

PRIMARY ENERGY SOURCES

- Fuel Sources and Technologies
- Worldwide energy consumption
- World's primary energy production & consumption
- World's proven reserves, production rate and remaining lifetime
- *US electric net generation*
- *US electric net summer capability*
- Philippine primary energy consumption
- Philippine electric generation mix
- Major power plants in the Philippines

PRIMARY ENERGY SOURCES

- The traditional way of classifying primary energy sources is as follows:
- **Fossil fuels:**
 - * **Solid** (coal, petroleum coke or petcoke)
 - * **Liquid** (petroleum fuels, gas liquids and derivatives e.g. condensate, methanol, ethanol)
 - * **Gas** (natural gas, LPG, hydrogen)
- **Nuclear fuels** (uranium, plutonium)
- **Renewable energy** (hydro, geothermal, wind, solar, ocean, biomass, wastes)
- The *California Energy Commission* has a different way of classifying fuel and technology cycles:

FUEL SOURCES & TECHNOLOGIES

■ 1.1 CONVENTIONAL FUELS

1.1.1 Petroleum or crude oil (Conventional/Enhanced Oil Extraction)

1.1.2 Natural gas

1.1.3 Conventional coal

1.1.4 Nuclear Fission

1.1.5 Liquid Petroleum Gas (LPG)

1.1.6 Liquid Natural Gas (LNG)

1.1.7 Petroleum Coke (“Petcoke” or “Coke”)

■ 1.2 ALTERNATIVE FUELS

1.2.1 Oil Shale

1.2.2 Tar Sands

1.2.3 Nuclear Fusion

1.2.4 Coal (Gasification, Direct/Indirect Liquifaction, Pyrolysis)

1.2.5 Ethanol

1.2.6 Methanol (from Natural Gas)

1.2.7 Hydrogen

FUEL SOURCES & TECHNOLOGIES (2)

■ 1.3 RENEWABLE FUELS

1.3.1 Geothermal (Hydrothermal, Hot Dry Rock, Magma)

1.3.2 Biomass Fuel

1.3.3 Municipal Solid Waste

1.3.4 Solar Resource

1.3.5 Wind

■ 2.0 OIL & GAS COMBUSTION

2.1 Rankine Cycles (Conventional, Supercritical)

2.2 Simple Cycle Gas Turbine

2.3 Combined Cycles (Conventional, Kalina)

2.4 Advanced Gas Turbine Cycles (Steam Recuperated, Inter-cooled, Chemically Recuperated, Humid Air Turbine, IRCC, Inter-cooled Aeroderivative)

2.5 Small-scale Turbines

FUEL SOURCES & TECHNOLOGIES (3)

■ 3.0 COAL

3.1 Conventional Steam Boiler Rankine Cycle

3.2 Fluidized Bed Combustion (Atmospheric, Pressurized)

3.3 Integrated Coal Gasification Combined Cycle

3.4 Integrated Gasification Humid Air Turbine

3.5 Brayton Cycles (Direct coal-fired combustion, Direct coal-fired Diesel)

■ 4.0 NUCLEAR FISSION

4.1 Pressurized Water Reactor

4.2 Boiling Water Reactor

4.3 High Temperature Gas Cooled Reactor

4.4 Liquid Metal Fast Breeder Reactor

■ 5.0 NUCLEAR FUSION

5.1 High Temperature

5.2 Cold Fusion

FUEL SOURCES & TECHNOLOGIES (4)

■ 6.0 GEOTHERMAL

6.1 Vapor-Dominated Resources

6.2 Liquid-Dominated Resources (Flashed Steam, Binary, Biphasic)

■ 7.0 HYDRO ELECTRIC

7.1 Conventional Hydro electric

7.2 Hydro Upgrading

7.3 Hydro Retrofit

■ 8.0 BIOMASS FIRED PLANTS

8.1 Direct Combustion

8.2 Gasification

8.3 Anaerobic Fermentation

■ 9.0 MUNICIPAL SOLID WASTE

9.1 Direct Combustion (Mass Burn, Refuse-Derived Fuel)

9.2 Gasification (Pyrolysis/Thermal Gasification, Landfill Gas Recovery)

FUEL SOURCES & TECHNOLOGIES (5)

