atmospheric pressure distillation unit), vacuum distillation unit, reformer, cracking unit, hydro-desulphurization unit, and others. They make up an oil refinery as a package. This model contains the Petron refinery and shell refinery, plus hypothetical general oil refineries.

- Power Plants

Power plants are classified into eight kinds based on the energy source as follows.

Hydro, domestic coal, import coal, gas, fuel oil, diesel, nuclear, and renewable energies

- Gas Processing Plant

At the gas processing plant, raw natural gas sent from offshore is processed. At first, condensate (C5+) is extracted and then the rest of the gas will be natural gas (C1, C2).

1.2.3 Objective Period

The objective period is 25 years from 2006 through 2030 to be covered by the Philippine Energy Plan.

1.2.4 Decision Items

These items are called as variables in the optimization model. The optimization model shall decide the value of these variables in order that the objective function gives the optimum value. These variables are typically production, consumption, import, export and cost of each energy items. The energy consumption quantities calculated by the model indicate the quantities fed to each transformation plant plus those straightly directed to the final consumption.

1.2.5 Objective Function

In the standard case such as the Reference Case, the objective function is defined as the net present value at 2006 of the total cost incurred during the projection period. This objective function can be defined applying other criterion subject to the purpose of analysis.

1.3 Energy Flow

Energy flow is the basic information in compiling an optimization model and is supposed to explain the current and future energy flow of Philippines. Of course, consideration is made on simplification and easiness to understand. Primary energy is produced from mines or oil/gas fields and transformed to secondary energies before delivered to the users via several routes and finally consumed. The energy flow chart illustrates such flow of energy. As it is difficult to show all of them in one figure, they are shown in several figures stage by stage hierarchically in Figure 1～Figure 3.

1.3.1 Total Model Flow

Figure 1 shows the total flow incorporated in this optimization model. This figure shows that demand data is given as input from the result separately forecasted by the demand forecasting model.

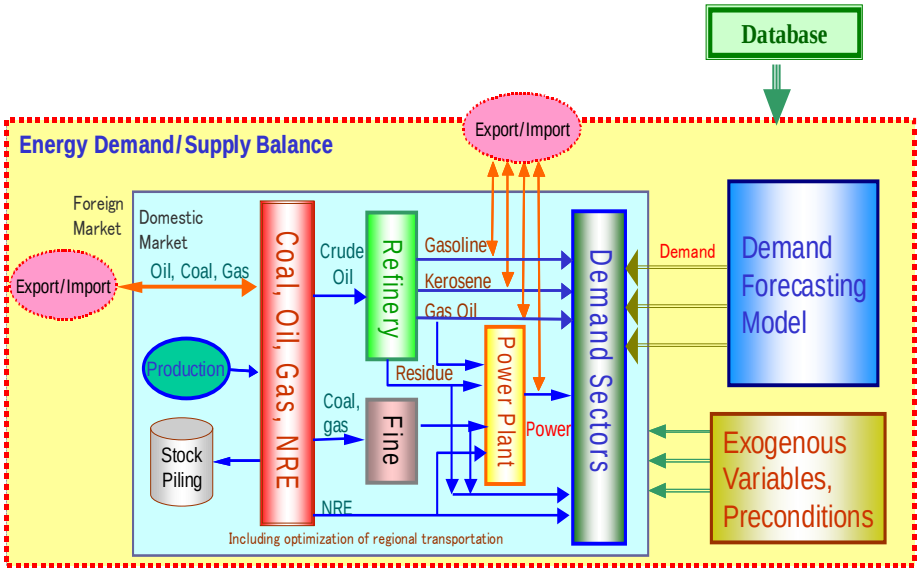


Figure 1 Energy Demand and Supply Optimization Model Total Flow

1.3.2 Model Flow by Energy Sector

The refinery part is composed of three plants. Figure 2 shows the hypothetical flow of No.1 through No.3 refineries incorporated in the model assuming processing of import crude oils.

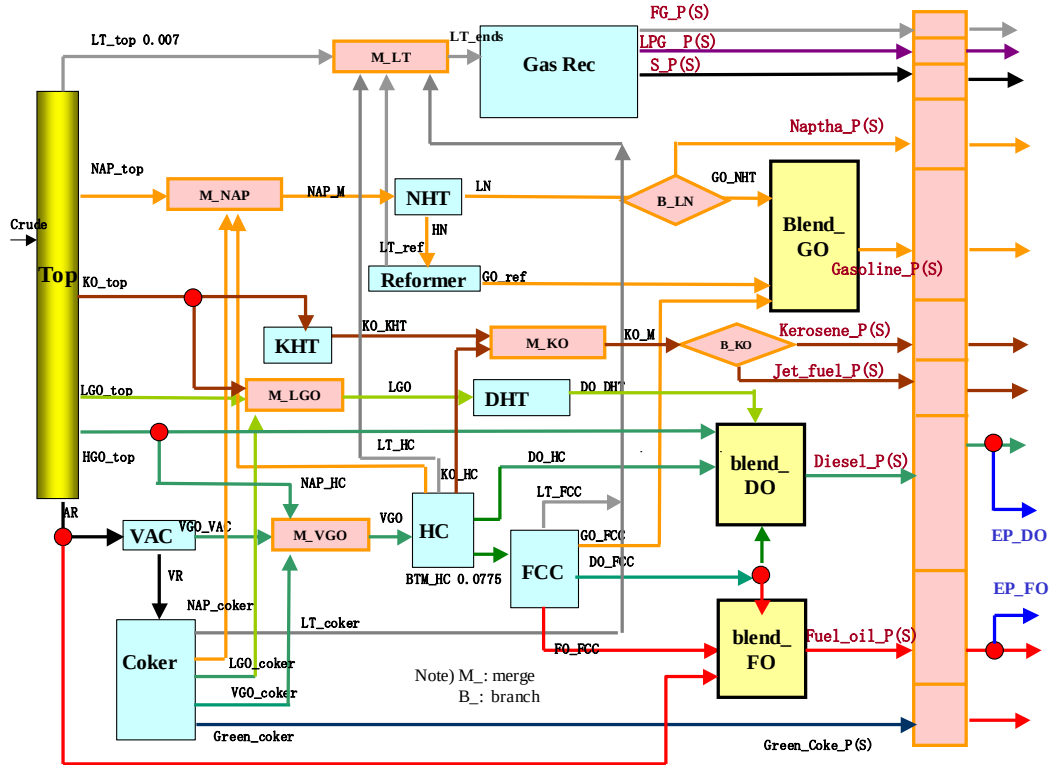


Figure 2 Refinery Plan

Figure 3 is the flow chart including flows of coal, natural gas and power plants. As shown here, produced domestic coal will be directly use for power plant or general users. The raw natural gas is separated at gas processing plant into condensate and natural gas. Among them, the flow chart shows that natural gas will be consumed at power plants and end users.

It is of course possible that, subject to future study, items and types of input/output energies and composition of transforming plants would be changed and the energy flow chart should be modified. Then, the supply optimization model should also be revised to these adjustments, accordingly.

1.3.3 Special Treatment

In this model, special treatments for simplification purpose are made in expression of flows of several energies as follows.

1) As there is no firm plan to utilize propylene produced from RFCC, they are delivered in the model to gasoline and diesel gas oil by 50/50 percents.
2) Whole quantity of BTX produced in the refining process is converted into gasoline.
3) Whole quantity of condensate produced at the gas processing plant is merged to light naphtha.

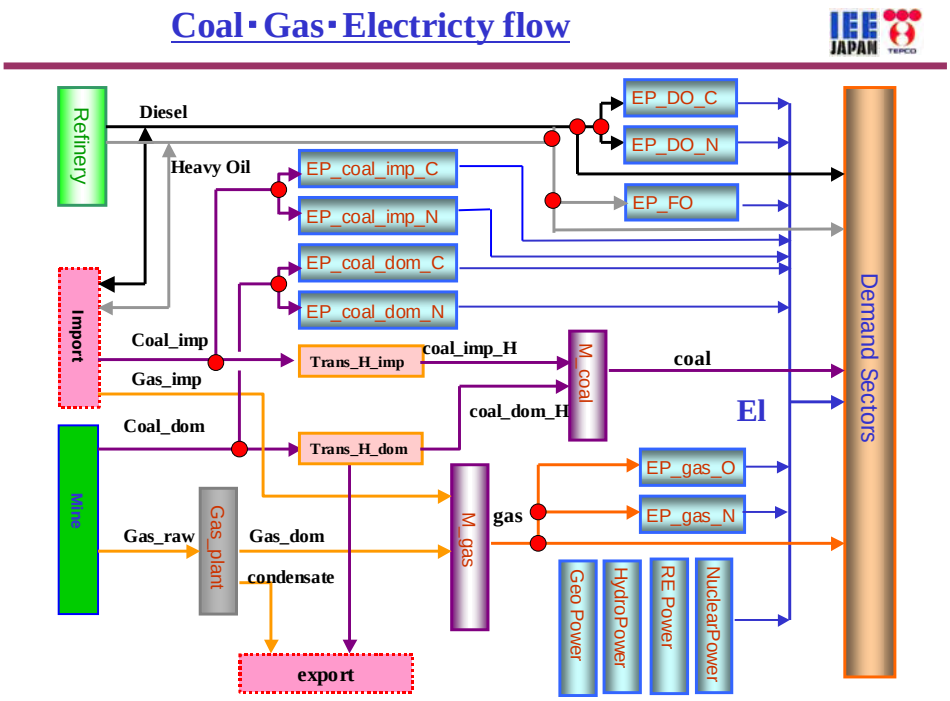


Figure 3 Coal, Gas, Electricity Energy Flow

1.4 Modeling Tool

The basic theory of modeling is LP (linear Programming). In this LP model, all constraints and one objective function should be represented in the form of linear equation. The solution in which an objective function is maximum or minimum under conditions of satisfying all constraints is called as the optimum solution. In case of linear analysis, the solution is mathematically guaranteed as optimal. In case of non-linear analysis, however, there is no mathematical assurance of optimum.

GAMS is used as a modeling tool. GAMS stands for General Algebraic Modeling System and is a product of GAMS Company. A commercial contract is required to use the GAMS official version, while the company distributes a student version GAMS as a free software. Though we can handle a huge model with the official version, there is a limitation on size for the student version, which is maximum 300 variables and 300 constraints. This model is designed that, if we operate it only for one year, we can handle it by the student version for demonstration.

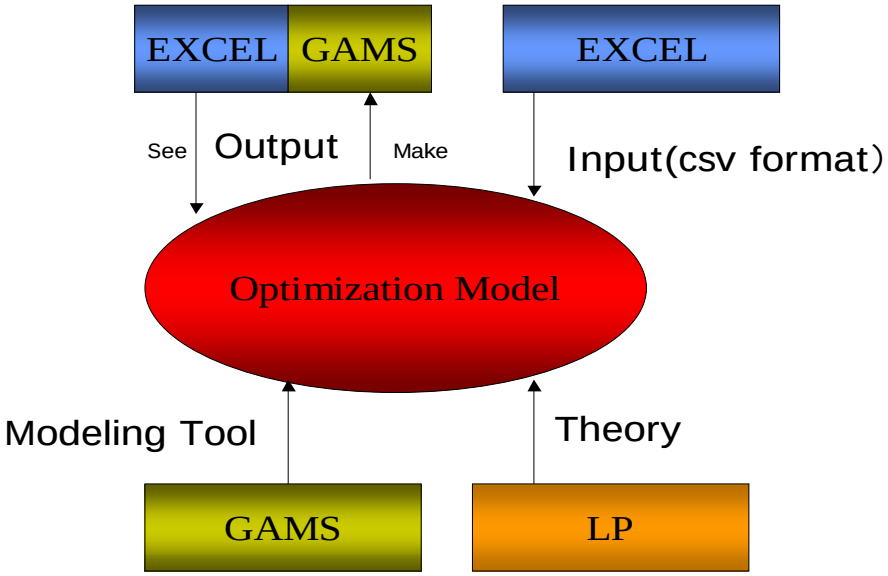


Figure 4 Tool for Model Building

This aims to make the technical transfer easier and familiarization of the Counterpart faster.

Input file is written in EXCEL. One sheet contains one data item. These sheets are housed in one book and there are 36 sheets. As GAMS cannot directly handle a book form of EXCEL, we need to convert them from an EXCEL sheet to a CSV (Comma Separated Value) file one by one. To make this easier, a macro program is added in this input EXCEL book with a function to automatically convert one sheet to one CSV file by one click.

Regarding the output file, over 10 output tables are generated in the CSV file form so that it is easy to read the output tables by EXCEL. The configuration of these tools is shown in Figure 4.

1.5 System Block Flow

Figure 5 shows the system block flow from receiving the demand forecast results to obtaining the final solutions. Extraction from the forecasting model can be done by cut & paste into the input_data.xls. The data from the forecasting model are as follows;

1) Demand by energy, by year
2) Sales price
3) Generation by power plant using RE such as hydro, geothermal, nuclear and RE.
4) Biofuel quantity
5) Non commercial energy(RE)

Other data are those peculiar to optimization model and should be input through key in.

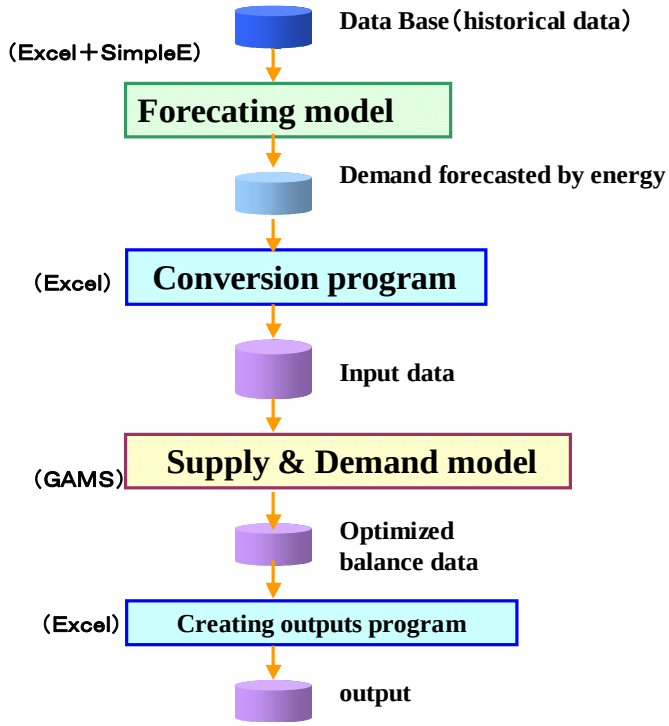


Figure 5 System Flow

1.6 Input Data

There are 43 kinds of data, which is shown in Table 1. The left column 'file name' is the name of input file to GAMS model with extension name 'csv'. The data of No31, 32, and 33 come from forecasting model file by cut & paste.

