8. Power Supply Planning

8.1 Present situation of power supply capability of Indonesia

8.1.1 Power supply capability of PLN

Perusahaan Umum Listrik Negara (PLN) is responsible for supplying electricity in Indonesia. This organization has been entrusted to generate,transmit and distribute electric power throughout the country under the control of the Directorate General of Electric Power and Energy Development of Ministry of Mines and Energy of Indonesia.

The maximum power supplied by PLN to the loads totals 7,137.3 MW as of fiscal 1993/94. By island, the integrated Java-Bali is the greatest with 5,425 MW(76.0%). Coming next is Sumatra with 965.9 MW(13.5%), followed by Sulawesi with 282.0 MW(4.0%), Kalimantan with 292.8 MW (4.1%), and the others with 171.1 MW(2.4%).

For the power generation to meet the power demand above, the installed capacity of power generating facilities owned by PLN totals 13,600 MW at the end of fiscal 1993/94. Capacities by island are : the integrated Java-Bali 10,138 MW (74.5% of total), Sumatra 2,026 MW(14.9%), Kalimantan 543 MW(4.0%), Sulawesi 548MW (4.0%) and the others 345 MW(2.5%). Table 8.1 gives a detailed breakdown of these figures.

Capacities by power source are : hydroelectric 2,179 MW(16.0%), oil-fired thermal 2,561 MW (18.8%), diesel 2,128 MW(15.7%), coal-fired thermal 2,130 MW(15.7%), combined cycle 3,411 MW (25.1%), gas turbine 996 MW (7.3%) and geothermal 195 MW(1.4%).

The share of oil fuel for power generation is high compared with that of Japan. About 35 % of PLN's generating capacity is shared by oil-fueled power plants such as oil-fired thermal and diesel. It is recognized that diesel generating units predominate in Indonesia, especially in the islands apart from Java. For reference, Table 8.2 provides the structure of power generating capability of Japan.

8.1.2 Power supply capability of cooperatives

Ministry of Cooperatives of Indonesia is a state organization which supplements power supply by PLN. It is aiming to promote the electrification program in the remote rural places where PLN can not supply electricity. The electrification program has been undertaken through many cooperatives

Table 8.1 Peak Demand and Capacity of Generating Facilities Owned by PLN

(as of fiscal 1993/94)

Island		Unit	Peak Demand	Hydro	Gasturbine	Thermal Oil/gas-fired	Thermal Coal-fired	Combined Cycle	Geothermal	Diesel	Total
Jawa-Bali		MW	5425.49	1879.35	687.05	2250	2000	3011.31	195	115.18	10137.89
		%	76.0	18.5	6.8	22.2	19.7	29.7	1.9	1.1	100.0
Sumatra	Region I	MW	71.16	0.76	0	0	0	0	0	161.73	162.49
	Region II	MW	395.69	6.7	123.1	260	0	400	0	111.1	900.9
	Region III	MW	197.4	79.14	42.7	0	0	0	0	216.59	338.43
	Region IV	MW	301.7	20.06	86.26	25.6	130	0	0	362.15	624.07
	Total	MW	965.9	106.66	252.06	285.6	130	400	0	851.57	2025.89
		%	13.5	5.3	12.4	14.1	6.4	19.7	0.0	42.0	100.0
Kalimantan	Region V	MW	78.2	0	0	0	0	0	0	143.2	143.2
	Region VI	MW	214.7	30	21	0	0	0	0	349.27	400.27
	Total	MW	292.8	30	21	0	0	0	0	492.47	543.47
		%	4.1	5.5	3.9	0.0	0.0	0.0	0.0	90.6	100.0
Sulawesi	RegionVII	MW	107.3	34.28	0	0	0	0	0	147.72	182
	RegionVIII	MW	174.8	127.71	35.82	25	0	0	0	177.57	366.1
	Total	MW	282.0	161.99	35.82	25	0	0	0	325.29	548.1
		%	4.0	29.6	6.5	4.6	0.0	0.0	0.0	59.3	100.0
Other Islands	Region IX	MW	42.2	0	0	0	0	0	0	83.06	83.06
	Region X	MW	33.8	0.36	0	0	0	0	0	66.41	66.77
	Region XI	MW	80.5	0.4	0	0	0	0	0	152.19	152.59
	Batam Island	MW	14.6	0	0	0	0	0	0	42.32	42.32
	Total	MW	171.1	0.76	0	0	0	0	0	343.98	344.74
		%	2.4	0.22	0	0	0	0	0	99.78	100
Indonesia Total		MW	7137.3	2178.76	995.93	2560.6	2130	3411.31	195	2128.49	13600.09
		%	100.0	16.0	7.3	18.8	15.7	25.1	1.4	15.7	100.0

Note : Data are based on PLN STATISTICS 1993/94 located throughout the country.

As of December 1991, the villages which have been electrified by the cooperatives are 364 and the capacity of generating facilities totals 15MW. This figure corresponds to less than 0.2% of the sum of the installed capacity of generating units owned by PLN.

8.1.3 Power supply capability of private sectors

In Indonesia there are a lot of independent power plants owned mostly by the private sectors.Most of these power plants are for industry use and called "Captive Power". Table 8.3 shows generating facilities of the Captive Powers.

It is said that the total installed capacity of power generation by Captive Powers accounts for more than 50 percent of the total generating capacity of Indonesia. The amount of energy produced by them is currently about equal to the amount of energy produced by PLN.

Though most of the Captive Powers have diesel units for power generation, some have big power plants such as Siguragura hydroelectric (293MW) and Tangga hydroelectric of the Asahan Aluminum Refinery Plant, Larona hydroelectric (201MW) of P.T.International Nickel Refinery Plant, gas turbines (about 470MW) of Caltex Petroleum Co.and power generating facilities (oil-fired thermal and gas turbines 400MW) of Purtamina. Table 8.3 shows the generating installed capacity owned by the captive powers.

It is becoming difficult for PLN to cope with the entire power demand which is increasing at a very high growth rate. For these circumstances, the government recognizes the necessity of private enterprises to make effective and economic use of their power sources. It is now giving an opportunity to them to participate in the power industry. Large-scale generating units will be installed by private sectors to sell power into the PLN system or directly to the consumers.

8.1.4 Power system network

(1) Transmission and Distribution Lines

There are more than ten thousand islands in Indonesia, and many islands are slow in developing a power supply network system. The transmission and distribution lines, however, are being constructed in limited areas near central cities in big islands such as Java-Bali

Table 8.2 Generating Facilities in Japan

(as of fiscal 1993)

Source	Installed Capacity (unit : 10 MW)	(%)
Hydroelectric	3,859	20.3
General hydro	1,965	10.3
Pumped storage	1,894	9.9
Thermal	11,346	59.6
Oil-fired	5,450	28.6
Coal-fired	1,597	8.4
LNG-fired	4,173	21.9
LPG-fired	100	0.5
Geothermal	26	0.1
Nuclear	3,838	20.2
Total	19,043	100.0

Note : Industry-owned facilities are excluded.

Table 8.3 Existing Generating Facilities of Captive Powers

(as of March 1993)

Region		Capacity (MVA)
Outside Java	Region I	524.84
	Region II	1378.28
	Region III	665.26
	Batam	113.29
	Region IV	765.42
	Region V	132.65
	Region VI	765.41
	Region VII	38.44
	Region VIII	328.9
	Region IX	78.07
	Region X	178.85
	Region XI	86.72
	Sub total	5056.13
Java	East Java	829.13
	Central Java	955.28
	West Java	1672.08
	Greater Jakarta	1148.29
	Sub total	4604.78
Whole Indonesia		9660.91

(already), Sumatra,Sulawesi and Kalimantan. Actually, the diesel power generation is increasing in many isolated areas and islands, but sooner or later, the power supply network will be replaced by large-power generation other than the diesel-power generation with improved transmission and distribution facilities in the above big islands.

Transmission and distribution lines of power system has been operated and managed by PLN in whole areas of Indonesia, and total length of transmission and distribution lines in 1992/93 are shown in Table 8.4 and Table 8.5.

Table 8.4 Length of Transmission lines (kmc)

30 kV	1,856
70 kV	4,366
150 kV	10,255
500 kV	1,189
Total	17,666

Table 8.5 Length of Distribution Lines(kmc)

6-7 kV	5,198
12 kV	832
15 kV	68
20 kV	86,142
Low Volt.	138,916
p.s Lighting	9,575
Total	240,731

Approximately 80 % of transmission lines are installed in Java-Bali network system and the only 500 kV transmission line is installed in Java island. Also, approximately 60 % of distribution lines are installed in Java-Bali network system, since in many islands outside Java, transmission and distribution lines are being constructed under the electrification program and interconnection plans.

Java-Bali system in 1992/93, the generation capacity was increased by 19.7 % , but the transmission lines almost remained the same (about 2.9 %),compared to the fiscal year 1991/92. This situation created bottle-necks which resulted in reduction of the voltage in some areas. Furthermore, the new big customers in these areas were postponed in line connection with System Network.

In the local power supply system outside Java islands, a grid of 150 kV and 70 kV transmission lines, and distribution lines which consist of 20 kV, 6.3 kV and 400 Volt lines.(30 kV, 15 kV and 12 kV lines are seen in certain areas.) are installed in Sumatra, Sulawesi and Kalimantan.

From around 1987, the 6.3 kV lines were gradually switched over to 20 kV lines because of the increase in power consumption due to improvement of the electrification ratio in each year, then supply areas were expanded.

PLN is now planning to unify medium voltage distribution lines into 20 kV and 70 kV in an effort to improve voltage drop and lessen power losses. Furthermore , the linkage of each system with 20 kV medium voltage distribution lines has been implemented in all Regions of PLN, since 1986/87.

(2) Substation and Distribution Facilities

The largest power system is the Java-Bali power system. Total installed capacity of PLN's substation and distribution facilities as of the fiscal year 1992/93 was 39,046 MVA, of which 32,263 MVA (82 %) was in Java-Bali system, and the remaining capacity 6,783 MVA (18 %) was in outside Java system. Associated substation and distribution facilities with the above mentioned generating facilities and a total substation capacity are shown in Table 8.6 as follows:

Table 8.6 Substation Capacity in 1992/93

Voltage	Capacity (MVA)	
(kV)	Java-Bali system	Outside Java system
500/150	4,833	0
275/150	0	80
150/ 70	2,900	227
150/ MV.	8,028	1,274
70/ MV.	2,009	605
Total	9,954	2,186
Medium Volt.	123	204
Low Volt.	14,370	4,393
Total	32,263	6,783

(3) Energy Losses

As mentioned in above item (1) (a), PLN's plan of unifying and interconnecting medium voltage distribution lines into 20 kV and 70 kV lines in an effort to improve voltage drop and lessen power losses has almost been completed.

Table 8.7 gives the results and an analysis.

Table 8.7 Energy Loss Ratio

Fiscal Year	Length of Medium Voltage Lines (kmc)			Energy Losses Distribution (%)	Villages Electrified (%)
	6-7 kV	20 kV	30 kV		
1984/85	9,131	16,096	2,678	16.36	15.02
1987/88	5,609	26,228	2,007	15.37	27.39
1991/92	6,876	76,584	1,833	11.44	43.72
1992/93	5,198	86,150	1,856	9.40	47.94

The improvement in the ratio of electrification of villages by the local electrification policy means increase of power consumption and the expansion of supply areas, so it can be said that the PLN's policy to unify and standardize into 20 kV and 70 kV medium voltage distribution lines is correct.

(4) Reliability and System Control

Reliability and control range of power system manage frequency control and voltage control based on the operation guideline of PLN as follows;

- Frequency Fluctuation Range

  Java-Bali system : 50 ± 0.2 Hz

  Outside Java system : 50 ± 0.5 Hz

- Voltage Fluctuation Range

500 kV system	: 500 ± 5 %
Other system	: +10 % - -5 %

The system operation in Java-Bali 500 kV power system has been operated over wide areas with interconnection lines, however, the 150 kV power system is operated with an open circuit at appropriate substations or switchyards in the system due to the following reasons:

- Short circuit capacity,
- Simple protection,
- Load limiting and
- Easy control power flows.

(5) Rural Electrification

Rural electrification(RE) program in Indonesia was formally started in the fiscal year 1977/78.

For the first 2 years of RE development, the RE program was funded entirely by PLN's own budget.

In REPELITA V(the 5th Five Year Development Plan), 9,023 (47.94%) villages were electrified covering 7,578,443 consumers.

Villages are being given priority for electrification but this has not been achieved due to imperfections in the PLN's power grid supply system and no non-oil energy resources and diesel power generation plants and limited use of solar energy.

RE plan is considered the following priority :

i) Expansion of existing distribution lines

ii) Supply by diesel generation

iii) Supply by non-oil potential energy, such as hydropower, peat,fire - wood, agricultural waste, geothermal power, biomass, solar etc.

(6) Non-PLN Power Supply System

In the Private Sector and Captive Power are basically isolated from PLN power grid system, however, some power plants have been connected with the PLN power system due to exchanging the power under the contract.

Transmission or distribution lines between PLN and Non-PLN system are provided by PLN taking into consideration of the cost performance, but progressing BOO or BOT by private sector project include transmission line in the project.

8.2 Power development plan of Indonesia by PLN

Below are main points of the power development plan of Indonesia, PROGRAM INVESTASI 1993 - 2003, which was issued on 17 June 1993 by PLN.

(1) Energy diversification is pushed forward to reduce dependence on oil and to replace it with other sources available in Indonesia by installation of power plants of hydroelectric, coal-fired, natural gas-fired and geothermal.

(2) Construction plan of coal-fired thermal and combined cycle power plants using natural gas is specially important in the development plan.

(3) Regarding hydroelectric and geothermal power, a considerable amount of capacity is to be developed by the end of fiscal 2008 - 09, the last year of the Eighth Five-Year Development Plan (Repelita VIII).

(4) The percentage of power-generating capability of gas turbines and oil-fired thermal power plants will be decreased gradually by the retirement of the existing old units.

The above-mentioned program includes power plants which will be constructed and operated by the private sectors to sell energy wholesale to PLN.

8.2.1 Power development plan of the islands of Java and Bali

Majority of power sources of Indonesia will be developed in Java island where the power demand, which now accounts for about 70% of the whole demand of the country, will continue to grow at a high rate in future.

Hydroelectric power plants which are planned to be constructed by fiscal 2008 - 09 are Citra II (500MW), Maung (360MW), Cimandiri (351MW) and Jatigede (175MW) and so on at 16 sites. Their total capacity amounts to 2,980MW. A pumped storage power plant of 1,000MW is also planned to be constructed by 2001 - 02.

Currently, PLN has been carrying on construction works of combined cycle power plants such as Gresik #1,2,3 (total capacity 1,578MW), Muara Karang (514MW), Priok #1,2(total capacity 1,200MW), Tambak Lorok(514MW) and coal-fired thermal power plants such as Paiton #1,2 (total capacity 800MW) and Suralaya #5,6,7(total capacity 1,800MW). Some of these plants, the total capacity of which is 3,240MW, were commissioned in fiscal 1993 - 94.

Besides the above projects, construction plan of a combined cycle power plant whose capacity amounts to 1,500MW is proceeded by PLN, aiming at being commissioned in fiscal 1995 - 96.

By 2008 - 09 coal-fired thermal will be developed at six locations with the total capacity 11,800MW and combined cycle power plants at three locations with the total capacity 4,428MW .

As for geothermal power, additional units #4&5 of Kamojan (110MW), Salak (220MW), Drajat (165MW) and Dieng (55MW) will be constructed.

Concerning nuclear power, the first unit with capacity 600MW has been studied for installation in Muria peninsular in the central part of Jawa island, aiming at operation in fiscal 2008.

It is also expected that the private investors will participate in construction of coal-fired thermal power plants, the capacity of which amounts to 6,400MW, and a combined cycle power plant of 400MW.

Table 8.8 shows the power development plan of the Java-Bali system.

8.2.2 Power development plan of other islands

Hydroelectric power plants including mini hydroelectric are to be developed at 48 locations outside Java island, such as Kotapanjang (114MW) and Singkarek (175MW) in Sumatra, and Bakaru (126MW) in Surawesi. The total capacity of these plants is about 3,760MW.

Table 8.8 Power Development Plan of Jawa-Bali System (PLN)

Utility	Kind of Source	Unit	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
(1) PLN	(a) Existing Facilities	MW	6357.4	6357.4	6357.4	5850.6	5555.4	5515.2	5515.2	5515.2	5515.2	5515.2	5293.8	4972.4	4951	4551	4351	4151	4121
	Hydro	MW	1964	1964	1964	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955
	Gasturbine	MW	667.2	667.2	667.2	299.6	104.4	64.2	64.2	64.2	64.2	64.2	42.8	21.4	0	0	0	0	0
	Thermal Oil-fired	MW	1900	1900	1900	1800	1700	1700	1700	1700	1700	1700	1500	1200	1200	800	600	400	400
	Thermal Coal-fired	MW	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
	Geothermal	MW	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	110
	Diesel	MW	86.2	86.2	86.2	56	56	56	56	56	56	56	56	56	56	56	56	56	56
	(b) Ongoing Project	MW	1463	3359	4700	4890	4890	4890	4890	4890	4890	4890	4890	4890	4890	4890	4890	4890	4890
	Hydro	MW	23	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59
	Gasturbine	MW	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Thermal Oil-fired	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thermal Gas-fired	MW	1380	2840	3616	3806	3806	3806	3806	3806	3806	3806	3806	3806	3806	3806	3806	3806	3806
	Thermal Coal-fired	MW	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
	Geothermal	MW	0	0	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
	Diesel	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	(c) Committed Project	MW	0	0	84	97	1297	2430	2430	2430	2430	2430	2430	2430	2430	2430	2430	2430	2430
	Hydro	MW	0	0	0	13	13	546	546	546	546	546	546	546	546	546	546	546	546
	Gasturbine	MW	0	0	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
	Thermal Oil-fired	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thermal Gas-fired	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thermal Coal-fired	MW	0	0	0	0	1200	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
	Geothermal	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diesel	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	(d) Planned project	MW	0	0	0	1500	2210	2375	2401	2856	3656	5016	5016	6186	8586	10800	13400	15900	18500
	Hydro	MW	0	0	0	0	0	0	26	26	26	1386	1386	1956	1956	2170	2170	2170	2170
	Gasturbine	MW	0	0	0	0	600	600	600	1000	1000	1000	1000	1600	1600	1800	2600	2700	3500
	Thermal Gas-fired	MW	0	0	0	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
	Thermal Coal-fired	MW	0	0	0	0	0	0	0	0	800	800	800	800	3200	5000	6800	9200	10400
	Nuclear	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600
	Geothermal	MW	0	0	0	0	110	275	275	330	330	330	330	330	330	330	330	330	330
	(e) PLN total (a+b+c+d)	MW	7820.4	9716.4	11141.4	12337.6	13952.4	15210.2	15236.2	15691.2	16491.2	17851.2	17629.8	18478.4	20857	22671	25071	27371	29941
(2) Private Sector	(f) Total	MW	0	0	0	0	0	1000	2735	3335	4535	5735	6935	6935	6935	6935	6935	6935	6935
	Hydro	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gasturbine	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thermal Gas-fired	MW	0	0	0	0	0	400	400	400	400	400	400	400	400	400	400	400	400
	Thermal Coal-fired	MW	0	0	0	0	0	600	2200	2800	4000	5200	6400	6400	6400	6400	6400	6400	6400
	Geothermal	MW	0	0	0	0	0	0	135	135	135	135	135	135	135	135	135	135	135
(1) + (2) Total	(g) Total	MW	7820.4	9716.4	11141.4	12337.6	13952.4	16210.2	17971.2	19026.2	21026.2	23586.2	24564.8	25413.4	27792	29606	32006	34306	36876
	Hydro	MW	1987	2023	2023	2027	2027	2560	2586	2586	2586	3946	3946	4516	4516	4730	4730	4730	4730
	Gasturbine	MW	727.2	727.2	811.2	443.6	848.4	808.2	808.2	1208.2	1208.2	1208.2	1186.8	1765.4	1744	1944	2744	2844	3644
	Thermal Oil-fired	MW	1900	1900	1900	1800	1700	1700	1700	1700	1700	1700	1500	1200	1200	800	600	400	400
	Thermal Gas-fired	MW	1380	2840	3616	5306	5306	5706	5706	5706	5706	5706	5706	5706	5706	5706	5706	5706	5706
	Thermal Coal-fired	MW	1600	2000	2400	2400	3600	4800	6400	7000	9000	10200	11400	11400	13800	15600	17400	19800	21000
	Nuclear	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600
	Geothermal	MW	140	140	305	305	415	580	715	770	770	770	770	770	770	770	770	770	740
	Diesel	MW	86.2	86.2	86.2	56	56	56	56	56	56	56	56	56	56	56	56	56	56
(h)	Predicted Peak Load	MW	5277	6512	7910.6	9839.4	10922	12117	13372	14693	16057	17402	18832	20356	21699	23571	25343	27121	28959
(g-h)/h*100	Reserve	%	48	49	41	25	28	34	34	29	31	36	30	25	28	26	26	26	27

Concerning coal-fired thermal, about 3,160MW in total will be constructed at eight locations which include Bukit Asam #3 &4 (total 130MW) and Ombilin (200MW) located in Sumatra, Banjar Masin (395MW) in Kalimantan and Ujung Pandang (585MW) in Surawesi.

Combined cycle power plants are also to be constructed such as T.Sang Kuang (420MW) located in Sumatra and Samarinda (330MW) in Kalimantan. 1542MW will be the total capacity constructed by 2008 - 09.

As for geothermal, 43MW will be developed in total at five locations, such as Lehendong (20MW) in Sumatra and Hu'u (10MW) in Region XI.

The power development plan of Sumatra, Kalimantan, Surawesi and other islands of Indonesia is indicated on Table 8.9, 8.10, 8.11 and 8.12, respectively.

8.3 Basic way of thinking on the development plan of power sources

8.3.1 Selection of power sources

It is considered in every country that the advantageous way of expanding power generation system to secure supply capability is to adopt a mixed pattern of generation options of several types and energy sources instead of only using one kind of generating method and one kind of energy source.

Oil has been a major energy source for power generation in Indonesia but the government places "energy diversification" as a policy of the country and is pushing to reduce the nation's oil consumption and to develop non-oil resources to use in place of oil. Saving energy, that is, an effective use of energy is one of the important items to be pushed forward.

Based on these conditions, the JICA team has considered generation options in power development as follows:

(1) Hydroelectric power

The islands of Sumatra, Kalimantan and Sulawesi have abundant water resources. Sites of economic superiority should be developed in harmony with environmental preservation.

(2) Coal-fired thermal power

Coal-fired thermal power shall be placed as an important pillar of power sources, as coal is

Table 8.9 Power Development Plan of Sumatra (1/2 Region I & II)

REGION	UTILITY	PROJECT		UNIT	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Region I	PLN	a Existing		MW	141.3	139.9	139.9	138.6	127	121.7	118.7	118.2	114.9	94.6	91.7	89.9	89.89	89.89	89.89	89.89	89.89
			Diesel	MW	140.9	139.5	139.5	138.2	126.6	121.3	118.3	117.8	114.5	94.2	91.3	89.5	89.49	89.49	89.49	89.49	89.49
			Minihydro	MW	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
		b Ongoing Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		c Committed Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		d Planned Project		MW	0	0	0	3.2	9.3	12.3	16.7	16.7	17.6	103.6	103.6	503.8	1331.8	1361.8	1683.8	1683.8	2083.8
		Peusangan I & II	Hydro	MW	-	-	-	-	-	-	-	-	-	86	86	86	86	86	86	86	86
		Peusangan IV	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30
		Tampur	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	428	426	428	428	428
		Lawe Alas	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	322	322	322
		Meulaboth	ThermalCoal-fired	MW	-	-	-	-	-	-	-	-	-	-	-	400	800	800	800	800	1200
			Minihydro	MW	-	-	-	1.2	1.2	1.2	3.6	3.6	4.5	4.5	4.5	4.7	4.7	4.7	4.7	4.7	4.7
			Diesel PP	MW	-	-	-	2	8.1	11.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
		e	Total	MW	141.3	139.9	139.9	141.8	136.3	134	135.4	134.9	132.5	198.2	195.3	593.7	1421.69	1451.69	1773.69	1773.69	2173.69
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		g=e+f	Region I Total Installed	MW	141.3	139.9	139.9	141.8	136.3	134	135.4	134.9	132.5	198.2	195.3	593.7	1421.69	1451.69	1773.69	1773.69	2173.69
			Peak Load	MW	61.7	77.1	87	97.6	109	121.4	134.7	145.2	156.5	166.7	177.8	188.1	200.1	212.5	224.3	238.1	247.9
			Reserve	%	129	81	61	45	25	10	1	-7	-15	19	10	216	610	583	691	645	777
Region II	PLN	a Existing		MW	676.3	675.9	675.5	672.6	635.9	629.6	598.9	597.3	597	575	524.2	520.6	520.6	520.6	520.6	520.6	520.6
			Minihydro	MW	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
			Thermal Oil-fired	MW	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
			Gastur bine	MW	139.4	139.4	139.4	139.4	139.4	139.4	118	118	118	118	118	118	118	118	118	118	118
			Diesel	MW	256.8	256.4	256	253.1	216.4	210.1	200.8	199.2	198.9	176.9	126.1	122.5	122.5	122.5	122.5	122.5	122.5
			Import from INALUM	MW	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
		b Ongoing Project		MW	140.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6	260.6
		Combined cycle Block I		MW	140	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
		Boho	Hydro	MW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Tonduhan	Hydro	MW	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
		c Committed Project		MW	-	-	-	400	400	400	400	482	482	482	482	482	482	482	482	482	482
		Combined cycle Block II		MW	-	-	-	400	400	400	400	400	400	400	400	400	400	400	400	400	400
		Renun	Hydro	MW	-	-	-	-	-	-	-	82	82	82	82	82	82	82	82	82	82
		d Planned Project		MW	-	0.8	0.8	100.8	207.8	307.8	307.8	357.8	757.8	758.9	762.5	777.7	861.7	986.7	986.7	986.7	986.7
		Sipansihaporas	Hydro	MW	-	-	-	-	-	-	-	50	50	50	50	50	50	50	50	50	50
		Wampu	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	84	84	84	84	84
		Asahan III	Hydro	MW	-	-	-	-	-	-	-	-	400	400	400	400	400	400	400	400	400
		Toru	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	125	125	125	125
			Minihydro	MW	-	0.8	0.8	0.8	2.2	2.2	2.2	2.2	2.2	3.3	6.9	22.1	22.1	22.1	22.1	22.1	22.1
			Diesel PP	MW	-	-	-	-	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
		Medan 1-8	Gasturbine	MW	-	-	-	100	200	300	300	300	300	300	300	300	300	300	300	300	300
		e	Total	MW	816.9	937.3	936.9	1434	1504.3	1598	1567.3	1697.7	2097.4	2076.5	2029.3	2040.9	2124.9	2249.9	2249.9	2249.9	2249.9
	Private	Sarulla 1- 6		MW	-	-	-	-	-	-	-	110	220	330	330	330	330	330	330	330	330
		Sibayak 1,2		MW	-	-	-	-	-	-	-	-	110	110	110	110	110	110	110	110	110
		f	Total	MW	0	0	0	0	0	0	0	110	330	440	440	440	440	440	440	440	440
		g=e+f	Region II Total Installed	MW	816.9	937.3	936.9	1434	1504.3	1598	1567.3	1807.7	2427.4	2516.5	2469.3	2480.9	2564.9	2689.9	2689.9	2689.9	2689.9
			Peak Load	MW	369.1	486	568	667	787	928	1075	1221	1387	1570	1772	1963	2211	2490	2792	3124	3484
			Reserve	%	121	93	65	115	91	72	46	48	75	60	39	26	16	8	-4	-14	-23

Table 6.9 Power Development Plan of Sumatra (2/2 Region III & IV)