■ 10.0 COGENERATION

10.1 Gas Turbine Bases Systems (Heat Recovery, Combined Cycle)

10.2 Combustion Engines (Reciprocating Engines, Stirling Engines)

10.3 Topping Stem Turbine Systems (Back-Pressure Turbines,
Extraction Steam Turbines)

10.4 Bottoming Cycle Systems (Low Pressure Steam Turbines,
Organic Rankine Engines)

10.5 Package Cogeneration Systems

10.6 Fuel Cell Cogenerators

■ 11.0 WIND

10.1 Small-Scale Applications

10.2 Utility-Scale Applications

■ 12.0 SOLAR THERMAL ELECTRIC

12.1 Concentrating Systems (Central Receivers, Parabolic Dishes,
Parabolic Troughs)

12.2 Salt Ponds

FUEL SOURCES & TECHNOLOGIES (6)

- **13.0 PHOTOVOLTAICS**
 - 13.1 Small-Scale Systems
 - 13.2 Utility-Scale Systems
- **14.0 OCEAN ENERGY CONVERSION**
 - 14.1 Wave Energy Conversion
 - 14.2 Tidal energy Conversion
 - 14.3 Ocean Thermal Energy Conversion
- **15.0 FUEL CELLS**
 - 15.1 Phosphoric Acid (Utility-Scale System)
 - 15.2 Molten Carbonate
 - 15.3 Solid Oxide
 - 15.4 Alkaline
 - 15.5 Proton Exchange Membrane

FUEL SOURCES & TECHNOLOGIES (6)