Table 1 The Input Data

NO	file name	content	input method
1	dummy-control.csv	Control whether balance includes dummy variable.	key in
2	el-data-control.csv	Control whether PDPAT data is used or not	key in
3	cost-unit.csv	Define the unit of cost in output	key in
4	unit-data	Define the constant of unit conversion	key in
5	SG.csv	specific gravity	key in
6	mining-max.csv	max of production of fossil domestic energy	key in
7	EP-capacity.csv	power plant development plan (data is increment)	key in
8	capacity.csv	capacity of facility exclude power plant	key in
9	own-use-crude	fuel amount used in refinery	key in
10	import.csv	import min/max	key in
11	export.csv	export min/max	key in
12	own-use.csv	own-use ration in power plant	key in
13	dist-loss	distribution loss of electricity	key in
14	p-factor.csv	power plant factor(load rate %)	key in
15	heat-value.csv	heat_value of energy	key in
16	therm-eff.csv	thermal efficiency of power plant	key in
17	yield.csv	yield of facility	key in
18	pp-max-rate	petroleum products of maximum rate	key in
19	CO2-max.csv	CO2 emission max in regulation	key in
20	co2-emission.csv	CO2 emission rate	key in
21	S-content	sulphur content ratio	key in
22	stock-init.csv	initial value of oil stockpiling	key in
23	stock-day.csv	oil stockpiling day	key in
24	unit-FOB	Unit of FOB	key in
25	unit-op	Unit of operation & maintenance cost	key in
26	cost-op.csv	Operation/maintenance cost in facility	key in
27	unit-freight	unit of freight	key in
28	freight	cost of freight	key in
29	interest.csv	interest by year	key in
30	exchange-rate.csv	exchange rate	key in
31	sales-price		cut & paste
32	demand-sec.csv	Demand of final users	cut & paste
33	base-sup-el	power generation by hydro, RE, nuclear =fix	cut & paste
34	connect	definition of connection among energies	key in
35	merge-set	definition input & output in merge virtual plant	key in
36	merge-cons-max	max feed in topper	key in
37	merge-cons-min	min feed to plant	key in
38	coal-dom-rate	ratio of domestic coal in coal plant	key in
39	diesel-rate	ratio of disel oil in diesel power plant	key in
40	EP-load-min	minimum load of plant	key in
41	brach-set	definition input & output in branch virtual plant	key in
42	prd-fix	production data fixed in past year 2006	key in
43	domestic-cost	cost of distribution in domestic market	key in

The above EXCEL file is EXCEL book and has many sheets. Each sheet has macro command icon and csv file with the same sheet name is automatically created by clicking the icon.

All data file are always required. Each data has following meanings.

1) dummy-control.csv : In order to avoid infeasibilities, dummy variables are incorporated in a balance equation. Mainly this dummy variables are used in oil product balance equation.

2) el-data-control.csv : Basically generation and fuel consumption data are given by PDPAT. In this case these

data are all fixed. But sometimes power source allocation should be free and the model should select the best power allocation. This control data indicates whether PDPAT data is used or not.

3) cost-unit.csv: These data are for output and means the pair of cost name and unit.

4) SG.csv : The energy which is usually measured by volume should be converted to weight base. In order to convert the unit from volume to weight, the SG(Specific gravity) is used.

5) mining-max.csv: It means the maximum of production of crude oil, coal, gas per year.

6) imp-crude-ratio.csv: This data is regarding an oil refinery. It means the minimum and maximum of import crude oil ratio to total feed to topper.

7)EP-capacity.csv: This data are the increment of power plant. The current capacity should be assigned at the first year (2006).

8) capacity.csv: This data are the capacity of each facility/unit excluding power plant.

9) own-use-crude.csv: The oil refinery uses oil as fuel, which the oil refinery produces by it self. This data means the ratio of crude oil to be used for fuel in its oil refinery.

10) import.csv: The minimum and maximum of import energy

11) export.csv : The minimum and maximum of export energy

12) own-use.csv: The power plant uses part of electricity generated as utility. Own use data is given as ratio to total generation. But in the Vietnamese statistics generation amount is measured at the point of sending end, so this data is always 0.

13) dist-loss.csv: Some of electricity distributed is lost during transmission / distribution. This amount is also proportional to generation, so this data is a ratio to generation.

14) p-factor.csv : Plant factor by power plant class (P-factor means the percentage of capacity use) or plant load

15) heat-value.csv: Every energy emits heat when it is burnt. That is heat value. This data is used for unit conversion from weight/volume to ton oil equipment (toe) or calculating fuel consumption in power plant. But in the case that PDPAT is used, this calculation is not done.

16) therm-eff : Thermal efficiency by power plant type

17) yield.csv : Yield means the ratio of products to one unit feed. For example, if 1 bbl of crude oil is fed into topper, the ratio of the amount of gasoline produced is gasoline yield.

18) pp-max-rate.csv: This data means the maximum the product rate of gasoline & diesel. This data is defined in order to match the calculated rate of petroleum product with the actual data. If the rate of gasoline and diesel are similar to the actual data, another petroleum product's rate will be similar.

19) CO2_max.csv: The specified value of CO2 emission max as regulation. If there is no regulation, this value should be very large.

20) CO2-emission.csv: In order to calculate total CO2 emission, the CO2 emission ratio of each energy per unit weight is required.

21) S-content.csv: In order to calculate SO2 emission, the sulfur emission rate of each energy per unit weight is required.

22) stock-init.csv: In order to calculate the oil stockpiling, the oil inventory of oil previous year when oil stockpiling calculation begins should be given as the initial stock(inventory)

23) stock-day.csv: The oil for stockpiling should be stocked for specified days of the total consumption of oil

products. This specified day is called stock_day.

24) unit-FOB.csv : The unit of sales-price

25) unit-op.csv : The unit of operation and maintenance cost

26) cost-op.csv : Cost of operation / maintenance of facilities

27) unit-freight.csv : The unit of freight

28) freight.csv : Cost of freight

29) interest.csv : Interest by year

30) exchange-rate.csv : Exchange rate by year

31) sales-price.csv : Sales price of each energy

32) demand-sec.csv : Demand by sector or total demand by energy

33) bas-sup-el.csv : Generation by power plant(hydro, nuclear, geothermal, RE)

34) connect.csv : This data represents the connection of every energy. The connection means here production (plant, feed), consumption(plant), import and export (permitted or allowed?)

35) merge-set.csv : Definition of product energy and feed energy in merge plant

36) merge-cons-max.csv : The plant with 2 different name but the only one plant like coal power plant with domestic and import coal as feed fuel has the maximum feed quantity.

37) merge-cons-min.csv : The plant with over 2 feeds has to be consumed a specified quantity.

38) cost-dom-rate.csv : The maximum rate of domestic coal feed to total feed into coal power plant.

39) diesel-rate.csv : The maximum rate of diesel oil feed to total feed into diesel oil power plant.

40) EP-load-min.csv: Minimum load of a specified power plant.

41) branch-set.csv : Definition of product energy and feed energy in branch plant

42) prd-fix.csv : Production data fixed in 2006

43) domestic-cost.csv : Expenditures of energy in order to deliver to users.

1.7 Constraints

There are 29 kinds of constraints. Table 2 shows all constraint lists. All these constraints are not always used. Sometimes some equations are not used. Sometimes the constraint is defined, but it has no meaning. For example if there is no CO2 emission regulation, input data CO2 emission max is very large value. So CO2 max constraints is substantially useless.

In the following explanation on equations , a rule applies that a blue letter means the variable which the model can decide with optimal objective function, and black letters mean data given as input data.

Table 2 Constraint List

No	name	target	content
1	eq_connect	all energies	Def of energy flow(prod, cons, import,export)
2	eq_dummy	all dummy variables	Def of plus and minus dummy variable
3	eq_branch	energy in branch plant	Def input and output of virtual plant 'branch'
4	eq_merge	energy in merge plant	Def input and output of virtual plant 'merge'
5	eq_merge_cons_max	crude feed to topper	total of domestic & import crude feeding to topper
6	eq_merge_cons_min	gas EP feed	minimum feed to gas EP
7	eq_merge_prd_max	gen max from coal EP	Total of generation from dom and imp coal in EP
8	eq_trans_heat	coal	Unit conversion from weight to calorie in coal
9	eq_pp_max_rate	PP=petoleum products	Final petroleum products max rate constraints
10	eq_yield	topper, gas plant	production = yield*(feed to plant)*(1-own_use_crude)
11	eq_power	EP=power plant	Def of the relation of fuel quantity and generation
12	eq_coal_dom_max	dom coal in EP_coal	Def of the max consumption of dom coal in EP-coal
13	eq_EP_coal_fix	coal in EP_coal	Def of total genaration from coal EP at 2006
14	eq_EP_DO_fix	feed in EP_DO	Def of total genaration from diesel EP at 2006
15	eq_EP_DO_rate	DO max in EP_DO	Def of the maximum consumption of DO in EP-DO
16	eq_EP_load_min	diesel oil EP	Def of load min of EP
17	eq_own_use	own use electricity	Def of own use electricity in EP itself
18	eq_dist_loss	power distribution loss	Def of power loss in sending& distribution line
19	eq_bal_stockpiling	crude imp for SP	import of crude oil for stockpiling
20	eq_stock_piling	crude inventry for SP	the necessary oil stockpiling this year
21	eq_co2_gas	gas	CO2 emission calculation from gas consumption
22	eq_co2_coal	coal	CO2 emission calculation from coal consumption
23	eq_co2_oil	petroleum production	CO2 emission calculation from PP consumption
24	eq_co2_max	total co2	Def of total co2 emission by year
25	eq_so2	all energy	SO2 emission calculation from all energy
26	eq_cost	cost	cost by each year
27	eq_cost_real	cost	cost exclude dummy cost
28	eq_obj_cost	eq_obj_cost	obj cost including dummy cost = objective function
29	eq_obj_cost_real	eq_obj_cost_real	obj cost excluding dummy cost

1) eq_connect (Balance equation of every energy)

production + import – export – consumption = 0

These constraints should be defined for every energy. All information for creating these equations are stored in connect.csv. Production, consumption, import, and export should all not always require to exist. Elements of these constraints are sometimes production and consumption, sometimes import and consumption, sometimes production and export like condensate. Production and consumption sometimes have over 2 elements. For example, feed materials are domestic crude and import crude oil. So energies produced from topper have 2 routes depending on feed energy. Sometimes consumption has also over 2 elements. For example, energies consumed in final user and power plant has 2 consumptions.

Coding : eq_connect(y,class,c)$connect_cc(y,class,c)..

sum((p,xc,f,xf,xclass,xp)$connect(y,c,class,p,xc,f,xf,xclass,xp),

(Xprd(y,class,p,xc,c) + p01(f)*Ximp(y,c)-p01(xf)*Xexp(y,c) -

Xcon(y,xclass,xp,c))) +

coeff_dum(y,c)*Xdum(y,c) =e= 0;

If this energy c can be imported, then p01(f) = 1 else p01(f) = 0;

If this energy c can be exported, then p01(f) = 1 else p01(f) = 0;

Xprd(y,class,p,xc,c) : production , y means year

class means petron or shell or whole

p means plant where energy c is produced

xc means feed material to plant p

c means target energy

Ximp(y,c) : import

Xexp(y,c) : export

Xcon(y,xclass,xp,c) : consumption, xp means plant where energy c is consumed

Xdum(y,c) : dummy

If energy c has dummy element, then coeff_dum(y,c)=1, else 0

Example : energy = diesel

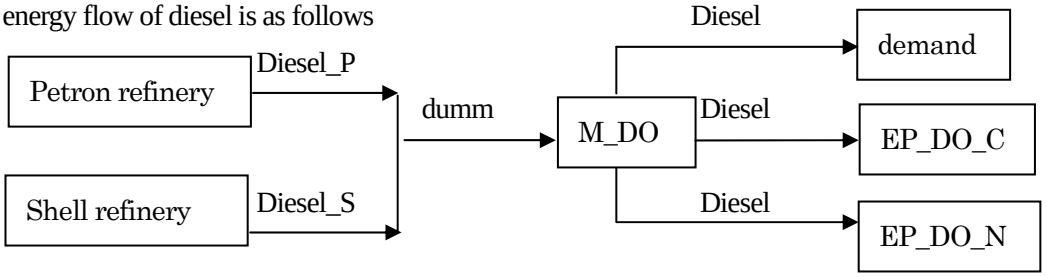
- Input data (connect.csv)-

Energy	class	plant	feed energy	import	export	class	plant	--------- heading
Diesel	whole	M_DO	dummy	yes	yes	whole	demand	(a)
Diesel	whole	NP	dummy	none	none	whole	EP_DO_C	(b)
Diesel	whole	NP	dummy	none	none	whole	EP_DO_N	(c)

- Input data (dummy-control.csv)-

year	energy	
2006*2030	diesel1	← coeff_dum(y,diesel)

The energy flow of diesel is as follows



The meaning of the above energy flow

Diesel oil can be produce at plant M_DO with feed material dummy

Dummy = diesel_P + diesel_S (P: petron, S: Shell)

This issue is defined in merge.csv

This equation is represented in another equation name later.

M_DO : merging plant (virtual plant)

Diesel oil can be imported and exported because the data have both yes under the import and export heading. Also diesel oil is consumed in final use. Demand means a kind of plant and means consumption in final user in this model.

Diesel oil is consumed in diesel current power plant, EP_DO_C.

NP means No Plant, that is the production is already defined in (a), so no need to define the production in this line.(NP is key word in this model.)

Diesel oil is also consumed in diesel new power plant, EP_DO_N.

Thus above 3 lines define the diesel oil balance. That is the diesel oil is produced from M_DO plant and can be imported / exported and is consumed in final user, current and new power plant.

GAMS develops the above equation definition as follows;

Example in 2030

eq_connect(2030,whole,diesel)..

Xprd(2030,whole,M_DO,dummy,diesel)

- Xcon(2030,whole,EP_DO_C,diesel) - Xcon(2030,whole,EP_DO_N,diesel)

+ Ximp(2030,diesel) - Xexp(2030,diesel) + Xdum(2030,diesel) =E=

9089.50633333333 ;

└──────→ demand(input data)

2) eq_dummy

Sometimes the system cannot get optimal solution. This thing is called infeasible. If infeasible phenomenon happens, the cause of infeasibility should be found out. Sometimes it is very easy to find the cause. Sometimes it takes much time to find out it. There is no royal road to find out the infeasible cause. It depends on the experience of model analyzer. In order to avoid the infeasibility each balance equation can include the dummy variable. Even if there is actually no feasible solution, the surplus or deficit can be absorbed in the dummy variable. So there is no infeasibility on the surface.

Of course after finishing calculation, the check whether every dummy variable has positive value or not should be done. If a dummy variable has positive variable, it means that there is no feasible solution. This Philippines model is not so complex comparing with usual LP system. So it is not so difficult to find the cause which the dummy variable has positive value.

There are 2 reasons that dummy variables have positive values. One is that there is surplus of energy, another is that deficit of energy. That means the energy cannot be balanced.

If surplus is positive, deficit is minus.

So 3 kinds of dummy variables should be defined like Xdum_P, Xdum_M and Xdum.

Xdum_P(non negative variable) : If the deficit occurs, Xdum_P has positive value.

Xdum_M(non negative variable) : If surplus occurs, Xdum_M has positive value.

Xdum(free variable) = Xdum_P – Xdum_M

Xdum can have positive value, 0, negative value.

It will not occur that both Xdum_P and Xdum_M have positive.

So Xdum = Xdum_P or Xdum = - Xdum_M.

These dummy variables are used as follows;

Xdum is used in the energy balance equation. Xdum_P and Xdum_M are used in cost definition equation. If dummy variables have positive value, the model is supposed that the cost will be very large. The objective function should be minimum. So if there is feasible solution, dummy variable should be = 0.

From above explanation, this equation is the technical and artificial equation.

coding :eq_dummy(y,c)$(target_year(y) And

coeff_dum(y,c)>0)..