REGION	UTILITY	PROJECT		UNIT	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Region III	PLN	a Existing		MW	264.5	264.1	263.9	263.9	253.6	241.7	190.7	190.7	189.7	181.9	177	160.7	160.7	160.7	160.7	160.7	160.7
		Minihydro	Hydro	MW	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		Hydro	Hydro	MW	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
		Gastur bine		MW	42.7	42.7	42.7	42.7	42.7	42.7	0	0	0	0	0	0	0	0	0	0	0
		Diesel		MW	142.7	142.3	142.1	142.1	131.8	119.9	111.6	111.6	110.6	102.8	97.9	81.6	81.6	81.6	81.6	81.6	81.6
		b Ongoing Project		MW	0	50.2	85.2	85.2	85.2	199.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2
		Padang	Gastur bine	MW	-	35	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Kotopanjang #1-3	Hydro	MW	-	-	-	-	-	114	114	114	114	114	114	114	114	114	114	114	114
		Singkarak #1-4	Hydro	MW	-	-	-	-	-	-	175	175	175	175	175	175	175	175	175	175	175
		P. Baru	Diesel		-	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		c Committed Project		MW	0	0	0	0	100	200	200	200	200	200	200	200	200	200	200	200	200
		Ombilin #1-2	Coal-fired	MW	-	-	-	-	100	200	200	200	200	200	200	200	200	200	200	200	200
		d Planned Project		MW	15.2	15.2	39.2	41.9	41.9	59.8	69.3	69.3	69.3	70.3	71.1	85.3	85.3	85.3	85.3	85.3	85.3
		Kerinci	Geothermal	MW	-	-	-	-	-	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
			Minihydro	MW	-	-	-	2.7	2.7	7.7	7.7	7.7	7.7	8.7	9.5	23.7	23.7	23.7	23.7	23.7	23.7
			Diesel	MW	15.2	15.2	39.2	39.2	39.2	49.7	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2
		e	Total	MW	279.7	329.5	388.3	391	480.7	700.7	834.2	834.2	833.2	826.4	822.3	820.2	820.2	820.2	820.2	820.2	820.2
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		g=e+f	Region III Total Installed	MW	279.7	329.5	388.3	391	480.7	700.7	834.2	834.2	833.2	826.4	822.3	820.2	820.2	820.2	820.2	820.2	820.2
			Peak Load	MW	169.6	206.2	262.4	303.1	348.7	397.7	452.6	505.2	563.2	617.8	674.7	738.4	810	891.7	963.1	1036.9	1112.5
			Reserve	%	65	60	48	29	38	76	84	65	48	34	22	11	1	-8	-15	-21	-26
Region IV	PLN	a Existing		MW	540.43	540.43	521.82	521.82	520.82	508.82	480.52	452.72	451.72	422.32	414.22	400.52	400.52	400.52	400.52	400.52	400.52
			Minihydro	MW	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
			Hydro	MW	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
			Gasturbine	MW	36.01	36.01	21.4	21.4	21.4	21.4	0	0	0	0	0	0	0	0	0	0	0
			Thermal Coal-fired	MW	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130
			Thermal Oil-fired	MW	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0
			Diesel	MW	331	331	327	327	326	314	307.1	304.3	303.3	273.9	265.8	252.1	252.1	252.1	252.1	252.1	252.1
		b Ongoing Project		MW	-	-	65	65	130	130	130	130	130	130	130	130	130	130	130	130	130
		B.Asam #3,4	Thermal Coal-fired	MW	-	-	65	65	130	130	130	130	130	130	130	130	130	130	130	130	130
		c Committed Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		d Planned Project		MW	0	0	70	114	191.3	310.3	528.8	820.2	822.4	1033.4	1373.6	1381.2	1381.2	1505.2	1905.2	2389.2	2589.2
		Besai	Hydro	MW	-	-	-	-	-	-	-	90	90	90	90	90	90	90	90	90	90
		Musi	Hydro	MW	-	-	-	-	-	-	-	-	-	210	210	210	210	210	210	210	210
		Merangin	Hydro	MW	-	-	-	-	-	-	-	-	-	-	338.5	338.5	338.5	338.5	338.5	338.5	338.5
		Ketaun	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	84	84
		Batutegi	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	24	24	24	24
		Palembang	Gasturbine	MW	-	-	70	105	175	175	175	175	175	175	175	175	175	175	175	175	175
		Lampung	Gasturbine	MW	-	-	-	-	-	100	200	200	200	200	200	200	200	300	300	300	500
		Tarahan #1- 2	Thermal Coal-fired	MW	-	-	-	-	-	-	-	200	200	200	200	200	200	200	200	200	200
		S.Sumatera # 1- 2	Thermal Coal-fired	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400	800	800
		Minihydro	Minihydro	MW	-	-	-	-	1.3	1.3	1.3	2.7	4.9	5.9	7.6	15.2	15.2	15.2	15.2	15.2	15.2
		Diesel	Diesel	MW	-	-	-	9	15	34	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
			Import from Java	MW	-	-	-	-	-	-	100	100	100	100	100	100	100	100	100	100	100
		e	Total	MW	540.43	540.43	656.82	700.82	842.12	949.12	1139.32	1402.92	1404.12	1585.72	1917.82	1911.72	1911.72	2035.72	2435.72	2919.72	3119.72
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		g=e+f	Region IV Total Installed	MW	540.43	540.43	656.82	700.82	842.12	949.12	1139.32	1402.92	1404.12	1585.72	1917.82	1911.72	1911.72	2035.72	2435.72	2919.72	3119.72
			Peak Load	MW	276.2	320	393.3	459.6	538.3	629.5	728.7	808.1	895.4	990.3	1094.7	1211.7	1349	1500.3	1662.5	1839.9	2033.2
			Reserve	%	96	69	67	52	56	51	56	74	57	60	75	58	42	36	47	59	53
Total Installed in Sumatra				MW	1778.33	1947.13	2121.92	2667.62	2963.42	3381.82	3676.22	4179.72	4797.22	5126.82	5404.72	5806.52	6718.51	6997.51	7719.51	8203.51	8803.51
Total of Peak Loads in Sumatra				MW	876.6	1089.3	1310.7	1527.3	1783	2076.6	2391	2679.5	3002.1	3344.8	3719.2	4101.2	4570.1	5094.5	5641.9	6238.9	6877.6

Table 8.10 Power Development Plan of kalimantan

REGION	UTILITY	PROJECT		UNIT	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Region V	PLN	a Existing		MW	113.4	111.2	111	107	106	91.1	90.5	90.5	89.9	89.1	85.2	84.4	84.4	84.4	84.4	84.4	84.4
			Diesel	MW	113.4	111.2	111	107	106	91.1	90.5	90.5	89.9	89.1	85.2	84.4	84.4	84.4	84.4	84.4	84.4
		b Ongoing Project		MW	-	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		Potianak	Diesel	MW	-	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		c Committed Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		d Planned Project		MW	0	15.2	15.2	48.2	59.6	91.6	94.3	94.3	94.3	124.3	154.3	154.3	184.3	214.3	279.3	404.3	434.3
		Pade Kembayung	Hydro	MW	-	-	-	-	-	-	-	-	-	-	30	30	30	30	30	30	30
		Pontianak	Diesel	MW	-	-	-	30	30	60	60	60	60	90	90	90	120	150	150	210	240
		Pontianak #5,6	Thermal Coal-fired	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65	130	130
		Tiang Aping	Minihydro	MW	-	-	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Merasap	Minihydro	MW	-	-	-	-	-	-	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			Diesel	MW	-	15.2	15.2	18.2	29.6	31.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
		e	Total	MW	113.4	141.6	141.4	170.4	180.8	197.9	200	200	199.4	228.6	254.7	253.9	283.9	313.9	378.9	503.9	533.9
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	50	75	100	100	100	100	100	100	100	100	100
	g=e+f		Region V Total Installed	MW	113.4	141.6	141.4	170.4	180.8	197.9	250	275	299.4	328.6	354.7	353.9	383.9	413.9	478.9	603.9	633.9
			Peak Load	MW	69	90.8	104.1	117.6	132.8	149.7	168.3	188.6	210.7	234.1	259	286.8	316.6	350	363.9	420.1	458.9
			Reserve	%	64	56	36	45	36	32	49	46	42	40	37	23	21	18	25	44	38
Region VI	PLN	a Existing		MW	272.2	270.4	269	269	265.9	211.3	186.1	185.9	185.6	182.4	174.5	155.9	134.9	134.9	134.9	134.9	134.9
			Hydro	MW	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
			Gasturbine	MW	21	21	21	21	21	21	21	21	21	21	21	21					
			Diesel	MW	221.2	219.4	218	218	214.9	160.3	135.1	134.9	134.6	131.4	123.5	104.9	104.9	104.9	104.9	104.9	104.9
		b Ongoing Project		MW	24	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2
		Samarinda	Diesel	MW	-	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		Banjarmasin	Diesel	MW	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
		c Committed Project		MW	-	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
		Banjarmasin	Diesel	MW	-	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
		d Planned Project		MW	0	0	0.4	67.9	183.9	350.9	416.9	511.9	541.9	607.9	705.95	736.63	802.63	932.63	998.63	1064.63	1329.63
		Kusan		MW	-	-	-	-	-	-	-	-	-	-	67.7	67.7	67.7	67.7	67.7	67.7	67.7
		B.masin #1-3	Thermal Coal-fired	MW	-	-	-	-	-	65	130	195	195	195	195	195	195	195	195	195	195
		B.masin #4-5	Thermal Coal-fired	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100	100	200
		B.masin #1-4	Gasturbine	MW	-	-	-	30	60	90	90	90	120	120	120	120	120	120	120	120	120
		Samarinda	Gasturbine	MW	-	-	-	30	30	90	90	120	120	120	150	180	180	210	210	210	210
		Samarinda #1-5	Combined Cycle	MW	-	-	-	-	66	66	66	66	66	132	132	132	198	198	264	330	330
		Kelai-2	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	165
			Minihydro	MW	-	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.75	1.43	1.43	1.43	1.43	1.43	1.43
			Diesel	MW	-	-	-	7.5	27.5	39.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5
		e	Total	MW	296.2	333.6	332.6	400.1	513	625.4	666.2	761	790.7	853.5	943.65	955.73	1000.73	1130.73	1196.73	1262.73	1527.73
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	g=e+f		Region VI Total Installed	MW	296.2	333.6	332.6	400.1	513	625.4	666.2	761	790.7	853.5	943.65	955.73	1000.73	1130.73	1196.73	1262.73	1527.73
			Peak Load	MW	181.1	194.6	230	269.1	305.8	346.9	391.5	435.7	484.1	539	598.6	665.5	737.2	816.6	899.2	988	1083.2
			Reserve	%	64	71	45	49	68	80	70	75	63	58	58	44	36	38	33	28	41
Total Installed in Kalimantan				MW	409.6	475.2	474	570.5	693.8	823.3	916.2	1036	1090.1	1182.1	1298.35	1309.63	1384.63	1544.63	1675.63	1866.63	2161.63
Total of Peak Loads in Kalimantan				MW	250.1	285.4	334.1	386.7	438.6	496.6	559.8	624.3	694.8	773.1	857.6	952.3	1053.8	1166.6	1283.1	1406.1	1542.1

Table 8.11 Power Development Plan of Sulawesi

REGION	UTILITY	PROJECT	UNIT	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Region VII	PLN	a Existing	MW	154.6	153.3	152.8	152.4	143.2	139.2	134.4	132.4	121.3	111.5	97.9	96.8	96.8	96.8	96.8	96.8	96.8
		Minihydro	MW	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6
		Hydro	MW	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.3
		Diesel	MW	120.3	119	118.5	118.1	108.9	104.9	100.1	98.3	87.2	77.4	63.9	62.9	62.9	62.9	62.9	62.9	62.9
		b Ongoing Project	MW	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
		Lahendong Geothermal	MW	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
		c Committed Project	MW	-	-	-	-	20	20	20	20	20	20	20	20	20	20	20	20	20
		Lahendong Geothermal	MW	-	-	-	-	20	20	20	20	20	20	20	20	20	20	20	20	20
		d Planned Project	MW	12	12	12	18.2	38	72	85.69	135.69	157.49	185.166	210.875	213.998	234.598	263.998	307.098	307.098	321.398
		Tanggari II Hydro	MW	-	-	-	-	-	19	19	19	19	19	19	19	19	19	19	19	19
		Palu III Hydro	MW	-	-	-	-	-	-	-	-	21.8	21.8	21.8	21.8	42.4	42.4	60.5	60.5	74.8
		Poigar II Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	16	16	16	16
		Poigar III Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	13.4	13.4	13.4	13.4
		Bitung #1-6 Gasturbine	MW	-	-	-	-	-	-	-	50	50	75	100	100	100	100	125	125	125
		Minihydro	MW	-	-	-	6.2	12.6	12.6	17.29	17.29	17.29	19.966	20.675	23.798	23.798	23.798	23.798	23.798	23.798
		Diesel	MW	12	12	12	12	25.4	40.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4
		e Total	MW	169.1	167.8	167.3	173.1	203.7	233.7	242.59	290.59	301.29	319.166	331.275	333.298	353.898	383.298	426.398	426.398	440.698
	Private	f Existing & Future Project	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	g=e+f	Region VII Total Installed	MW	169.1	167.8	167.3	173.1	203.7	233.7	242.59	290.59	301.29	319.166	331.275	333.298	353.898	383.298	426.398	426.398	440.698
		Peak Load	MW	94.1	102.7	116.3	130.7	145.3	161.5	178.9	196.4	214.6	231.8	250.2	265.8	283.6	300.6	318.2	335.2	351.7
		Reserve	%	80	63	44	32	40	45	36	48	40	38	32	25	25	28	34	27	25
Region VIII	PLN	a Existing	MW	321.3	315.6	315.5	314.8	288	285.6	283	259.2	257.5	242.6	237.7	235.9	235.9	235.9	235.9	235.9	235.9
		Minihydro	MW	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
		Hydro	MW	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
		Oil-fired thermal	MW	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0
		Gasturbine	MW	21.4	21.4	21.4	21.4	21.4	21.4	21.4	0	0	0	0	0	0	0	0	0	0
		Diesel	MW	147.2	141.5	141.4	140.7	138.9	136.5	133.9	131.5	129.8	114.9	110	108.2	108.2	108.2	108.2	108.2	108.2
		b Ongoing Project	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		c Committed Project	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		d Planned Project	MW	0	0	5.8	40.8	95.9	234.2	246.2	311.2	392.4	572.2	574	646.1	830.1	830.1	895.1	1090.1	1220.1
		Bakaru II Hydro	MW	-	-	-	-	-	-	-	-	-	126	126	126	126	126	126	126	126
		Poko Hydro	MW	-	-	-	-	-	-	-	-	-	53	53	53	53	53	53	53	53
		Malea Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	184	184	184	184	184
		Bili-Bili Hydro	MW	-	-	-	-	-	-	-	-	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
		Batu Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		U.Pandang Gasturbine	MW	-	-	-	35	70	70	70	70	70	70	70	70	70	70	70	70	70
		U.Pandang #1-9 Coal-fired	MW	-	-	-	-	-	-	-	65	130	130	130	195	195	195	260	455	585
		Sengkang Combined cycle	MW	-	-	-	-	-	132	132	132	132	132	132	132	132	132	132	132	132
		Minihydro	MW	-	-	5.8	5.8	7.3	7.3	10.8	10.8	10.8	11.6	13.4	20.5	20.5	20.5	20.5	20.5	20.5
		Diesel	MW	-	-	-	-	18.6	24.9	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
		e Total	MW	321.3	315.6	321.3	355.6	383.9	519.8	529.2	570.4	649.9	814.8	811.7	882	1066	1066	1131	1326	1456
	Private	f Tonasa Coal-fired	MW	-	-	-	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	g=e+f	Region VIII Total Installed	MW	321.3	315.6	321.3	405.6	433.9	569.8	579.2	620.4	699.9	864.8	861.7	932	1116	1116	1181	1376	1506
		Peak Load	MW	172.7	213.4	265.1	330	373.5	428.2	486.9	545	612.1	682.3	759.5	841.6	933.2	1029.7	1133.5	1244.7	1363.7
		Reserve	%	86	48	21	23	16	33	19	14	14	27	13	11	20	8	4	11	10
Total Installed in Sulawesi			MW	490.4	483.4	488.6	578.7	637.6	803.5	821.79	910.99	1001.19	1183.97	1192.98	1265.3	1469.9	1499.3	1607.4	1802.4	1946.7
Total of Peak Loads in Sulawesi			MW	266.8	316.1	381.4	460.7	518.8	589.7	665.8	741.4	826.7	914.1	1009.7	1107.4	1216.8	1330.3	1451.7	1579.9	1715.4

Table 8.12 Power Development Plan of The Other Islands of Indonesia (1/2 Region IX & X)

REGION	UTILITY	PROJECT		UNIT	1992~93	1993~94	1994~95	1995~96	1996~97	1997~98	1998~99	1999~00	2000~01	2001~02	2002~03	2003~04	2004~05	2005~06	2006~07	2007~08	2008~09
Region IX	PLN	a Existing		MW	64	64	63.7	63.7	63.7	57.4	56.4	56.4	56.4	56.1	54.3	41.8	41.8	41.8	41.8	41.8	41.8
			Diesel	MW	64	64	63.7	63.7	63.7	57.4	56.4	56.4	56.4	56.1	54.3	41.8	41.8	41.8	41.8	41.8	41.8
		b Ongoing Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		c Committed Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		d Planned Project		MW	0	0	0	0	6	7.3	19.8	49.8	69.8	69.8	70.1	120.6	120.6	120.6	140.6	166.6	166.6
		Isal-2	Hydro	MW	-	-	-	-	-	-	-	-	20	20	20	40	40	40	60	60	60
		Sapalewa	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	26
		Ambon	Gasturbine	MW	-	-	-	-	-	-	-	30	30	30	30	60	60	60	60	60	60
		Goal	Minihydro	MW	-	-	-	-	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Ira	Minihydro	MW	-	-	-	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Ngaoli	Minihydro	MW	-	-	-	-	-	-	-	-	-	-	0.3	0.3	0.3	0.3	0.3	0.3	0.3
		Hatu	Minihydro	MW	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5
			Diesel	MW	-	-	-	-	5	6.3	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
		e	Total	MW	64	63.7	63.7	63.7	63.4	63.7	76.2	106.2	125.9	124.1	111.9	182.4	182.4	182.4	182.4	206.4	166.6
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	g=e+f		Region IX Total Installed	MW	64	63.7	63.7	63.7	63.4	63.7	76.2	106.2	125.9	124.1	111.9	182.4	182.4	182.4	182.4	206.4	166.6
			Peak Load	MW	37.8	44	47	51.1	55.8	60.3	65.4	70.8	76.5	82.2	88.2	94.6	100.7	107	113.8	120.6	127.6
			Reserve	%	69	45	36	25	14	6	17	50	65	51	27	72	61	52	60	73	31
Region X	PLN	a Existing		MW	65.9	65.7	65.2	65.2	65.2	63.4	63.4	63.4	63.4	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3
			Minihydro	MW	0.4	0.4	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
			Diesel	MW	65.9	65.7	65.2	65.2	65.2	63.4	63.4	63.4	63.4	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3
		b Ongoing Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		c Committed Project		MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		d Planned Project		MW	0	0	0	7.5	14.8	16.8	32.5	32.5	32.5	32.5	62.5	88.3	88.3	88.3	115.9	115.9	115.9
		Sentani #1-2	Hydro	MW	-	-	-	-	-	-	12	12	12	12	12	12	12	12	12	12	12
		Warsomson	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	15.2	15.2	15.2	15.2	15.2	15.2
		Tami	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.6	27.6	27.6
		Jayapura	Gasturbine	MW	-	-	-	-	-	-	-	-	-	-	30	30	30	30	30	30	30
			Minihydro	MW	-	-	-	-	1	2	4.2	4.2	4.2	4.2	4.2	14.8	14.8	14.8	14.8	14.8	14.8
			Diesel	MW	-	-	-	7.5	13.8	14.8	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
		e	Total	MW	65.9	65.7	65.2	72.7	80	80.2	95.9	95.9	95.9	95.8	125.8	151.6	151.6	151.6	179.2	179.2	179.2
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	g=e+f		Region X Total Installed	MW	65.9	65.7	65.2	72.7	80	80.2	95.9	95.9	95.9	95.8	125.8	151.6	151.6	151.6	179.2	179.2	179.2
			Peak Load	MW	34.4	43.4	47.3	51.5	55.9	61	66.6	73	73	73	73	73	73	73	73	73	73
			Reserve	%	92	51	38	41	43	31	44	31	31	31	72	108	108	108	145	145	145

Table 8.12 Power Development Plan of The Other Islands of Indonesia (2/2 Region XI & Batam)

REGION	UTILITY	PROJECT		UNIT	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Region XI (Excl. Bali)	PLN	a Existing		MW	145.9	141.4	136.7	136.3	130.8	128.8	123.9	117.8	111.9	110.5	105.3	97.8	97.8	97.8	97.8	97.8	97.8
			Minihydro	MW	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
			Diesel	MW	145.4	140.9	136.2	135.8	130.3	128.3	123.5	117.4	111.5	110.1	104.9	97.4	97.4	97.4	97.4	97.4	97.4
		b Ongoing Project		MW	0	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		Lombok	Diesel	MW	-	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
		c Committed Project		MW	0	0	7.6	18.2	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8
		Ulumbu		MW	-	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Lombok	Diesel	MW	-	-	7.6	15.2	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8
		d Planned Project		MW	0	0	2.8	7.8	19.9	47.2	57.2	74.7	97.1	97.1	137.1	167.5	167.5	167.5	217.5	217.5	241.5
		Beburung	Hydro	MW	-	-	-	-	-	-	-	-	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4
		Iralalaro	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	27	27	27	27	27	27
		Beh	Hydro	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
		Lombok	Gasturbine	MW	-	-	-	-	-	20	20	20	20	20	60	60	60	60	60	60	60
		Lombok	Coal-fired	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	50	50
			Diesel	MW	-	-	-	5	17.1	21.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1
			Minihydro	MW	-	-	2.8	2.8	2.8	6.1	6.1	6.1	6.1	6.1	6.1	9.5	9.5	9.5	9.5	9.5	9.5
		Hu'u #1-2	Geothermal	MW	-	-	-	-	-	-	-	10	10	10	10	10	10	10	10	10	10
		Mutubusa #1-2	Geothermal	MW	-	-	-	-	-	-	-	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
		e	Total	MW	145.9	156.6	162.3	177.5	191.7	217	222.1	233.5	250	248.6	283.4	306.3	306.3	306.3	356.3	356.3	380.3
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		g=e+f	Region XI Total Installed	MW	145.9	156.6	162.3	177.5	191.7	217	222.1	233.5	250	248.6	283.4	306.3	306.3	306.3	356.3	356.3	380.3
			Peak Load	MW	65.1	89.4	101.1	114.1	128.2	143.7	161	179.2	196.4	218.1	239.9	261	281.3	299.6	317.4	337.3	355.5
			Reserve	%	124	75	61	56	50	51	38	30	26	14	18	17	9	2	12	6	7
Batam	PLN	a Existing		MW	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	44.4	44.4	44.4	44.4	44.4	44.4	44.4
			Diesel	MW	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	44.4	44.4	44.4	44.4	44.4	44.4	44.4
		b Ongoing Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		c Committed Project		MW	-	-	22.5	45	45	45	45	45	45	45	45	45	45	45	45	45	45
		KFW	Diesel	MW	-	-	22.5	45	45	45	45	45	45	45	45	45	45	45	45	45	45
		d Planned Project		MW	0	0	24.8	84.8	84.8	84.8	364.8	394.8	424.8	424.8	454.8	484.8	484.8	624.8	624.8	624.8	624.8
			Diesel (2 x 12.39)	MW	-	-	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
		T.Sengkuang Blok I & II	Thermal	MW	-	-	-	-	-	-	280	280	280	280	280	280	280	420	420	420	420
		Kabil	Gasturbine	MW	-	-	-	60	60	60	60	90	120	120	150	180	180	180	180	180	180
		e	Total	MW	47.5	47.5	94.8	177.3	177.3	177.3	457.3	487.3	517.3	517.3	544.2	574.2	574.2	714.2	714.2	714.2	714.2
	Private	f Existing & Future Project		MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		g=e+f	Batam Total Installed	MW	47.5	47.5	94.8	177.3	177.3	177.3	457.3	487.3	517.3	517.3	544.2	574.2	574.2	714.2	714.2	714.2	714.2
			Peak Load	MW	10.9	32.4	55	100.3	127.6	144.1	165.9	189.5	216	243.8	274.7	309.6	344.9	348	427.4	475.5	528.7
			Reserve	%	336	47	72	77	39	23	176	157	139	112	98	85	66	105	67	50	35
Total Installed in The Other Islands				MW	323.3	333.5	386	491.2	512.4	538.2	851.5	922.9	989.1	985.8	1065.3	1194.5	1194.5	1334.5	1432.1	1458.1	1440.3

produced abundantly in Indonesia to be used as one of the main resources in place of oil.

(3) Combined cycle thermal power

Introduction of combined cycle thermal power should be pushed forward to make an effective use of natural gas, which is also abundant in Indonesia.

(4) Gas turbine

Gas turbine units should be installed in the region where the development of water resources can not be expected. However, it is recommended that the gas turbine units shall be converted to the combined cycle thermal units to make effective use of energy sources(natural gas), adding steam turbine units when the power system grows.

(5) Diesel

For the time being, in the small power systems dotted outside Jawa island diesel generating units will be installed because of the high thermal efficiency for its scale.

(6) Pumped storage power

Because Jawa island has few prospective hydroelectric power project sites remaining, pumped storage power plants shall be constructed because of the necessity to secure sufficient peaking capacity.

In the planning process of the power development, the JICA team has dealt with hydroelectric power and thermal power using coal and/or natural gas as a main power source to be developed, and also dealt with pumped storage as a power source to be introduced in future.

The JICA team considered the geothermal power plants and nuclear power plant listed in the power development plan made by Indonesian organization as well.

Current combined cycle thermal units have an efficiency higher than that of conventional thermal generating units and can decrease fuel consumption greatly. They excel at load regulating performance such as starts and stops and load control in normal operation. Therefore, combined cycle thermal will be considered as a power source utilized for the base load area and the intermediate load area.

8.3.2 Mixed pattern of power generation

The load duration curve comprises three load areas such as peak, intermediate and base. Each load area should be served by the power sources suitable from the viewpoint of economic and operating characteristics.

The JICA team has set up the aim of a mixed pattern of generation as below. However, in some of the regions the team thought it an advisable way to utilize abundant water resources effectively to develop hydroelectric power.

Hydroelectric, gas turbine and pumped storage	15% - 25%
Combined cycle	20% - 40%
Coal-fired thermal, geothermal and nuclear	45% - 55%

8.3.3 Generating capacity

The JICA team has forecast future power demand including the industrial load by the captive powers who have their own generating units. The JICA team has also dealt with the generating capacity of the captive powers as part of the supply capacity of the generating system.

Capacity of the diesel generating units owned by the captive powers shall be decreased at a rate of 5%/year from fiscal 2001. This means that the country's overall power demand will be covered entirely by the utilities,i.e. PLN and private sectors, in 2020.

Reserve margin of the generating system is closely related to the reliability level of power generation. The JICA team considered an operation reserve of 15 - 20% for the predicted peak demand, even in case hydroelectric power decreases its output to 35% of the installed capacity in a dry season.

It is assumed that each generating unit needs a scheduled maintenance once a year. Maintenance inspections shall be conducted not in the specific month or season but through the whole year evenly. The power source reduces its load carrying capability according to the length of maintenance period, because the generating unit under inspection is disconnected from the system.

8.3.4 Development of hydroelectric power and pumped storage

The majority of prospective hydroelectric project sites are situated in the islands of Sumatra, Kalimantan and Surawesi where the demand for electricity is expected to grow with the advance of development. Economically superior hydroelectric projects should be carried on positively with consideration of the environment.

Hydroelectric power of about 5% would be required in generating capability for frequency control of the power system. Considering the great reduction of generating capability in a dry season, the installed capacity of the general hydroelectric and pumped storage shall account for more than 15% of the total installed capacity of power generating units in the system.

In Jawa island, which has few prospective hydroelectric power projects, a pumped storage power of large scale shall be developed to secure peaking load capability.