■ 16.0 STORAGE SYSTEMS

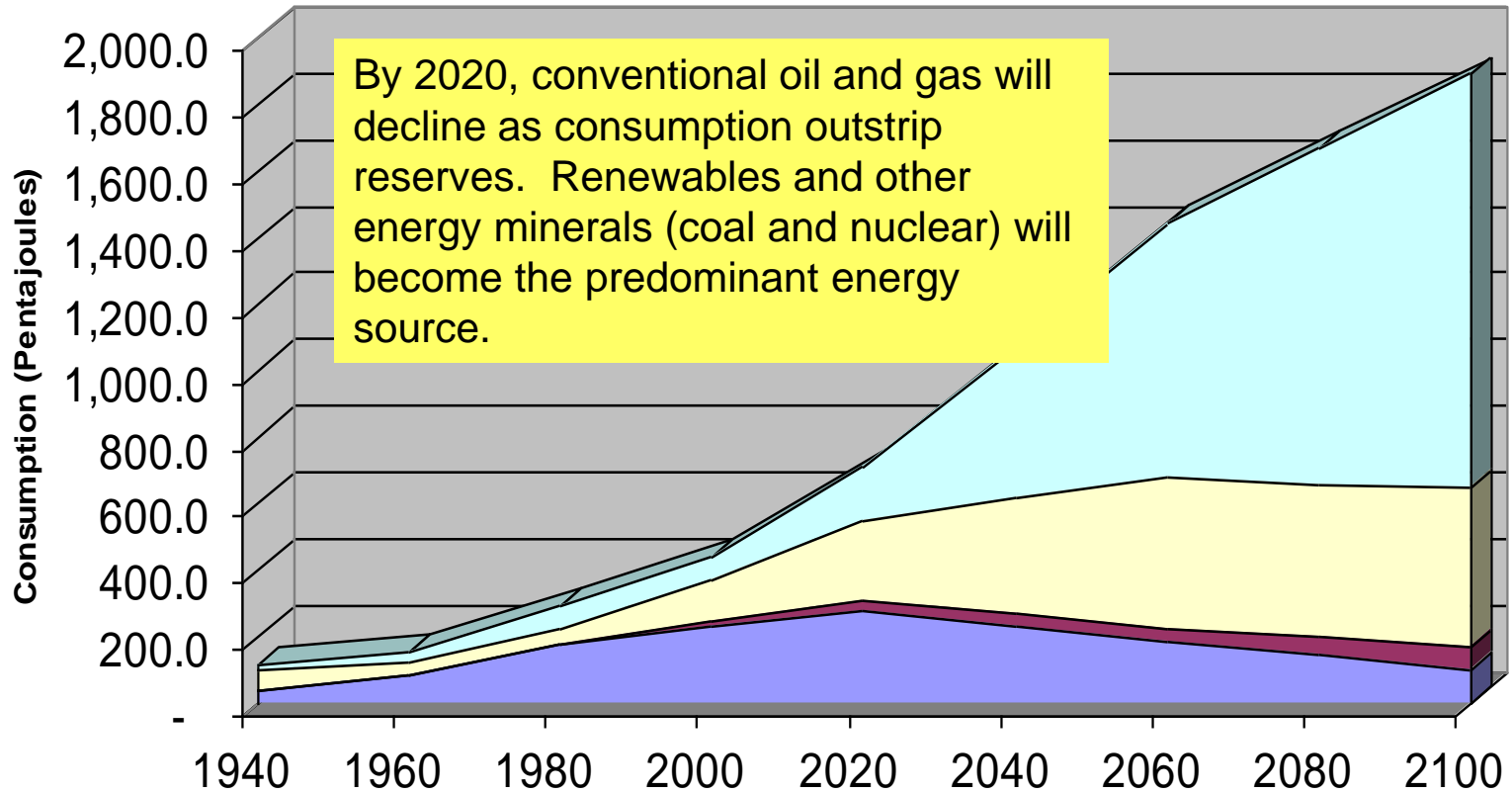
16.1 Pumped Hydro Electric (Conventional, Modular)

16.2 Compressed Air Energy Storage

16.3 Utility-Scale Batteries

16.4 Superconducting Magnetic Energy

WORLDWIDE ENERGY CONSUMPTION



- Conventional Oil and Gas
- Unconventional Hydrocarbons
- Energy Minerals
- Renewables

WORLD PRIMARY ENERGY

(energy for power generation, process heat, transportation, domestic, commercial)

Primary Energy Source	1999 Production (Table 2.1)	Quadrillion (10^{15}) Btu (Table 2.9)	% of Total
Fossil Fuels:		321.93	85.4
Coal (million short tons)	4,737	84.90	22.5
Petroleum (1000 bbl/day)	71,854	149.72	39.7
Natural Gas(trillion ft ³)	85	87.31	23.2
Nuclear Electric (billion kilowatthours)	2,396	25.25	6.7
Renewable Energy: (billion kilowatthours)	2,835	29.93	7.9
Hydro Electric	2,607	27.10	7.2
Others (geothermal, solar, wind, wood and wastes)	227	2.83	0.8
WORLD PRIMARY ENERGY	398 X 10^{18} Joules	377.11 X 10^{15} Btu	100.0

so World energy consumption in 1999: 85.4% fossil, 6.7% nuclear and 7.9 % renewable. Oil supplied 39.7% followed by natural gas 23.2%, coal 22.5%, hydro 7.1% and other renewables 0.8%.