Xdum(y,c) =e= XdumP(y,c) - XdumM(y,c);

GAMS develops the above equation definition as follows;

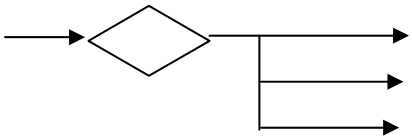
Example electricity in 2030

eq_dummy(2030,el).. - XdumP(2030,el) + XdumM(2030,el) + Xdum(2030,el) =E= 0 ;

3) eq_branch (target : material which branches into over 2 materials)

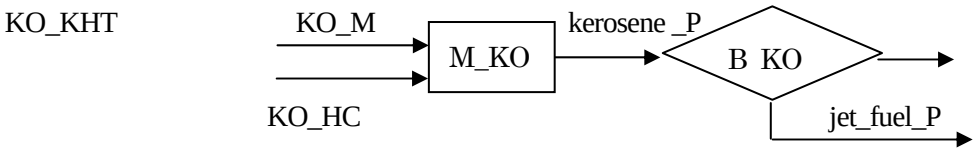
consumption(feed to branch virtual plant) = production(energy1) + production(energy2) + …..

Example1 : kerosene can be evaluated as kerosene and jet fuel based on objective function.
Example2 : Some of the residue from topper goes to Vacuum distillation and fuel oil blend.



consumption (feed to branch plant) = sum(branch amount ai)
coding: eq_branch(y,class,c,p)$(target_year(y) And
branch_cp(y,class,c,p))..
Xcon(y,class,p,c) =e= sum(xc$branch(y,class,c,p,xc),Xprd(y,class,p,c,xc));

Example kerosene in petron refinery branches into kerosene and jet fuel



The meaning of above flow.

KO_KHT : kerosene after hydro treating operation
KO_HC : kerosene after Hydro cracking operation
KO_M : kerosene merged by KO_KHT and KO_HC
(KO_KHT+KO_HC = KO_M)
kerosene_P : kerosene from petron refinery
jet_fuel_P jet_fuel from petron refinery

GAMS develops the above equation definition as follows;
Example B_KO petron refinery in 2030
eq_branch(2030,petron,KO_M,B_KO)..
- Xprd(2030,petron,B_KO,KO_M,kerosene_P)
- Xprd(2030,petron,B_KO,KO_M,jet_fuel_P) + Xcon(2030,petron,B_KO,KO_M)

The equation regarding M_KO is defined in equation eq_merge explained in the next paragraph “eq_merge”.

4) eq_merge (target : merge virtual plant)

Merging

The merging operation is the reverse to branch operation. That is, many feed materials are merged into 1 material.

This data is defined in input data, merge.csv

The sample of M_KO

year	class	feed	plant	output			
2006*2030				petron	KO_KHT	M_KO	KO_M
merge(y,class,xc,p,c),							
2006*2030				petron	KO_HC	M_KO	KO_M

(input data)

coding:eq_merge(y,class,p,c)$(target_year(y) And
merge_pc(y,class,p,c))..

Xprd(y,class,p,'dummy',c) =e= sum(xc$merge(y,class,xc,p,c),Xcon(y,class,p,xc)) ;

GAMS develops the above equation definition as follows;

Example M_KO of petron refinery in 2030

eq_merge(2030,petron,M_KO,KO_M)..

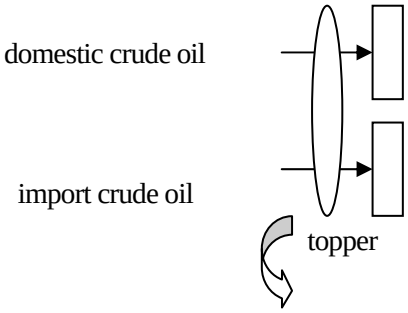
Xprd(2030,petron,M_KO,dummy,KO_M)

- Xcon(2030,petron,M_KO,KO_KHT) - Xcon(2030,petron,M_KO,KO_HC) =E= 0 ;

5) eq_merge_cons_max (target : topper plant)

consumption in (domestic crude oil feed + import crude oil) =< maximum feed crude oil

The topper plant consumes simultaneously both domestic crude oil and import crude oil. But the yield of topper plant depends on feed crude oil. But topper plant's capacity is defined as the maximum total feed crude oil. This maximum capacity is defined in this equation.



Total feed has the maximum which is the capacity of topper.

input data

sample (petron refinery)

*year	class	plant	feed	value
2006*2030	petron	topper	crude_dom	180
2006*2030	petron	topper	crude_imp	0

In this case the topper capacity is 180 + 0 = 180 (bpsd)

coding: eq_merge_cons_max(y,class,p)$(target_year(y) And
merge_cons_max1(y,class,p))..

sum(xc$set_merge_cons_max(y,class,p,xc),Xcon(y,class,p,xc)) =l=

sum(xc$set_merge_cons_max(y,class,p,xc),merge_cons_max(y,class,p,xc));

GAMS develops the above equation definition as follows;

Example petron refinery in 2030

eq_merge_cons_max(2030,petron,topper)..

Xcon(2030,petron,topper,crude_dom)

+ Xcon(2030,petron,topper,crude_imp) =L= 8983.818 ⟶

=180bpsd=8983kton/year

6) eq_merge_cons_max (target : gas power plant)

The gas power plant has to consume a specified amount of ga as fuel. This specifid amount is the maximum possible production. From 2019 gas max possible production begins to decrese, so the gas power plant possibly begins to work-down, but it is not preferable. In order to keep the specified load of gas power plant, thes constraint is required.

Equation eq_merge_cons_min(y,seq,class);

eq_merge_cons_min(y,seq,class)$(target_year(y) And

merge_cons_min1(y,seq,class))..

sum((p,c)$set_merge_cons_min(y,seq,class,p,c),Xcon(y,class,p,c)) =g=

sum((p,c)$set_merge_cons_min(y,seq,class,p,c),merge_cons_min(y,seq,class,p,c));

GAMS develops the above equation definition as follows;

eq_merge_cons_min(2020,1,whole)..

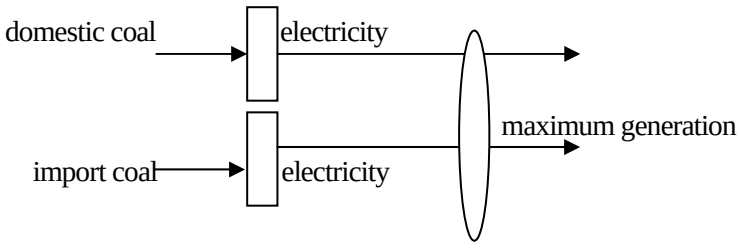
Xcon(2020,whole,EP_gas_C,gas) + Xcon(2020,whole,EP_gas_N,gas) =G= 3964.36 ;

The consumption of total of domestic gas and LNG import in gas power plant should be greater than a specified value=3964.36.

7) eq_merge_prd_max (target : domestic coal)

production from (domestic coal power plant +import power plant) =< maximum generation

The coal power plant uses simultaneously both domestic coal and import coal. But these 2 kinds of coal has different heat value. The formula between fuel consumption and generation in power plant includes the heat value of fuel. So the coal power plant has to be handled separately corresponding to the fuel kind. So there are 2 kinds of coal power plant, domestic coal power plant and import coal power plant. But the coal power plant's maximum capacity is defined by the maximum generation as just only coal power plant. This rule is represented by this eq_merge_prd_max constraint.



The information of coal power plant capacity is given in input data (EP-capacity.csv).

coding: eq_merge_prd_max(y,seq,class,c)$(target_year(y) And
merge_prd_max1(y,seq,class,c))..
sum((p,xc)$set_merge_prd_max(y,seq,class,p,xc,c),Xprd(y,class,p,xc,c)) =l=
sum((p,xc)$set_merge_prd_max(y,seq,class,p,xc,c),merge_prd_max(y,seq,class,p,xc,c)*p_factor(y,p,xc)/100)
* (365*24/1000);

Power capacity is given in MW unit. But generation unit = GWh. So the maximum generation has to be transformed from MW to GWh like the above equation.

Xprd(y,class,p,xc,c) : generation by individual power plant

class = whole

p = domestic coal power plant and import coal power plant

xc = domestic coal and import coal

c = electricity

merge_prd_max(y,seq,class,p,xc,c) : automatically calculated from EP_capacity input data maximum generation of individual power plant

seq : current power plant and new coal power plant

other indexes are the same to ones of Xprd(y,class,p,xc,c)

unit = MW

p_factor(y,p,xc) : input data (p_factor.csv)

plant factor = load factor (unit= %) means the utilizing rate per year.

The conversion formula from MW to GWh

= MW * plant factor/100 * 365 days/year * 24 hours/day /1000

GAMS develops the above equation definition as follows;

Example in 2030

eq_merge_prd_max(2030,1,whole,el)..

Xprd(2030,whole,EP_coal_dom_C,coal_dom,el)

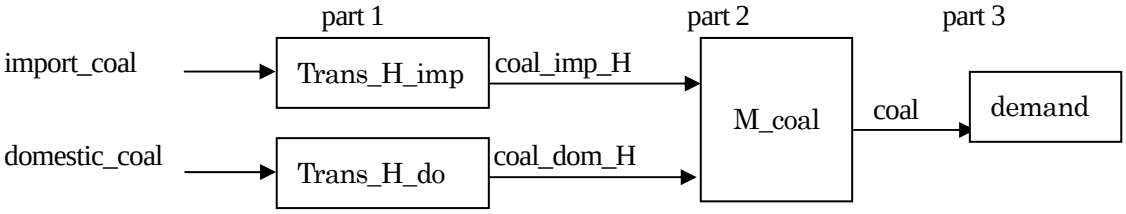
+ Xprd(2030,whole,EP_coal_imp_C,coal_imp,el) =L= 25613.364 ;

maximum generation (GWh)

8) eq_trans_heat(y,p,xc,c) (target : domestic and import coal)

heat of coal to demand = weight of coal to demand * heat_value

Coal demand is given in input data with unit “ktoe”. This demand is the total of domestic coal and import coal. Both coal have different heat value. So in order to create the constraint to satisfy the demand should be represented by the ktoe unit. The coal production is measured by weight base, kton. So these weight base should be converted to calorie base. This conversion can be represented by this eq_trans_heat



consumption in weight base production in calorie base

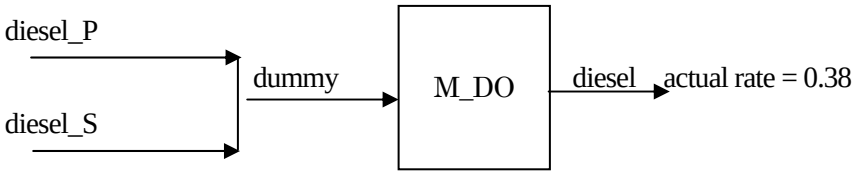
coding : eq_trans_heat(y,p,xc,c)$(target_year(y) And
trans_heat(p,xc,c))..
Xprd(y,'whole',p,xc,c) =e= heat_value(y,xc)/10000 * Xcon(y,'whole',p,xc);

Xprd(y,'whole',p,xc,c): coal after unit conversion = calorie base
p = conversion operation for domestic and import
(Trans_H_dom, Trans_H_imp)
xc = domestic coal and import coal in weight base
c = domestic coal and import coal in calorie base
. heat_value(y,xc) : conversion factor = heat value of individual coal
Xcon(y,'whole',p,xc) : coal before conversion – weight base

GAMS develops the above equation definition as follows;
Example in 2030
eq_trans_heat(2030,trans_H_dom,coal_dom,coal_dom_H)..
Xprd(2030,whole,trans_H_dom,coal_dom,coal_dom_H)
- 0.5557*Xcon(2030,whole,trans_H_dom,coal_dom) =E= 0 ;

for reference)
Part 1 is represented by eq_trans_heat
Part 2 is represented by eq_merge.
Part 3 is represented by by eq_connect.

9) eq_ eq_pp_max_rate(y,c) (target : petroleum products)
calculated rate of petroleum product <= petroleum product/ crude_oil consumed * (1-0.96)
The yield data cannot be gotten in this model. So they are estimated data. But there are data regarding the rate of final refinery products. In order to match the rate of calculated petroleum products with the actual data, the actual data must be given by input data as maximum rate of refinery products. In this model main product, gasoline and diesel oil product's rates are given. Then yields should be adjusted in order that rates of other products will automatically match with actual data.



crude_oil consumed * (1-0.96)
The rate of refinery product is calculated by the equation
calculated rate of diesel <= diesel / crude_oil consumed * (1-0.96)

coding : eq_pp_max_rate(y,c)$set_pp_max_rate(y,c)..

sum(p$pp_max(p,c), Xprd(y,'whole',p,'dummy',c)) =l=

sum((class,p)$(topper(p) And

not whole(class)),

(Xcon(y,class,p,'crude_dom')+Xcon(y,class,p,'crude_imp')) *

own_use_crude(class,p)/100)) * pp_max_rate(y,c)/100;

Xprd(y,'whole',p,'dummy',c) **:** production of petroleum product

p : merging plant of petron and shell products

c : petroleum product

Xcon(y,class,p,'crude_dom')+Xcon(y,class,p,'crude_imp') : total feed of crude oil

own_use_crude(class,p) : 4% of crude oil is consumed as utility in refinery

pp_max_rate(y,c) : actual rate of petroleum product

GAMS develops the above equation definition as follows;

Example in 2030

eq_pp_max_rate(2030,diesel)..

Xprd(2030,whole,M_DO,dummy,diesel)

- 0.3456*Xcon(2030,petron,topper,crude_dom)
- 0.3456*Xcon(2030,petron,topper,crude_imp)
- 0.3456*Xcon(2030,shell,topper,crude_dom)
- 0.3456*Xcon(2030,shell,topper,crude_imp) =L= 0 ;

ref1) own_use_crude = 4%

pp_max_rate of diesel = 38%

Then (1-0.04)*0.38 ＝ 0.3456

ref2)This method is not recommendable.

If actual yield can be gotten, this constraints should be deleted.

10) eq_yield (target : refinery unit, gas plant)

production = yield * feed to plant * (1-own_use_crude/100)

A feed material is crude oil in the case of topper plant. The feed material is oil which is produced in this refinery in the case of refinery units excluding topper. The feed material is raw gas in the case of gas plant. An oil refinery uses oil as utility, which is produced in oil refinery itself. This self use oil is assumed as a linear proportion to the total feed crude oil. This proportional rate is assumed at 4% defined in input data. The own-use-crude data is defined only for topper. It is 0 for gas plant.

coding: eq_yield(y,class,p,xc,c)$(target_year(y) And

set_yield4(y,class,p,xc,c))..