In order to evaluate the prospective hydroelectric power projects from an economical point of view, Benefit/Cost(B/C) method, which is also called Cost/Value (C/V) method, was adopted.

This is a method to evaluate the planned hydroelectric power plants economically by comparing them with the alternative power plant which is thought to supply the same amount of power and energy as those by the hydroelectric power to the power system. A thermal power plant is usually adopted as the alternative power plant for this method.

A thermal power plant of 200MW with desulfurization equipment is dealt with as the reference thermal power plant for economical evaluation of the hydropower projects in this study. Table 8.13 outlines the study results.

Table 8.14 shows the results of the evaluation study of the hydroelectric power projects in Indonesia by the method mentioned above. In this table, the greater than 1.0 the ratio B/C is, the more superior the project is in terms of economy. The hydroelectric power projects, which are thought to be superior in economy at present are taken into the development plan commissioned in and after 2004, ten years from now.

Table 8.13 Outline of The Reference Thermal Power

Coal-fired Thermal Unit Capacity : 200MW class
(with De-Sox Equipment)

Generating Unit		
Construction Cost	$/kW	1,757
Fuel Cost	$/Mkcal	6.42
Average Efficiency	%	36.00
kW Plant Use	%	7
kWh Plant Use	%	7.7
kW Correction Factor		1.2
Transmission Line		
kW Loss	%	2
kWh Loss	%	1.57
Construction Cost	$/kW	87.86

Item	Unit	Fixed Cost	Variable Cost
Power Plant			
Capital Recovery	$/kW	224.05	
O&M Cost	$/kW	26.89	
Sub-total	$/kW	250.94	
Transmission Line	$/kW	8.79	
Total Cost	$/kW	259.73	
kW Value	$/kW	341.97	
kWh Value (Fuel Cost)	$/kWh		0.0169

kW Value = 259.73 x 1.2 / (1- 0.07) / (1- 0.02) ($/kW)

kWh Value = 6.42 / (10)^6 x 860 / 0.36 / (1- 0.077) / (1- 0.0157) ($/kWh)

Table 8.14 Economic Evaluation of The Hydro Power Plants by Benefit / Cost Method (1/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Sumatra						
PLN Region		Region I						
Name		Tampur	Jambu Aye	Teunom-1	Aceh-2	Peusangan-4	Lawe Alas-4	Jambu Aye-3
Installed Capacity	MW	330	176	24.25	7.33	30.89	321.6	36.4
Annual Energy Generation	10^3MWh	1067	659.2	195.21	59.33	234.2	1928	194.6
Construction Cost	10^6$	614	344.2	95.5	54.2	53.4	453.4	184.1
Generation Cost	$/kWh	0.0589	0.0534	0.0501	0.0935	0.0233	0.0241	0.0968
Economic Evaluation								
1) Cost C	10^6$	62.85	35.20	9.78	5.55	5.46	46.46	18.84
2) Benefit								
kW Benefit B1	10^6$	112.85	60.19	8.29	2.51	10.56	109.98	12.45
kWh Benefit B2	10^6$	18.03	11.14	3.30	1.00	3.96	32.58	3.29
Total Benefit B=B1+B2	10^6$	130.88	71.33	11.59	3.51	14.52	142.56	15.74
3) Annual Surplus Benefit (B-C)	10^6$	68.04	36.13	1.81	-2.04	9.06	96.10	-3.10
4) Benefit /Cost Ratio (B/C)		2.08	2.03	1.19	0.63	2.66	3.07	0.84
Study Stage		F/S level	F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	M/P level

Name of Island		Sumatra						
PLN Region		Region I						
Name		Bidin-2	Ramasan-1	Ramasan-2	Jambu Aye-6A	Jambu Aye-8	Lawe Mamas-1	Lawe Mamas-2
Installed Capacity	MW	99	63.2	35.4	137.6	196.2	66.6	51.8
Annual Energy Generation	10^3MWh	493.6	441.3	244.4	718.7	916.4	329.7	252.5
Construction Cost	10^6$	339.5	196.3	94	445.8	716.3	220.2	145.7
Generation Cost	$/kWh	0.0704	0.0455	0.0394	0.0635	0.08	0.0684	0.0591
Economic Evaluation								
1) Cost C	10^6$	34.75	20.08	9.63	45.64	73.31	22.55	14.92
2) Benefit								
kW Benefit B1	10^6$	33.86	21.61	12.11	47.06	67.09	22.78	17.71
kWh Benefit B2	10^6$	8.34	7.46	4.13	12.15	15.49	5.57	4.27
Total Benefit B=B1+B2	10^6$	42.20	29.07	16.24	59.20	82.58	28.35	21.98
3) Annual Surplus Benefit (B-C)	10^6$	7.45	8.99	6.61	13.56	9.27	5.80	7.06
4) Benefit /Cost Ratio (B/C)		1.21	1.45	1.69	1.30	1.13	1.26	1.47
Study Stage		M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (2/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Sumatra						
PLN Region		Region II						
Name		Wampu	Toru-1	Waini Utug	Laubiang	Wampu-1A	Asahan-4	Gadis-2
Installed Capacity	MW	84	125	40.6	121.5	114.8	75.2	103.8
Annual Energy Generation	10^3MWh	475.3	308.1	226.8	284.3	532.6	505.1	482.6
Construction Cost	10^6$	124.5	?	172.3	209.5	135.2	245.2	251.5
Generation Cost	$/kWh	0.0268	?	0.0776	0.0754	0.026	0.0497	0.0533
Economic Evaluation								
1) Cost C	10^6$	12.74	?	17.65	21.44	13.85	25.10	25.72
2) Benefit								
kW Benefit B1	10^6$	28.73	42.75	13.88	41.55	39.26	25.72	35.50
kWh Benefit B2	10^6$	8.03	5.21	3.83	4.80	9.00	8.54	8.16
Total Benefit B=B1+B2	10^6$	36.76	47.95	17.72	46.35	48.26	34.25	43.65
3) Annual Surplus Benefit (B-C)	10^6$	24.02		0.07	24.92	34.41	9.15	17.93
4) Benefit /Cost Ratio (B/C)		2.89		1.00	2.16	3.49	1.36	1.70
Study Stage		F/S level	F/S level	M/P level	M/P level	M/P level	M/P level	M/P level

Name of Island		Sumatra							
PLN Region		Region II							
Name		Gadis-3	Gadis-4	Toru-3	A.Sibundong-4	A.Sibundong-5	Lau Gunung-2	A.Simanggo-3	Sirahar
Installed Capacity	MW	69.9	45	148.2	19.6	47.6	14.5	57.6	21.4
Annual Energy Generation	10^3MWh	332.2	227.87	674.1	161.5	283.5	118.4	341.3	174.3
Construction Cost	10^6$	194.4	255.1	521.6	66.2	186.5	42.6	228.5	54.2
Generation Cost	$/kWh	0.0599	0.1146	0.0792	0.042	0.0673	0.0368	0.0679	0.0318
Economic Evaluation									
1) Cost C	10^6$	19.90	26.11	53.39	6.78	19.08	4.36	23.17	5.54
2) Benefit									
kW Benefit B1	10^6$	23.90	15.39	50.68	6.77	16.28	4.96	19.70	7.32
kWh Benefit B2	10^6$	5.61	3.85	11.39	2.73	4.79	2.00	5.77	2.95
Total Benefit B=B1+B2	10^6$	29.52	19.24	62.07	9.50	21.07	6.96	25.47	10.26
3) Annual Surplus Benefit (B-C)	10^6$	9.62	-6.87	8.68	2.72	1.99	2.60	2.29	4.72
4) Benefit /Cost Ratio (B/C)		1.48	0.74	1.16	1.40	1.10	1.60	1.10	1.85
Study Stage		M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (3/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Sumatra							
PLN Region		Region III							
Name		Batang Bayang-1	Batang Bayang-2	Sempur	Rokan Kiri-1	Rokan Kiri-2	Sinamar-1	Sinamar-2	Kuantan-2
Installed Capacity	MW	13.2	30.9	60.8	74.4	76.7	7.4	22.8	126
Annual Energy Generation	10^3MWh	71.27	202.7	287.3	515.9	336.1	228.1	199.7	944.9
Construction Cost	10^6$	42.2	50.7	233.8	248.7	438.6	82.8	67.2	454.5
Generation Cost	$/kWh	0.0606	0.0256	0.0833	0.0493	0.1336	0.0372	0.0344	0.0492
Economic Evaluation									
1) Cost C	10^6$	4.32	5.19	23.93	25.43	44.90	8.49	6.87	46.49
2) Benefit									
kW Benefit B1	10^6$	4.51	10.57	20.79	25.44	26.23	2.53	7.80	43.09
kWh Benefit B2	10^6$	1.20	3.43	4.86	8.72	5.68	3.85	3.37	15.97
Total Benefit B=B1+B2	10^6$	5.72	13.99	25.65	34.16	31.91	6.39	11.17	59.06
3) Annual Surplus Benefit (B-C)	10^6$	1.40	8.80	1.72	8.73	-12.99	-2.10	4.30	12.57
4) Benefit /Cost Ratio (B/C)		1.32	2.70	1.07	1.34	0.71	0.75	1.63	1.27
Study Stage		Pre F/S level	Pre F/S level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level

Name of Island		Sumatra	
PLN Region		Region III	
Name		Bayang-3	Sangir
Installed Capacity	MW	22.4	27
Annual Energy Generation	10^3MWh	180	225
Construction Cost	10^6$	82.8	71.9
Generation Cost	$/kWh	0.0471	0.0327
Economic Evaluation			
1) Cost C	10^6$	8.48	7.36
2) Benefit			
kW Benefit B1	10^6$	7.66	9.23
kWh Benefit B2	10^6$	3.04	3.80
Total Benefit B=B1+B2	10^6$	10.70	13.04
3) Annual Surplus Benefit (B-C)	10^6$	2.22	5.68
4) Benefit /Cost Ratio (B/C)		1.26	1.77
Study Stage		M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (4/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility
Fixed Cost 341.968$/kW
Variable Cost 0.0169$/kWh

Name of Island		Sumatra								
PLN Region		Region IV								
Name		Ranau	Ketaun-1	Merangin-2	Tes II	Merangin-5	Lematang-4	Merangin-1	Merangin-3	Anai-4
Installed Capacity	MW	60	84	340	17	23.9	12.15	41.2	57.4	41.9
Annual Energy Generation	10^3MWh	146	174.9	1297	74.5	155.5	105.53	217.5	302.4	203.1
Construction Cost	10^6$	146	114.2	247.9	?	76.3	141	172.4	213.9	198.2
Generation Cost	$/kWh	0.1024	0.0668	0.0196	?	0.0502	0.1368	0.0811	0.0724	0.0989
Economic Evaluation										
1) Cost C	10^6$	14.95	11.68	25.42	?	7.81	14.44	17.64	21.89	20.09
2) Benefit										
kW Benefit B1	10^6$	20.52	28.73	116.27	5.81	8.17	4.15	14.09	19.63	14.33
kWh Benefit B2	10^6$	2.47	2.96	21.92	1.26	2.63	1.78	3.68	5.11	3.43
Total Benefit B=B1+B2	10^6$	22.99	31.68	138.19	7.07	10.80	5.94	17.76	24.74	17.76
3) Annual Surplus Benefit (B-C)	10^6$	8.04	20.00	112.77	?	2.99	-8.50	0.13	2.85	-2.33
4) Benefit /Cost Ratio (B/C)		1.54	2.71	5.44	?	1.38	0.41	1.01	1.13	0.88
Study Stage		F/S level	F/S level	F/S level	Pre F/S level	Pre F/S level	Pre F/S level	M/P level	M/P level	M/P level

Name of Island		Sumatra								
PLN Region		Region IV								
Name		Selabung-2	Selabung-3	Kutu	Besai-2	Semangko-3	Luas-3	Manna-1	Ketaun-4	Enim-3
Installed Capacity	MW	73	35.4	39.6	12.64	118.2	32.2	109	40.8	47
Annual Energy Generation	10^3MWh	443.7	184	268.4	100.3	580.87	200	626.6	216.7	300.9
Construction Cost	10^6$	344	114.4	239.8	36.8	444.3	166.4	166.2	156.6	319.2
Generation Cost	$/kWh	0.0794	0.0636	0.0921	0.0376	0.0783	0.0852	0.0271	0.074	0.1086
Economic Evaluation										
1) Cost C	10^6$	35.23	11.70	24.54	3.77	45.48	17.04	16.98	16.04	32.68
2) Benefit										
kW Benefit B1	10^6$	24.98	12.11	13.54	4.32	40.42	11.01	37.27	13.95	16.07
kWh Benefit B2	10^6$	7.50	3.11	4.50	1.70	9.82	3.38	10.59	3.66	5.09
Total Benefit B=B1+B2	10^6$	32.46	15.22	18.04	6.02	50.24	14.39	47.86	17.61	21.16
3) Annual Surplus Benefit (B-C)	10^6$	-2.77	3.51	-6.49	2.25	4.76	-2.65	30.88	1.58	-11.52
4) Benefit /Cost Ratio (B/C)		0.92	1.30	0.74	1.60	1.10	0.84	2.82	1.10	0.65
Study Stage		M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (5/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Kalimantan					
PLN Region		Region V					
Name		Pade Kembayung	Pinoh	Silat	Melawai-9	Ambalau-7	Landak-4
Installed Capacity	MW	30	198.4	26.7	182.4	143.5	11
Annual Energy Generation	10^3MWh	235	1374.8	129.5	798.7	628.5	58.99
Construction Cost	10^6$	185.5	499.6	135.6	955.8	935.6	104.6
Generation Cost	$/kWh	0.0721	0.0372	0.1072	0.1225	0.1524	0.1879
Economic Evaluation							
1) Cost C	10^6$	16.94	51.14	13.88	97.64	95.78	10.71
2) Benefit							
kW Benefit B1	10^6$	10.26	67.85	9.81	62.38	49.07	3.76
kWh Benefit B2	10^6$	3.97	23.23	2.19	13.50	10.62	0.96
Total Benefit B=B1+B2	10^6$	14.23	91.08	12.00	75.87	59.69	4.72
3) Annual Surplus Benefit (B-C)	10^6$	-2.71	39.94	-1.88	-21.97	-36.09	-5.98
4) Benefit /Cost Ratio (B/C)		0.84	1.78	0.86	0.78	0.62	0.44
Study Stage		F/S level	Pre F/S level	Pre F/S level	M/P level	M/P level	M/P level

Name of Island		Kalimantan					
PLN Region		Region VI					
Name		Kusan-3	Amandit-2	Kelai-2	Kayan-2	Kelai-1	Kelai-3
Installed Capacity	MW	67.7	2.5	188	2072.7	128.3	74
Annual Energy Generation	10^3MWh	100.5	20.1	1102.9	13468.27	683.66	324
Construction Cost	10^6$	129.1	33.4	274.2	2444.4	377.8	337.1
Generation Cost	$/kWh	0.1315	0.1701	0.0254	0.0186	0.0566	0.1065
Economic Evaluation							
1) Cost C	10^6$	13.22	3.42	28.01	250.51	38.70	34.51
2) Benefit							
kW Benefit B1	10^6$	23.15	0.85	57.45	708.80	43.87	25.31
kWh Benefit B2	10^6$	1.70	0.34	18.64	227.61	11.55	5.48
Total Benefit B=B1+B2	10^6$	24.85	1.19	76.09	936.41	55.43	30.78
3) Annual Surplus Benefit (B-C)	10^6$	11.63	-2.22	48.08	685.91	16.73	-3.72
4) Benefit /Cost Ratio (B/C)		1.88	0.35	2.72	3.74	1.43	0.89
Study Stage		F/S level	Pre F/S level	Pre F/S level	Pre F/S level	M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (6/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Sulawesi				
PLN Region		Region VII				
Name		Palu-3	Poigar-2	Poigar-3	Poso-1	Poso-2
Installed Capacity	MW	74.8	25.4	13.5	201	166
Annual Energy Generation	10^3MWh	510	149	96.6	1763.4	1455.9
Construction Cost	10^6$	102.6	32	26.9	286.3	278.3
Generation Cost	$/kWh	0.0206	0.022	0.0279	0.0166	0.0196
Economic Evaluation						
1) Cost C	10^6$	10.51	3.28	2.75	29.27	28.54
2) Benefit						
kW Benefit B1	10^6$	25.58	8.69	4.62	68.74	56.77
kWh Benefit B2	10^6$	8.62	2.52	1.67	29.80	24.60
Total Benefit B=B1+B2	10^6$	34.20	11.20	6.28	98.54	81.37
3) Annual Surplus Benefit (B-C)	10^6$	23.69	7.93	3.53	69.26	52.84
4) Benefit /Cost Ratio (B/C)		3.26	3.42	2.28	3.37	2.85
Study Stage		F/S level	Pre F/S level	Pre F/S level	M/P level	M/P level

Name of Island		Sulawesi						
PLN Region					Region VIII			
Name		Malea	Batu	Poko	Bakaru II	Masupu-2	Paleleng	Bonto Butu
Installed Capacity	MW	182	271.1	53	63	78	31.4	130
Annual Energy Generation	10^3MWh	1477	1740.2	308	565	396.6	258.8	654.5
Construction Cost	10^6$	247.1	466.7	166	164.7	380.2	82.4	655.6
Generation Cost	$/kWh	0.0171	0.0275	0.0552	0.0298	0.0981	0.0326	0.1025
Economic Evaluation								
1) Cost C	10^6$	25.26	47.86	17.00	16.84	38.91	8.44	67.09
2) Benefit								
kW Benefit B1	10^6$	62.24	92.71	18.12	21.54	26.67	10.74	44.46
kWh Benefit B2	10^6$	24.96	29.41	5.21	9.55	6.70	4.37	11.06
Total Benefit B=B1+B2	10^6$	87.20	122.12	23.33	31.09	33.38	15.11	55.52
3) Annual Surplus Benefit (B-C)	10^6$	61.94	74.26	6.33	14.26	-5.53	6.67	-11.57
4) Benefit /Cost Ratio (B/C)		3.45	2.55	1.37	1.85	0.86	1.79	0.83
Study Stage		F/S level	Pre F/S level	Pre F/S level	Pre F/S level	M/P level	M/P level	M/P level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (7/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Maluku			New Guinea		
PLN Region		Region IX			Region X		
Name		Isal-2	W.Mala-2	W.Tala	Warsamson	Tami	Marender
Installed Capacity	MW	60	7.6	24.1	15.2	28	8
Annual Energy Generation	10^3MWh	447	64.9	105.6	44.2	133.9	37
Construction Cost	10^6$	96	33.2	135.4	18.5	236.5	32
Generation Cost	$/kWh	0.022	0.0524	0.1312	0.0428	0.1608	0.0885
Economic Evaluation							
1) Cost C	10^6$	9.83	3.40	13.85	1.89	24.21	3.27
2) Benefit							
kW Benefit B1	10^6$	20.52	2.60	8.24	5.20	9.58	2.74
kWh Benefit B2	10^6$	7.55	1.10	1.78	0.75	2.26	0.63
Total Benefit B=B1+B2	10^6$	28.07	3.70	10.03	5.94	11.84	3.36
3) Annual Surplus Benefit (B-C)	10^6$	18.24	0.30	-3.83	4.05	-12.37	0.09
4) Benefit /Cost Ratio (B/C)		2.85	1.09	0.72	3.14	0.49	1.03
Study Stage		F/S level	M/P level	M/P level	Pre F/S level	M/P level	M/P level

Name of Island		Timor Timur			E.Nusatenggara	W.Nusatenggara
PLN Region		Region XI				
Name		Iralalaro	Laclo-1	Belulic-1	Mina	Beburung
Installed Capacity	MW	27	6.5	14	13	22.4
Annual Energy Generation	10^3MWh	191	105.5	72.7	113.6	90.8
Construction Cost	10^6$	58.3	81.2	54.4	168.4	47.1
Generation Cost	$/kWh	0.0312	0.0312	0.0312	0.0312	0.0532
Economic Evaluation						
1) Cost C	10^6$	5.96	3.29	2.27	3.54	4.82
2) Benefit						
kW Benefit B1	10^6$	9.23	2.22	4.79	4.45	7.66
kWh Benefit B2	10^6$	3.23	1.78	1.23	1.92	1.53
Total Benefit B=B1+B2	10^6$	12.46	4.01	6.02	6.37	9.19
3) Annual Surplus Benefit (B-C)	10^6$	6.50	0.71	3.75	2.82	4.37
4) Benefit /Cost Ratio (B/C)		2.09	1.22	2.65	1.80	1.91
Study Stage		F/S level	F/S level	M/P level	M/P level	F/S level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (8/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility

Fixed Cost 341.968$/kW

Variable Cost 0.0169$/kWh

Name of Island		Java					
PLN Region		Java - Bali					
Name		Kont II	Cibuni-3	Cipasang	Cimandiri-3	Parungbadak	Cisangkuy
Installed Capacity	MW	62	172	400	352	55	79.1
Annual Energy Generation	10^3MWh	207	568	751.1	575	316.6	428
Construction Cost	10^6$	218.2	348.7	576.6	336.1	369.3	?
Generation Cost	$/kWh	0.1079	0.0628	0.0786	0.0598	-	-
Economic Evaluation							
1) Cost C	10^6$	22.34	35.67	59.04	34.39	37.82	?
2) Benefit							
kW Benefit B1	10^6$	21.20	58.82	136.79	120.37	18.81	27.05
kWh Benefit B2	10^6$	3.50	9.60	12.69	9.72	5.35	7.23
Total Benefit B=B1+B2	10^6$	24.70	68.42	149.48	130.09	24.16	34.28
3) Annual Surplus Benefit (B-C)	10^6$	2.37	32.75	90.45	95.71	-13.66	?
4) Benefit /Cost Ratio (B/C)		1.11	1.92	2.53	3.78	0.64	?
Study Stage		F/S level	F/S level	F/S level	F/S level	F/S level	F/S level

Name of Island		Java						
PLN Region		Java - Bali						
Name		Tanjung	Grindulu	Kepanjen	Babadan	Beng	Lumbang Sari	Kesamben
Installed Capacity	MW	5	16.3	6	9.4	18	10.8	32
Annual Energy Generation	10^3MWh	28.3	63.9	32.5	26.1	10.4	46.9	101
Construction Cost	10^6$	158	81.4	22.3	150.8	66	37.6	91.3
Generation Cost	$/kWh	-	0.1304	0.0702	?	?	0.0821	0.0925
Economic Evaluation								
1) Cost C	10^6$	16.18	8.34	2.28	15.44	6.76	3.85	9.35
2) Benefit								
kW Benefit B1	10^6$	1.71	5.57	2.05	3.21	6.16	3.69	10.94
kWh Benefit B2	10^6$	0.48	1.08	0.55	0.47	0.16	0.79	1.71
Total Benefit B=B1+B2	10^6$	2.19	6.65	2.60	3.69	6.33	4.49	12.65
3) Annual Surplus Benefit (B-C)	10^6$	-13.99	-1.66	0.32	-11.75	-0.43	0.64	3.30
4) Benefit /Cost Ratio (B/C)		0.14	0.80	1.14	0.24	0.94	1.17	1.35
Study Stage		F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level

Table 8.14 Economic Evaluation of Hydro Power Plants by Benefit / Cost Method (9/9)

Reference Thermal Power : 200MW class coal-fired thermal with a flue gas desulfurization facility
Fixed Cost 341.988$/kW
Variable Cost 0.0169$/kWh

Name of Island		Java						
PLN Region		Java - Bali						
Name		Genteng I	Gintung	Rawalo-1	Matenggeng	Rajamandala	Cibuni-4	Cikaso-3
Installed Capacity	MW	16.6	19.2	0.6	100	25.5	71.1	29.8
Annual Energy Generation	10^3MWh	54.9	163.4	5.2	175	78.7	247	204
Construction Cost	10^6$	98	111.4	3.2	?	62.5	113.3	143.1
Generation Cost	$/kWh	?	0.0698	0.063	?	0.0813	0.047	0.0718
Economic Evaluation								
1) Cost C	10^6$	10.04	11.41	0.33	?	6.40	11.60	14.65
2) Benefit								
kW Benefit B1	10^6$	6.36	6.57	0.21	34.20	8.72	24.31	10.19
kWh Benefit B2	10^6$	0.93	2.76	0.09	2.96	1.33	4.17	3.45
Total Benefit B=B1+B2	10^6$	7.29	9.33	0.29	37.15	10.05	28.49	13.64
3) Annual Surplus Benefit (B-C)	10^6$	-2.75	-2.08	-0.03	?	3.65	16.89	-1.02
4) Benefit/Cost Ratio (B/C)		0.73	0.82	0.89	?	1.57	2.46	0.93
Study Stage		Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level	Pre F/S level

Name of Island		Java					Bali
PLN Region		Java - Bali					
Name		Watukumpul	Cipunegara	Cilaki-2	Cibuni-2	Cibareno-1	Ayung
Installed Capacity	MW	16.5	52.4	6.6	10.2	6.8	43.9
Annual Energy Generation	10^3MWh	85.2	266.5	55.9	71.9	50.8	136.9
Construction Cost	10^6$	83.6	266.3	56.4	36.7	37.2	125.2
Generation Cost	$/kWh	0.1004	0.1023	0.1033	0.0522	0.075	0.0936
Economic Evaluation							
1) Cost C	10^6$	8.56	27.27	5.78	3.76	3.81	12.81
2) Benefit							
kW Benefit B1	10^6$	5.64	17.92	2.26	3.49	2.33	15.01
kWh Benefit B2	10^6$	1.44	4.50	0.94	1.22	0.86	2.31
Total Benefit B=B1+B2	10^6$	7.08	22.42	3.20	4.70	3.18	17.33
3) Annual Surplus Benefit (B-C)	10^6$	-1.48	-4.85	-2.57	0.95	-0.63	4.51
4) Benefit/Cost Ratio (B/C)		0.83	0.82	0.55	1.25	0.84	1.35
Study Stage		M/P level	M/P level	M/P level	M/P level	M/P level	F/S level

8.4 Power development plan

8.4.1 Development plan of power sources

(1) Development Plan of Power Sources for the Jawa/Bali Islands

Prior to working out a power development plan for the power system which covers these islands, power and energy demand at generating end have been forecasted up to the year of 2008.

Table 8.15 shows the results of load forecast which include the demand for power and energy utilized by the industries (captive powers).

Table 8.16 shows the power development plan worked out by the JICA team. The mark ??? indicates a power source which the JICA team thinks is necessary to meet the predicted maximum demand.

Coal-fired thermal and combined cycle will be main sources to be developed, but general hydroelectric power and pumped storage power of a large scale should be also developed to possess a necessary peaking capacity.

The power system will need the total installed capacity to be 1.42 to 1.48 times as much as the peaking demand to ensure an operating reserve of 18% even in a dry season.

In Repelita VI (1994/95~1998/99), coal-fired thermal 400MW and combined cycle 4,286MW are to be developed. Though being smaller in scale than these power sources, hydroelectric power of about 500MW and geothermal 575MW are to be developed as well. Besides, the existing oil-fired thermal, Gresik #1-4 (600MW), will be converted to a gas-fired thermal as a part of national policy of reducing dependence on oil.

In Repelita VII (1999/2000~2003/04), not only the planned coal-fired thermal, such as Paiton, Tanjung Jati, Java Barat, Awar Awar whose capacity is 6,320MW in total but also additional coal-fired thermal 2,400MW were planned to be constructed. Accordingly,the sum of the capacities of the coal-fired thermal developed in this period is 8,720MW.