WORLD PROVEN RESERVES, PRODUCTION AND REMAINING LIFE TIME

Being finite and most commonly used, petroleum crude oil and NGL would be gone in 39 years at present reserves and extraction rates

Primary Energy Source	Proven Reserves (Jan. 1, 2000)	Annual Production 1999	Life Time (years)
Fossil Fuels:			
Coal (million short tons)	1,088,602 (Table 8.2)	4,737 (Table 2.5)	230
Petroleum (billion bbls) (crude oil & NGL)	1,017 (Table 8.1)	71,854 (Table 2.2 & 2.3)	39
Natural Gas(trillion ft3)	5,150	85 (Table 2.4)	61
Nuclear Electric (billion kilowatthours)		2,396 (Table 2.7)	
Renewable Energy:			
(billion kilowatthours)			
Hydro Electric		2,607 (Table 2.6)	
Others (geothermal, solar, wind, wood and wastes)		227 (Table 2.8)	

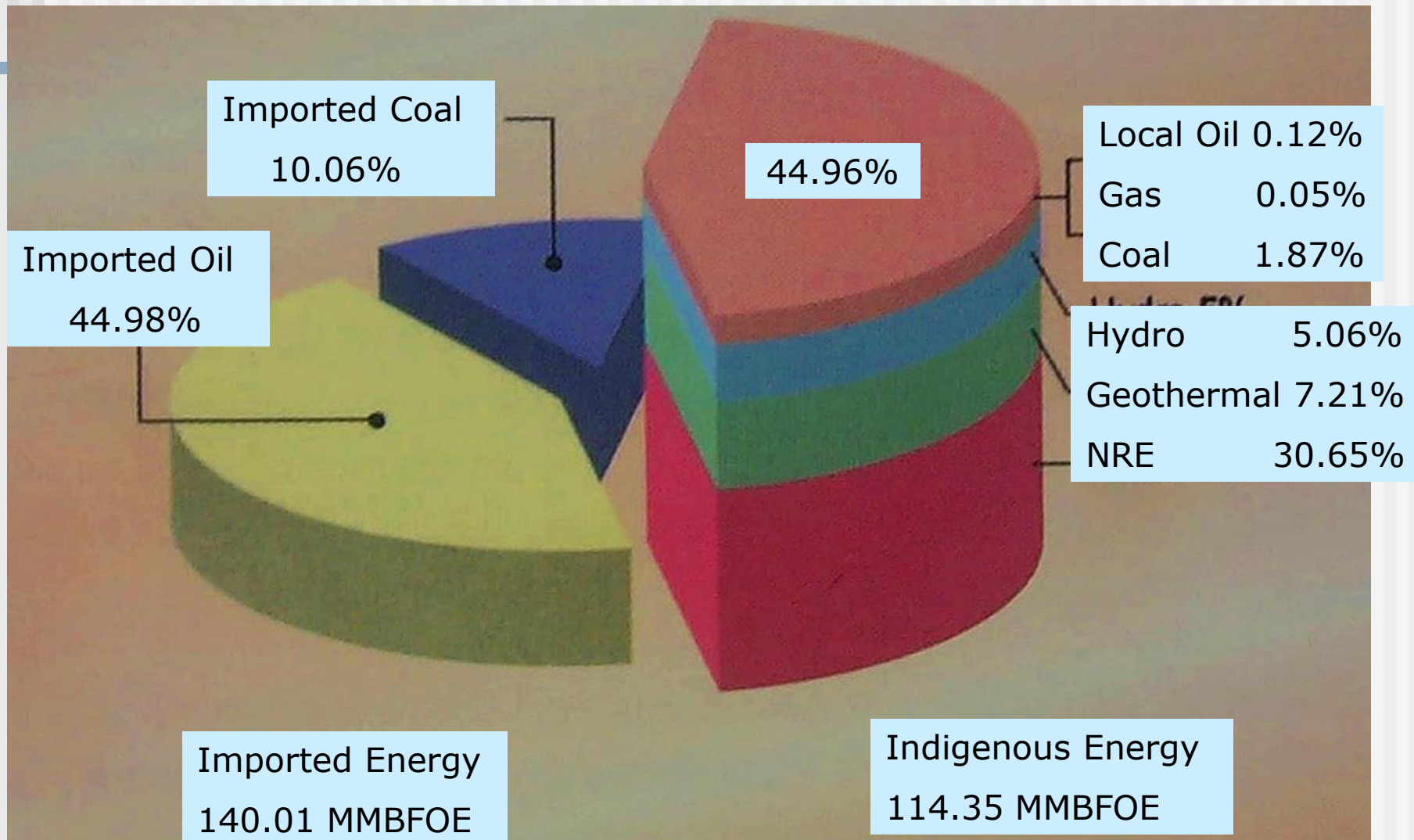
SOURCE: US DOE - EIA

US Nuclear Reserves

US Energy Reserves: (Quad = 10^{16} Btu approx. 10^{18} Joules)

Fuel	Quads	Years	Remarks
Coal	5,000	60	
Oil	500	6	
Gas	500	6	
U3O8	1,600	20	no breeding
U3O8	4,000	50	present reactors
U3O8	220,000	2750	breeding; high-grade ore

Philippine Primary Energy, 2001



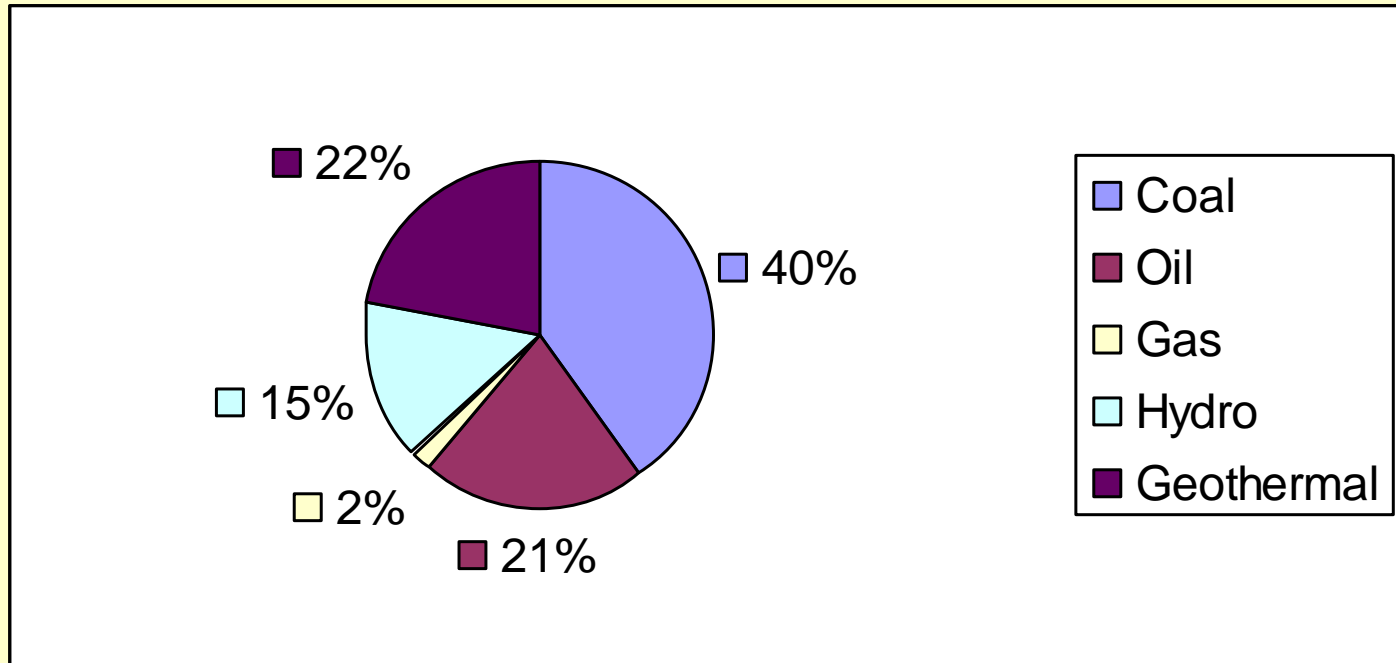
PHILIPPINE PRIMARY ENERGY CONSUMPTION, 2000-2001