Xprd(y,class,p,xc,c)

=e=

yield(y,class,p,xc,c)*Xcon(y,class,p,xc)*(1-own_use_crude(class,p)/100);

Xprd(y,class,p,xc,c) : production from plant p of class unit , feed material is xc, target material is c

(class means petron or shell in refinery, whole in gas plant)

yield(y,class,p,xc,c) : yield in plant p of class unit, feed material is xc, target material is c

Xcon(y,class,p,xc) : consumption in plant p of class unit, feed is xc

own_use_crude(class,p) : fuel rate to crude oil consumed in refinery plant : input data

GAMS develops the above equation definition as follows;

Example LGO_top of petron topper in 2030

```
eq_yield(2030,petron,topper,crude_imp,LGO_top)..
        Xprd(2030,petron,topper,crude_imp,LGO_top)
- 0.0864*Xcon(2030,petron,topper,crude_imp) =E= 0 ;
```

→ yield(input data)

11) eq_power (target : electricity)

fuel consumption=generation * 860/(heat value*thermal efficiency)

This equation is the formula between fuel consumption and generation

unit : 1KWh = 860kcal

coding : eq_power(y,p,c)$(target_year(y) And elp(p) And pair_pc(p,c) And therm_eff(y,p,c)>0 And (capacity(y,'whole',p,c)>0 or merge_prd_max2(y,p,c)))..

```
Xcon(y,'whole',p,c)
=e=
Xprd(y,'whole',p,c,'el')*860/(heat_value(y,c)*therm_eff(y,p,c)/100);
```

Xcon(y,'whole',p,c) : consumption of fuel in power plant

p : power plant excluding geothermal, hydro, nuclear, RE

c = electricity

Xprd(y,'whole',p,c,'el') : generation from power plant p unit=GWh

heat_value(y,c) : heat value

therm_eff(y,p,c) : thermal efficiency

GAMS develops the above equation definition as follows;

Example domestic coal power plant in 2030

eq_power(2030,EP_coal_dom_C,coal_dom)..

- 0.396254393050397*Xprd(2030,whole,EP_coal_dom_C,coal_dom,el)

+ Xcon(2030,whole,EP_coal_dom_C,coal_dom) =E= 0 ;

= 860/(heat_value(y,c)*therm_eff(y,p,c)/100);

12) eq_coal_dom_max (target:coal power plant)

domestic coal / (domestic + import) in power plant <= a specified value

The domestic coal in Philippines includes an alkali material. So when domestic coal is burned in power plant, import coal should be mixed. This rate is given as input data.

coding : equation eq_coal_dom_max(y,seq);

eq_coal_dom_max(y,seq)$(target_year2(y) And
ord(seq)<3)..
sum((p,c)$(pair_pc_seq(p,c,seq) And
coal_dom(c)), Xcon(y,'whole',p,c)/heat_value(y,c))
=l= coal_dom_rate(y)/100 * sum((xp,c)$(pair_pc_seq(xp,c,seq)),
Xcon(y,'whole',xp,c)/heat_value(y,c));

GAMS develops the above equation definition as follows;

eq_coal_dom_max(2007,1)..

0.00014396256973187*Xcon(2007,whole,EP_coal_dom_C,coal_dom)
3.125E-5*Xcon(2007,whole,EP_coal_imp_C,coal_imp) =L= 0 ;

13) eq_EP_DO_fix (target : EP-DO)

The rate of diesel oil in feed to DO power plant is specified at 15%.

Actually DOE staff insists that this rate is maximum. But if it is maximum, the diesel oil has high value, LP model does not use diesel but fuel oil, so it is not realistic. So at present the model adopts that this rate is fixed.

coding : equation eq_EP_DO_rate(y,p);

diesel oil / (diesel oil + fuel oil) in power plant = a specified value(=15%)

eq_EP_DO_rate(y,p)$set_diesel_rate(y,p)..
Xcon(y,'whole',p,'diesel') =e= diesel_rate(y,p)/100*sum(c$pair_pc(p,c),Xcon(y,'whole',p,c)));

GAMS develops the above equation definition as follows;

eq_EP_DO_rate(2007,EP_DO_C).. 0.85*Xcon(2007,whole,EP_DO_C,diesel)

- 0.15*Xcon(2007,whole,EP_DO_C,fuel_oil) =E= 0 ;

14) eq_own_use (target : electricity)

own use power = own_ use_ * generation

Since Generation is measured at generating end in Philippines, this equation is required. But if power generation is measured at the sending end, this equation is not necessary.

coding : eq_own_use(y)$target_year(y)..

Xcon(y,'whole','own','el')

=e=

sum((p,c)$(elp(p) And

pair_pc(p,c)),Xprd(y,'whole',p,c,'el'))*own_use(y)/100 ;

GAMS develops the above equation definition as follows;

Example in 2030

eq_own_use(2030)..

- 0.07125487106*Xprd(2030,whole,EP_coal_dom_C,coal_dom,el)

- 0.07125487106*Xprd(2030,whole,EP_coal_imp_C,coal_imp,el)

- 0.07125487106*Xprd(2030,whole,EP_coal_dom_N,coal_dom,el)

- 0.07125487106*Xprd(2030,whole,EP_coal_imp_N,coal_imp,el)

- 0.07125487106*Xprd(2030,whole,EP_gas_C,gas,el)

- 0.07125487106*Xprd(2030,whole,EP_gas_N,gas,el)

- 0.07125487106*Xprd(2030,whole,EP_DO_C,diesel,el)

- 0.07125487106*Xprd(2030,whole,EP_DO_C,fuel_oil,el)

- 0.07125487106*Xprd(2030,whole,EP_DO_N,diesel,el)

- 0.07125487106*Xprd(2030,whole,EP_DO_N,fuel_oil,el)

- 0.07125487106*Xprd(2030,whole,EP_FO,fuel_oil,el)

+ Xcon(2030,whole,own,el) =E= 3125.32136662563 ;

generation from nuclear, hydro, geothermal, RE is fixed.

15) eq_dist_loss (target : electricity)

distribution loss = loss rate*((generation -own_use) + import + export)

coding : eq_dist_loss(y)$target_year(y)..

Xcon(y,'whole','distribution','el')

=e=

dist_loss(y)/100 *(sum((p,c,xc)$(elp(p) And

el(c) And

pair_pc(p,xc)),Xprd(y,'whole',p,xc,c)) - Xcon(y,'whole','own','el') + sum(c$el(c),Ximp(y,c)+Xexp(y,c))) ;

GAMS develops the above equation definition as follows;

Example in 2030

eq_dist_loss(2030)..

- 0.121752*Xprd(2030,whole,EP_coal_dom_C,coal_dom,el)

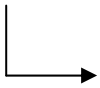
- 0.121752*Xprd(2030,whole,EP_coal_imp_C,coal_imp,el)

- 0.121752*Xprd(2030,whole,EP_coal_dom_N,coal_dom,el)

- 0.121752*Xprd(2030,whole,EP_coal_imp_N,coal_imp,el)

- 0.121752*Xprd(2030,whole,EP_gas_C,gas,el)

- 0.121752*Xprd(2030,whole,EP_gas_N,gas,el)
- 0.121752*Xprd(2030,whole,EP_DO_C,diesel,el)
- 0.121752*Xprd(2030,whole,EP_DO_C,fuel_oil,el)
- 0.121752*Xprd(2030,whole,EP_DO_N,diesel,el)
- 0.121752*Xprd(2030,whole,EP_DO_N,fuel_oil,el)
- 0.121752*Xprd(2030,whole,EP_FO,fuel_oil,el)
+ 0.121752*Xcon(2030,whole,own,el) + Xcon(2030,whole,distribution,el) =E=
5340.18406557767 ;



generation from nuclear, hydro, geothermal, RE is fixed

16) eq_stock_piling (target : Arabian light crud oil)

oil stockpiling to be put * 0.95 = stock day * demand of refinery

Crude oil is evaluated as equivalent to 95 % of oil products after considering processing loss. This amount of crude oil should be stocked as oil stockpiling.

(95% is the Japanese specification)

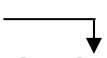
coding : eq_stock_piling(y,c)$(target_year(y) And
crude_stock(c))..
Xstk(y,c)*0.95 =g= sum(xc$refc(xc),demand_tot_kt(y,xc)*stock_day(y,xc)/365);

Reason that operator is "g" is that Xstk should always be >= 0.

If the consumption of target of oil stockpiling products of this year is very large, oil stockpiling will be also large. But if that demand of the next year is smaller than this year, the oil stockpiling required will be smaller than one of this year. If operator is =, oil to be stocked should be minus.

The minus means to extract from stockpiling. But from the viewpoint of the objective of oil security extract is not recommendable. Furthermore the minus value of variables is not allowed in LP system.

GAMS develops the above equation definition as follows;
Example in 2030
q_stock_piling(2030,crude_stock)..
0.95*Xstk(2030,crude_stock) =G= 1024.76103466522 ;



Calculated from demand and stock oil day for refinery products.

17) eq_bal_stockpiling(y,c) (target : Arabian light crud oil)

import crude oil for oil stockpiling = Increment of stockpiling from this year to last year

GAMS develops the above equation definition as follows;
Example in 2030
eq_bal_stockpiling(2030,crude_stock)..
Ximp(2030,crude_stock)
+ Xstk(2029,crude_stock) - Xstk(2030,crude_stock) =E= 0 ;

18) eq_co2_gas (target : gas)

This equation calculates the total CO2 emission by some of oil product and gas

CO2 emission = emission rate * (demand + consumption in EP) * 44/12

This result is measured by CO2 kton.

coding : eq_co2_gas(y,c)$(target_year(y) And
gas_rep(c))..

Xco2(y,c) =e=CO2_emission(y,c)*44/12 *
(sum(p$EP_gas(p),Xcon(y,'whole',p,c)) + from gas power plant
demand_tot_kt(y,c)); from demand

GAMS develops the above equation definition as follows;

Example in 2030

eq_co2_gas(2030,gas)..
- 2139.0369*Xcon(2030,whole,EP_gas_C,gas)
- 2139.0369*Xcon(2030,whole,EP_gas_N,gas) + Xco2(2030,gas) =E=
1075421.42860743 ;

19) eq_co2_coal (target :coal)

This equation calculates the total CO2 emission by coal.

CO2 emission = emission rate * (production of coal + import coal - export)*44/12

This result is measured by CO2 kton.

coding : eq_co2_coal(y,c)$(target_year(y) And
coal_rep(c))..

Xco2(y,c) =e= co2_emission(y,c)*44/12*
(sum((p,xc)$(elp(p) And
coal(xc) And } from power palnt
pair_pc(p,xc)),Xcon(y,'whole',p,xc))+
sum((p,xc,xxc)$trans_heat(p,xc,xxc),
Xcon(y,'whole','M_coal',xxc)/(heat_value(y,xc)/10000))); from demand

GAMS develops the above equation definition as follows;

Example in 2030

eq_co2_coal(2030,coal)..
- 4117.37333333333*Xcon(2030,whole,EP_coal_dom_C,coal_dom)
- 4117.37333333333*Xcon(2030,whole,EP_coal_imp_C,coal_imp)
- 4117.37333333333*Xcon(2030,whole,EP_coal_dom_N,coal_dom)
- 4117.37333333333*Xcon(2030,whole,EP_coal_imp_N,coal_imp)
- 7409.34557015176*Xcon(2030,whole,M_coal,coal_dom_H)
- 6023.95513289442*Xcon(2030,whole,M_coal,coal_imp_H) + Xco2(2030,coal) =E= 0

20) eq_co2_oil (target : oil)

This equation calculates the total CO2 emission by some of oil products.

CO2 emission = emission rate * (demand + consumption in EP) * 44/12

coding : eq_co2_oil(y,c)$(target_year(y) And refc(c))..

Xco2(y,c) =e= co2_emission(y,c)*44/12*(demand_tot_kt(y,c) + sum(p$(elp(p) And pair_pc(p,c)),Xcon(y,'whole',p,c))) ;

from demand

from power plant

GAMS develops the above equation definition as follows;

Example fuel_oil in 2030

```
eq_co2_oil(2030,fuel_oil)..
        - 3371.32986666667*Xcon(2030,whole,EP_DO_C,fuel_oil)
        - 3371.32986666667*Xcon(2030,whole,EP_DO_N,fuel_oil)
- 3371.32986666667*Xcon(2030,whole,EP_FO,fuel_oil) + Xco2(2030,fuel_oil)
  =E= 21146893.2749419
```

21) eq_so2 (target : so2)

This equation calculates total SO2 emission.

total SO2 emission= 32/16*sulfur content ratio * (demand + consumption in EP)

coding : eq_so2(y,r,c)$(target_year(y) And s_content(y,c)>0)..

Xso2(y,r,c) =e= 32/16*s_content(y,c)/100*(demand_tot_kt(y,r,c) + sum(p$pair_pc(p,c),Xcon(y,r,p,c)));

GAMS develops the above equation definition as follows;

Example in 2030

```
eq_so2(2030,coal_dom)..    - 0.032*Xcon(2030,petron,EP_coal_dom_C,coal_dom)
        - 0.032*Xcon(2030,petron,EP_coal_dom_N,coal_dom)
        - 0.032*Xcon(2030,petron,trans_H_dom,coal_dom)
        - 0.032*Xcon(2030,shell,EP_coal_dom_C,coal_dom)
        - 0.032*Xcon(2030,shell,EP_coal_dom_N,coal_dom)
        - 0.032*Xcon(2030,shell,trans_H_dom,coal_dom)
        - 0.032*Xcon(2030,whole,EP_coal_dom_C,coal_dom)
        - 0.032*Xcon(2030,whole,EP_coal_dom_N,coal_dom)
- 0.032*Xcon(2030,whole,trans_H_dom,coal_dom) + Xso2(2030,coal_dom) =E= 0
```

22) eq_cost (target : cost)

This equation calculates the cost by year

cost = import cost*import + acquisition cost*production + operation cost*feed to facility + export price * export

coding : eq_cost(y)$target_year(y)..

```
  Xcost(y) =e=
sum((r,c)$(crude(c) Or refc(c) Or import_gas_coal(c) Or el(c)), Ximp(y,r,c)*cost_imp(y,r,c))    +
  sum((r,p,c)$(mine(p) And mine_pc(p,c)),Xprd(y,r,p,'earth',c)*cost_prd(y,c))    +
```

sum((r,p,c)$(pair_pc(p,c) And elp(p)),cost_op(y,r,p)) +
sum((r,p,c)$(pair_pc(p,c) And not elp(p)), Xcon(y,r,p,c)*cost_op(y,r,p)) -
sum((r,c)$export(c),Xexp(y,r,c)*sale_exp(y,r,c));

GAMS develops the above equation definition as follows;

Example in 2030

eq_cost(2030).. - 51.9819418604651*Xprd(2030,whole,mine,earth,crude_dom)
- 4.4594459*Xprd(2030,whole,mine,earth,coal_dom)
- 30.3712965487227*Xprd(2030,whole,mine,earth,gas_raw)
- 54.8837209302326*Ximp(2030,crude_imp)
- 57.7906976744186*Ximp(2030,crude_stock) - 6.664*Ximp(2030,coal_imp)
- 72.970479704797*Ximp(2030,LPG) - 135.405405405405*Ximp(2030,gasoline)
- 109.322660098522*Ximp(2030,kerosene)
- 148.048090523338*Ximp(2030,jet_fuel)
- 101.954976303318*Ximp(2030,diesel)
- 76.8240850059032*Ximp(2030,fuel_oil) + 71.1254612546125*Xexp(2030,LPG)
+ 110.405405405405*Xexp(2030,gasoline)
+ 86.7857142857143*Xexp(2030,kerosene)
+ 122.164073550212*Xexp(2030,jet_fuel) + 81.457345971564*Xexp(2030,diesel)
+ 62.7744982290437*Xexp(2030,fuel_oil) - 1000000*XdumP(2030,crude_dom)
- 1000000*XdumP(2030,crude_imp) - 1000000*XdumP(2030,coal_dom)
- 1000000*XdumP(2030,coal_imp) - 1000000*XdumP(2030,gas)
- 1000000*XdumP(2030,gas_raw) - 1000000*XdumP(2030,gas_imp)
- 1000000*XdumP(2030,LPG) - 1000000*XdumP(2030,LPG_P)
- 1000000*XdumP(2030,LPG_S) - 1000000*XdumP(2030,gasoline)
- 1000000*XdumP(2030,gasoline_P) - 1000000*XdumP(2030,gasoline_S)
- 1000000*XdumP(2030,kerosene) - 1000000*XdumP(2030,kerosene_P)
- 1000000*XdumP(2030,kerosene_S) - 1000000*XdumP(2030,jet_fuel)
- 1000000*XdumP(2030,jet_fuel_P) - 1000000*XdumP(2030,jet_fuel_S)
- 1000000*XdumP(2030,diesel) - 1000000*XdumP(2030,diesel_P)
- 1000000*XdumP(2030,diesel_S) - 1000000*XdumP(2030,fuel_oil)
- 1000000*XdumP(2030,fuel_oil_P) - 1000000*XdumP(2030,fuel_oil_S)
- 1000000*XdumP(2030,el) - 1000000*XdumM(2030,crude_dom)
- 1000000*XdumM(2030,crude_imp) - 1000000*XdumM(2030,coal_dom)
- 1000000*XdumM(2030,coal_imp) - 1000000*XdumM(2030,gas)
- 1000000*XdumM(2030,gas_raw) - 1000000*XdumM(2030,gas_imp)
- 1000000*XdumM(2030,LPG) - 1000000*XdumM(2030,LPG_P)
- 1000000*XdumM(2030,LPG_S) - 1000000*XdumM(2030,gasoline)
- 1000000*XdumM(2030,gasoline_P) - 1000000*XdumM(2030,gasoline_S)
- 1000000*XdumM(2030,kerosene) - 1000000*XdumM(2030,kerosene_P)
- 1000000*XdumM(2030,kerosene_S) - 1000000*XdumM(2030,jet_fuel)

- 1000000*XdumM(2030,jet_fuel_P) - 1000000*XdumM(2030,jet_fuel_S)
- 1000000*XdumM(2030,diesel) - 1000000*XdumM(2030,diesel_P)
- 1000000*XdumM(2030,diesel_S) - 1000000*XdumM(2030,fuel_oil)
- 1000000*XdumM(2030,fuel_oil_P) - 1000000*XdumM(2030,fuel_oil_S)
- 1000000*XdumM(2030,el) + Xcost(2030) =E= 127186.111106024 ;

The cost of dummy variable is very large.