As for combined cycle, development of 1,400MW was planned. Capacity of hydroelectric power planned to be developed is 1,014MW in total which includes projects such as Maun 360MW, Jatigede 175MW, Cimandiri 351MW and so on. Upper Cisokan 1,000MW and Pumped Storage II

Table 8.15 Load Forecast for The Java - Bali System

Fiscal Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Residential (GWh)	9987.0	11589.0	13273.6	15030.7	16909.3	18936.9	21020.2	23200.2	25281.3	27445.4	29701.3	31927.7	34287.0
Commercial (GWh)	2809.2	3326.4	3654.5	4404.0	5016.6	5780.2	6577.9	7486.8	8275.8	9133.4	10067.2	11018.5	12073.7
Public & Others (GWh)	2012.2	2380.7	2769.6	3164.4	3597.7	4136.6	4692.3	5301.1	5859.1	6460.9	7111.0	7770.8	8496.8
Industry(PLN sales) (GWh)	18955.6	23957.4	31960.1	34788.8	38002.1	41033.9	44266.4	47437.6	50846.9	54507.8	58433.5	62480.6	66887.2
Industry(Captive) (GWh)	9976.0	8113.3	3711.8	5200.5	6891.6	8487.2	9758.7	11427.6	13221.9	15148.5	17214.6	19430.4	21749.6
Total Energy Consumption (Gwh)	43740.0	49366.8	55369.6	62588.4	70417.3	78354.8	86315.5	94853.3	103485.0	112696.0	122527.6	132628.0	143494.3
Growth Rate (%)	16.0	12.9	12.2	13.0	12.5	11.3	10.2	9.9	9.1	8.9	8.7	8.2	8.2
Population (10^3)	115855.1	117727.9	119592.1	121422.4	123251.1	125097.0	126958.9	128825.2	130670.5	132470.1	134282.8	136065.2	137864.9
Growth Rate (%)	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.3	1.2
Energy Consumption Per Capita (kWh)	377.5	419.3	463.0	515.5	571.3	626.4	679.9	736.3	792.0	850.7	912.6	974.7	1042.3
Growth Rate (%)	14.1	11.1	10.4	11.3	10.8	9.6	8.5	8.3	7.6	7.4	7.3	6.8	6.9
Load Factor (%)	74.0	73.9	73.8	73.7	73.6	73.5	73.4	73.3	73.2	73.1	73.0	72.9	72.8
Power at Receiving End (MW)	6747.5	7625.8	8564.7	9694.4	10921.9	12169.5	13424.2	14772.2	16138.5	17599.0	19160.5	20768.4	22500.9
kWh T&D Losses (%)	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Energy Sent (GWh)	50860.5	57403.3	64383.3	72777.2	81880.6	91110.2	100366.9	110294.5	120331.4	131041.9	142474.0	154218.6	166853.8
Loss Factor (%)	60.5	60.4	60.3	60.1	60.0	59.9	59.7	59.6	59.5	59.3	59.2	59.1	58.9
kW T&D Losses (%)	17.1	17.1	17.1	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.3	17.3	17.3
Power at Sending End (MW)	8140.8	9202.1	10336.9	11702.4	13186.5	14695.5	16213.4	17844.7	19498.6	21267.0	23158.2	25106.2	27205.3
kWh Plant Use (%)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
kW Plant Use (%)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Energy Produced (GWh)	53369	60234	67559	76366	85919	95604	105317	115734	126266	137505	149500	161824	175083
Peak Generation (MW)	8498	9606	10790	12215	13765	15340	16924	18627	20353	22199	24174	26207	28398

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Residential (GWh)	36733.3	39187.0	41668.0	44130.8	46605.7	49072.6	51544.8	54013.5	56484.5	58953.9	61424.4	63894.2	66364.5
Commercial (GWh)	13198.5	14314.8	15477.8	16609.7	17762.3	18901.1	20049.1	21190.9	22336.9	23480.1	24625.2	25769.0	26913.7
Public & Others (GWh)	9266.3	10027.7	10817.1	11587.8	12371.0	13145.9	13926.3	14703.0	15482.2	16259.8	17038.4	17816.3	18594.7
Industry(PLN sales) (GWh)	71616.1	76399.2	81402.9	86259.5	91214.2	96103.5	101036.4	105940.3	110863.5	115773.8	120692.7	125605.8	130522.8
Industry(Captive) (GWh)	24238.3	26755.5	29388.9	32899.5	36368.0	39869.7	43712.4	47796.2	51989.9	56471.0	61237.3	66248.3	71394.3
Total Energy Consumption (Gwh)	155052.5	166684.2	178754.7	191487.3	204321.2	217092.8	230269.0	243643.9	257157.0	270938.6	285018.0	299333.7	313790.0
Growth Rate (%)	8.1	7.5	7.2	7.1	6.7	6.3	6.1	5.8	5.5	5.4	5.2	5.0	4.8
Population (10^3)	139666.3	141451.1	143200.3	144966.4	146722.0	148465.2	150197.6	151921.2	153635.5	155337.1	157025.4	158701.8	160368.7
Growth Rate (%)	1.5	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Energy Consumption Per Capita (kWh)	1110.2	1178.4	1248.3	1320.9	1392.6	1462.2	1533.1	1603.8	1673.8	1744.2	1815.1	1886.1	1956.7
Growth Rate (%)	6.5	6.1	5.9	5.8	5.4	5.0	4.8	4.6	4.4	4.2	4.1	3.9	3.7
Load Factor (%)	72.7	72.6	72.5	72.4	72.3	72.2	72.1	72.0	71.9	71.8	71.7	71.6	71.5
Power at Receiving End (MW)	24346.7	26209.2	28145.9	30192.4	32260.5	34324.5	36458.3	38629.5	40828.7	43076.7	45378.4	47724.2	50099.0
kWh T&D Losses (%)	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Energy Sent (GWh)	180293.6	193818.8	207854.3	222659.7	237582.8	252433.5	267754.7	283306.9	299019.8	315044.9	331416.2	348062.5	364872.1
Loss Factor (%)	58.8	58.7	58.5	58.4	58.3	58.1	58.0	57.9	57.8	57.6	57.5	57.4	57.2
kW T&D Losses (%)	17.3	17.3	17.3	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.5	17.5	17.5
Power at Sending End (MW)	29442.4	31700.5	34049.2	36531.5	39041.0	41546.4	44137.2	46774.3	49446.2	52178.3	54976.5	57829.1	60718.0
kWh Plant Use (%)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
kW Plant Use (%)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Energy Produced (GWh)	189185	203378	218105	233641	249300	264883	280960	297279	313767	330582	347761	365228	382867
Peak Generation (MW)	30733	33090	35542	38133	40753	43368	46072	48825	51614	54466	57387	60364	63380

Table 8.16 POWER DEVELOPMENT PLAN OF THE JAVA-BALI SYSTEM (1/5)

Unit : MW

Owner	Source		1993		1994		1995		1996		1997		1998	
Captive Powers	Diesel			251.1										
	Gasturbine													
PLN or Private Utilities	Diesel						Kebayoran retired	-10.1						
							Bali (3 units) retired	-20.1						
		Sub-total						-30.2						
	Gasturbine		Ex Tosan Prima	60	Bali	84	Priok #1-3 retired	-72.1	Java Gas turbine#1-6	600.0	Gresik #1,2 retired	-40.2		
							Pulogadung #1-6 retired	-132.2						
					Tala Jabar Sejahtera	19	Sunyaragi #1-4 retired	-80.3						
							Perak retired	-29.0						
							Pandeanlamper#1-3retired	-54.0	Priok #4-7 retired	-195.2				
		Sub-total		60		103		-367.6		404.8		-40.2		
	Hydro		Telung Agung	36							Cirata II	500		
		Sub-total		36								500		
	Oil-fired thermal						Priok #1,2 retired	-50	Priok #3,4 retired	-100				
					Gresik#3,4 fuel conversion	-400	Perak #1,2 retired	-50						
							Gresik#1,2 fuel conversion	-200						
		Sub-total				-400		-300		-100				
	Gas-fired thermal				Gresik#3,4 fuel conversion	400	Gresik#1,2 fuel conversion	200						
		Sub-total				400		200						
	Combined Cycle		Gresik #1,#2	1,052	Gresik #3	166			Pasuruan	800				
			Gresik #3	360	Muara Karang	190	Tambak Lorok #1	190	Tambak Lorok #2	520				
			Muara Karang	324	Priok #1,2 (ST)	420			Muara Tawara	1,100				
			Priok #1,2 (GT)	780							Serpong	400		
			Tambak Lorok #1	324							Jawa Timur	500		
		Sub-total		2,640		776		190		2,420		900		
	Coal-fired thermal		Paiton #1	400	Paiton #2	400			Suralaya #5,6	1,200	Suralaya #7	600		
											Paiton #7	600	Paiton #8	600
													Paiton #5	600
													Jawa Barat (Cilegon)	400
		Sub-total		400		400				1,200		1,200		1,600
	Geothermal				Salak #1,2	110			Kamojang #4	55	Kamojang #5	55		
					Drajat #1	55			Salak #3	55	Salak #4	55	Patuha	40
											Drajat #2	55	Wayang Windu	40
													Dieng	55
		Sub-total				165				110		165		136
	Nuclear													
	Pumped Storage													
		Sub-total												
Net Additional Capacity		Total		3,587.1		1,444.0		-307.6		4,034.8		2,724.8		1,735.0

ACCUMULATED GENERATING CAPACITY OF THE JAWA-BALI SYSTEM

Owner	Source	1982	1993		1994		1995		1996		1997		1998	
		MW	MW	%	MW	%	MW	%	MW	%	MW	%	MW	%
Captive Powers	Diesel	3,263.6	3,534.9	25.7	3,534.9	23.3	3,534.9	23.7	3,534.9	18.7	3,534.9	16.3	3,534.9	15.1
	Gasturbine	400.0	400.0	2.9	400.0	2.6	400.0	2.7	400.0	2.1	400.0	1.8	400.0	1.7
	A Sub-total	3,663.6	3,934.9	28.6	3,934.9	25.9	3,934.9	26.4	3,934.9	20.8	3,934.9	18.2	3,934.9	16.8
PLN & Private Utilities	Diesel	119.5	119.5	0.9	119.5	0.8	89.3	0.6	89.3	0.5	89.3	0.4	89.3	0.4
	Gasturbine	733.2	793.2	5.8	896.2	5.9	528.6	3.6	933.4	4.9	893.2	4.1	893.2	3.8
	Hydro	1,987.5	2,023.5	14.7	2,023.5	13.3	2,023.5	13.6	2,023.5	10.7	2,523.5	11.7	2,523.5	10.8
	Oil-fired thermal	1,900	1,900	13.8	1,500	9.9	1,200	8.1	1,100	5.8	1,100	5.1	1,100	4.7
	Gas-fired thermal	0	0	0	400	2.6	600	4.0	600	3.2	600	2.8	600	2.6
	Combined Cycle	0	2,840	20.7	3,616	23.8	3,806	25.6	6,226	32.9	7,126	32.9	7,126	30.5
	Coal-fired thermal	1,600	2,000	14.5	2,400	15.8	2,400	16.1	3,600	19.0	4,800	22.2	6,400	27.4
	Geothermal	140	140	1.0	305	2.0	305	2.0	415	2.2	580	2.7	715	3.1
	Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pumped storage	0	0	0	0	0	0	0	0	0	0	0	0	0
	B Sub-total	6,480.2	9,816.2	71.4	11,260.2	74.1	10,952.4	73.6	14,987.2	79.2	17,712.0	81.8	19,447.0	83.2
C =	A + B Total	10,164.0	13,751.1	100.0	15,195.1	100.0	14,887.3	100.0	18,922.1	100.0	21,646.9	100.0	23,381.9	100.0
D	Peak Generation (MW)		8,498		9,608		10,790		12,215		13,765		15,340	

Table 8.16 POWER DEVELOPMENT PLAN OF THE JAVA-BALI SYSTEM (2/5)

Unit : MW

Owner	Source		1999		2000		2001		2002		2003	
Captive Powers	Diesel						Retired	-176.7	Retired	-176.7	Retired	-176.7
	Gasturbine											
PLN or Private Utilities	Diesel											
		Sub-total										
	Gasturbine		Java Gas turbine#7-10	400					Tambak Lorok retired	-21.4	Gresik #3 retired	-21.4
											Java Gas turbine #11-16	600
		Sub-total		400						-21.4		578.6
	Hydro						Tulis	13.0			Jatigede	175
			Rajamandala	25.5	Cirug	6	Wonorejo	6.2	Kesambon	33	Cimandiri	351
							Maung	360.0			Ayung	44
		Sub-total		25.5		6		379.2		33		570
	Oil-fired thermal								Tambak Lorok#1,2 retired	-100	Muara Karang#1-3 retired	-300
									Perak #3,4 retired	-100		
		Sub-total								-200		-300
	Gas-fired thermal											
		Sub-total										
	Combined Cycle						???	700			???	700
		Sub-total						700				700
	Coal-fired thermal				Paiton#3,4	800						
			Paiton #6	600	Tanjung Jati #1,2	1,200	Tanjung Jati #3,4	1,200	Jawa Barat I #1,2	1,200		
			???	1,200			???	600	Awar-Awar #1,2	1,320	???	600
		Sub-total		1,800		2,000		1,800		2,520		600
	Geothermal		Drajat #3	55								
		Sub-total		55								
	Nuclear											
	Pumped Storage						Upper Cisokan #1,2	500	Upper Cisokan #3,4	500	Pumped Storage II #1,2	500
		Sub-total						500		500		500
	Net Additional Capacity			2,280.5		2,006.0		3,202.5		2,654.9		2,471.9

ACCUMULATED GENERATING CAPACITY OF THE JAWA-BALI SYSTEM

Owner	Source	1999 MW	1999 %	2000 MW	2000 %	2001 MW	2001 %	2002 MW	2002 %	2003 MW	2003 %
Captive Powers	Diesel	3,534.9	13.8	3534.9	12.8	3356.2	10.9	3181.4	9.5	3004.7	8.3
	Gasturbine	400.0	1.6	400.0	1.4	400.0	1.3	400.0	1.2	400.0	1.1
	A Sub-total	3,934.9	15.3	3934.9	14.2	3756.2	12.2	3581.4	10.7	3404.7	9.5
PLN & Private Utilities	Diesel	89.3	0.3	89.3	0.3	89.3	0.3	89.3	0.3	89.3	0.2
	Gasturbine	1,293.2	5.0	1293.2	4.7	1293.2	4.2	1271.8	3.8	1850.4	5.1
	Hydro	2,549.0	9.9	2555.0	9.2	2934.2	9.5	2967.2	8.9	3537.2	9.8
	Oil-fired thermal	1,100	4.3	1,100	4.0	1,100	3.6	900	2.7	600	1.7
	Gas-fired thermal	600	2.3	600	2.2	600	1.9	600	1.8	600	1.7
	Combined Cycle	7,126	27.8	7,126	25.8	7,826	25.4	7,826	23.3	8,526	23.7
	Coal-fired thermal	8,200	32.0	10,200	36.9	12,000	38.9	14,520	43.3	15,120	42.0
	Geothermal	770	3.0	770	2.8	770	2.5	770	2.3	770	2.1
	Nuclear	0	0	0	0	0	0	0	0	0	0
	Pumped storage	0	0	0	0	600	1.6	1,000	3.0	1,500	4.2
	B Sub-total	21,727.5	84.7	23,733.5	85.8	27,112.7	87.8	29,944.3	89.3	32,592.9	90.5
C -	A + B Total	25,662.4	100.0	27,668.4	100.0	30,870.9	100.0	33,525.7	100.0	35,997.6	100.0
D -	Peak Generation (MW)	16,924		18,627		20,353		22,199		24,174	

Table 8.16 POWER DEVELOPMENT PLAN OF THE JAVA-BALI SYSTEM (3/5)

Unit : MW

Owner	Source		2004		2005		2006		2007		2008	
Captive Powers	Diesel		Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7
	Gasturbine											
PLN or Private Utilities	Diesel		Bali (4units) retired	-28								
		Sub-total		-28								
	Gasturbine		Bali retired	-21.4	Java Gas turbine#17-18	200	Java Gas turbine#19-26	800	Java Gas turbine#27	100	Java Gas turbine#28-32	500
		Sub-total		-21.4		200		800		100		500
	Hydro		Cipasang	400	Cibuni-3	172	Cibuni-4	71.1	Lumbang Sari	10.8	Kepanjen	6
					Lesti	13						
					Kali Oyo	29						
		Sub-total		400		214		71.1		10.8		6
	Oil-fired thermal				Muara Karang #4 retired	-200	Muara Karang #5 retired	-200	Tambak Lorok #3 retired	-200		
		Sub-total				-200		-200		-200		
	Gas-fired thermal				Gresik #1,2 retired	-200						
		Sub-total				-200						
	Combined Cycle						??? (Bali)	400	???	700		
		Sub-total						400		700		
	Coal-fired thermal		West Java I #3-5	1,800	West Java I #6	600	Central Java #7,8	1,200	West Java II #1		West Java II #2	600
					Central Java #5,6	1,200	Mine Mouth #1	600	Mine Mouth #2-4	1,800	Lokasi Baru #1	600
			???	600							???	700
		Sub-total		2,400		1,800		1,800		1,800		1,900
	Geothermal										Kamojang #1 retired	-30
		Sub-total										-30
	Nuclear											600
	Pumped Storage		Pumped Storage II #3,4	500	Pumped Storage III #1,2	500	Pumped Storage III #3,4	500	Pumped Storage IV #1,2	500	Pumped Storage IV #3,4	500
		Sub-total		500		500		500		500		500
Net Additional Net Additional Capacity				3,073.9		2,137.3		3,194.4		2,734.1		3,299.3

ACCUMULATED GENERATING CAPACITY OF THE JAWA-BALI SYSTEM

Owner	Source	2004 MW	2004 %	2005 MW	2005 %	2006 MW	2006 %	2007 MW	2007 %	2008 MW	2008 %
Captive Powers	Diesel	2,827.9	7.2	2,651.2	6.4	2,474.4	5.6	2,297.7	4.9	2,120.9	4.2
	Gasturbine	400.0	1.0	400.0	1.0	400.0	0.9	400.0	0.8	400.0	0.8
	A Sub-total	3,227.9	8.3	3,051.2	7.4	2,874.4	6.6	2,697.7	5.7	2,520.9	5.0
PLN & Private Utilities	Diesel	61.3	0.2	61.3	0.1	61.3	0.1	61.3	0.1	61.3	0.1
	Gasturbine	1,829.0	4.7	2,029.0	4.9	2,829.0	6.4	2,929.0	6.2	3,429.0	6.8
	Hydro	3,937.2	10.1	4,151.2	10.1	4,222.3	9.5	4,233.1	9.0	4,239.1	8.4
	Oil-fired thermal	400	1.5	400	1.0	200	0.5	0	0	0	0
	Gas-fired thermal	600	1.5	400	1.0	400	0.9	400	0.8	400	0.8
	Combined Cycle	8,526	21.8	8,526	20.7	8,926	20.1	9,626	20.4	9,626	19.1
	Coal-fired thermal	17,520	44.8	19,320	46.9	21,120	47.6	22,920	48.6	24,820	49.2
	Geothermal	770	2.0	770	1.9	770	1.7	770	1.6	740	1.5
	Nuclear	0	0	0	0	0	0	0	0.0	600	1.3
	Pumped storage	2,000	5.1	2,500	6.1	3,000	6.8	3,500	7.4	4,000	7.9
	B Sub-total	35,843.6	91.7	38,157.5	92.6	41,528.6	93.5	44,439.4	94.3	47,916.4	95.0
C =	A + B Total	39,071.4	100.0	41,208.7	100.0	44,403.0	100.0	47,137.1	100.0	50,436.3	100.0
D	Peak Generation (MW)	26,207		28,398		30,733		33,090		35,542	

Table 8.16 POWER DEVELOPMENT PLAN OF THE JAVA-BALI SYSTEM (4/5)

Unit : MW

Owner	Source	2009		2010		2011		2012		2013	
Captive Powers	Diesel	Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7
	Gasturbine										
PLN or Private Utilities	Diesel			Bali (4units) retired	-28	Sunayan retired	-6				
	Sub-total				-28		-6				
	Gasturbine	Ex Tosan Prima retired	-60.0	Bali retired	-84.0			Java Gas turbine#1-6 retired	-600.0		
	Sub-total		-60.0		-84.0				-600.0		
	Hydro	Cibuni-2	10.2	Koni II	62						
	Sub-total		10.2		62						
	Oil-fired thermal										
	Sub-total										
	Gas-fired thermal										
	Sub-total										
	Combined Cycle	???	2,800	???	1,400	???	1,400	???	1,400	???	700
	Sub-total		2,800		1,400		1,400		1,400		700
	Coal-fired thermal			Suralaya #1 retired	-400	Suralaya #2 retired	-400				
		???	700	???	2,100	???	2,100	???	2,800	???	2,800
	Sub-total		700		1,700		1,700		2,800		2,800
	Geothermal					???	55				
	Sub-total						55				
	Nuclear										
	Pumped Storage	Pumped Storage V #1,2	500	Pumped Storage V #3,4	500	Pumped Storage VI #1,2	500	Pumped Storage VI #3,4	500	Pumped Storage VII#1,2	500
	Sub-total		500		500		500		500		500
Net Additional Capacity	Total		3,773.5		3,373.3		3,472.3		3,923.3		3,823.3

ACCUMULATED GENERATING CAPACITY OF THE JAVA-BALI SYSTEM

Owner	Source	2009 MW	%	2010 MW	%	2011 MW	%	2012 MW	%	2013 MW	%
Captive Powers	Diesel	1,944.2	3.6	1,757.5	3.1	1,590.7	2.6	1,414.0	2.2	1237.2	1.4
	Gasturbine	400.0	0.7	400.0	0.7	400.0	0.7	400.0	0.6	400.0	0.6
	A Sub-total	2,344.2	4.3	2,157.5	3.8	1,990.7	3.3	1,814.0	2.8	1637.2	2.4
PLN & Private Utilities	Diesel	61.3	0.1	33.3	0.1	27.3	0.0	27.3	0.0	27.3	0.0
	Gasturbine	3,369.0	6.2	3,285.0	5.7	3,285.0	5.4	2,685.0	4.1	2685.0	3.9
	Hydro	4,249.3	7.8	4,311.3	7.5	4,311.3	7.1	4,311.3	6.6	4311.3	6.3
	Oil-fired thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Gas-fired thermal	400.0	0.7	400.0	0.7	400.0	0.7	400.0	0.6	400.0	0.6
	Combined Cycle	12,426.0	22.9	13,826.0	24.0	15,226.0	24.9	16,626.0	25.6	17326.0	25.2
	Coal-fired thermal	25,520.0	47.1	27,220.0	47.3	28,920.0	47.4	31,720.0	48.8	34520.0	50.2
	Geothermal	740.0	1.4	740.0	1.3	795.0	1.3	795.0	1.2	795.0	1.2
	Nuclear	600.0	1.1	600.0	1.0	600.0	1.0	600.0	0.9	600.0	0.9
	Pumped storage	4,500.0	8.3	5,000.0	8.7	5,500.0	9.0	6,000.0	9.2	6500.0	9.4
	B Sub-total	51,865.6	95.7	55,415.6	96.2	59,064.6	96.7	63,164.6	97.2	67,164.6	97.6
C =	A + B Total	54,209.8	100.0	57,583.1	100.0	61,055.3	100.0	64,978.6	100.0	68,801.8	100.0
D	Peak Generation (MW)	38,133		40,753		43,356		46,072		48,825	

Table 8.16 POWER DEVELOPMENT PLAN OF THE JAVA-BALI SYSTEM (5/5)

Unit : MW

Owner	Source	2014		2015		2016		2017		2018	
Captive Powers	Diesel	Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7	Retired	-176.7
	Gasturbine										
PLN or Private Utilities	Diesel										
	Sub-total										
	Gasturbine			Java Gas turbine#7-10 retired	-400						
	Sub-total				-400.0						
	Hydro										
	Sub-total										
	Oil-fired thermal										
	Sub-total										
	Gas-fired thermal	Gresik #3,4 retired	-400								
	Sub-total		-400.0								
	Combined Cycle	Gresik #1,2 retired	-1052	Gresik #3 retired	-526	Tambak Lorok retired	-614				
		Priok #1 retired	-600	Muara Karang retired	-514						
				Priok #2 retired	-600						
		???	4200	???	2800	???	2100	???	2100	???	1400
	Sub-total		2548		1160		1586		2100		1400
	Coal-fired thermal	Suralaya #3 retired	-400	Suralaya #4 retired	-400						
		???	2100	???	2800	???	2800	???	1400	???	2100
	Sub-total		1700		2400		2800		1400		2100
	Geothermal			Kamojang #2,3 retired	-110					???	110
	Sub-total				-110						110
	Nuclear										
	Pumped Storage	Pumped Storage VII #3,4	500	Pumped Storage VIII #1,2	500	Pumped Storage VIII #3,4	500	Pumped Storage IX #1,2	500	Pumped Storage IX #3,4	500
	Sub-total		500		500		600		500		500
Net Additional Capacity	Total		4,171.3		3,373.3		4,709.3		3,823.3		3,933.3

ACCUMULATED GENERATING CAPACITY OF THE JAWA-BALI SYSTEM

Owner	Source	2014 MW	2014 %	2015 MW	2015 %	2016 MW	2016 %	2017 MW	2017 %	2018 MW	2018 %
Captive Powers	Diesel	1060.5	1.5	883.7	1.2	707.0	0.9	530.2	0.6	353.5	0.4
	Gasturbine	400.0	0.5	400.0	0.5	400.0	0.5	400.0	0.5	400.0	0.5
	A Sub-total	1460.5	2.0	1283.7	1.7	1107.0	1.4	930.2	1.1	753.5	0.8
PLN & Private Utilities	Diesel	27.3	0.0	27.3	0.0	27.3	0.0	27.3	0.0	27.3	0.0
	Gasturbine	2685.0	3.7	2285.0	3.0	2285.0	2.8	2285.0	2.7	2285.0	2.6
	Hydro	4311.3	5.9	4311.3	5.6	4311.3	6.3	4311.3	5.1	4311.3	4.9
	Oil-fired thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Gas-fired thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Combined Cycle	19874.0	27.2	21034.0	27.6	22620.0	27.9	24720.0	29.1	26120.0	29.4
	Coal-fired thermal	36220.0	49.6	38620.0	50.6	41420.0	51.1	42820.0	50.4	44920.0	50.6
	Geothermal	795.0	1.1	685.0	0.9	685.0	0.8	685.0	0.8	795.0	0.9
	Nuclear	600.0	0.8	600.0	0.8	600.0	0.7	600.0	0.7	600.0	0.7
	Pumped storage	7000.0	9.6	7500.0	9.8	8000.0	9.9	8500.0	10.0	9000.0	10.1
	B Sub-total	71,512.6	98.0	75,062.6	98.3	79,948.6	98.6	83,948.6	98.9	88,058.6	99.2
C =	A + B Total	72,973.1	100.0	76,346.3	100.0	81,055.6	100.0	84,878.8	100.0	88,812.1	100.0
D	Peak Generation (MW)	51,614		54,466		57,387		60,364		63,380	

#1,2 (500MW) were planned to be developed as pumped storage power.

On top of these projects there are development of Java gas turbine 1,000MW and geothermal Draja#3 (50MW) and retirement of the existing oil-fired thermal (total capacity 500MW).

Development of coal-fired thermal in Repelita VIII (2004/05 - 2008/09) includes West Java, Central Java, Mine Mouth and the total capacity of them is 9,700MW.

Mine Mouth is to be constructed nearby a coal mine in the south Sumatra and power generated is to be sent to Jawa. Accordingly, direct current transmission lines will have to be constructed between Sumatra and Java in parallel with development of this power source.

For hydroelectric power, Cipasang, Cibuni-3 and so on, whose capacity is about 700MW, will be constructed and for pumped storage a total capacity of 2,500MW including Pumped Storage II #3,4 (500MW) will be at three locations .

Development of nuclear power 600MW in fiscal 2008 was taken into account.

It is recommendable that Jawa gas turbines which will be installed by 2008 should be converted to combined cycle thermal plants by adding steam turbines in future because of a high thermal efficiency.

Capacity of the coal-fired thermal and combined cycle developed in Repelita IX (2009/10 - 2013/14) is 10,500MW and 7,700MW,respectively. Pumped storage developed in this period will be at three locations with a capacity 2,500MW in total.

In Repelita X (2014/15 - 2018/19), capacity of the coal-fired thermal and combined cycle developed is 11,200MW and 12,600MW, respectively, and pumped storage will be developed at three locations with a capacity 2500MW in total as in Repelita IX.