Consumption	MBFOE				% Change
	Previous 2000	% Share	Current 2001	% Share	
Primary Energy	249,858	100.00	254,356	100.00	1.80%
Imported Energy	136,694	54.71	140,008	55.04	2.42%
Imported Oil	113,296	45.34	114,419	44.98	0.99%
Imported Coal	23,398	9.36	25,589	10.06	9.36%
Indigenous Energy	113,164	45.29	114,348	44.96	1.05%
Conventional	38,091	15.25	36,387	14.31	-4.47%
Geothermal	20,045	8.02	18,333	7.21	-8.54%
Hydro	13,446	5.38	12,859	5.06	-4.37%
Local Oil	316	0.13	299	0.12	-5.38%
Local Gas	30	0.01	132	0.05	340.00%
Local Coal	4,254	1.70	4,764	1.87	11.99%
Non-Conventional	75,073	30.05	77,961	30.65	3.85%
Animal Waste			190	0.07	
Other Biomass			4,859	1.91	
Bagasse	10,678	4.27	11,088	4.36	3.84%
Agriwastes	64,218	25.70	61,612	24.22	-4.06%
Coconut Husk/Shell	11,689	4.68	11,998	4.72	2.64%
Rice Husk	4,729	1.89	4,945	1.94	4.57%
Wood/Woodwaste	42,581	17.04	39,287	15.45	-7.74%
Charcoal	5,219	2.09	5,382	2.12	3.12%
Others	177	0.07	212	0.08	19.77%
Industrial Waste			7	0.00	
Solar			179	0.07	
Wind			1	0.00	
Micro/Mini Hydro			25	0.01	

SOURCE: Phil. DOE

Philippine Electric Generation Mix, 2001

2001 Philippine Electric Generation by Fuel						
Coal	Oil	Gas	Hydro	Geothermal	Total	
40.0	20.9	1.8	15.0	22.2	100.0	Percent
18,789,159	9,818,044	847,579	7,057,997	10,438,070	46,950,849	MWh



MAJOR POWER PLANTS IN THE PHILIPPINES

Total Philippine generating capacity will be 14,046 MW: 23.7% coal, 22.8% oil thermal & diesel, 20.8% natural gas, 19.8% hydro and 12.7% geothermal power.

Fuel Type/Plant Name/ Proponent	Capacity MW	Total Capacity MW	% of Total Capacity	Generation 2001 MWh	% of Total Generation
OIL - Thermal	1,050.00	1,050.00	7.29	3,528,377	7.52
OIL - Combined Cycle	820.00	820.00	5.69	1,801,256	3.84
Diesel - Piston	1,260.90	1,260.90	8.75	4,424,875	9.42
Diesel - GT	365.00	365.00	2.53	63,536	0.14
TOTAL OIL	3,285.90	3,285.90	22.81	9,818,044	20.91
NATURAL GAS		3,000.00	20.82	847,579	1.81
COAL	3,418.00	3,418.00	23.73	18,789,159	40.02
HYDRO	2,092.30	2,857.30	19.83	7,057,997	15.03
GEOHERMAL	1,836.70	1,836.70	12.75	10,438,070	22.23
NRE (Biomass)	8.00	8.00	0.06		
TOTAL	10,640.90	14,405.90	100.00	46,950,849	100.00
COMMITTED NPC PROJECTS					
HYDRO					
Bakun Hydro	70.00				
KPSHPP-IMPISA	350.00				
San Roque Hydro	345.00				
	765.00				
NATURAL GAS					
Sta. Rita CCGT	1,000.00				
San Lorenzo CCGT	500.00				
Ilijan Natural Gas-KEPCO	1,200.00				
San Pascual Cogen	300.00				
	3,000.00				