23) eq_obj_cost(target : objective function)

This equation defines objective function.

obj_cost = sum(total cost by year)

coding : eq_obj_cost..

Obj_cost =e= sum(y$target_year(y),Xcost(y)/(1+interest(y)/100)**(ord(y)-1));

GAMS develops the above equation definition as follows;

Example in 2030

eq_obj_cost..

- Xcost(2006) - 0.925925925925926*Xcost(2007)
- 0.857338820301783*Xcost(2008) - 0.793832241020169*Xcost(2009)
- 0.735029852796453*Xcost(2010) - 0.680583197033753*Xcost(2011)
- 0.630169626883105*Xcost(2012) - 0.583490395262134*Xcost(2013)
- 0.540268884501976*Xcost(2014) - 0.500248967131459*Xcost(2015)
- 0.463193488084684*Xcost(2016) - 0.428882859337671*Xcost(2017)
- 0.397113758645991*Xcost(2018) - 0.367697924672214*Xcost(2019)
- 0.340461041363161*Xcost(2020) - 0.31524170496589*Xcost(2021)
- 0.291890467561009*Xcost(2022) - 0.270268951445379*Xcost(2023)
- 0.250249029116091*Xcost(2024) - 0.231712063996381*Xcost(2025)
- 0.214548207404056*Xcost(2026) - 0.198655747596349*Xcost(2027)
- 0.183940507033656*Xcost(2028) - 0.170315284290422*Xcost(2029)
- 0.157699337305947*Xcost(2030) + obj_cost =E= 0 ;

1. 8 Output Data Table

GAMS automatically creates a text file, which includes all information about model such as code, input data, constraints, solution and statistics. This text file has the extension name list. It is big size file and it is not easy to analyze the result. Therefore, for easy reference, this system built by the JICA project has a function to create 17 kinds of tables in order to analyze the result correspondent to the purpose. These tables are as follows;

1) Energy balance table （typical table used in energy analysis）
2) Summary table with unit ktoe (for comparing some cases)
3) Summary table with unit kton/MMm3(for analyzing in time series)
4) Refinery result(balance data in oil refinery with yield data)
5) Electric result (power generation, fuel consumption, technical data etc)
6) List of import(amount list of import energy as result) for check
7) List of export (amount list of export energy as result) for check
8) List of product(amount of production as result) for check
9) List of consumption(amount of consumption in plant as result) for check
10) Demand table(input data)
11) List of unit cost(input data with unit change)
12) Cost result(cost, amount of flow, total cost)
13) List of dummy variable(value of dummy variable)
14) CO2 emission result
15) Detail information of CO" emission
16) Oil stockpiling
17) Coal result detail information

1.9 Program Structure

main program : PEP2008.gms

sub program
- 1) set_definition : Define various index, parameter, table
- 2) data_read.inc : Read input data
- 3) unit_change.inc : Change the unit
- 4) set_definition2.inc : Define new sets based on input data
- 5) eq_definition.inc : Define constraits
- 6) bound_set.inc : set the bound of variables
- 7) after_process.inc : Traeting the solution for output
- 8) output.inc : create various outputs in kton
- 9) kt_ktoe.inc : unit change from kton to ktoe
- 10) output_ktoe.inc : create various outputs in ktoe
- 11)output_ws.inc :create a file for work sheet

These files are all text file. So they can easily be read by usual text editor.

Extension gms is fixed by GAMS system. But extension inc is free. these inc files are read into main program "PEP2008.gms" by $include. Therefore, for convenience the extension inc is used.

1.10 Model Size and Execution Time

The size of a LP model can be measured by the number of variables and constraints incorporated. Now there are around 10600 variables and 7700 constraints covering 25 years in the standard model. Should the energy flow change, new plants be installed or new energy item be added, the model size would greatly increase. At present, execution time of this 25 year model is less than 1 second. The execution time would also increase if constraints overlapping years are levied or strong constraints are added. At any rate, however, the execution time would not become a serious problem.

1.11 Functions and Operations of the Optimization Model

This energy supply optimization model has following functions.

1.11.1 Information Created (main function)

a. To calculate the logically correct demand and supply balance of each energy that should comprehensively satisfy the energy demands given as input data. They are for example,
   - Raw material feed amount into each facility at oil refinery
   - Petroleum products production amount
   - Converted amount of petroleum products to other energy, e.g., from kerosene to jet fuel or diesel gas oil

b. To calculate the minimum total cost as the net present value at 2006

1.11.2 Service Functions for Convenience of Users

c. To automatically convert from a sheet in a book of EXCEL to a CSV file (EXCEL macro)

d. To output tables to show the optimum solutions in various forms (CSV file)

1.11.3 Functions of GAMS Itself

e. To make a text file including all information of the model. The first file houses the following information.
   - Original program created by modeler
   - Input data
   - Developed constraints
   - Various statistics on the model (scale, execution time, etc)
   - Solution itself

f. To show grammatical error message

g. To point an infeasible constraint or a variable as a cause of infeasible solution

h. To show the number of infeasibility if infeasible

i. To show name of the output table created

j. etc

2 Operations Procedure

In order to execute the model the basic flow of operation is as follows;

1) Create input data file
2) Execute the model
3) Analyze the model

This document only refer to operation of the Energy Supply / Demand Optimization Model for PEP2008. Regarding GAMS including its installment, please refer to the GAMS Manual.

2.1 Input Data Source

All input data should be stored in input_data.xls.

This file gets demand, sales price, generation from nuclear, hydro, geothermal and RE, non commercial energy from demand forecasting model file by cut & paste. Other all data should be inputted by hand.

2.1.1 Common Operation

(1) Make a new holder /How to create a csv file from EXCEL

(condition) You already have the model including program and data) in the standard holder name. for example, 'Reference'.

a To define the new holder name where the model data and output file are stored.

It is better to the naming of the holder, which helps to understand assumptions.

b To copy all files of reference model into this holder

(2) New assumptions for case study you are planning should be inputted into the specified sheet in the input-data.xls. If the case study will request the modification of programming, you have to revise the program. But in many cases it is enough to change only data.

(3) Click once the icon 'Save file' with color yellow as below. GAMS cannot read EXCEL file directly. So EXCEL file should be converted to csv form file. A csv file is the text file and each data is separated by comma. For example

*heat_value,
*year, energy, heat value
2006*2030,coal_dom,5557
2006,coal_imp,6250
2007,coal_imp,6400
2008*2030,coal_imp,6835
2006*2030,gas,9100
2006*2030,crude,10500
2006*2030,LPG,11800
2006*2030,gasoline,11500

GAMS can read the csv file. A csv file should be created by sheet in EXCEL file. There are many sheets in this EXCEL file. In order to create csv file, this conversion operation should be done many times sheet by

sheet. It is rather nuisance operation. So the macro which enables to create a csv file by one touch is prepared at each sheet. The csv file created has the same name with the sheet name. In order to kick off this macro, it is enough just to click the following icon with name 'Save file', which can be seen on every sheet.

The function of this MACRO.

1) The original EXCEL file is overwriting with the same name.
   The EXCEL asks you whether overwritten is permitted or not ?
   You must answer 'yes'. If you answer no, the next csv file would not be created.
2) The csv file is created . The file name is sheet name + .csv.
   If the same name exists in the holder, EXCEL asks you whether overwritten is permitted or not ?
   You must answer 'yes'. If you answer no, the next csv file would not be created.

Note) In order that MACRO is executable,

1) you have to answer 'yes' against the question from EXCEL that enable MACRO when EXCEL starts?
2) you have to change that the security level is less than middle level at the time EXCEL begins to work as follows; (in the case of Windows XP)
   tool---macro--security
   security level to middle.

The operation to create input files is outlined below

2.1.2 Key-in Data

All data of input-data.xls in the column ' input data file name' in table 1 should be inputted by key in operation.

(1) dummy-control.csv :
   format : energy name, '1' or '0'
   related place in program : constraint=eq_bal_ref
   meaning : '1' : dummy variable is automatically inserted in the balance equation.
   '0' : dummy variable is not used.
   If oil products balance seems to be difficult to realize, 1 should be set, otherwise 0.
   For security it is recommended that '1' is set. So it is better not to change the base model.

(2) el-data-control.csv
   format: the first line 'gen', '1' or '0'
   the second line 'con', '1' or '0'
   related place in program : el_flag definition in 'unit_change.inc'
   eq_power in 'eq_definition.inc'
   meaning : 'gen' ,'1' : generation data comes from PDPAT, so fixed
   '0' : generation free

'con', '1' : fuel consumption comes from PDPAT, so fixed

'0' : generation free

el_flag = 0 at 'gen'=1 and 'con'=1

relation between fuel consumption and generation cannot be defined.

=1 otherwise

relation between fuel consumption and generation is defined.

el_flag is automatically set according to el_data_control in 'unit_change.inc'.

In PEP2008, usually you should have input always 0.

(3) cost-unit.csv

format: energy name, unit

related place in program : 'output.inc'

meaning : used in heading

(4) unit-data.csv

format: from unit, to unit, value

related place in program : 'unit_change.inc'

meaning : constant data of unit change

(5) SG.csv

format: energy name, specific gravity

related place in program : 'unit_change.inc', 'bound_set', 'after_process.inc', 'output.inc'

eq_bal_gas, eq_co2_ethanol in eq_definition.inc

meaning : used in unit change from volume unit to weight unit

(6) mining-max.csv : (used by parameter 'product-max' in program)

format: year, 'whole', energy, production maximum

related place in program : 'bound_set'

meaning : primary fossil energy production max by year

source : This data comes from electricity group.

(7) EP_capacity.csv

format: year, district, fuel, capacity of power plant

related place in program : 'bound_set' , unit_change, eq_definition

meaning: Maximum generation of power plant

starting year(2006) : currenct capacity

from 2007 : increment capacity of power plant

(8) capacity.csv

format: year, class, plant, energy, max-capacity

related place in program : 'bound_set'

meaning : Plants cannot produce or consume specified energy over this value.

(9) own-use-crude.csv

format: topper name, %

related place in program : eq_yield in 'eq_definition.inc'

meaning : Oil refinery uses fuel which it produces as fuel for its own plants. It is the ratio to the total feed of crude oil.

(10) import.csv (used by table import_minmax in program)

format: year, energy name, min of import, max of import

related place in program : 'bound.inc'

meaning : min and max of import

(11) export.csv (used by table export_minmax in program)

format: year, energy name, min of export, max of export

related place in program : 'bound.inc'

meaning : min and max of export

(12) own-use.csv

format: power plant name, own use ratio

related place in program : eq_own_use in 'eq_definition.inc'

meaning : A power plant uses electricity which it generates by itself. As power generation in this model is measured at sending end in this model, this input term should always be 0. But if this rule will change in future, this input term is defined.

(13) dist-loss.csv

format: year, 'whole', loss rate(%)

related place in program : eq_dist_loss in 'eq_definition.inc'

meaning : Sending electricity, electricity is lost through transmission-distribution line. It is proportional to amount of electricity sent. This loss electricity should be considered in balance equation

(14) p-factor.csv

format: year, 'whole', power plant name, fuel name, plant factor

related place in program : 'bound.inc'

meaning : Each power plant has specific load (%), or this load is controlled by power policy.
Load means the percent of capacity use.

(15) heat-value.csv

format: year, energy, heat value

related place in program : 'unit_change.inc', 'output.inc', 'eq_definition.inc'

meaning : Considering energy issues, calorie unit is important. Changing unit from weight to calorie, heat value plays a base role.
Heat value differs among energy and country.

(16) therm-eff.csv

format: year, power plant name, fuel name, termal efficiency (%)

related place in program : 'bound.inc', 'output.inc'
eq_coal_dom, eq_power, in 'eq_definition.inc'

meaning : Each power plant has thermal efficiency (%).
It depends on power plant, fuel plant, year.

(17) yield.csv

format: year, plant (facility), raw energy, product energy, yield

related place in program : ‘output.inc’

eq_yield, eq_yield_ref, in ‘eq_definition.inc’

meaning : This means how much each product is produced against 1 unit raw material feed. This is the basic data in considering energy balance because energy produced is calculated based on the yield. The total yield in a facility should be always 1.

(18) pp-max-rate max .csv

format: year, energy, rate (%)

related place in program : ‘output.inc’

eq_pp_max_rate in ‘eq_definition.inc’

meaning :The max rate of petroleum product

(19) CO2_max

format: year,max CO2 emission to be allowed

related place in program : eq_co2_max in ‘eq_definition.inc’

meaning : total CO2 emission should be less than CO2_emission max. Such regulation should be decided by the government

(20) CO2_emission.csv

format: year,energy, CO2_emission rate

related place in program : ‘unit_change.inc’, ‘output’.inc’

eq_set_definition2, eq_CO2_oil_gas, eq_ethanol in ‘eq_definition.inc’

meaning : It means the emission amount of CO2 when 1 unit of an energy is burnt.

It is used in calculating CO2 emission.

(21) S-content.csv

format: year, max SO2 emission to be permitted

related place in program : ‘output.inc’

eq_so2 in ‘eq_definition.inc’

meaning : It means the emission amount of SO2 when 1 unit of an energy is consumed. It is used in calculating SO2 emission.

(22) stock-init.csv

format: year,max SO2 emission to be permitted

related place in program : ‘bound.inc’

meaning : Considering oil stockpiling, the initial stockpiling should be given as data.