Areas which center Jakarta and Bandung will continue to have high demand for electricity in the future. Therefore, power development should be pushed forwards in the west Jawa, including these two areas. Moreover, development of large-scale power sources in the central and east Jawa and to reinforce the transmission system to send power to the west.

(2) Development plan of power sources for Sumatra islands

In Region I, there are many hydroelectric projects economically superior to thermal power. However, main power sources of power development will be coal-fired thermal and combined cycle for the next ten years. After that hydroelectric power will be a center of power development. By capacity power sources developed in this region up to fiscal 2018 will be hydroelectric 1,403.6 MW, coal-fired thermal 800 MW, combined cycle 300 MW and so on.

In Region II, main power sources of power development will be coal-fired thermal and combined cycle as well, but after Repelita VII(1999/2000~2003/04) development of hydroelectric power should be carried on.Geothermal and pumped storage will be also developed.

By capacity power sources developed in this region up to fiscal 2018 will be gas turbine 300 MW, hydroelectric 1,572.9 MW, coal-fired thermal 9,000 MW, combined cycle 7,000 MW geothermal 440 MW, pumped storage 2,000 MW and so on.

Region I and II differ from each other in the constitution of power supply capability. So it is recommended that interconnection of these regions should be reinforced to develop and use power sources effectively over an extensive area.

In Region III, coal-fired thermal and combined cycle are main power sources to be developed,too, but hydroelectric power is very hopeful. Power sources developed in this region up to fiscal 2018 will be gas turbine 35 MW, hydroelectric 629.4 MW, coal-fired thermal 1,600 MW, combined cycle 1,400 MW and so on.

In Region IV, main power sources to be developed will be coal-fired thermal and combined cycle, too, but development of advantageous hydroelectric projects should be pushed forward after Repelita VII(1999/2000~2003/04). Pumped storage was planned to be developed after fiscal 2015.

Power sources developed in this region up to fiscal 2018 will be gas turbine 375 MW, hydroelectric 1,276.4 MW, coal-fired thermal 4,730 MW, combined cycle 5,200 MW, pumped storage 300 MW and so on.

In Repelita VIII, Mine Mouth (coal-fired thermal 2,400 MW) is to be constructed at the site of Bukit Asam in Region IV and most of its generated power is to be sent to Jawa island. Taking this opportunity, the power system of the south part of Sumatra is connected with Jawa-Bali power system. It is advisable that power sources are developed and used over the two power systems effectively.

It should be examined that gas turbines installed in Medan, Lampung, etc. are developed into combined cycles.

Table 8.17 shows the outline of power development plan of each region.

(3) Jawa-Sumatra power system interconnection and power development

As mentioned above, 400 kV HVDC transmission line will be constructed between Sumatra and Jawa islands in the period of Repelita VIII to send power generated at the coal-fired thermal power plant, mine mouth, developed in the south of Sumatra.

Though chiefly aiming at sending most of power generated by this thermal power, the HVDC transmission line will be used for economical power exchange between the two islands as well, utilizing surplus power of the hydroelectric power plants and the difference in their peaking hours.

It will be also effective for improving the reliability of the power system by controlling a power flow of the link to curb a disturbance and to continue stable power supply at emergencies when abrupt shortage of power supply, an outage of the generating units or others occurs in either power system.

It is advisable to study that power sources are developed and utilized widely and effectively over the two power systems in future on the assumption of utilization of the link between the two islands.

It is conceivable that if the interconnection between the two islands is to be expanded some hydroelectric power projects planned in the south part of Sumatra shall be restudied on their development scale toward being greater.

It is recommendable that development of power sources such as coal-fired thermal and hydroelectric

Table 8.17 Power Development Of Each Region In Sumatra

MW

Region	Source	Repelita VI 1994/95-1998/99		Repelita VII 1999/00-2003/04		Repelita VIII 2004/05-2008/09		Repelita IX 2009/10-2013/14		Repelita X 2014/15-2018/19	
		Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired
I	Diesel	13.1	-21.2		-47.7		-81.5		-81.5		-34.1
	Gasturbine				-254.5		-19.4		-19.3		
	Hydro	3.6		87.5		682.89		326.4		303.2	
	Oil-fired thermal										
	Coal-fired thermal			400				200		200	
	Combined cycle			300							
	Geothermal										
	Pumped storage										
	Sub-total	16.7	-21.2	787.5	-302.2	682.89	-100.9	526.4	-100.8	503.2	-34.1
	accumulated capacity	(in 1998/99)	555.2	(in 2003/04)	1040.4	(in 2008/09)	1622.3	(in 2013/14)	2047.7	(in 2018/19)	2516.7
	Peak load	(in 1998/99)	447	(in 2003/04)	603	(in 2008/09)	785	(in 2013/14)	968	(in 2018/19)	1152
II	Diesel	5.6	-55.6		-160.2		-200.6		-200.6		-136.5
	Gasturbine	300	-21.4								
	Hydro	1.4		551.9		588.2		283.2		148.2	
	Oil-fired thermal								-130		-130
	Coal-fired thermal			1100		3000		2800		2100	
	Combined cycle	400		1100		1400		2000		2100	
	Geothermal			440							
	Pumped storage					300		750		950	
	Sub-total	707	-77	3191.9	-160.2	5288.2	-200.6	5833.2	-330.6	5298.2	-266.5
	accumulated capacity	(in 1998/99)	2696.7	(in 2003/04)	5828.3	(in 2008/09)	10815.9	(in 2013/14)	16318.4	(in 2018/19)	21350
	Peak load	(in 1998/99)	1955	(in 2003/04)	3878	(in 2008/09)	7237	(in 2013/14)	10790	(in 2018/19)	14430
III	Diesel	44	-30.7		-77.1		-130.5		-130.5		-130.5
	Gasturbine	35	-42.7								
	Hydro	296.7		16		93.9		222.8			
	Oil-fired thermal										
	Coal-fired thermal	200		300		200		300		600	
	Combined cycle			200		400		400		400	
	Geothermal	2.7									
	Pumped storage										
	Sub-total	578.4	-73.4	516	-77.1	693.9	-130.5	922.8	-130.5	1000	-130.5
	accumulated capacity	(in 1998/99)	1366.4	(in 2003/04)	1805.3	(in 2008/09)	2368.6	(in 2013/14)	3160.9	(in 2018/19)	4030.3
	Peak load	(in 1998/99)	744.3	(in 2003/04)	1112.2	(in 2008/09)	1578.6	(in 2013/14)	2045	(in 2018/19)	2511.8
IV	Diesel	52.5	-23.9		-147.7		-253		-253		-253
	Gasturbine	375	-36								
	Hydro	1.3		652.4		168		356.54		98.2	
	Oil-fired thermal				-25						
	Coal-fired thermal	130		400		700		1100		1400	
	Combined cycle			1000		1000		1600		1600	
	Geothermal										
	Pumped storage									300	
	Sub-total	558.8	-59.9	2052.4	-172.7	1868	-253	3056.54	-253	3398.2	-253
	accumulated capacity	(in 1998/99)	1657.8	(in 2003/04)	3537.3	(in 2008/09)	6152.3	(in 2013/14)	8955.8	(in 2018/19)	12101
	Peak load	(in 1998/99)	1300.4	(in 2003/04)	2337.2	(in 2008/09)	4135.3	(in 2013/14)	6032.7	(in 2018/19)	7977.5
Sumatra	Diesel	115.2	-131.4	0	-432.7	0	-665.6	0	-665.6	0	-554.1
	Gasturbine	710	-100.1	0	-254.5	0	-19.4	0	-19.3	0	0
	Hydro	303	0	1307.8	0	1532.99	0	1188.94	0	549.6	0
	Oil-fired thermal	0	0	0	-25	0	0	0	-130	0	-130
	Coal-fired thermal	330	0	2200	0	3900	0	4400	0	4300	0
	Combined cycle	400	0	2600	0	2800	0	4000	0	4100	0
	Geothermal	2.7	0	440	0	0	0	0	0	0	0
	Pumped storage	0	0	0	0	300	0	750	0	1250	0
	Total	1860.9	-231.5	6547.8	-712.2	8532.99	-685	10338.94	-814.9	10199.6	-684.1
	accumulated capacity	(in 1998/99)	6275.9	(in 2003/04)	12211.3	(in 2008/09)	20959.1	(in 2013/14)	30482.8	(in 2018/19)	39998
	Peak load	(in 1998/99)	4446.7	(in 2003/04)	7830.4	(in 2008/09)	13735.9	(in 2013/14)	19835.7	(in 2018/19)	26071.3

Note : All the figures include the captive powers' facilities and their power demand.

power of a large scale should be studied including possibility of sending power from them to Jawa island, in case that the reinforcement of the transmission network inside Sumatra proceeds and a 500 kV transmission system is introduced.

(4) Development plan of power sources for the other islands

(a) Development plan for Kalimantan island

Main power sources developed in Region V will be coal-fired thermal and combined cycle. However, diesel and gas turbine will be needed to some extent as power sources to be developed in the near future. Power sources developed up to 2018 in this region will be gas turbine 270 MW, hydroelectric 230 MW, combined cycle 1,150 MW, coal-fired thermal 1,475 MW and so on.

In Region VI, main power sources developed are coal-fired thermal, combined cycle and hydroelectric which includes Kelai and Kayan. It is recommendable that the power system of Banjar Masin and that of Samarinda are linked each other in Repelita VIII to make it possible to adopt units of large capacity and to use the power sources over a wide area. Power sources developed up to 2018 in this region are gas turbine 330 MW, hydroelectric 2,502.8 MW, combined cycle 2,282 MW, coal-fired thermal 2,695 MW and so on.

Table 8.18 shows the outline of power development of each region in Kalimantan.

(b) Development plan for Sulawesi island

Main power sources of the development plan will be hydroelectric and combined cycle in Region VII. However, for the time being, diesel is a main power source and will need to be installed yet in the near future with gas turbines which will be installed in Bitung, for instance. It should be examined that the gas turbines are developed into combined cycle plants with higher efficiency in future.

In parallel with development of a hydroelectric project, Palu, it is requested for the scattered village loads to be linked together into a transmission network in order to make an effective use of power generated at the hydroelectric power plants. Concerning the development of the large-scale hydroelectric power source, Poso, an examination is needed about a method to send power from the plant to the load center.

Power sources developed up to 2018 in this region will be gas turbine 150 MW, hydroelectric 523.4

Table 8.18 Power Development Of Each Region In Kalimantan

MW

Region	Source	Repelita VI 1994/95-1998/99		Repelita VII 1999/00-2003/04		Repelita VIII 2004/05-2008/09		Repelita IX 2009/10-2013/14		Repelita X 2014/15-2018/19	
		Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired
V	Diesel	17.4	-20.7		-22		-70.5		-70.5		-70.5
	Gasturbine	90		30		150					
	Hydro	1.7		30		198.4					
	Oil-fired thermal										
	Coal-fired thermal	50		50		375		400		600	
	Combined cycle			300		350		300		200	
	Geothermal										
	Pumped storage									100	
	Sub-total	159.1	-20.7	410	-22	1073.4	-70.5	700	-70.5	900	-70.5
	accumulated capacity	(in 1998/99)	386.1	(in 2003/04)	774.1	(in 2008/09)	1776.9	(in 2013/14)	2406.3	(in 2018/19)	3235.7
	Peak load	(in 1998/99)	300.7	(in 2003/04)	577.5	(in 2008/09)	1047.7	(in 2013/14)	1542.8	(in 2018/19)	2049.2
VI	Diesel	40.5	-84.3		-139.7		-252		-252		-252
	Gasturbine	180		120		30	-21				
	Hydro	0.4		68.7		165		2268.7			
	Oil-fired thermal										
	Coal-fired thermal	130		565		400		700		900	
	Combined cycle	66		366		1000		450		400	
	Geothermal										
	Pumped storage									950	
	Sub-total	416.9	-84.3	1119.7	-139.7	1595	-273	3418.7	-252	2250	-252
	accumulated capacity	(in 1998/99)	1396.9	(in 2003/04)	2376.8	(in 2008/09)	3698.6	(in 2013/14)	6865.1	(in 2018/19)	7912.9
	Peak load	(in 1998/99)	1037.4	(in 2003/04)	1704.2	(in 2008/09)	2668.6	(in 2013/14)	3667.5	(in 2018/19)	4681.3
Kalimantan	Diesel	57.9	-105	0	-161.7	0	-322.5	0	-322.5	0	-322.5
	Gasturbine	270	0	150	0	180	-21	0	0	0	0
	Hydro	2.1	0	98.7	0	363.4	0	2268.7	0	0	0
	Oil-fired thermal	0	0	0	0	0	0	0	0	0	0
	Coal-fired thermal	180	0	615	0	775	0	1100	0	1500	0
	Combined cycle	66	0	666	0	1350	0	750	0	600	0
	Geothermal	0	0	0	0	0	0	0	0	0	0
	Pumped storage	0	0	0	0	0	0	0	0	1050	0
	Total	576	-105	1529.7	-161.7	2668.4	-343.5	4118.7	-322.5	3150	-322.5
	accumulated capacity	(in 1998/99)	1783	(in 2003/04)	3150.9	(in 2008/09)	5475.5	(in 2013/14)	9271.4	(in 2018/19)	11148.6
	Peak load	(in 1998/99)	1338.1	(in 2003/04)	2281.7	(in 2008/09)	3716.3	(in 2013/14)	5210.3	(in 2018/19)	6730.5

MW, combined cycle 280 MW, coal-fired thermal 150 MW, geothermal 20 MW and so on.

Main power sources of the development plan in Region VIII will be coal-fired thermal and combined cycle, but some hydroelectric power projects are advantageous to be pushed forward for development. Pumped storage was planned to be developed in Repelita X.

Power sources developed up to 2018 in this region will be gas turbine 210 MW, hydroelectric 637 MW, combined cycle 4,032 MW, coal-fired thermal 2,980 MW, pumped storage 150 MW and so on.

Table 8.19 shows the outline of power development of each region in Surawesi.

(c) Development plan for the other islands

Main power sources to be developed in the other islands will be diesel and combined cycle. Especially diesel will be the most important power source for some ten years.

In Region IX, Region X and Region XI, small loads of village exist in many scattered islands or are dispersed extensively being interrupted by a marsh or thick forest, so it will not be possible to install power plants of a large scale unless these small loads are integrated into a large load. Therefore, diesel, gas turbine and hydroelectric power of a small scale will be power sources to be developed for a while. The gas turbines should be developed into combined cycle power plants in the future. It is necessary to link the scattered village loads and build a power transmission network in order to develop power sources economically and to make an effective use of them.

Table 8.20 shows the outline of power development in the regions except Jawa, Bali, Sumatra, Kalimantan and Surawesi.

8.4.2 Expansion plan of power system network

(1) Transmission Line and Substation Plan for Future

In the energy/power demand projection of this Master Plan, the growth of demands in the future 25 years have been projected based on the Gross National Consumption (for PLN supply area and outside this area). On the other hand, the energy/power demand projection formulated by PLN has been established for the current supply area of PLN and the areas which should be included in the

Table 8.19 Power Development Of Each Region In Sulawesi

MW

Region	Source	Repelita VI 1994/95-1998/99		Repelita VII 1999/00-2003/04		Repelita VIII 2004/05-2008/09		Repelita IX 2009/10-2013/14		Repelita X 2014/15-2018/19	
		Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired
VII	Diesel	37.4	-18.9		-43.02		-47.2		-47.2		-47.2
	Gasturbine			125		25					
	Hydro	36.3		28.3		91.8		201		166	
	Oil-fired thermal										
	Coal-fired thermal									150	
	Combined cycle			40		120		120			
	Geothermal										
	Pumped storage										
	Sub-total	73.7	-18.9	193.3	-43.02	236.8	-47.2	321	-47.2	316	-47.2
	accumulated capacity	(in 1998/99)	281.4	(in 2003/04)	431.5	(in 2008/09)	621.1	(in 2013/14)	895	(in 2018/19)	1163.9
	Peak load	(in 1998/99)	195	(in 2003/04)	282.9	(in 2008/09)	377.7	(in 2013/14)	472.6	(in 2018/19)	567.4
VIII	Diesel	33.4	-7.6		-93.5		-160		-160		-160
	Gasturbine	210			-21.4						
	Hydro	10.8		141.9		453		31.4			
	Oil-fired thermal		-25								
	Coal-fired thermal	50		230		900		1000		800	
	Combined cycle	132		900		800		1200		1000	
	Geothermal										
	Pumped storage									150	
	Sub-total	436.2	-32.6	1271.9	-114.9	2153	-160	2231.4	-160	1950	-160
	accumulated capacity	(in 1998/99)	1170.7	(in 2003/04)	2327.8	(in 2008/09)	4320.8	(in 2013/14)	6392.1	(in 2018/19)	8182.1
	Peak load	(in 1998/99)	859.7	(in 2003/04)	1608	(in 2008/09)	2834	(in 2013/14)	4120.6	(in 2018/19)	5435.6
Sulaswesi	Diesel	70.8	-26.5	0	-136.52	0	-207.2	0	-207.2	0	-207.2
	Gasturbine	210	0	125	-21.4	25	0	0	0	0	0
	Hydro	47.1	0	170.2	0	544.8	0	232.4	0	166	0
	Oil-fired thermal	0	-25	0	0	0	0	0	0	0	0
	Coal-fired thermal	50	0	230	0	900	0	1000	0	950	0
	Combined cycle	132	0	940	0	920	0	1320	0	1000	0
	Geothermal	0	0	0	0	0	0	0	0	0	0
	Pumped storage	0	0	0	0	0	0	0	0	150	0
	Sub-total	509.9	-51.5	1465.2	-157.92	2389.8	-207.2	2552.4	-207.2	2266	-207.2
	accumulated capacity	(in 1998/99)	1452.1	(in 2003/04)	2759.3	(in 2008/09)	4941.9	(in 2013/14)	7287.1	(in 2018/19)	9346
	Peak load	(in 1998/99)	1054.7	(in 2003/04)	1890.9	(in 2008/09)	3211.7	(in 2013/14)	4593.2	(in 2018/19)	6003

Note : All the figures include the captive powers' facilities and their power demand.

Table 8.20 Power Development Of Region IX, X And XI, and Batam

MW

Region	Source	Repelita VI 1994/95-1998/99		Repelita VII 1999/00-2003/04		Repelita VIII 2004/05-2008/09		Repelita IX 2009/10-2013/14		Repelita X 2014/15-2018/19	
		Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired	Installed	Retired
IX	Diesel	23.5	-7.6	60	-24.5	54	-36.5	24	-36.5	18	-36.5
	Gasturbine			60							
	Hydro	1		40.8		46		7.6			
	Oil-fired thermal										
	Coal-fired thermal										
	Combined cycle					120		180		180	
	Geothermal										
	Pumped storage										
	Sub-total	24.5	-7.6	160.8	-24.5	220	-36.5	211.6	-36.5	198	-36.5
	accumulated capacity	(in 1998/99) 147.8		(in 2003/04) 283.8		(in 2008/09) 466.9		(in 2013/14) 641.6		(in 2018/19) 802.8	
	Peak load	(in 1998/99) 116.9		(in 2003/04) 192.9		(in 2008/09) 300.8		(in 2013/14) 412.8		(in 2018/19) 526.6	
X	Diesel	16.3	-2.3	16	-21.6	90	-62.5		-62.5		-62.5
	Gasturbine			45							
	Hydro	16.2	-0.2	25.8		8					
	Oil-fired thermal										
	Coal-fired thermal										
	Combined cycle							150		150	
	Geothermal										
	Pumped storage										
	Sub-total	32.5	-2.5	86.8	-21.6	98	-62.5	150	-62.5	150	-62.5
	accumulated capacity	(in 1998/99) 240.2		(in 2003/04) 305.3		(in 2008/09) 346.1		(in 2013/14) 433.5		(in 2018/19) 520.9	
	Peak load	(in 1998/99) 123		(in 2003/04) 169		(in 2008/09) 223		(in 2013/14) 278		(in 2018/19) 333.7	
XI	Diesel	53.9	-17.4		-29.7		-61.5		-61.5		-61.5
	Gasturbine	20		60		80					
	Hydro	6.1	-0.1	52.8		44.5					
	Oil-fired thermal										
	Coal-fired thermal									150	
	Combined cycle					100		200			
	Geothermal	3		17.5							
	Pumped storage										
	Sub-total	83	-17.5	130.3	-29.7	224.5	-61.5	200	-61.5	150	-61.5
	accumulated capacity	(in 1998/99) 246.5		(in 2003/04) 347		(in 2008/09) 509.9		(in 2013/14) 648.3		(in 2018/19) 738.7	
	Peak load	(in 1998/99) 160.7		(in 2003/04) 244.3		(in 2008/09) 329.9		(in 2013/14) 411.8		(in 2018/19) 492.5	
Batam	Diesel	69.8			-16.6		-60.5		-60.5		-60.5
	Gasturbine	60		120							
	Hydro										
	Oil-fired thermal										
	Coal-fired thermal					75		425		150	
	Combined cycle	280				140				300	
	Geothermal										
	Pumped storage										
	Sub-total	409.8	0	120	-16.6	215	-60.5	425	-60.5	450	-60.5
	accumulated capacity	(in 1998/99) 547.9		(in 2003/04) 651.2		(in 2008/09) 805.5		(in 2013/14) 1169.8		(in 2018/19) 1559.1	
	Peak load	(in 1998/99) 181.1		(in 2003/04) 338.6		(in 2008/09) 582.1		(in 2013/14) 839.9		(in 2018/19) 1104.5	

Note : All the figures include the captive powers' facilities and their power demand.

supply area in future.

The power development plan of this Master Plan is designed to include the non-PLN supply area (for captive power and private sector) which would be taken 5% of total demand per year for the projection period after year 2000 and be completed by 2018/19. Therefore, the power system development plan up to year 2003 has been formulated by reviewing the basic plan of PLN.

(a) Transmission Line and Substation System Configuration

According to the progress of power plant construction projects, the plans for expansion of power transmission and distribution networks are being formulated for various areas of the Nation with the objective of improving the transmission/distribution losses and enhancing supply reliability.

The power systems of Indonesia are spread over a large number of islands. These power systems in independent islands, except for Java-Bali Power System, are built around large cities of each island, and practically no system interconnection has been realized. However, as the power consumption increases in future, and the power systems are improved and refined corresponding to such load growth, sophisticated power systems will be developed in the future.

Concerning Java-Bali Power System, the power systems have been interconnected one by one by a 500-kV transmission line, which was introduced in 1984. The refinement and expansion of the secondary 150 kV system, as well as 70 kV and 20 kV systems of lower hierarchy, are being refined and expanded.

When we think about the power systems of Indonesia based on this history of development, we believe it necessary to unify the standard voltage of trunk power systems that efficiently transport the power from power plant to the load centers and the distribution line voltage at load centers. In reference to the scale of power development in the future Indonesia and the line voltage of existing PLN power systems, the voltage standard to be adopted would be basically as described below.

Java-Bali System

500 kV -- 150 kV -- 70 kV

Sumatra System

275 kV -- 150 kV -- 70 kV

Outside Java System

150 kV -- 70 kV

Note:
1. The 70-kV systems in Java-Bali System and Sumatra System would not be further expanded in future.
2. Adoption of 500 kV AC and 400 kV DC will be required in Sumatra System, with considerations on the future interconnection of Java System.

(b) Substation Facilities

The substation facilities have also been expanded step by step corresponding to the expansion of transmission facilities.

The adoption of the 500-kV system has enabled the bulk power, long-distance power transmission, and the power supplied from newly constructed power plants to be supplied to the 150-kV and 70-kV secondary substations via primary substations having interconnection transformers (500 / 150 kV).

Under the circumstances, these interconnection transformers and the substations equipped with the secondary system transformers are rapidly being expanded. However, the load factors of transformers in some substations are extremely high (being 90% to 1005), and it seems that these facilities are sufficient for the rapid load growth. Therefore, the reinforcement of transformer facilities, together with the construction of new substations, is an important item in the future power system planning.

Concerning the substation facilities of Outside Java System, feasibility studies and detailed designs must be developed corresponding to power development plans for future load growth, to formulate expansion plans for new substations and the replacement of existing transformers, further considering relocation of diesel power plants.

(c) Transmission Line/Substation Expansion Plan

Criteria of Transmission and Substation

The criteria of predicting the future trend for power transmission/substation plan have been formulated as follows by considering the past trend of growth of demand, electrification rate, and progress of construction work.

1. Transmission line

The length of 500 kV line is estimated from a power system diagram forecasted for Java-Bali in the future. Main power sources including pumped storage will be development in east, central and west regions and will be connected to the 500 kV network which forms a large loop system and is expanded to Bali.

The length of 275 kV line is also estimated from a power system diagram forecasted for Sumatra in the future.

The length of 150 kV line is estimated from the length of 500 kV and 275 kV lines estimated considering the difference in power transmission capability by difference of voltage.

2. Substation

Capacity of transformers are estimated assuming line flows and some margines as follows;

500 kV/150 kV:	peak load (MW) * 90 % * 1.6 (MVA)
275 kV/150 kV:	peak load (MW) * 35 % * 1.6 (MVA)
150 kV/20 kV:	peak load (MW) * 100 % * 1.5 (MVA)

The expansion plan for the whole transmission/substation facilities in Indonesia is presented in Table 8.21.

Table 8.21 Expansion Plan of Transmission/Substation Facilities for Whole Indonesia

REPELITA F. Year	VI *1998/99	VII 2003/04	VIII 2008/09	IX 2013/14	X 2018/19
Transmission Lines (kmc)					
500 kV	1,978	2,899	2,536	2,624	3,016
400 kV D.C	0	0	950	0	0
275 kV	140	2,986	2,929	4,249	5,379
150 kV	9,901	10,326	13,190	14,992	15,265
70 kV	91	0	0	0	0
Substations (MVA)					
500/150 kV	11,500	11,740	15,120	17,600	19,325
500/167 kV	0	0	2,400	0	0
275/150 kV	0	3,750	7,409	6,864	6,491
275/167 kV	0	0	2,400	0	0
150/ 70 kV	1,690	0	0	0	0
150/ 20 kV	22,810	20,660	29,180	32,530	34,636
70/ 20 kV	1,186	110	0	0	0

* Including F.Y. 1993 plan.

(2) Future Distribution System Plan

(a) Distribution System Configuration

Power distribution facilities must be expanded and improved with the objective of assuring supply capacity for the future growth of demand, enhancement of supply reliability, and promotion of safety measures.

Although the existing distribution facilities generally have a tree-type configuration, it is proposed that such system configuration as radial ring system illustrated are actively adopted in areas where high supply reliability is required.

(b) Distribution System Plan

Table 8.22 gives the recent trend of numbers of medium to low voltage lines in the distribution facilities.

Table 8.22 Trend of members of medium to voltage lines in the distribution facilities

F. Year	Total Length of Distribution Lines (kmc)							Transf. Capacity (MVA)
	Middle Voltage						Low Volt.	
	6-7 kV	10-11 kV	12 kV	15 kV	20 kV	Total	220/380V	
1984/85	9,131	0	1,284	415	160,096	26,926	54,914	6,360
1989/90	7,593	2	1,133	183	61,752	70,663	103,896	12,285
1992/93	5,198	0	832	68	86,150	92,248	148,492	18,762

The total extension of medium and low voltage lines has increased by approximately 90,000 km-cct in the 5 years from 1984/85 to 1989/90. This extension is similar to the magnitude of extensions in the nine electric power companies in Japan in the same period. In recent years, the growth of the total extension has been still higher, being approximately 19% on average.

The distribution transformers have increased by approximately 6 million kVA (approximately 90%) in the same 5 years. Comparing these figures with the trend in Japan, the increase in capacity was approximately 1/6 of Japan (approximately 34 million kVA in the nine electric power companies), indicating that the load density in Indonesia is lower.
The load density increases with the number of customers and the consumption per customer. The growth in the number of contracting customers in recent years is approximately 12 to 15%. Since it looks as if the current growth rate of distribution transformers of 18 to 20% is a limit, the method for drastically increasing the distribution transformer is a problem in dealing with future load growth.