(23) stock-day.csv

format: year, ‘whole’, ’crude’

related place in program : ‘output.inc’

eq_stock_piling in ‘eq_definition.inc’

meaning : In this model oil stockpiling is calculated by following equation;

oil stockpiling*0.95 = stock_day * consumption of all oil products per year/365

This stock day can be decided by the oil security policy.

(24) unit-FOB.csv

format : energy, unit

related place in program : ‘unit_change.inc’

meaning : The unit of FOB

(25) unit-op.csv

format : plant, unit

related place in program : ‘unit_change.inc’, ‘output.inc’

meaning : The unit of operation and maintenance cost

(26) cost-op.csv

format: year, class, plant , operation cost, maintenance cost

related place in program : ‘unit_change.inc’

meaning : Cost of operation and maintenance per 1 unit feed

But regarding power plant, operation cost is given by PDPAT on per year basis including maintenance cost

Ref)In PEP2008, operation and maintenance cost should be negligible.

(27) unit-freight.csv

format : energy, unit of freight

related place in program : ‘unit_change.inc’

meaning : The unit of freight

(28) freight.csv

format : energy, (cost of freight by energy)

related place in program : ‘unit_change.inc’, ‘output.inc’

meaning : Cost of freight

(29) interest.csv

format: year, interest

related place in program : ‘after_process.inc’

meaning : Interest (it depends on year)

(30) exchange-rate.csv

format: year, exchange rate

related place in program : ‘unit_change.inc’ , ‘output.inc’

eq_obj_cost in eq_definition

meaning : Exchage rate of peso and US dollar (it depends on year)

(31) sales-price.csv

format : year, (various cost of sales by energy)

related place in program : ‘unit_change.inc’

meaning : Cost of sales

FOB cost = sales price – freight

(32) demand-sec.csv

format : year, class, demand by energy(coal, gas, LPG, AVI gaso, bio ethanol, jet_fuel, kerosene, diesel, bio diesel, fuel_oil, el, RE)

related place in program : ‘unit_change.inc’, eq_definition.inc

meaning : The demand by energy. The demand of each energy should be satisfied.

These data should given from the forecasting model, sheet name ‘simulation’
unit is ktoe.

(33) base-sup-el.csv

format : year, generation by power plant(Hydro, geo, nualear, RE)

related place in program : ‘unit_change.inc’, eq_definition.inc

meaning : The generation fixed by specified power plant.

These data should given from the forecasting model, sheet name ‘simulation’
unit is ktoe.

--Operation from forecasting model into the input-data.xls of optimization model--

(NOTES)The forecasting model includes the information for optimization model .
That information should be done cut & paste by hand to input-data.xls.

operation 1. cut & paste demand data by year and by energy from the forecasting model with sheet name ‘Simulation’ line no= 376-386, and 389 to input-data.xls with sheet name ‘demand-sec’
(ref: property = change the row and column and only value copy)

operation 2. cut & paste non-commercial energy by year from the forecasting model with sheet name ‘Simulation’ line no= 488 to input-data.xls’ most right column with sheet name ‘demand-sec’
(ref: property = change the row and column and only value copy)

operation 3. cut & paste sales price by year and by energy from the forecasting model with sheet name ‘Simulation’ line no= 67-76 to input-data.xls with sheet name ‘sales-price’
(ref: property = change the row and column and only value copy)

(34) connect.csv

format : year, energy,class,plant,feed,import,export,class,plant

related place in program : ‘set_definition2.inc’, ‘eq_definition.inc’, ’bound_set.inc’, ’kt_ktoe’, ‘output_inc’

meaning : It represents the energy flow.

Target is energy. This energy can be produced from class, plant, feed, and consumed in class, plant. If this energy is allowed to be import, data should be yes, if not allowed, ’none’ should be inputted. If this energy has over 2 production way or over 2 consumption, these information is represented after 2’nd line. If there is no plant or feed data, ‘NP’ or ‘dummy’ should be inputted under the heading plant or feed.

example) Here regarding gasoline flow is picked up as follows.

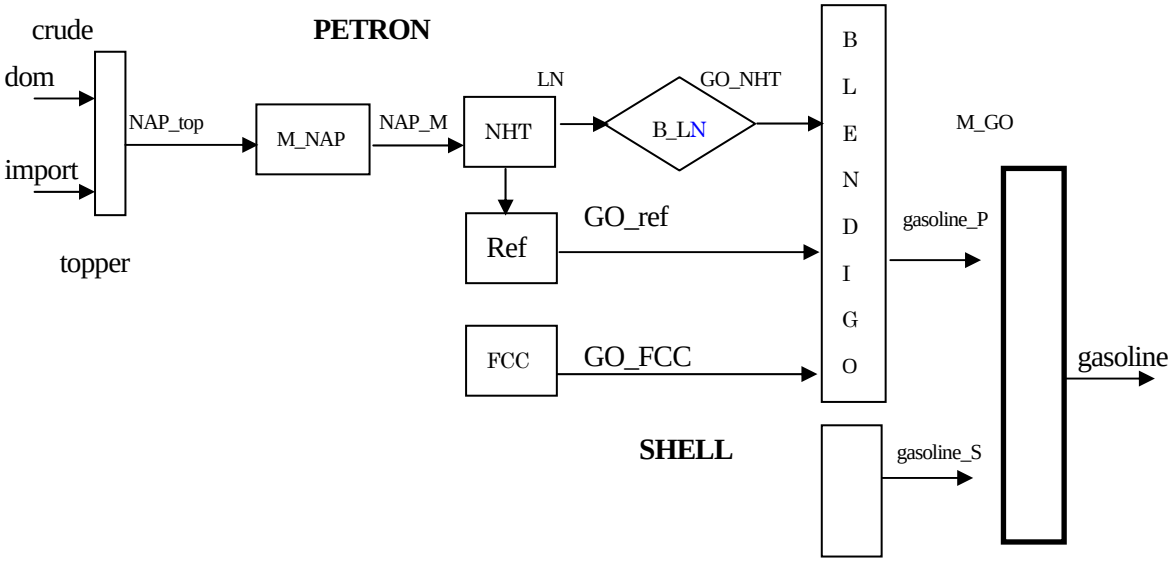


Figure 6 Flow regarding gasoline

This flow can be represented by the following input data

2006*2030	NAP_top petron	topper	crude_dom	none	none	petron	M_NAP	1)
2006*2030	NAP_top petron	topper	crude_imp	none	none	petron	NP	2)
2006*2030	NAP_M petron	M_NAP	dummy	none	none	petron	NHT	3)
2006*2030	LN	petron	NHT	NAP_M	none	none	petron	B_LN 4)
2006*2030	GO_NHT	petron	B_LN	LN	none	none	petron	blend_GO 5)
2006*2030	GO_ref	petron	reformer	HN	none	none	petron	blend_GO 6)
2006*2030	GO_FCC petron	FCC	BTM_HC	none	none	petron	blend_GO	7)
2006*2030	gasoline_P	petron	blend_GO	dummy	none	none	whole	M_GO 8)
2006*2030	gasoline whole	M_GO	dummy	yes	yes	whole	demand	9)

explanation)

1) (PETRON) NAP_top can be produced from topper with feed material crude_dom and consumed in plant M_NAP(merging naptha). Neither import and export are not allowed in NAP_top.
2) (PETRON) NAP_top can be also proceed from topper with feed material crude_imp. Consumption is already defined in 1), so consumption should be defined no more.
3) (PETRON)NAP_M is the products from plant M_NAP and consumed in NHT as feed material. Neither import and export are not allowed in M_NAP.
4) (PETRON)LN(Light Naptha) is the product from NHT(Naptha Hydro Treating) with feed material NAP_M, and is consumed B_LN(Branch LN). Neither import and export are not allowed in LN
5) (PETRON)GO_NHT(Gasoline from plant NHT) is the product from plant B_LN and consumed in blend_GO(blender of Gasoline). Both import and export are not allowed in LN
6) (PETRON)GO_ref(Gasoline from plant Reformer) is the product from plant Reformer and consumed in blend_GO(blender of Gasoline). Neither import and export are not allowed in LN
7) (PETRON)GO_FCC(Gasoline from plant FCC) is the product from plant FCC(Fluid Catalystic Cracking) and consumed in blend_GO(blender of Gasoline). Neither import and export are not allowed in LN

8) (PETRON)total gasoline of PETRON refinery is produced from blend GO and is consumed in M_GO
(Merging_Gasoline : feed material is gasorine from PETRON and SHELL refineries)

9) (Whole)The flow of above from 1) to 8) lines are PETRON refinery,. There is the exactly same flow in SHELL refinery. Both gasoline_P and gasoline S are merged in plant M_GO.
Gasoline is produced from M_GO and consumed in demand. (Demand is defined as one of plants.)

NOTES) Plant is composed of some kinds.

a actual plants like many facilities in refinery,, power plants

b merging and branching plant with name M_xxxx and B_xxxx

c blending plant with name blend_GO and blend_FO

d peculiarity of this LP model such as

* demand (consumed as demand)
* calculate(just only calculation so not target of balance)
* Trans_H_dom and Trans_H_imp(transformation weight base to calorie in coal)
* own (electricity used own power plant)
* distribution (transmit and distribution loss in electricity)

(35) merge-set.csv

format : year, class,feed,plant,final

related place in program : 'set_definition2.inc', 'eq_definition.inc','output.inc'

meaning : (look Figure 6 : blend_GO is the same of merging plant)

1 final product and many feed materials.
If there are n feed materials this data is represented by n lines and
final is always the same energy.

(calss =Petron, feed = GO_NHT, GO_ref, GO_FCC, final = gasoline_P in Fig2.1)

(Example)

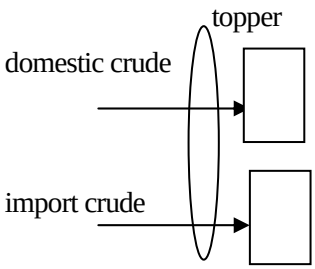
2006*2030	petron	GO_NHT	blend_GO	gasoline_P
2006*2030	petron	GO_ref	blend_GO	gasoline_P
2006*2030	petron	GO_FCC	blend_GO	gasoline_P

(36) merge-cons-max.csv

format : year, class,plant,feed, max of consumption

related place in program : 'set_definition2.inc', 'eq_definition.inc', 'output.inc', 'unit_change.inc'

meaning : Topper plant has 2 kinds of feed such as domestic crude and import crude
The capacity of topper plant is measured by total feed amount. But the yield greatly depend on the feed material property. So a topper plant is virtually divided 2 plants such as topper distillation domestic crude and import crude. The capacity of the individual plant cannot be defined. This data defines as the total maximum feed.



(Sample) 2006*2030 petron topper crude_dom 180
2006*2030 petron topper crude_imp 0
total feed = capacity of topper
180 + 0 = 180

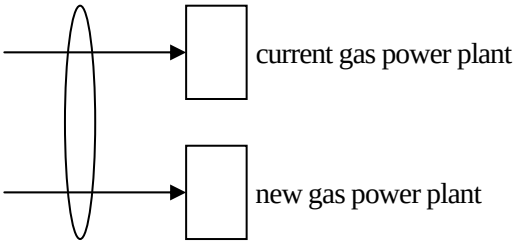
maximum feed should be given

(37) merge-cons-min.csv

format : year, seq,class,plant,feed, min of consumption

related place in program : :'set_definition2.inc', 'eq_definition.inc'

meaning : There are 2 gas power plants. One is current plant, another is new plant. Gas consumed in these 2 gas plants should be consumed at least a specified amount. The gas power plant should keep the minimum load. The minimum load is equivalent to the consumption of gas production whose is the highest production in domestic gas.



minimum consumtion

(38) coal_dom_rate.csv

format : year, max rate of domestic coal in coal power plant

related place in program : 'eq_definition.inc'

meaning : The domestic coal in Philippines is rich of alkali. So the rate of domestic coal of being used in power plant has limit.

(Sample) 2007*2030 20

In this sample that rate is 20%.

(39) diesel-rate.csv

format : year, max rate of diesel oil in diesel power plant

related place in program : 'eq_definition.inc'

meaning : This data is the max rate of diesel oil in diesel power plant.

(40) EP-load-min

format : year, plant, minimum load

related place in program : 'eq_definition.inc'

meaning : Diesel power plant should work at minimum load a year..

(41) branch_set.csv

format : year, class,feed,plant,final

related place in program : ‘set_definition2.inc’, ‘eq_definition.inc’,’output.inc’

meaning : (look Figure 6 : B_LN is the branch plant)

1 feed and many output materials.

If there are n output materials this data is represented by n lines and

feed is always the same energy.

(42) prd_fix.csv

format: year, class, feed, plant, final energy

related place in program : ‘eq_definition.inc’,’output.inc’

meaning : In the past year, 2006 in this model, production actual data is directly adopted, not calculated

(43) domestic-cost.csv

format: year, energy, domestic cost

related place in program : ‘unit_change.inc’,’output.inc’

meaning : used for calculation of FOB

FOB = sales price – domestic freight cost

2.2 Procedure of Execution

After preparing all input data, the model can be executed via following procedure

2.2.1 Load GAMS into Memory and Execute the Model

(1) Double click the following icon IDE on the desktop

IDE is the interface of GAMS. By using this interface, the various actions become possible as follows

1) GAMS coding

2) Execute model by GAMS

3) Get all information of results

note) IDE icon is automatically created on the desktop by installing GAMS system.

(2) Move a gpr(Gams PRject file) to one in which the model exists.

1) Click the ‘file’ in the tool bar.

2) Click the name in the drop down in sequence

project-new project

3) Select the holder name in which the model and data exits.

4) Key in the project name.

Project name is the file name to control the model.

So 1 project corresponds to 1 model.

The name can be defined freely and has automatically the extension name ‘gpr’.

(3) Click the ‘file’ in the tool bar and ‘open’

(4) Select the model text file name with the extension name ‘.gms’ you coded. (pep2008.gms)

(5) One Click the following execution icon.

note)If this icon is not colored with red, the model cannot be worked. In order to work the GAMS, click the tab with the name ‘PEP2008.gms’. Then this icon becomes red.

(6) GAMS automatically runs and creates the output file with the name ‘PEP2008.lst’ called list file.

note) Refer the GAMS manual regarding lst file

(7) Many kinds of output are automatically created under the same holder as described above.

These outputs are created by this model itself but not by GAMS. They are created in order to analyze and check the various results. How to use these outputs are described later.

2.2.2 In the Case that Error Happens.

There are 2 kinds of errors. One is grammatical error and the other is infeasible/unbounded error.

(1) Grammatical error

In case of grammatical error, there are some grammatical errors in the model coding. You have to fix them according to the GAMS grammar. The place where the error happened is pointed by ‘****’, so you can easily find the error place in the list file. Also the list file gives the error contents by code. The meaning of the code is written after the model coding.

The error message are, for example as follows;

```
   17    put out_testt;
****                    $140,294
```

The error meaning are, for example, as follows;

```
140    Unknown symbol
294    No external file assigned - A file has to be made current by
           using the name on a put statement, i.e. PUTxxx fname ....
```

note)Refer the GAMS manual regarding the detail grammar

(2) Infeasible/Unbounded error

1) Infeasible error

There is no royal road to find the real cause of this infeasible error. It depends on the experience.

But there is a basic procedure to find the cause. Many data are required in LP model. Man kind is apt to mistake. So errors happen from input data error with probability of over 80%.