The distribution voltage is now being standardized to 20 kV for medium voltage lines and 200/380 V for low voltage lines. Eenforcement of this standardization must be maintained.

Criteria for Distribution Plan

The criteria of predicting the future trend for power distribution plan have been formulated as follows by considering the past trend of growth of customers, electrification rate, and progress of construction work. The target values used by PLN for formulation of long-term plan have been referred to in developing these criteria. Our future plan has been formulated according to these criteria based on the projection of electric power consumption in future.

Distribution facilities are estimated from the future energy demand forecast and the values of length and capacity per 100 MWh as follows.

		Java-Bali	Outside Java
1.	Medium Voltage Line	0.27~0.22 kmc/100MWh	0.62~0.42 kmc/100MWh
2.	Low Voltage Line	0.85~0.52 kmc/100MWh	1.13~0.55 kmc/100MWh
3.	Distribution Transformer	97~70 kVA/100MWh	98~70 kVA/100MWh

Table 8.23 summarizes of the distribution system expansion plan of Indonesia for the next 25 years.

Table 8.23 Distribution System Expansion Plan

REPELITA F. Year	VI *1998/99	VII 2003/04	VIII 2008/09	IX 2013/14	X 2018/19
Distribution Lines (kmc)					
- Middle Volt (20~6 kV)	152,089	191,300	270,160	301,180	320,647
- Low Volt (440/220 V)	225,697	240,440	339,560	378,540	402,996
Distribution Transformers (MVA)	24,994	31,070	43,880	48,910	52,075
Consumers Connection (1,000 x pcs)	12,438	8,800	6,881	5,408	4,184

* Including plan value of F.Y. 1993.

9. Review and Assessment of Energy Sources for Power Generation

9.1 Energy Supply and Demand in the Coming 25 Years

9.1.1 Forecast of Energy consumption

The well known energy demand forecast in Indonesia is the MARKAL model that has been studied in the group of the agency for the assessment and application of technology (BPPT). This model is based on the consumers choice of energy resources at the market prices of each energy resource to minimize their total cost for energy consumption. With the 1992 model, the average consumption in REPELITA XI compared to the REPELITA V, oil increased by 3.7 times, natural gas 4.2 times, coal 34 times, hydro and geothermal 3.8 times, biomass 1.7 times, coal had the greatest increase. Because the model had the lowest cost per calory among resources. In the 1993 model, the case of high economic growth and suppressed exhaust, oil and natural gas increase 4.3%/year, coal increases 12.3%, hydro and geothermal 4.5% and biomass 1.8% increase per year. The new forecasts by MARKAL model is now beeing studying and will be shown next March, they said.

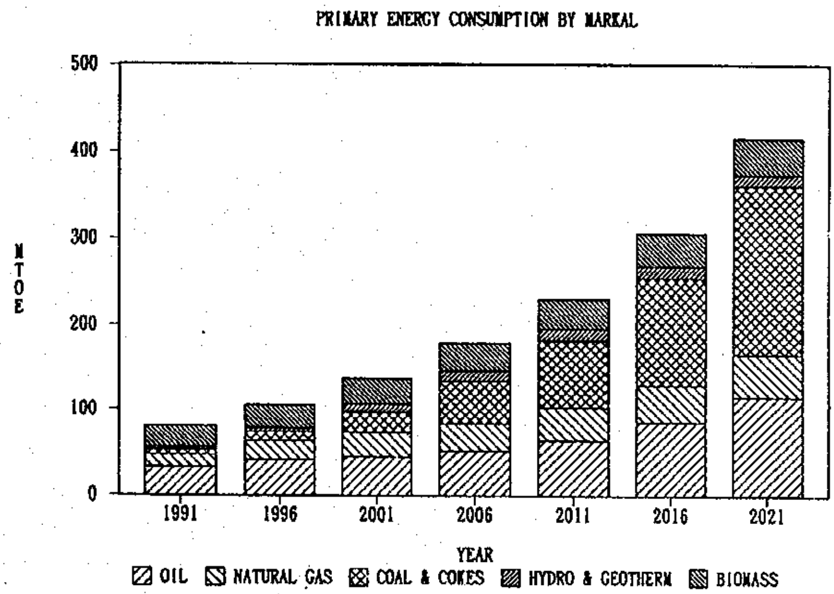


Figure 9.1 The forecast of energy demand by MARKAL model

Our total energy demand forecast based on the electric sector demand and summing of the other sectors such as industry, commercial, public, transportation and households(urban and rural). The energy resources are oil, natural gas, coal, hydropower, geothermal, nuclear, biomass and LPG(finally included in oil). According to this forecast, increases from the year of 1990 to 2020 for each energy resource are: oil 6 times, natural gas 20 times, coal 26 times hydropower/geothermal 18 times, biomass 1.7 times.

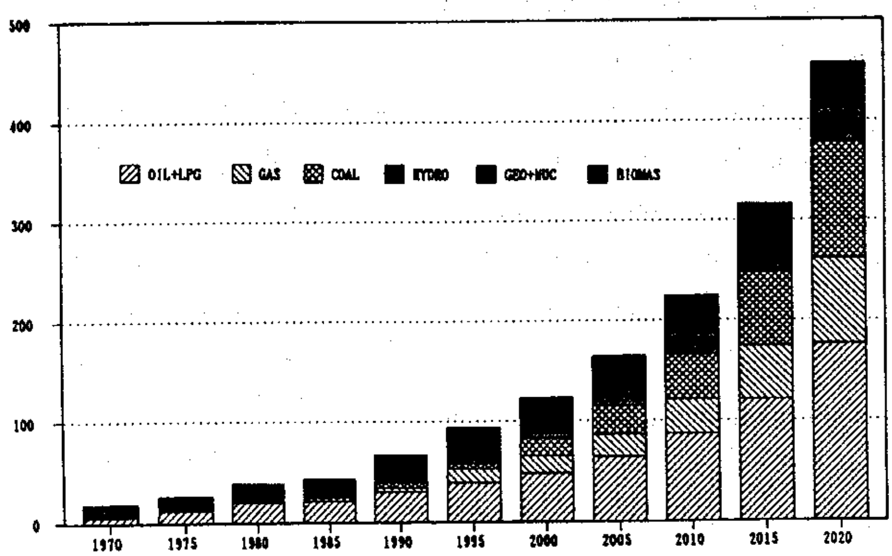


Figure 9.2 Forecast of energy demand (JICA)

The consumption of energy per capita is compared to other countries, in 1990, the consumption of energy per capita was 0.38 TOE(ton oil equivalent)/capita (including biomass energy) and 0.26 TOE/capita(excluding biomass) was the lowest value among the representative countries in Asia and Pacific.

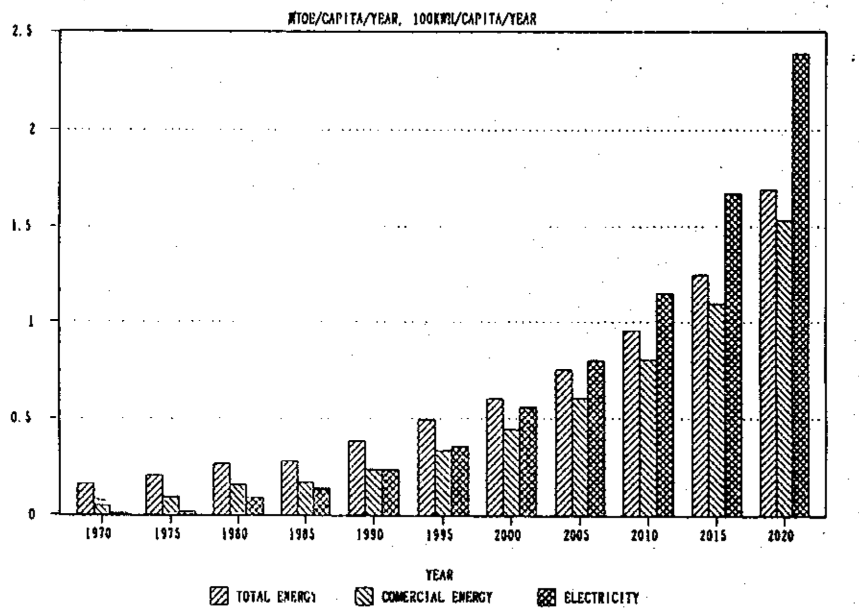


Figure 9.3 Energy and electricity consumption per capita

In the year 2020, the energy consumption per capita in Indonesia will reach 1.5 TOE/capita that equals the average consumption of world in 1990. For the consumption of electricity in 1990 was 230 kWh/capita/year and like energy consumption was lowest in the main Asia and Pacific countries. In the year 2020, electricity demand per capita of Indonesia will reach 2,400 kWh/capita/year which equals South Korea in the 1990s. As for sectors of consumption, industrial sector shows the largest gain and transportation sector follows, the rural household sector decreases its share and urban households remains nearly constant.

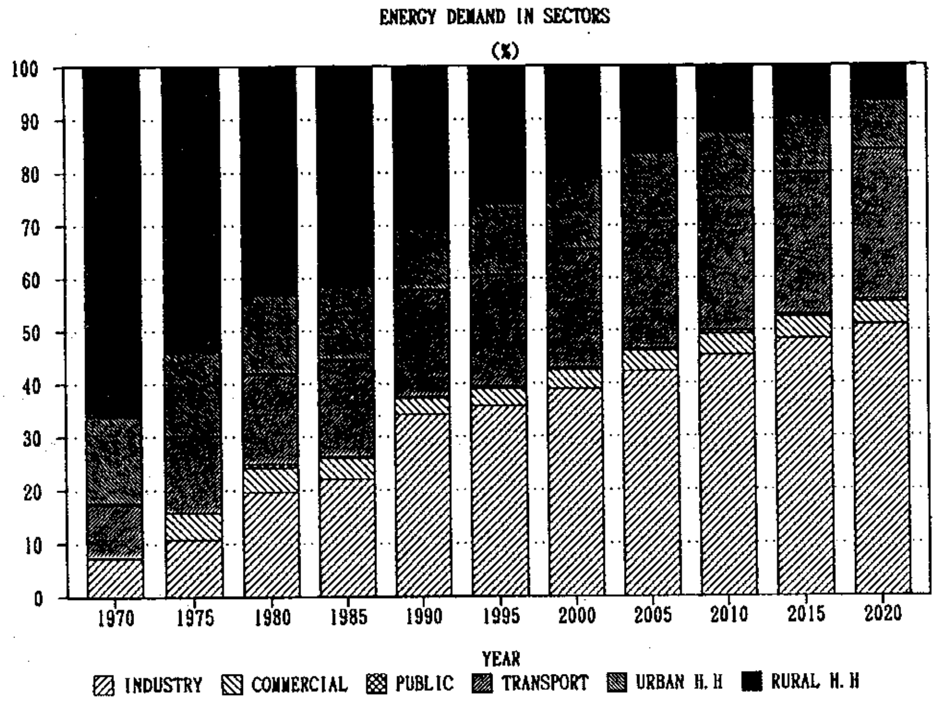


Figure 9.4 Energy consumption ratio in each sectors

9.1.2 Forecast of Energy Supply

The reserves of energy resources in Indonesia are: oil 11.3 billion barrel(1.58 billion ton), natural gas 101.6 trillion SCF(Standard Cubic Feet)(2.70 billion TOE), coal 36.3 billion ton(19.1 BTOE), hydropower 75.6 GW, geothermal 16 GW.

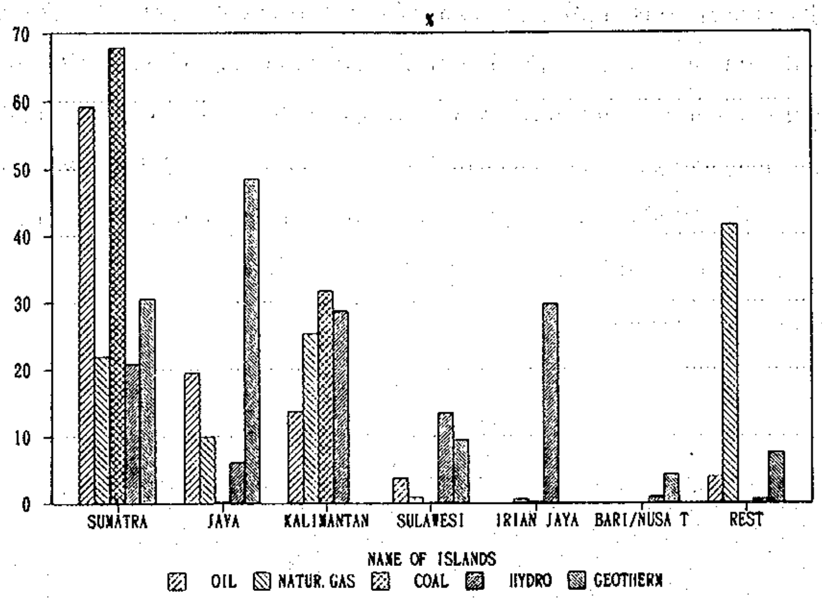


Figure 9.5 Distribution of energy reserves

The estimation of the availability of energy resources are:

Oil: Between the year of 2005 to 2010(REPERITA VIII), the domestic consumption of oil products will exceed the supply of domestic production of crude oil and Indonesia will become an oil import country.

Natural gas: Between the year of 2015 to 2020(REPELITA X), the domestic consumption of natural gas will exceed the production of natural gas.

Coal: The supply of coal in 1998 is expected to be over 70 million tons, and the development of coal mining will be possible to supply farther demand on coal.

Hydropower, geothermal, nuclear: They are used only for power generation as they are developed.

Biomass: The by-products of agriculture and forest industry will be sufficient for the demand but the circulation of biomass energy should be developed for effective use.

LPG: LPG is supplied from oil refineries and LNG plants, the amount of LPG depends on the operation of those plants.

9.1.3 Energy Supply for Power Generation

The forecast of energy demand of power generation was made from the past energy consumption data and future demand forecast(studied by Mr. Kibune) and composition of power plant(studied by Mr.Omori) and a small alteration is made for simplify the forecast.

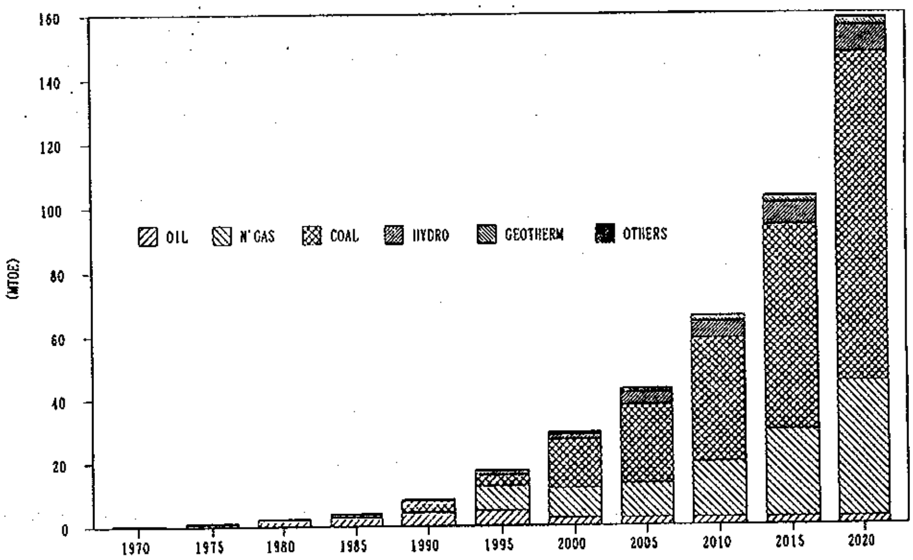


Figure 9.6 Energy consumption for power generation

The overall evaluation of each energy.

Oil: in 1990 oil was substantial energy source for power generation but will drop from this position, remaining as the fuel of the rural diesel power plant.

Natural gas: will increase by the installation of large gas combined cycle power plants from the year of 1995 and a gas supply pipeline net work will be constructed.

Coal: After 2000, coal will be the substantial energy resource for power generation, the share will surpass more than 50% and the amount of consumption will be 30 million tons in the year 2000, transportation and environmental considerations will be needed.

Hydropower: pumped storage hydropower plants are included.

Geothermal: in the year 2020, 4,000 MW of geothermal power plant will be installed and should be the largest in the world.

Nuclear power: be installed in REPELITA VII and will be in operation in 2008.

Others: new and renewable energy, biomass and peat is also used for power generation but they are considered for the rural electrification.

The share of the energy consumption in power generation to the total energy consumption in Indonesia is 12.7% in 1990 will increase up to 40% in 2020. Each energy resources consumed in power generation are as follows:

Oil: reduces from 13.5%(1990) to 1.2%(2020)

Natural gas: increases from 8.4%(1990) to 50.4%(2020)

Coal: increases from 70.8%(1990) to 87%(2020).

Indonesia has these resources in her own territory but to supply such huge amounts of energy will require a vast investment for exploration, exploitation, mining/production, transportation, refining and so on. The raise of funds for these investment will be the most important requirement on energy sector.

9.2 Technical and Economic Assessment of Energy Sources for Power Generation

9.2.1 Oil

(1) Reserves and Areas

The history of oil production in Indonesia started in the beginning of 20th century in the southern part of Sumatra and the exploration has found about 60 hydrocarbon accumulated basins around Indonesia. The proven reserves of crude oil in 1991 are 5,780 million barrels, the potential reserves are 5,520 million barrels (Source: the 1993 petroleum report) and original oil in place is estimated as 48 to 54 billion barrels. Large potential reserve areas are Central Sumatra, West Java and East Kalimantan.

Figure 9.7 Hydrocarbon Accumulated basins in Indonesia

(2) Production, Refining and Transportation

A. Production of crude oil

The production of crude oil and condensate in these years are 500 to 580 million barrels per year (1.4 to 1.6 million barrels/day) and key production oil companies are ARCO(Northwest Java sea), CALTEX(Riau and Central Sumatra), MOBIL OIL(North Sumatra), TOTAL(East Kalimantan), UNOCAL(East Kalimantan) and PERTAMINA. The future production of crude oil will be 500 million barrels by 2018 but the demand of oil products will exceed over 600 million barrels and import of crude oil will be 300 million barrels.

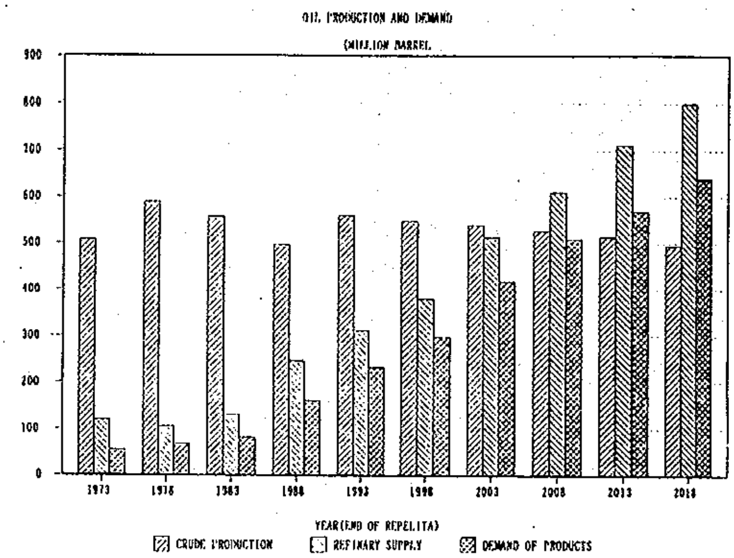


Figure 9.8 Forecast of oil production, Refinery supply and Demand of oil products

B. Refinery and Oil products

The capacity of crude oil refinery in Indonesia in 1992 is 870 thousand barrels per day (BPD) and treated 820 thousand BPD in 1992. The enhancement of exist refineries and construction of new refineries are planned to satisfy future demand of domestic oil products and export of oil products not as crude oil. The balance of oil products in Indonesia, gasoline and fuel oil are in balance with demand and supply, some amounts of kerosene and diesel oil are imported. The growth of oil products demand from 1988 to 1992 was 9%/year.

C. Export of crude oil and oil products

Indonesia exports 300 million barrels a year of crude oil to Japan, South Korea, China, United States, Australia and Taiwan but the domestic consumption will increase rapidly and the production of crude oil is difficult to increase to match the demand, the export of crude oil will decrease and in the year around 2010 Indonesia will become an oil-importing country.

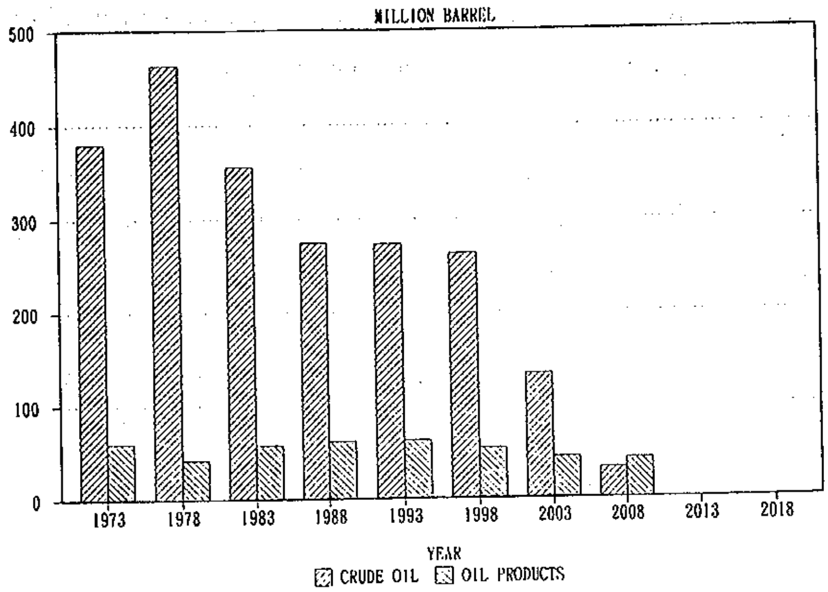


Figure 9.9 Forecast of crude oil and oil products export

(3) Cost and Prices

It is difficult to calculate the cost of crude oil production but in "The 1993 Petroleum Report" we found the gross amount of Petroleum company expenditure from 1982 to 1992, calculating from these figures by totalizing all expenditures and dividing it by total crude oil production, the average cost is US$5.62/barrel. Itemized, exploration/exploitation 40%, production 50% and other is 10%. On the other hand, the selling price of crude oil is decided by GOI Government Schedule of Price (GSP), principal crude oil's GSP are around US$ 30/barrel in 1983 to US$ 18/barrel in 1993. The export price of crude oil in 1992 and 1993 was almost same as GSP for Minas oil. The market price of oil products in Indonesia is decided by GOI and same around all Indonesia, despite the fall of the crude oil price, market price of oil products are increased especially for gasolines.

The prices of oil products effective from January 1993 are:
aviation gasoline Rp420/l, super gasoline Rp840/l, regular gasoline Rp700/l, kerosene Rp280/l, diesel(auto) Rp380/l, diesel(industry) Rp240/l.

(4) Environmental and Social Effects by Production and Consumption of Oil

A. Existing reserves of oil in Indonesia is limited in their future supply capacity and new reserves in eastern areas of Indonesia such as Timor, Irian Jaya are expected to exploited and explored for the future supply of oil and development of social and economic conditions of the areas. GOI has prepared some incentives for the exploration of these areas.

B. The air pollution caused by automobile exhaust gas has become severe problem in urban areas, gasoline and diesel oil quality needs improvement. The addition of lead will be limited and another octane booster will be introduced.

C. The increase of domestic consumption will change Indonesia from oil exporting country to oil importing country, therfore, Indonesia should develop other export commodities or substitute fuels for transportation and effective use of other energy sources.

9.2.2 Natural gas

(1) Reserves and Areas

The proven reserves of natural gas are 64.4 trillion Standard Cubic Feet (SCF) and potential reserves are 37.2 trillion SCF, total 101.6 trillion SCF equals to 17.5 billion barrel oil (BOE) (Source: the 1993 petroleum report). Large potential reserves are: Natuna sea, North Sumatra, West Java and East Kalimantan, the accumulated basins are the same as for oil (Figure 9.7).

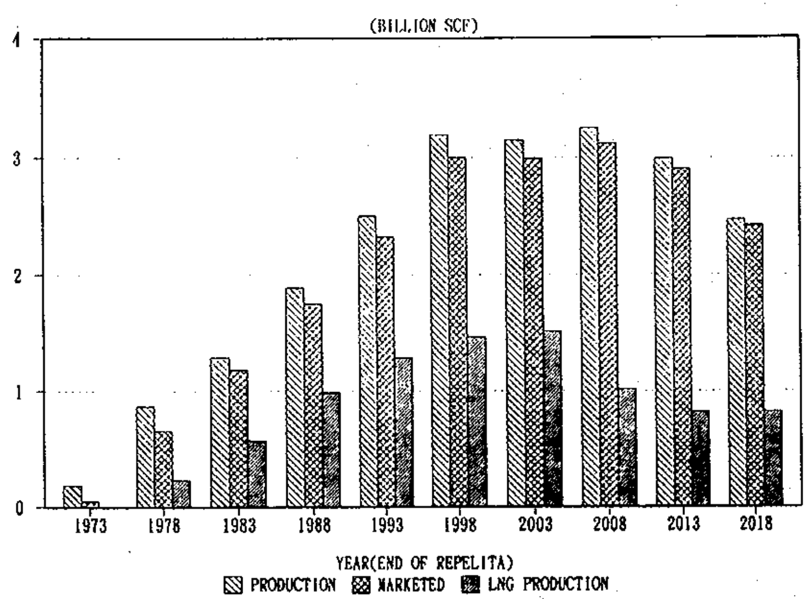


Figure 9.10 Change of Production, Consumption and LNG Production

(2) Production, Treatment and Transportation

A. Production of natural gas

The production of natural gas is planned to be increased by 2010 then will decrease by MIGAS; the reason for the decrease is uncertain but seems the consumption by power sector does not count after 2008 and uncertaintity of Arun project after 2003. In January 1995, the Natuna project is anounced to start from 2003 and 35 million tons of LNG will supply by the project, then total production and consumption of natural gas in Indonesia will increase after 2003 too.

B. Treatment and Usage of Natural Gas

LNG plants in Indonesia are in Arun (North Sumatra) and Bontang (East Kalimantan) their capacity is 25 million ton/year, main destination countries are Japan, South Korea and Taiwan. Natuna will be added 35 million ton/year in LNG capacity after 2003. Natural gas is mainly used as LNG (liquified natural gas) and exported. Domestic uses are raw material for fertilizer plants and methanol plant, fuels for steel plant and refineries, injection for oil production wells and small amount for city gas. The amount as fuel for power generation is still small at this time, but it will grow rapidly as existing oil-burning power plants are changed to gas-burning, and as a number of gas combined cycle power plants are constructed in Java Island, they will consume a lot of natural gas.

C. Transportation

Beside LNG, a gas pipeline network is necessary for the effective supply of natural gas. There are small gas pipeline networks in West Java and East Java, but GOI is planning to construct a total gas pipeline network to connect Natuna-Batam-Sumatra -Java-Kalimantan.