The list file created by GAMS points the row (constraint) names or variable names where infeasible errors happened. When the infeasible error happens in the constraint, the constraint cannot be satisfied. When the infeasible error happens in the variable, the variable(solution) cannot exist between the minimum and maximum. Therefore at first the most important method to find an infeasible error is to check the input data regarding row and variables where they happen. Especially lower and upper bound data, fixed data are apt to

make errors. If you cannot find the cause of infeasible checking input data, check the equations developed by GAMS itself. Check whether the equation developed is one you intended or not.

example of REPORT SUMMARY)

**** REPORT SUMMARY : 0 NONOPT

12 INFEASIBLE (INFES)

SUM 9994.526

MAX 4830.000

MEAN 832.877

0 UNBOUNDED

example of infeasible error in the constraint)

2025.whole.EP_coal_dom.L_coal . . . . INFES

example of infeasible error in the variable)

2018.whole.EP_gas .gas

.el . 73333.524 72567.840 . INFES

Especially, check the index and coefficients consisting equations. Usually you can find over 80% course of errors by easy checking of data and equations. Even doing so, if you cannot find the error cause, imagine the solution you think to be correct and fix the variable by its value. Check what happens. You may find questionable results. Analyze the solution in detail. Sometimes you may be able to find the cause. The model creates many kinds of output. There are some output files for checking such as list of production, consumption, import, export, bound of variable, refinery results and electricity results. You may be able to find questionable results in these checking of output files. Then you may be able to find the error cause. The above described checking have to be repeated done in detail many times, before the model stabilizes.

2) Unbounded error

This error means that the objective function value would have gone to the infinity. As one example, this case may come from the phenomenon such that the material can be sold at infinity with cost 0. If you meet this unbounded error, you should check the cost definition.

2.2.3 After Processing the Execution of the Model

After executing the model, even if there are no errors, the solution may not be correct. The solution is apparently optimal. But it often happens that the solution is not one you had expected. So detail check should be done by implementing doing following procedures.

(1) Check ‘out_dummy.csv’

If you will find the output with nonzero data, it means that the solution is not optimal.

Plus value means that the demand side is over than supply sand. So plus value is the deficit amount. Minus value means that the supply side is over than demand side. So minus value is the surplus amount. You should correct input data or programming in order that all data in out_dummy.csv are 0.

(2) Check ‘out_refinery rate.csv’ (Table 3 out-refinery table)

If you will find the unnatural rate of petroleum products, you have to check data regarding refinery model. The ratio of petroleum products represents whether the refinery calculation is suitable or not. The reason is that the main data of refinery is the yield, but that data is usually confident in the refinery company, so the data are

estimated ones in order that the final petroleum products rates match the actual ones. Gasoline is produced through some facilities and some routes. Regarding individual facility, there not may be correct production of products, but totally the ratios are matched to the actual data. So it is required to check the final petroleum products.

(3) Check 'out_load.csv'(Table 4 out load table)

If you will find that the value of this file are all 100, it may be infeasible.

If you cannot explain the trend of this result, something is wrong.

Here refer the following how to analyze this output file.

Table 3 Out-refinery rate table

year	LPG	gasoline	kerosene	jet_fuel	diesel	fuel_oil
2006	3.45	16.44	1.58	7.02	37.46	29.27
2007	4.5	17.71	1.36	8.16	36	27.77
2008	4.5	17.72	0	9.52	36	27.76
2009	4.5	17.72	0	9.52	36	27.76
2010	4.5	17.72	0	9.52	36	27.76
2011	4.49	17.7	0	9.52	36	27.8
2012	4.5	17.72	0	9.52	36	27.76
2013	4.49	17.7	0	9.52	36	27.8
2014	4.5	17.72	0	9.52	36	27.76
2015	4.5	17.72	0	9.52	36	27.76
2016	4.5	17.72	0	9.52	36	27.76
2017	4.5	17.72	0	9.52	36	27.76
2018	4.5	17.72	0	9.52	36	27.76
2019	4.5	17.72	0	9.52	36	27.76
2020	4.5	17.72	0	9.52	36	27.76
2021	4.5	17.72	0	9.52	36	27.76
2022	4.5	17.72	0	9.52	36	27.76
2023	4.5	17.72	0	9.52	36	27.76
2024	4.5	17.72	0	9.52	36	27.76
2025	4.5	17.72	0	9.52	36	27.76
2026	4.5	17.72	0	9.52	36	27.76
2027	4.5	17.72	0	9.52	36	27.76
2028	4.5	17.72	0	9.52	36	27.76
2029	4.5	17.72	0	9.52	36	27.76
2030	4.5	17.72	0	9.52	36	27.76

actual data at 2007

LPG 4.6%

gasoline 16.8 %

kerosene + jet-fuel 10.2 %

diesel 35.4%

fuel oil 29.4%

In this model there are 2 constraints as follow;

maximum rate of gasoline = 18%

maximum rate of diesel = 36%

Other rate are calculated based on total energy minimum cost.

Table 4 Out-load table

year	production		plant				
	coal	gas	coal power	gas power	Diesel power	Fuel oil power	topper
2006	100	100	57.06	100	9.43	100	68.93
2007	100	81.4	100	75.51	0	0	100
2008	100	63.38	100	80.82	0	0	100
2009	100	75.17	100	95.38	0	0	100
2010	79.2	79.46	100	100	13.98	100	100
2011	81.38	80.21	100	100	75.88	100	100
2012	89.21	80.97	100	100	20.03	100	100
2013	91.28	81.67	100	100	81.92	100	100
2014	93.34	100	100	97.86	53.65	100	100
2015	80.35	100	100	97.15	31.87	100	100
2016	86.96	100	100	96.29	0	36.1	100
2017	88.83	100	100	95.43	59.82	100	100
2018	95.44	100	100	94.56	16.2	100	100
2019	99.68	100	100	83.92	79.21	100	100
2020	82.57	100	100	89.28	17.16	100	100
2021	84.1	100	100	99.09	39.67	100	100
2022	87.49	100	100	93.51	36.87	100	100
2023	92.71	100	100	86.98	29.83	100	100
2024	96.07	100	100	75.31	72.9	100	100
2025	86.67	100	100	87.85	45.11	100	100
2026	88.02	100	100	85.73	88.99	100	100
2027	92.63	100	100	89.88	19.86	100	100
2028	97.22	100	100	86.5	0	98.01	100
2029	98.54	100	100	83.29	89.12	100	100
2030	81.5	100	100	80.36	53.59	100	100

Assumptions: Hydro, geothermal, Renewable power plant generate at specify power. It gradually continue to increase.

example at 2007,

a) Coal production is at maximum at first. Yet it cannot satisfy the demand of electricity.

b) Coal continues to be imported till coal power plant load becomes maximum at second, yet cannot satisfy the demand of electricity

c) Next, gas plant begins to work till load 75.51%. It means that it can satisfy the demand of electricity. So diesel power plant and fuel oil power plant are not required to work.

These situation continues by 2009. Gas power plant load increases for 3 years.

example at 2010 (till 2010 there is no new power plant enlargement)

a) Coal power plant load is 100%. But it cannot satisfy the demand.

But production does not reach at the maximum because the maximum of coal production increases. (maximum of production 3,736 kton at 2007, 5,036,kton at 2010). Furthermore domestic coal ratio to total feed to coal power plant is less than 20%.

b) Next gas plant works at maximum load before production reaches at maximum. So eve if gas is produced more, there is no room of consumption. Yet it cannot satisfy the demand.

c) Next fuel oil power plant works at maximum load. Yet it cannot satisfy the demand.

d) Next diesel power plant begins to work. It can satisfy the demand before the load of diesel oil power plant reaches at maximum.

This situation continues till 2015. For this 6 years, coal and gas power plant capacity are enlarged. So it occurs that coal power plant is working at maximum load, but production rate is down at 2005.

From 2014, gas production reaches at maximum before gas power plant load reaches at maximum. But load of gas plant is down comparing to the previous year because 2015 gas plant capacity is up.

Thus looking at this table, there is no unnatural phenomenon. We can judge this solution has no mistakes from this load analysis viewpoint.

If every field has all 100% at one year, it means that there may be some mistakes. If you encounter this thing look the out-dummy.csv, then you will find out that some dummy variables have non zero value.

After these 3 check procedures, go to the following steps.

(4) Open the out_summary_kton.xls and click the icon name 'Macro Execute' in sheet name is 'out-summary'

--Macro content--

a) Open the out_summary.csv. (Double click this file name)

This file includes almost all energy balance information by year and is automatically created by the model. This file uses the unit by kton or MMm3.

b) copy data of all E column out_summary.csv.

c) Paste into E column of the sheet name 'out_summary' in the out_summary_kton.xls.

d) In out_summary.csv is longitudinally represented by year and energy. This macro changes this format horizontally by year.

e) This file automatically draws graph of each energy balance.

This graph is drawn on each sheet by energy. (Each sheet name is the same to the energy name.) So check the graph whether questionable trends exist or not.

If you find the questionable results, fix them and execute the model again till you satisfy.

(5) Open the out_summary_ktoe.xls and click the icon name 'Macro Execute'

This macro content is the same to the macro of out_summary-kton.xls

(6) Open the primary-energy-ktoe.xls and copy the sheet name out_summry of out-summary-ktoe.xls into a sheet name out-summary of the primary-energy-ktoe. So automatically you can get some graphs regarding primary energy supply.

2.2.4 Execute Case Studies（1）

After creating the basic model, you can conduct many case studies. Procedures of case study are as follows;

(1) Make sure that what is difference between the basic model and case study you want to do.

This difference should be represented as input data or in the model.

(2) Make a new holder under the holder which the original model exists.

(3) Copy all files under the original model holder to new holder for case study.

(4) Change the data or GAMS model according to conditions of the case study.

(5) execute the case study

(6) Do usual analysis of the case study

(7) In order to compare the case studies(ex: case A and case B)

1) open the out_summary.csv of case A

2) file save as xxxxxxx.xls

3) open the out_summry.csv of case B

4) copy all column E data in case B into column F in xxxxxx.xls

5) Calculate the difference from the data E column (case A)minus the data F column(case B)

6) Analyze the difference by sorting or thinking

2.2.5 Execute Case Studies（2）

Case study procedures using GAMS may be classified into several types as follows;

(1) Calculate the only specified year(only one year)

1) Click the IDE icon

2) Move the specified holder (refer 2.2.1 (1), (2))

3) file-open

file type = Includes files(*.inc)

select set_definition.inc

4) find the line

set target_year /

2006*2030

/;

5) In case that target year is 2010

change 2006*2030 into 2010*2010

6) execute the case study

(2) Only key in data change is required.

For example CO2 max value is required to be changed.

1) open the input-data.xls

2) Click the sheet name ‘CO2-max’

3) input a new data of CO2-max

4) click the icon ‘Save file’

5) execute the case study

(3) Demand data are changed

If some assumptions like GDP growth rate which would affect the energy demand are changed,

1) The forecasting model should be executed.

2) Copy the demand data into the sheet ‘demand-sec’ of input-data.xls.

3) execute the case study.(refer 2.2.1)

(4) Demand does not change, but power development plan changes

1) According to the plan, input the capacity of power plant increment into the sheet ‘EP-capacity’ of input-data.xls.

2) execute the case study (ref 2.2.1)

(5)Energy flow changes

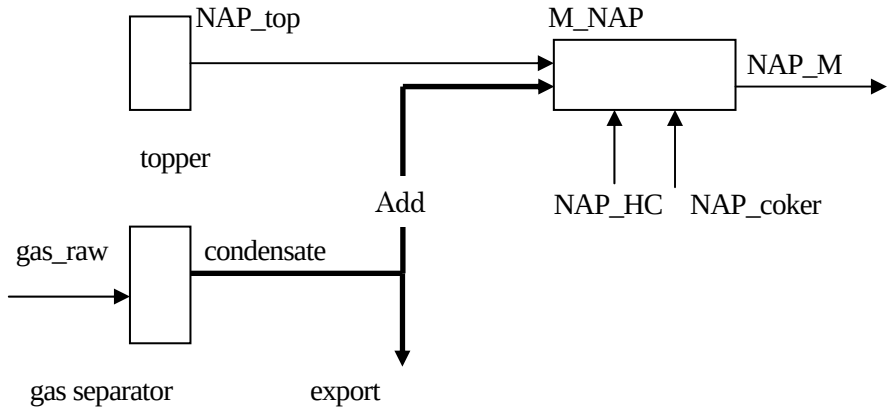
If energy flow changes, change carefully the data in sheet ‘connect’ of input-data.xls.

It often occurs that if the energy flow changes, it is required to change the constraints in eq_definition.inc. This operation is not so easy. You have to master GAMS to some extent in order to do this.

(Example)

current : Condensate goes only to export.

after chage : Condensate goes to export and merge into naptha.



Current data of sheet 'connect' of input-data.xls regarding condensate is as follows;

*year	energy	class	plant	feed	import	export	class	plant
2006*2030	condensate	whole	gas_plant	gas_rawnone	yes	whole	NP	

after change

current data regarding condensate is as follows;

*year	energy	class	plant	feed	import	export	class	plant
2006*2030	condensate	whole	gas_plant	gas_rawnone	yes	petron	M_NAP	

(in this case class 'petron' is picked up. If you select shell instead of petron, there is no problem. There is no diffrence between petron and shell, because M_NAp is virtual plant, so there is no physical property.)

At the same time merging line should be defined in sheet 'merge-set' of input data.xls

*year	class	feed	plant	final	
2006*2030	petron	NAP_top	M_NAP	NAP_M	
2006*2030	petron	NAP_HC	M_NAP	NAP_M	current
2006*2030	petron	NAP_coker	M_NAP	NAP_M	
2006*2030	petron	condensate	M_NAP	NAP_M	←Add
2006*2030	shell	NAP_top	M_NAP	NAP_M	
2006*2030	shell	NAP_HC	M_NAP	NAP_M	current
2006*2030	shell	NAP_coker	M_NAP	NAP_M	
2006*2030	shell	condensate	M_NAP	NAP_M	←Add

before change

eq_connect (2007,whole,condensate)..

Xprd (2007,whole,gas_plant,gas_raw,condensate) - Xexp(2007,condensate) =E= 0;

eq_merge (2007,petron,M_NAP,NAP_M)..

Xprd(2007,petron,M_NAP,dummy,NAP_M)

- Xcon (2007,petron,M_NAP,NAP_top) - Xcon(2007,petron,M_NAP,NAP_coker)

- Xcon (2007,petron,M_NAP,NAP_HC) =E= 0 ;

(skip regarding shell)

after change

eq_connect(2007,whole,condensate)..

Xprd(2007,whole,gas_plant,gas_raw,condensate)

Xcon(2007,petron,M_NAP,condensate) - Xexp(2007,condensate) =E= 0 ;

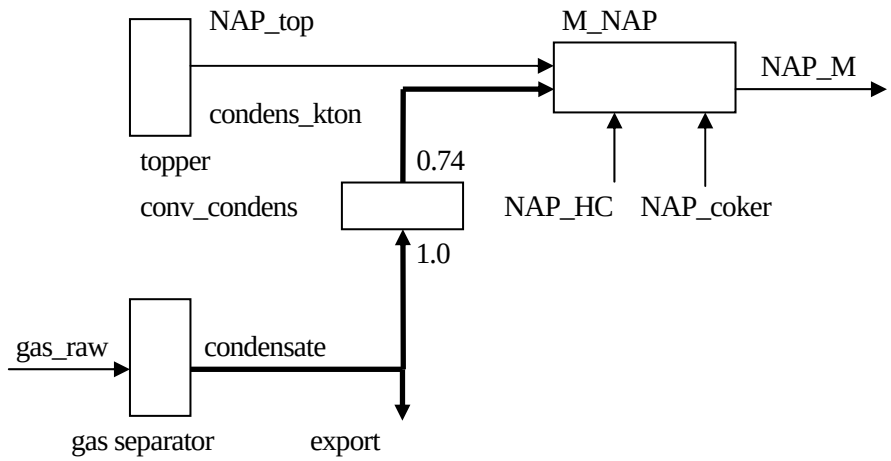
eq_merge(2007,petron,M_NAP,NAP_M).. Xprd(2007,petron,M_NAP,dummy,NAP_M)

- Xcon(2007,petron,M_NAP,condensate) - Xcon(2007,petron,M_NAP,NAP_top)

- Xcon(2007,petron,M_NAP,NAP_coker) - Xcon(2007,petron,M_NAP,NAP_HC) =E= 0

After executing and analysing this case study, condensate stops export, and it is consumed as naptha. it looks that there is no mistake in this case study.

But there is one great mistake. It is the unit. Balance equations like equation eq_connenct and eq_merge have ‘kton’ as unit. But condensate is measured ‘MMm3’ as unit. So the unit of condensate should be conveted from MMm3 to kton. So the definition of new set such as new name of condensate after unit conversion and new virtual conversion plant, for example condensate_kton and trans_condensate.



a) sheet name 'connect' should be revised as follows;

*year energy class plant feed import export class plant

2006*2030 condensate whole gas_plant gas_raw none yes petron conv_condensate

2006*2030 condens_kton petron conv_condens condensate none none petron M_NAP

b) sheet name 'merge-set' should be revised as follows;

*year class feed plant final

2006*2030 petron condens_kton M_NAP NAP_M

c) sheet name 'yield' should be added as follows;

2006*2030 petron conv_condens condensate condens_kton 740

Analyzing the result, there are no unnatural values. But comparing the reference case, the rate of petroleum products varies by year. It comes from the reason why petroleum products (naptha) come from another plant which is not refinery site. Gas production gives the effect of production situation from refinery.

(6) An objective function is required to be changed.

1) Click the IDE icon

2) Move the specified holder (refer 2.2.1 (1), (2))

3) file-open

file type = Includes files(*.inc)

select eq_definition.inc

4) Define the new objective function

5) file-open

main program = Vietnam.gms

6) Modify the objective function name by new name

solve vietnam_1 using LP minimizing obj_cos-→solve vietnam_1 using LP minimizing xxxxx

7) execute the case study.

Appendix-6

Operation Manual of Outlook Summary

Appendix-6 Operation Manual of Outlook Summary

1. Model Configuration

The Energy Demand Forecasting Model and Energy Supply Optimization Model combined provide energy supply and demand outlook of the future. These models produce a bunch of figures. In order to identify features of energy supply and demand outlook projected for each case easily, Combined Simulation Summary is prepared. This Outlook Summary consists of 7 sheets, Summary, Overview, Energy Balance Table, Base Table, Supply, Simulation and OUT_WS. Data of Simulation sheet and OUT_WS sheet are imported from Energy Demand Forecasting Model and Energy Supply/Demand Optimization Model, respectively.

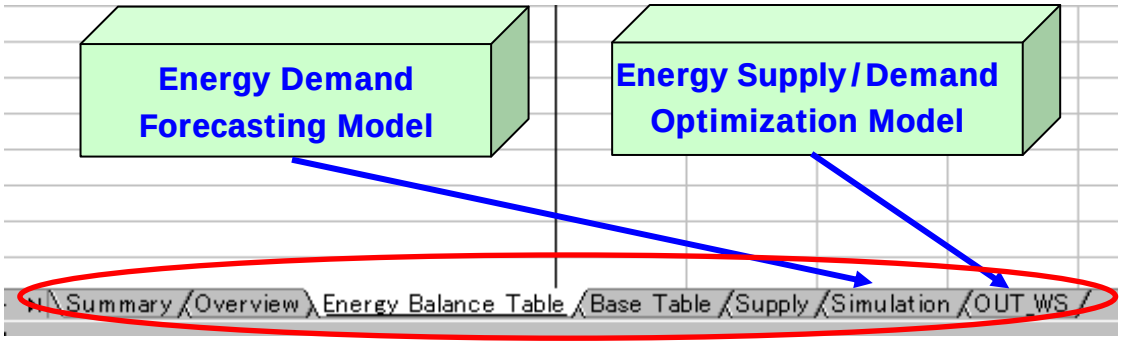
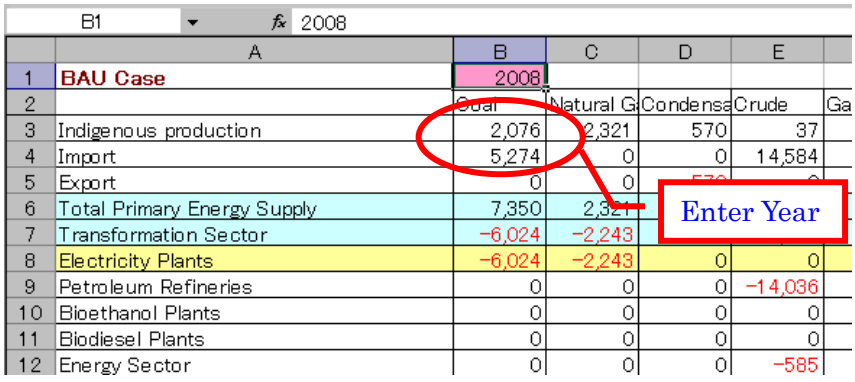


Figure-1 Outlook Summary Book Sheets

The "Summary" sheet is designed to show typical energy indicators to highlight features of scenarios, cases or policy options such as primary energy supply, final energy demand and other important sectoral figures. Projected figures are prepared annually from 2005 to 2030 with 5 year average growth rates. The "Overview" Sheet is a one-page brief summary of the Outlook Summary for easy reference carrying data on every five year. "Energy Balance Table" Sheet provides energy balance table from 2008 to 2030. When entering any year from 2008 to 2030 on Cell B1, you can see energy balance table in the year that you entered as illustrated in Figure-2. These data are linked to the "Simulation" and "OUT_WS" sheets. Appenxix-1, Appendix-2, and Appendix-3 in this report show the samples of the "Overview" sheet, "Summary" sheet, and "Energy Balance Table" sheet.



	A	B	C	D	E	
1	BAU Case	2008				
2		Coal	Natural G	Condensa	Crude	Ga
3	Indigenous production	2,076	2,321	570	37	
4	Import	5,274	0	0	14,584	
5	Export	0	0			
6	Total Primary Energy Supply	7,350	2,321			
7	Transformation Sector	-6,024	-2,243			
8	Electricity Plants	-6,024	-2,243	0	0	
9	Petroleum Refineries	0	0	0	-14,036	
10	Bioethanol Plants	0	0	0	0	
11	Biodiesel Plants	0	0	0	0	
12	Energy Sector	0	0	0	-585	

Figure-2 Energy Balance Table Sheets

2. Copy & Paste of Simulation Sheet

Data on the “Simulation” sheet is copied from Simulation sheet of the Energy Demand Forecasting Model. When you paste the data on the “Simulation” sheet in Demand Forecasting Model, you should select “paste special” and “value” as illustrated in Figure-3. Do not copy the “Simulation” sheet itself but the “Value” only, since the contents of the table are linked to other sheets within the Outlook Summary book.

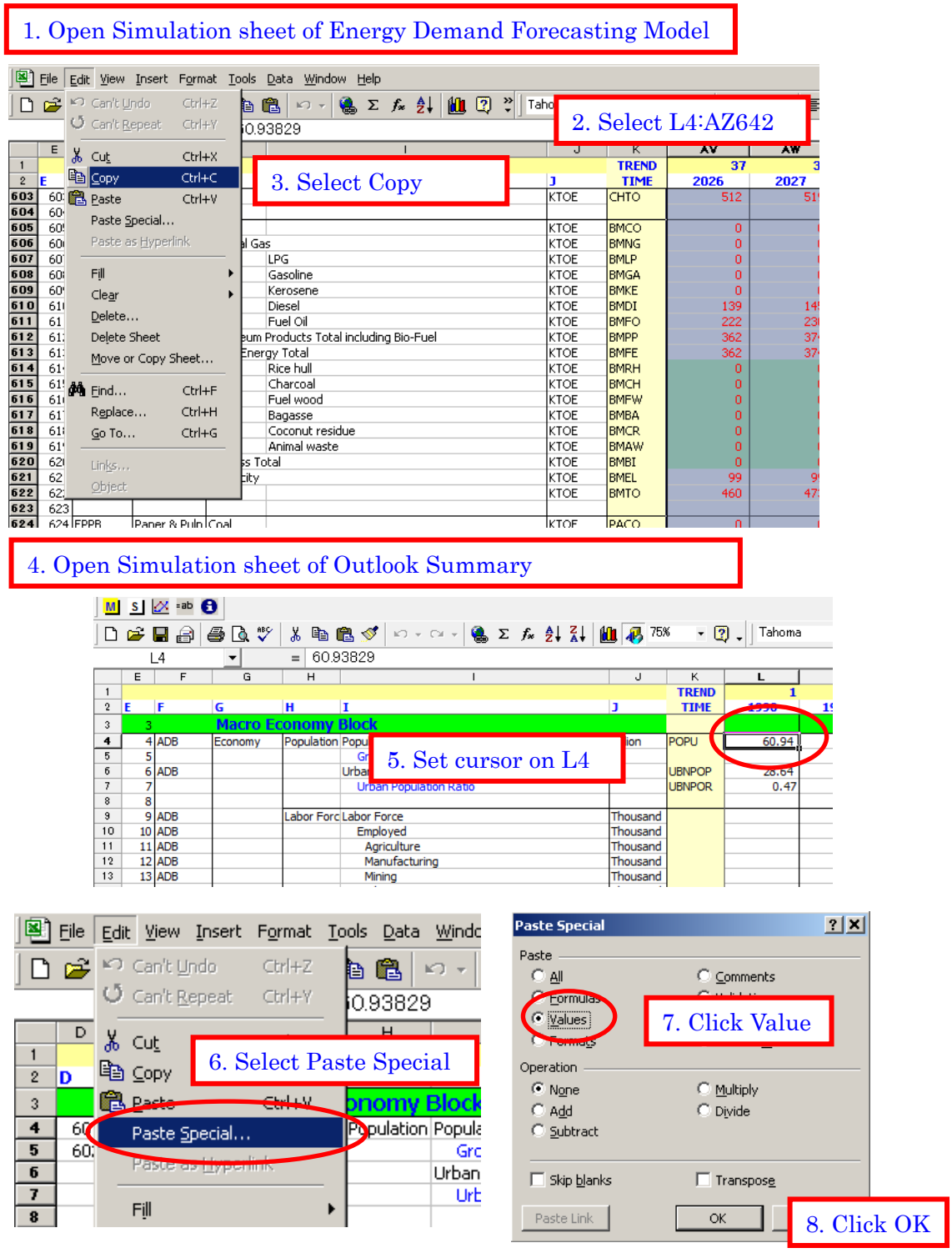


Figure-3 Copy and Paste of Simulation Sheet

3. Copy & Paste of OUT_WS Sheet

Data on the "OUT_WS" sheet is copied from "OUT_WS.CSV" file that is created by Energy Supply/Demand Optimization Model as illustrated in Figure-4.

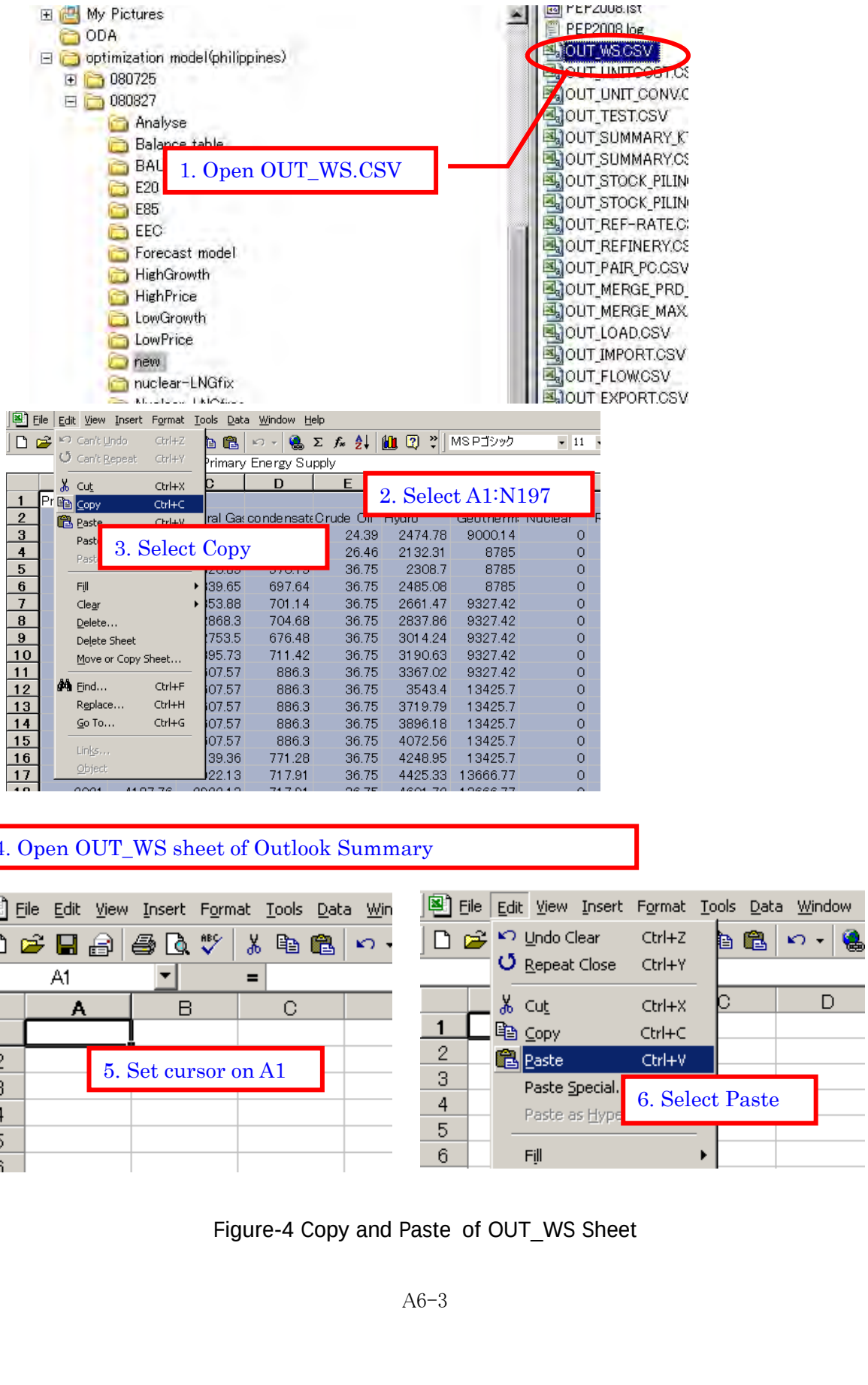


Figure-4 Copy and Paste of OUT_WS Sheet

Now you have completed the procedure to produce three summary sheets, namely, summary, overview and Energy Balance Table, where other four sheets are used to provide base data.