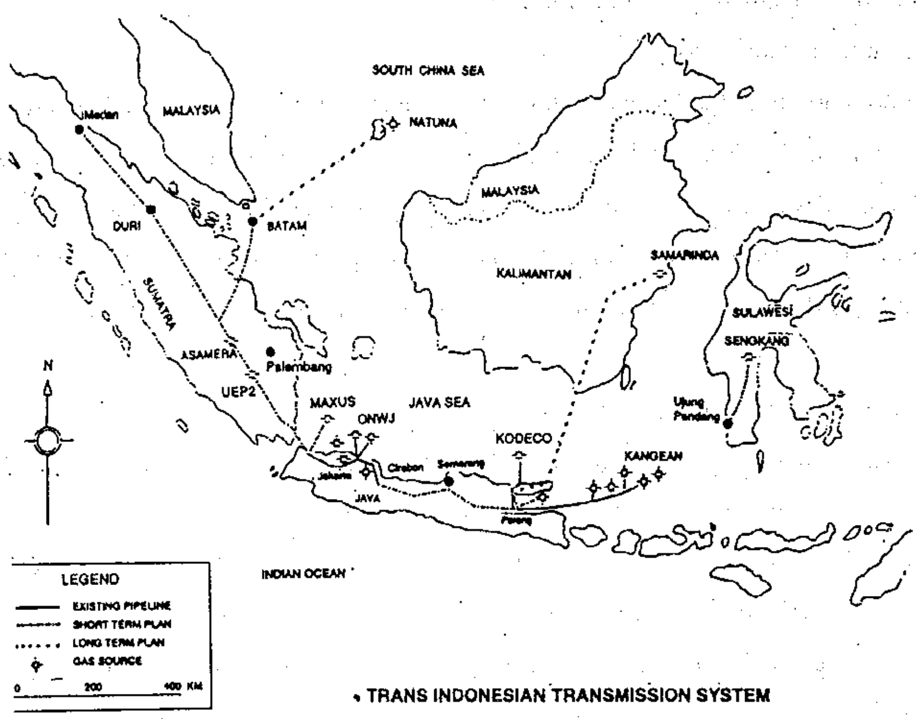


Figure 9.11 Pipeline Network Plan

(3) Cost and Price

A. Cost

A tentative cost calculation on Natuna development project, whose potential reserve is 210 trillion SCF (including 70% carbon dioxide) and recoverable hydrocarbon is expected to be 45 trillion SCF, according to the Institute of Energy Economics Japan (IEEJ), will be US$ 4.3 to 5.2/million BTU.(International Energy Analysis No.195 April, 1994). This cost seems 20 to 30% more expensive than LNG projects of Malaysia, Oman and Qatar. The project will treat 10 billion SCF/day and send gas to LNG plant that will be constructed in Natuna Island 200 Km from gas field. Total investment will be US$ 16 billion in 1991 value, construction on the ocean is US$ 11 billion (including pipeline) and LNG plant (6 trains) is US$ 5 billion.

B. Price

Domestic gas prices are decided by GOI and as a policy of GOI, the price for raw material use is favored over fuel use.

Fuels for PLN power generation US$ 3.00/million BTU

Fuels for Krakatau steel	US$ 2.00/million BTU
Process gas for Krakatau steel	US$ 0.65/million BTU
Raw material for fertilizer	US$ 1.00/million BTU
Town gas in Surabaya	US$ 2.15/million BTU

Even for the PLN power generation, for Gresik: US$ 2.53, for Muara Karan and Tanjung Priok: 2.45/million BTU. The export price of LNG varies with world oil prices, the peak was in 1982 as US$ 5.6/million BTU and has now fallen to US$ 3.4/million BTU.

(4) Environmental and Social Effects by Production and Consumption of Natural Gas

Natural gas is known as a clean energy source and is expected to reduce the environmental pollution. Indonesia has a lot of natural gas reserves and recent explorations has increased its volume. As for the Natuna project, the development of a new natural gas field will require a huge investment, and as there are many natural gas producing companies, the incentive to invest Indonesia natural gas should be promoted. Natural gas generates less sulfur oxides and nitrogen oxides when it burns, but generation of carbon dioxide and emission of methane as its production are marked. Consequently, studies to fix the carbon dioxide in several ways have been undertaken.

9.2.3 Coal

(1) Reserves and Areas

The coal development in Indonesia has been industrialized recently and is growing rapidly. The potential reserves of coal in Indonesia are 36 billion tons, and areas of coal reserves are: Central Sumatra, South Sumatra, East Kalimantan and East Kalimantan. A half of Indonesian coal is a brown coal so the usage of coal will be a little limited.

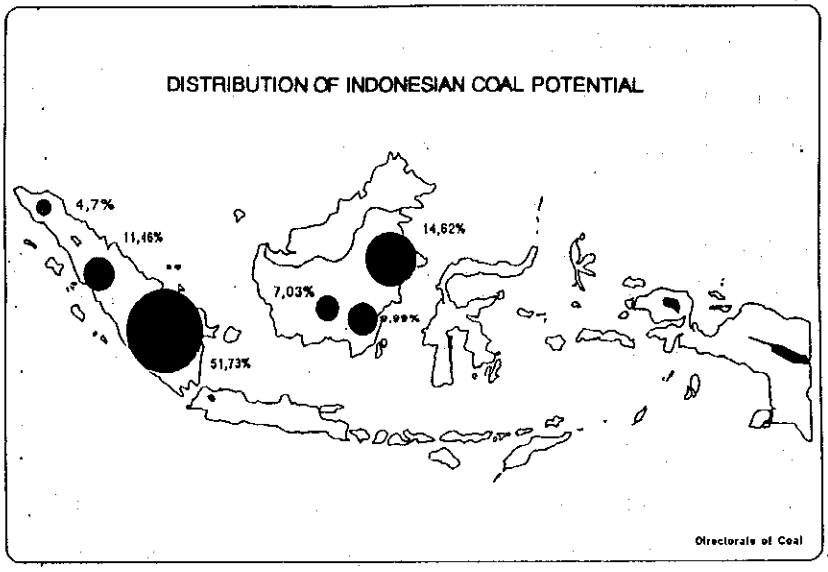


Figure 9.12 Coal reserve areas in Indonesia

(2) Production, Treatment and Transportation

A. Production

The coal production in Indonesia is owned by states mining company and contractors. State mining company (PTBA) operates in Sumatra (Bukit Asam and Ombilin) and supplies their coal to state power company (PLN) and to cement companies, on the otherhand, contractors operate in Kalimantan, export most of their coal and supply the rest to domestic PLN and industries.

B. Usage of Coal

The domestic coal uses are power generation, cement production, industrial use and household use. Large-scale coal-fired power generation plants are being constructed by PLN and private companies, and future coal consumption for power generation will increase dramatically.

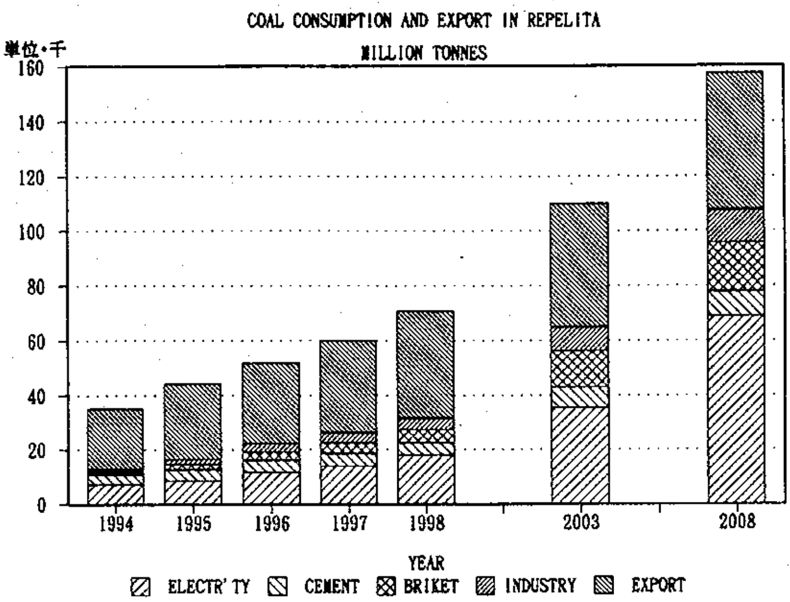


Figure 9.13 Usage of coal

C. Transportation of Coal

Coal is transported from mines to consumers, by train or tracks or barges to coal terminal port then carried by cargo-ship to a foreign port or domestic users wharf. In Indonesia, a number of coal terminal ports have been constructed or are under construction.

(3) Cost and price

A. Cost

The development cost of new coal mining is reported for the South Sumatra coal (Kinhill-Otto Gold Report, 1987). According to this report, the 30 years average production costs are US$ 15 to 30/ton (1987 value), differing by the location of mine fields. Examples of coal transportation cost in domestic are:

South Sumatra to Suralaya	US$ 17/ton
South Kalimantan to Suralaya	US$ 7.5/ton

B. Price

The export prices of coal are decided by contracts, and average price peaked in 1991. Examples of domestic coal price are:(1992)

PTBA Tanjung Enim to PLN Suralaya power plant	CIF Rp 70,000/ton
PTBA Ombilin to general consumer	FOB Rp 46,000/ton

(4) Environmental and Social Effects by Production and Consumption of Coal

A. Environmental effects

Coal mines located in the rural areas of Indonesia so the environment effects accompanying coal production does not seem clear but the deforestration, disposal of surface mud and inserts, as well as spontaneous combustion and water pollution are considered to be environment effects accompaning coal production. When coal burned as fuel, sulfur oxides(Sox), nitrogen oxides(NOx) and dust are generated, at power plants, dust is collected effectively but this is not the case with other industries or households. SOx and NOx are not treated sufficiently, simple and low-cost treating methods are expected to suppress the environment effects of these emissions.

B. Social effects

Diversification of energy sources from oil to coal is a world-wide trend and Indonesia has large coal reserves. The development of coal mining develops rural areas and improves the rural infrastructures such as transportation(rail and road), communication systems, electricity, water and supplies job opportunities. In the method of coal usage, new technologies will be introduced such as:

mine-mouth power generation(transport energy as electricity not as coal), gasification of coal(transport or use energy in gas state not in solid state), liquefaction of coal(transport or use energy as liquid not as solid), these new technology will bring new industries. For household use, "briquette" will be commercialized to diversify the use of kerosene and woods.

9.2.4 Hydropower

(1) Reserves and Areas

The detailed potential of hydropower is described in another chapter. The total potential of Indonesia is about 75,000MW and is distributed mainly in Irian Jaya, Kalimantan, Sumatra, Sulawesi and small amount in Java. 45% of total potential has been developed and Java shares 63% of it.

(2) Environmental and Social Effects by Developing Hydropower

Accompanying the construction of hydropower dam will be: migration of habitants, sinking of lands, effects to aquatic animals and change of water quality. On the other hand, by the construction of a multi-purpose dam, irrigation, water flow control, introduction of fresh-water cultivation and tourism are expected to bring some economic profits to the locations.

(3) Mini and Micro Hydropower

The capacity of generator from 200 kW to 5,000kW is called Mini hydropower and capacity below 200 kW is called Micro hydropower, they are developed as supply sources for the rural electrification. Not only PLN but Ministry of Cooperatives and Ministry of Public works will take part in their development. By a survey in November 1990, there are 527 locations and total potential is 1,200 MW, at the end of 1993, 69 locations have been developed and the total capacity is 48 MW.

9.2.5 Geothermal Energy

(1) Reserves and Areas

Indonesia, except for Kalimantan, is active with volcanic and is rich in geothermal resources, the total potential reserves of geothermal is 16,000 MW, and it distributes 30.4% in Sumatra, 50.5% in Java-Bali, 9.3% in Sulawesi and 9.7% in others. Existing geothermal power plants are: Kamojang (140.2MW), Dieng (2MW), Lahendoug (2.5MW), Gunung Salak (110MW) and Darajat (55MW) total 310MW.

(2) Production and Utilization

Geothermal energy is used to supply the steam to power generation plants. Like oil and natural gas, PERTAMINA develops geothermal steam and supplies it to PLN through a pipeline. Recently, some private or contractor company have developed geothermal steam and supply to power companies; in case of small geothermal plants, PLN also develop geothermal steam by themselves. Geothermal power plants are located near by the geothermal reserves as long range transportation of steam is not economical. Fortunately, Java Island is rich in geothermal reserves and has large demand of electricity, GOI is promoting the development of geothermal power generation. The development of geothermal power generation also needs a large investment, GOI admitted the participation of private companies in the development of geothermal power generation and sales of electricity to PLN.

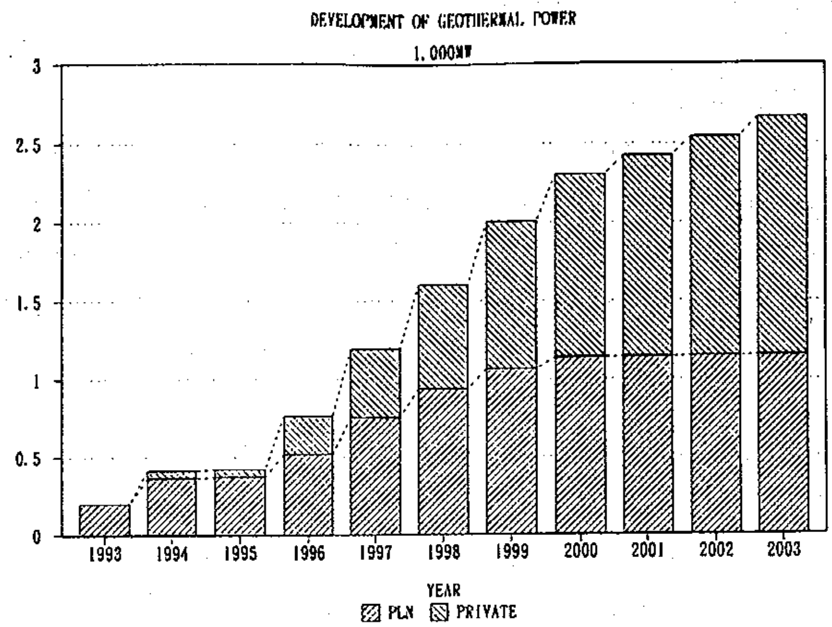


Figure 9.14 Development Plan of Geothermal Power Generation

(3) Cost and Prices

The example of cost calculation of geothermal power generation at Salula (North Sumatra) is: (55 MW x 6 = 330 MW)

(Mill : 0.001$)

steam cost	US Mills 43.07/kWh
fixed cost	US Mills 18.20/kWh
operation cost	US Mills 2.76/kWh
total	US Mills 64.03/kWh (Rp 128/kWh)

(Source: Majarah Pertambangan dan Energi No.1 1994)

The steam cost will link to the price of oil so it will vary by world oil market prices. Prices of electricity when private companies sell to PLN are estimated as:

Dieng US Mills 74/kWh, Lampung US Mills 75/kWh and Gunung Salak US Mills 53 to 60/kWh.

(4) Environmental and Social Effects by Development of Geothermal

Geothermal energy is same as hydropower which does not exhaust combustion gas and occupies little land for power generation. Sometimes geothermal steam contains sulfur compounds and toxic heavy metal compounds, however, properly treated geothermal energy has least effect on the environment.

9.2.6 Peat

(1) Reserves and Areas

The study of peat in Indonesia has started from 1980. It was confirmed that the thickness of peat over 1 m is 16.5 million hectare, the thickness over 2 m in Sumatra is 4.8 million, in Kalimantan 3.2 million, in Irian Jaya 0.9 million hectare. If calculated as the density equal to 1, the total is 178 billion ton and 5 times larger than coal.

(2) Usage

The quality of peat is different by areas, an outline of them are: water content 5 to 10%, volatile matter about 50%, fixed carbon about 30%, ash 2 to 8% and heat value 4,000 to 5,000 kcal/kg. Their usage is fuels for households, fuels for rural industries and is expected to be used as the fuel for small-power generation; in Palanka Laya (Central Kalimantan) 4 MW power plant and Pontianak (West Kalimantan) 22 MW power plant are using some peat as their fuels.

The effective usage of peat are under studying as follows:

A. Coking: by partial thermo-cracking, to get gas, tar and cokes.

B. Gasification: by high-temperature gasification, to get hydrogen and carbon mono-oxide.

C. Liquefaction: by hydrogenation, to get liquid hydrocarbon oil.

D. Briquetting: by compression, to get briquette for households fuels.

9.2.7 Biomass

(1) Reserves and areas

Sources of biomass are classified as follows:

A. Agriculture byproducts: cultivation of rice, corn, beans, cassava etc.

B. Plantation byproducts: plantation of sugar, coconuts, gum, coffee, cocoa etc.

C. Forest industry: stumps, branches, logging process residue, plywood mills etc.

D. Livestock: cow and buffalo dung

E. Municipal waste: Solid wastes and sewage sludge.

The study in 1992 by Center for Research on Energy, Institute Teknologi Bandung estimated the amount of biomass reserves, excluding municipal waste, about 60 million TOE. In Sumatra, the plantation byproduct shares the large part of biomass reserves, in Java, the agriculture byproduct is primary and in Kalimantan, byproducts from forest industry are primary and reflect key industries in those areas.

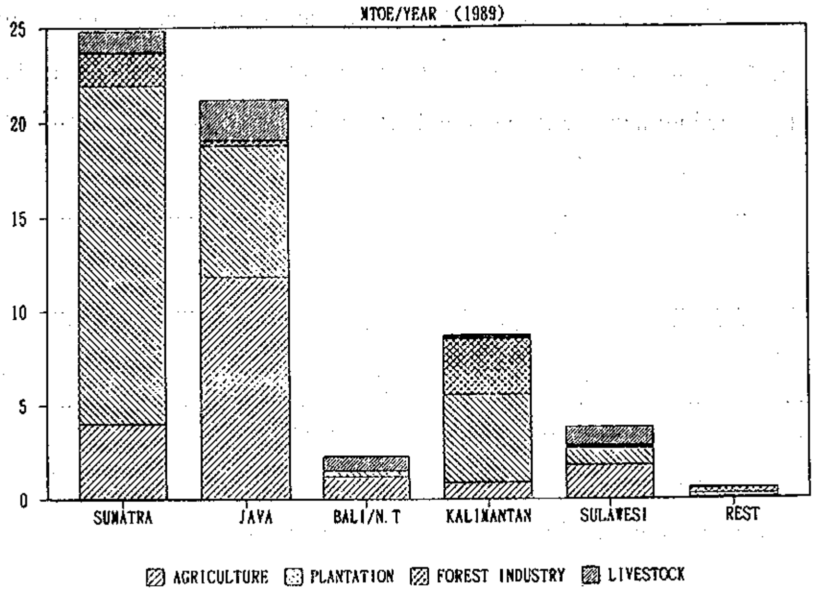


Figure 9.15 Biomass Energy Potential in each Areas

(2) Usage of Biomass Energy

There are several way to utilize bio energies such as:

simple burning, partial combustion(charcoal), gasification, briquetting, bio-gasification etc.

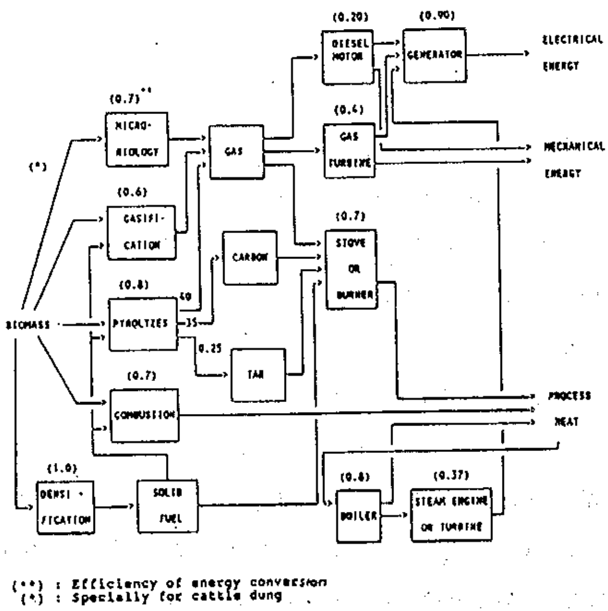


Figure 9.16 Utilization of Biomass Energy

The use of bagasse as a fuel for power generation at sugar plants. In 1990, there are 60 power generation plants in sugar industry and its total capacity is 168 MW. The heat contents of biomass is low and their transport is troublesome so the commercialization of biomass will be difficult.

(3) Cost and Prices

Most of biomass energies are byproducts or selfproduced so costs and prices are difficult to calculate.

(4) Environment and Social effects

The study for rural household energy consumption in 1990 (Studi Kebutuhan Enerugi Sector Rumahtangga, DPDE dan BPS) reported the consumption of fuel wood in rural households is about 2 ton/year/household, assuming the total number of households in Indonesia as 40 million, the total demand for fuelwood is calculated at 80 million ton/year (21.6 million TOE). If effective supply processes are completed, it is possible to supply the fuelwood demand of rural households by biomass reserves. In the biomass utilization, the apparatus for their usage is not developed enough and the efficiency is very low, the development to use biomass energy efficiently is necessorry such as briquetting, charcoalization and gasification; also, the apparatus for burn them efficiently needs to be developed. Indonesia has wide land, good sunshine and a lot of rainfall that is possible to plant high productive trees for energy use, they can produce 20 ton/hectare per year (equal to 5.4 TOE/hectare/ year).

(5) Others

There are more than 100 biomass pyrolysis-power generation plants and 170 bio-gasifiers for households gas supply plants are installed in Indonesia.

9.2.8 New and renewable energy

(1) Reserves and Area

Indonesia has a great potential in solar energy its averaged insolation energy is about 4.5 kWh/square meter/day. The fluctuations during months and areas are small so that Indonesia can very well utilize solar energy nationwide. As the wind power, the average wind speed is 3 to 4 meter/second, which is not enough to utilize as power generation sources except in particular areas (coast and mountainous areas). Ocean energy can be used by the technology called Ocean Thermal Energy Conversion (OTEC), but it will need more research for development. Mini and Micro hydropower are also classified as renewable energy; they already are mentioned in section of hydropower.

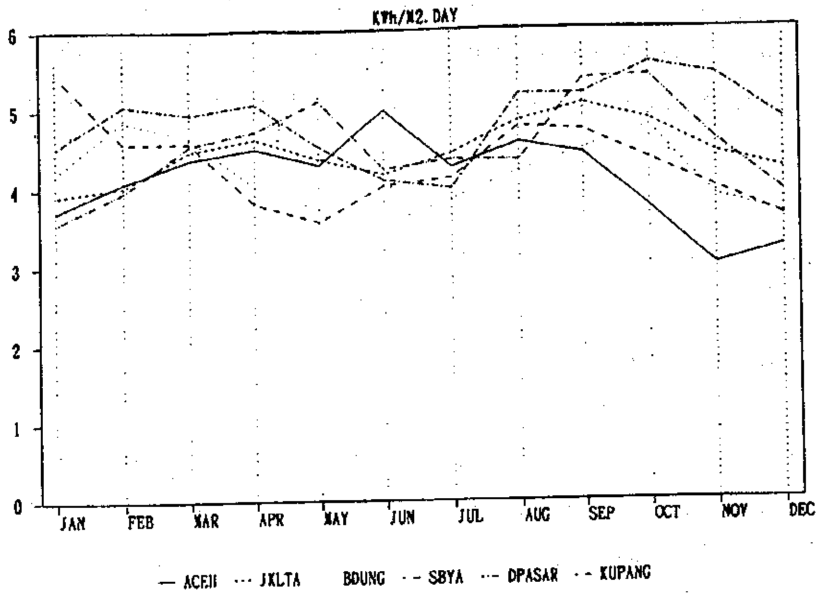


Figure 9.17 Change of Insolation

(2) Production and Treatment

These new and renewable energies are used very close to demand area without need for transportation of original energy, but supply of these energies is unstable so the system requires some energy deposit function such as batteries to keep energy supply constant.

(3) Cost and Prices

The original energy cost is free but nor the system to convert these energy into conventional energies such as electricity. For conversion of solar energy to electricity, the system consists of photovoltaic cell, charge/discharge controller, battery, AC/DC converter and electric appliances. These system components are developed, improved and cost was reduced but is still expensive to install in rural households in developing countries by themselves. The most simple system to use solar energy for lighting and listening to radio costs about US$ 10 to 15/W, therefore to install 40 to 50W system needs US$ 400 to 500/system and for the renewal of batteries (once in three to five years) and fee for maintenance person will need US$5 to 7/Household·Month.

(4) Environmental and Social Effects

The new and renewable energy is the least effective for environment and best means to rural electrification with scattered users and a small demand/user. Obstacles are:

A. High investment per unit capacity
B. Maintenance and management organization
C. Training of persons to maintain the system and organization

The purpose to introduce small-scale rural electrification will not be for economic development but for improving the level of human life, transmission of information, opportunity for education and so on, but after spreading these systems, jobs will be created to supply system components and work for their repair or maintenance.

(5) Others

In Indonesia, There are already installed 60 wind-power pump and generation plants and 500 locations of solar power system have installed capacity of 2,000 kW. The usage of these solar generator is for lighting and TV/VCR.

9.2.9 Nuclear (Uranium)

The generation by nuclear energy in Indonesia is still being studied carefully and the preliminary survey of uranium reserves shows that Indonesia also has potential sources of uranium. Potential reserves areas are West Kalimantan, South Kalimantan and Irian Jaya, the recoverable amount (treatment cost below US$ 80/kg-U) is 4,320 ton-U by 1992 Survey of Energy Resources, World Energy Council. The price of Uranium in 1991 was US$ 8.7/Lb-U3O8 (US$ 22.6/kg-U), and in 1994 it was US$ 7.0 to 7.2/Lb-U3O8.

9.3 Assessment of Energy Resources for Power Generation

9.3.1 Power generation cost by each energy resources

There are several method to estimate the generation cost, this is based on the calculation by PLN presented on Electric Power Supply in Indonesia: Development Plans and Major Issues toward the 21st Century 1989. The calculation is to recover the investment, operation and maintenance cost and fuel cost assuming unit construction cost, life time, availability, fuel efficiency and operation/maintenance cost. The cost estimation in 1988 are: coal-fired USc 3.05/kWh(coal US$ 33/ton), gas-fired combined cycle USc 3.16/kWh(natural gas US$ 2.0/10^3 cubic feet), oil-fired USc 4.78/kWh, Geothermal USc 6.43/kWh and nuclear USc 7.20/kWh. Same calculation with data in 1993 is shown in Figure 9.18, from left to right, coal-fired, gas-fired combined cycle, hydro, gas-turbine, diesel, geothermal, nuclear and pumped-storage. Cost is separated by O & M cost, fixed cost and fuel cost(top to bottom).

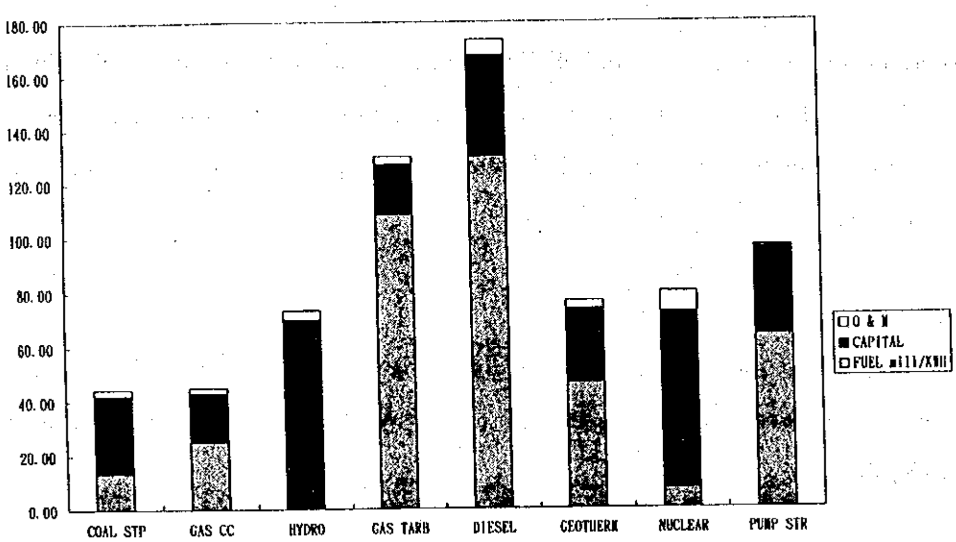


Figure 9.18 Generation cost from energy resources

Cost of coal-fired is USc 4.45/kWh(coal US$ 34.3/ton), gas-fired combined cycle is USc 4.08/kWh(natural gas US$ 2.5/MCF). The construction cost of coal-fired raised more expensive than gas fired combined cycle from 1988 to 1993 then generation cost of gas-fired combined cycle is lower than coal fired. The equivalent natural gas price for equal generation cost to coal-fired is US$ 3.0/MCF which equal to the government selling price to PLN.

9.3.2 Assessment for regional distribution of energy resources

(1) Oil

Power generation consumes oil products and the supply of oil products is distributed by PERTAMINA from their oil refineries to their own depot and retail stands. The distribution of oil products in Indonesia had been almost completed except very remoter rural area. The consumption of oil products in power generation sector will be decreased in future, the regional distribution of oil resources is not an issue but for the rural electrification, secured supply of oil product should be confirmed.

(2) Natural gas

Natural gas is transported through a pipeline network or carried by LNG tanker after liquified in LNG plant(mainly for export). A tentative cost for gas transportation is shown in Figure 9.19. Completion of pipeline network(s) is expecting to utilize small- to middle-scale gas reserves for domestic consumption and large-scale gas reserves for export as LNG.

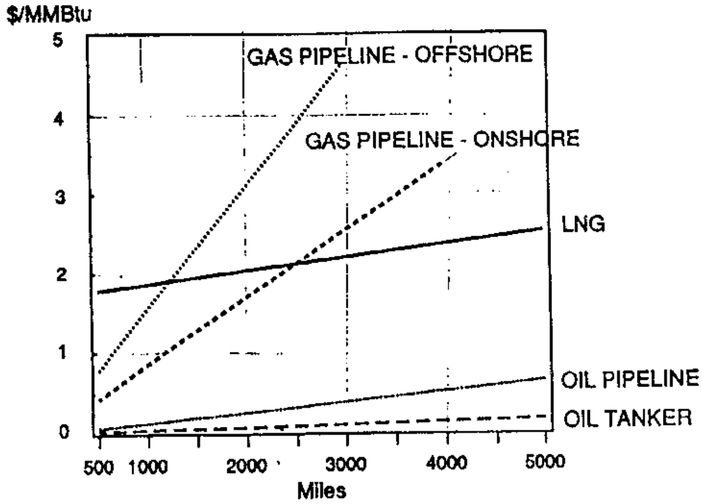


Figure 9.19 Representative costs of oil and gas transportation

(3) Coal

The main coal consumption area(s) and the main coal production areas are apart from each other and the means of transportation is troublesome. The rough calculation shows in Jawa will be installed coal-fired power plant 10,000MW in 2000, 25,000MW in 2010, 40,000MW in 2020 and they will consume about 22 million tons, 55 million tons and 88 million tons coal per year correspondingly. If from Sumatra and from Kalimantan supply each half of them daily transportation will be 30,000 tons, 75,000tons and 120,000tons per day. Coal has to transport from mines to coal terminals and to consumers terminals, the coal terminals and consumers terminals can scale up according to their capacity but from mines to coal terminals is difficult to develop by coal supplier only, such as to extend rails, roads, canals and so on, they will require the support of Government. The feasibility study of transportation of electricity generated by mine-mouth power plants in Sumatra to Jawa instead of coal transportation is studied and will be one of an alteration means for coal transportation.

(4) Hydro and geothermal

These resources are difficult to transport without a conversion to electricity. The potential of hydro in Jawa had been developed mostly but recent study added potentials as pumped-storage or run on river type hydro power in Jawa. Jawa has many geothermal reserves and will be developed and supply to customers by grid.

10. Energy Conservation and Environmental Protection

10.1 Energy conservation

10.1.1 Energy conservation in thermal power generation

(1) National policies and current situation in Indonesia

(a)National targets of a 20% cutdown in the industrial section, and 15% in the transportation and domestic sections, being a total of 17%e were established and efforts have been being made successively. Establishment, examination, and the indication of Energy Conservation Standards, together with control methods promotion measures as well as restriction measures are also included in the targets to be attained by the year 2000.

(b) While the related authorities are taking action in accordance with the Energy Conservation Programs, the process is hindered by obstacles such as the lack of knowledge and information and insufficient economic incentives in the industries. In view of this, a President's Ordinance obliging energy incentive factories to report their energy conservation activities was issued in 1991. Whether this ordinance can be fully executed is seen as a touchstone for the promotion of energy conservation.

(2) Basic concept of energy conservation measures

(a) Measures to enhance the effects of energy conservation should include 1) facility renovation, 2) facility improvement, and 3) improved maintenance and operation in all plants.
It is necessary to examine which measure provides the greatest cost effectiveness and determine countermeasure technologies accordingly. Of these countermeasures, maximum effect can be expected from the full application of item No.3, improved maintenance and operation, because long-hour operation to meet shortage of electricity etc., without sufficient maintenance results in poor plant performance, bringing the level of that plant far below its potential.
However, when introducing successful counter-measures undertaken by others, it is imperative that in-depth preliminary studies be done on the causes of the problems involved and the course of events up until the subsequent actions were taken.

(b) In order to realize energy conservation, the introduction of equipment is required but equally as important is the introduction of the related software enabling the utilization of that equipment. And here is an importance of a system to diffuse the cognition that energy conservation is important. In Indonesia, as the Sub Directorate of Energy Conservation in its Ministry of Mining and Energy promotes energy conservation, it is necessary to pursue energy conservation from that institu-tion's point of view as well by learning from systems such as Japan's 'Licensed Energy Controller' which obliges factories which use and/or consume more energy than a set standard to retain specialists who have passed a national examination in heat and electric energy control, based on the law, 'regarding the rationalization of energy use (June 1979)'.

(c) Please refer to the attached 'Energy Conservation in Thermal Power Generation/Chapter 2~5' for concrete suggestions regarding measures for energy conservation in terms of steam, combustion and electricity in thermal power plants.

(3) Concrete examples of energy conservation

(a) Japan has stepped up its efforts in energy conservation since suffering the oil shock of 1973. Table 10.1 shows a summary of cases of energy conservation measures taken in thermal power plants. Of these, outlines of the following five major cases are provided in the attached, 'Energy Conservation in Thermal Power Generation/Chapter 6'.

i) measures to lower leakage from air preheater
ii) operation of decreased number of auxiliary machines
iii) auxiliary machine speed control by thyristor inverter
iv) control of heavy oil viscosity by viscosity gauge
v) energy conservation by installation of new high pressure feedwater heaters, and deaeration and feedwater preheating by process waste heat

(b) From the list of energy conservation measures, the basics of energy conservation are both simple and small. Measures such as preventing motors from idling unnecessarily and preventing steam leakage are prime examples. Since their continuous practice provide a large effect, large energy conservation can be expected were they to be promoted on a national scale.

(4) Efficient operation of aged thermal plant

(a) Measures to extend life

i) With the introduction of high-efficiency large-capacity thermal power plants as the base

Table 10.1 List of Energy Conservation Measures Actually Executed

[Improvement of Air Preheater]
* Reduced air/gas leakage by censor drive system
* Improved turbine efficiency by changeover of bleed steam for heating SAH
* Reduction in mean temperature of low temperature metal to incorporate with the reduction of sulfur content of heavy oil
* Conversion of SAH steam source to low pressure steam
* Reduction of steam by SAH temperature control to incorporate with the reduction of sulfur content of heavy oil
* Waste heat management in factories by additional AH

[Turbine Remodeling]
* Replacement with high-efficiency turbine blades
* Change in turbine labyrinth structure
* Change in turbine shaft seal from water seal to steam seal
* Expansion of turbine capacity by turbine replacement

[Expansion of Generation Capacity]
* Additional installation of high pressure feed water heater
* Increased capacity of high pressure feed water heater
* Acceptance of steam from factory's waste heat to deaerator
* Reduced turbine back pressure by design change of back pressure
* Reduced turbine bleed pressure by replacement of bleed steam flow meter
* Conversion of back pressure turbine into condensing turbine
* Additional installation of superheater
* Reduced number of turbines by introduction of large-scale turbines
* Increased turbine inlet steam pressure by resetting
* Stoppage of back pressure control by turbine by-pass valve
* Replacement of let-down valve with back pressure turbine

[Utilization of By-product Gas]
* Expansion of capacity by turbine replacement
* Expansion of capacity by boiler replacement
* Improved mixed combustion ratio of low grade by-product gas for boiler fuel
* Improved availability factor by increased turbine air bleed
* Improved availability factor by installation of low pressure condensing turbine

[Rationalization of Operation]
(Main Equipment)
* Reduced boiler exhaust gas temperature by installation of AH
* Resetting lower air limit air for boiler combustion
* Sliding pressure operation during partial loading
* Non-blow during short-time start
* Reduced boiler water blow during start time
* Reduced unit start time
* Appropriate boiler combination
* Reduced start/stop loss by shutdown of high-temperature high-pressure boiler
* Control of load distribution among a group of boilers

(Auxiliary Equipment)
* Operation of reduced number of auxiliary boilers
* Operation of reduced number of auxiliary turbines
* Review of operation interval of auxiliary equipment
* Change of execution pattern of soot blow
* Control of large-scale motor revolution
* Detachment from the auxiliary transformer circuit during unit's shutdown
* Operation of reduced number of main transformer cooling fans
* Stoppage/Load transfer of light-load transformer
* Optimum computer operation of boiler combination
* Replacement with optimum capacity motors
* Downsizing boiler feed pump
* Cut boiler feed pump blower impeller to go with adequate pressure
* Optimization of the number of transformers in operation

[Steam Drain Recovery]
* Addition of drain trap temperature control function (oil line)
* Feeding water and heating of boiler by factory's waste heat
* Feeding water and preheating boiler by processing thermal effluent
* Recovery of SAH drain deaeration steam
* Recovery of feed water heater drain
* Heat recovery of continuous blow down water
* Recovery of factory waste heat by boiler feed water circulation
* Recovery of factory condensate into deaerator
* Recovery of high-pressure boiler blow down water into low pressure boiler feed water
* Recovery of generator cooling water
* Concurrent heating of reserved boilers by continuous blow down water

[Others]
* Installation of condenser continuous washer
* Reduced heavy oil heating temperature
* Reduced cooling water temperature by changing intake position of condenser cooling water
* Hot heavy oil tank insulation
* Reduced steam ejector output
* Reinforcement of hot insulation of boiler dock house
* Low air-ratio operation by burner remodeling
* Utilization of atmosphere-relief H2 within the boiler
* Saving of heating steam by installation of CO meter
* Low air-ratio operation by viscometer
* Improved combustion efficiency by heavy oil magnetization

supplies, existing aged thermal power plants which are mainly the oil-fired type are shifted to middle peak operation. Because of this their facilities tend to be operated under harsh conditions due to frequent start-stop operation. However, from the viewpoint of supply stability, economy, and operability, there would be no major change for the positioning of thermal power plants, although there may be room to reconsider the issue of the optimum mix of power sources. Therefore, as the number of aged thermal power plants will increase, it becomes an important issue to extend the life of these facilities, and to secure their reliability as power sources, and to enable their economic operation for many hours.

ii) Measures taken to extend the life of thermal power will vary by plant. Generally, however, it would be effective to make an accurate evaluation of the life expectancy for locations and parts that require attention, and to replace and/or repair them during periodic inspections.
As the diagramed measures to extend the life of provided in Figure 10.1 shows, peaks occur every one hundred thousand hours of operation. It is important to initiate a plan to extend life and which will clarify ranking by plants which have the above characteristics based on the life cycle of the construction costs. Please refer to the 'Energy Conservation in Thermal Power Generation/Chapter 7' herein for the life and approach to life extension for each location and part.

iii) Regarding the life cycle of construction costs, the relationship between the operating time and the years of operation naturally varies according to capacity factors. For instance, when a plant is shifted from base supply to middle peak supply its capacity factor drops and the time to carry out large-scale renovations of the aged facilities is postponed. Therefore, with the change in capacity factors taken into consideration, thermal power plants ranging from a few percent to about 70% in capacity factor can be generally classified into two. In this manner, countermeasures for aged thermal power plants can be broadly classified into two categories as shown in Figure 10.2 whether it should be regarded as a plant for which life extension measures should be taken or merely by the constant replacement of aged parts. In the case of the latter facilities, the choice of scrap-and-build method should be determined based on comprehensive economy such as the state of the existing facilities, problems of environment and location etc.

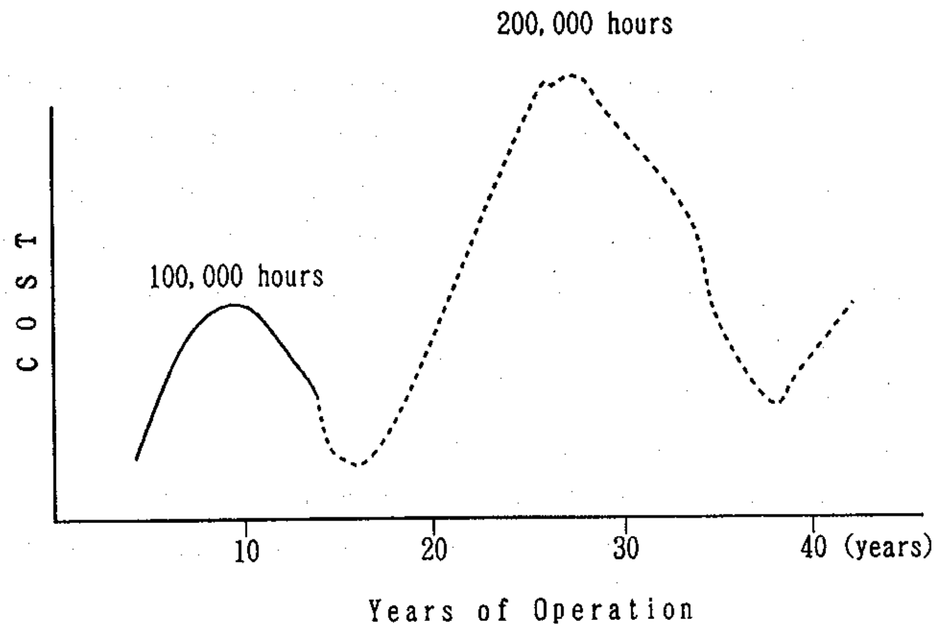


Figure 10.1 Life Cycle of Construction Cost for Life Extension

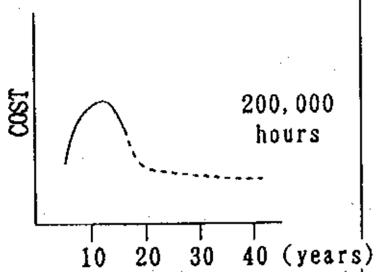
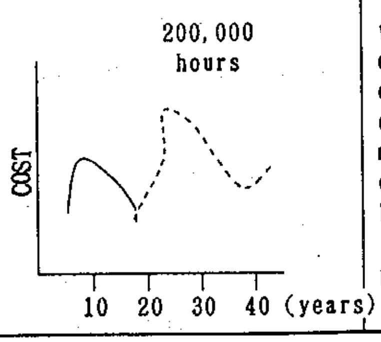
	Unit Capacity	Efficiency	Cost Pattern	How to do renewal
Utilization Factor About 10 %	S , M	Low ~ Medium		to carry out constant renewal
Utilization Factor More than 30 % or so	M , L	Medium ~ High		to carry out evaluation of life expectancy and execute economic measures for life extension just before reaching the 200,000-hour point of renewal

Figure 10.2 Renewal Method of Aged Thermal Power Facilities

(b) Measures for improved plant efficiency

When thermal power plants are used for many years, deterioration due to corrosion and wear advances resulting in the lowered performance of machinery and equipment. Efficient maintenance of plant performance is made possible by executing countermeasures positively to improve performance at an appropriate time, e.g. when the replacement of aged parts should be done. Major examples in Japan are as follows. For their outlines, please refer to 'Energy Conservation in Thermal Power Generation/Chapter 8' herein.

1) improved steam turbine blade efficiency
2) improved steam turbine operation system control valves
3) reduced air leakage from air preheaters and improved element structure
4) adoption of variable pitch blade for forced draft fans and recirculating water pumps
5) reduced plant start loss
6) diesel engine waste heat recovery power generation

(c) Improved load following performance

With the increase of base supplies such as large-scale coal-fired thermal power and changes in load characteristics, the existing thermal power plants are to be operated for middle peak as load adjusters. This will necessitate an improvement in operation characteristics such as improvement in the rate of output change and the lowering of minimum output. It is, therefore, necessary to fully examine the necessities involved and the related safety factors but considering the economy as a base before taking such steps.

(d) Measures to prevent deterioration during shutdown

Those thermal power facilities with relatively low efficiency may occasionally require scheduled shutdowns for a long period to regulate demands. In this case, during their shutdown it is necessary to establish appropriate maintenance technologies which will ensure smooth resumption of operation by keeping the facilities in good condition. Please refer to 'Energy Conservation in Thermal Power Generation/Chapter 9' herein for actual cases in Japan.

(5) Advancement of operations and maintenance

(a) Highly advanced maintenance technologies

i) Today it is essential to secure highly efficient, accident free operation through providing the appropriate maintenance to fully utilize the aged thermal power plants for middle peak operation under severe operational conditions. This necessitates efforts toward the advancement of maintenance technologies such as the positive introduction of new technologies of facility diagnosis and examination, and the development of maintenance management systems, etc.

ii) The diversification of power facilities has brought with it an increase in the work load in terms of operations and maintenance. It is, therefore, necessary to make every effort to cut costs, for instance, providing efficient facility operation by positively enhancing automatization and labor savings such as through the introduction of centralized monitoring and control at the both the power plants and also at transformer substations. Further efforts in labor saving is necessary to link automatization and labor saving in the field of maintenance and inspection with the overall automatization of operations and monitoring. However, an important problem requiring solution is wherein the advancement of automatization and labor saving in operation and inspection and/or black-boxing of equipment has brought about a deterioration in the engineers' maintenance and inspection expertise together with difficulty in transmitting the technologies efficiently.

iii) Problems occurring in facilities are broadly divided into two, i.e. one that occurs at a certain stage of life, and the other that occurs accidentally. As Figure 10.3 indicates, these generally change with the passage of time. Power facilities are obliged, from the viewpoint of securing trustworthiness, to carry out certain inspections within a set period of time in order to prevent such troubles and to secure safe operation of the facilities. This becomes the base for plans to execute facility inspections and maintenance on a regular basis. In the case of accidental troubles, it is necessary to carry out stringent testing of safety and quality at and throughout the stages of design and production, installation and test run, to restrain the occurrence of troubles to a minimum, and to adopt a system that enables either to continue operation of the entire facilities safely - or to stop operation safely even when accidental troubles occur during operation. Troubles caused by aging should be dealt with by ex post facto preservation such as recurrence prevention measures after the relevant causes have been identified. Please refer to 'Energy Conservation in Thermal Power Generation/Chapter 10' herein for the direction and new techniques of maintenance and inspection technologies.

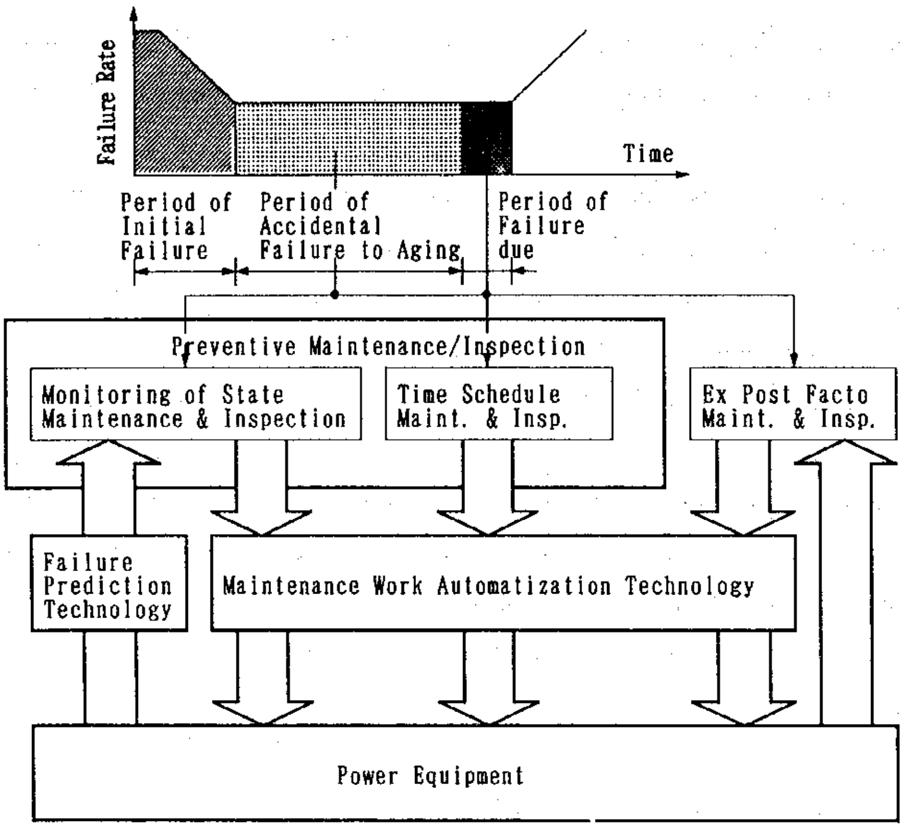


Figure 10.3 Outline of Maintenance and Inspection System

(b) Enhancement of manpower

i) When thermal power plants are aging and are operated under severe conditions while they get more inclined for middle peak operation, it is necessary to enhance manpower such as the operators and maintenance personnel while maintaining the activation of the job site in order to secure accident free, efficient operation with the thermal power plants being the center pillar for the electricity supplies. As carried out by PLN, the government should also consider measures to positively support the expansion and enrichment of education and training facilities, and positively promote participation in the training schemes of other organizations (including those in foreign countries) and others.

ii) The following methods enhance the quality of operators and maintenance personnel;

[Operators]

1) Simulator training

As automatized systems continue to advance, to upgrade operator efficiency, it is necessary to consider the introduction of training simulators which enable easy and effective training in matters such as emergency procedures.

2) Development and introduction of operation support systems.

It is necessary to consider the positive introduction of a system able to support operators in making appropriate judgements and control, such as the multiple display of operational information utilizing graphic CRTs and sound notification equipment etc., together with others to monitor and diagnose the operational conditions of machinery, etc.

[Maintenance personnel]

It is necessary to systematically carry out practical training using various machinery actually installed in order to assist maintenance personnel to acquire and transmit basic skills and techniques, and to enhance their abilities to cope with new technologies.

(6) Future thermal power plant facilities

The use of steam with a higher temperature and pressure has enhanced generation efficiency and provides greater energy conservation. In Japan, efforts to improve steam conditions even further are now under way through the following research and development projects of high-efficiency generation technologies. The expected efficiencies and estimated times of introduction for each technology are shown in Table 10.2. Please refer to 'Energy Conservation in Thermal Power

Table 10.2 Expected Efficiency & Estimated Time of Introduction of High Efficiency Power Generation Technology

Generation Method		Sending End Efficiency (%)	When to be put into Practical use (Target)
Coal	Pulverized Coal	38	existing
	Atmospheric Fluidized Bed Combustion (A-FBC)	38	existing
	Pulverized Coal - Ultra Super Critical Pressure Turbine (USC-T)	41	1990's
	Pressurized Fluidized Bed	42	approx. 2000
	Pressurized Fluidized Bed-Ultra Super Critical Pressure Turbine (USC-T)	44	approx. 2000
	Integrated Gasification Combined Cycle (1300 degrees C)	43	approx. 2010
	Integrated Gasification - Fuel Cell Combined Cycle	more than 50	approx. 2010
	Advanced Pressurized Fluidized Bed	46	—
	MHD Combined Cycle	more than 50	—
Fuel Cell	Molten Carbonate Fuel Cell	more than 45	approx. 2000
	Solid Electrolyte Fuel Cell	more than 50	approx. 2010
LNG	Ultra Super Critical Pressure Turbine (USC-T)	42	existing
	Combined Cycle (1100 degrees C)	43	existing
	High Efficiency Combined Cycle (1300 degrees C)	47	1990's
	High Efficiency Combined Cycle (1500 degrees C)	50	approx. 2000
	LNG - Solid Electrolyte Fuel Cell	more than 60	approx. 2010
	MHD Combined Cycle	more than 50	approx. 2010

Generation/Chapter 11' herein for their outlines.

1) Ultra-super Critical Pressure Turbine (USC-T)
2) Pressurized Fluidized Bed Combined Cycle (PFBC)
3) Integrated Gasification Combined Cycle (IGCC)
4) MHD Combined Cycle
5) Fuel Cell (FC)

10.1.2 Countermeasures Against Transmission/Distribution Loss

(1) Present Condition of Transmission/distribution Losses

In Indonesia, transmission/distribution loss (energy loss ratio) throughout the systems nationwide was 12.53% in fiscal 1993. The loss ratio in the major systems in fiscal 1993 are described in Table 10.3.

Table 10.3 Own Used and Energy Losses (%)

Province	Own Used * %	Energy Losses (%)		
		Transmission	Distribution	Total
Region I	4.16	-	14.97	14.97
Region II	3.59	3.26	13.19	16.45
Region III	3.73	0.79	14.39	15.71
Region IV	8.16	4.02	10.93	14.95
Region V	4.11	-	13.30	13.30
Region VI	3.44	0.74	8.13	8.87
Region VII	2.98	1.62	10.96	12.59
Region VIII	1.39	4.93	8.69	13.62
Region IX	5.36	-	12.38	12.38
Region X	3.21	-	11.42	11.42
Region XI	1.12	-	12.13	12.13
Batam	5.0	-	34.16	34.16
Outside Java	3.96	2.18	11.96	14.14
Java-Bali	4.1	2.64	9.49	12.13
All Indonesia	4.07	2.54	9.99	12.53

Note) * Own used for the power stations, substations and distribution transformers

Table 10.4 shows the energy loss ratio in the past.

Table 10.4 Loss Trends

Fiscal year	Own Used* (%)	Energy Losses(%)		
		Transmission	Distribution	Total
1986/87	4.39	4.78	14.96	19.74
1987/88	4.71	3.36	15.37	18.73
1988/89	4.95	3.01	13.87	16.88
1989/90	4.92	2.97	12.85	15.82
1990/91	4.80	2.53	13.10	15.63
1991/92	4.62	2.68	11.44	14.12
1992/93	4.25	2.96	9.42	12.38
1993/94	4.07	2.54	9.99	12.53

Note) * Own used for the power stations, substations and distribution transformers

As seen in Table 10.3, the losses in the Java-Bali system represent 12.13% with losses outside the Java system being 14.14%. Outside of Java, no other island experienced losses in the distribution systems, showing that most systems are isolated systems and no interconnection between these systems has been developed. The consumption for own used at those power stations has increased due to developing of large scale thermal power stations.

(2) Countermeasures for Loss Reduction

The reduction of loss in transmission and distribution facilities contributes toward the effective use of valuable electricity, thereby resulting in a significant economical performance.

Especially, of the 12.53% loss in the trans-mission/distribution system approximately 10% are losses in the distribution system. Therefore, the remaining 2.54% losses are in the transmission system.

Compared to the losses in other developing countries, the losses in Indonesia's distribution system are not particularly large. However, considering the future demand increase and extension of the new distribution line, the loss ratio may increase if the current facilities continue to be used.

According to the past data and a recent computer analysis (See Table 10.4) these losses have improved each year.

The losses are mainly classified in the following categories. (data of 1993)

(a)	Power plant own used consumption :	4.07%
(b)	High voltage transmission/distribution lines :	2.54%
(c)	Medium/low voltage transmission/distribution lines :	9.99%
	Total :	16.6%

The own used consumption in (a) means that electricity consumed for power generation and transmission.

Regarding (c), the major loss is in the low voltage distribution lines. Line loss (depending on the conductor size and kinds), meter loss and loss due to illegal supply may be included in these losses.

The losses in the distribution transformer is determined by the design value, which is approx. 2%.

A minimum of approx. 1% can be improved by computerized load flow analysis and voltage adjustment.

Based on the above analysis, the following countermeasures are proposed for loss reduction;

a) Countermeasure for Line Facilities

The most effective measure is to use larger size conductor in a bid to lower conductor resistance. Considering future load increases and line extension plans, it is ideal to install optimum size conductor providing a low conductor resistance to all medium and low voltage distribution lines. Regarding the low voltage line, replace aged and small size conductor with new lines of larger size conductor. It is also necessary to inspect for strand damage and faulty connections and carry out the necessary repairs.

b) Elimination of Heavy Load Circuit

Use the section switch to divide the load so that the load is not concentrated to one circuit. Distribute the load in all circuits as evenly as possible.