No.

Japan International Cooperation Agency (JICA)

Ministry of Energy and Mineral Resources (MEMR),
The Republic of Indonesia

Study on The Optimal Electric Power Development and Operation in Indonesia

FINAL REPORT
(Summary)

August, 2002

Chubu Electric Power Co,. INC.
The Institute of Energy Economics, Japan

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Preface

In response to the request from the Government of Republic of Indonesia, the Government of Japan decided to conduct the Study on The Optimal Electric Power Development and Operation in Indonesia, and the study was implemented by the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Akihisa MIZUNO of Chubu Electric Power Co., INC. and organized by Chubu Electric Power Co., INC. and The Institute of Energy Economics, Japan four times from July 2001 to August 2002.

The team held discussions with the officials concerned of the Government of Republic of Indonesia and conducted related field surveys. After returning to Japan, the study team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Republic of Indonesia for their close cooperation throughout the study.

August 2002

Takao KAWAKAMI
President
Japan International Cooperation Agency

August 2002

Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. KAWAKAMI,

Letter of Transmittal

We are pleased to submit to you the report of Study on The Optimal Electric Power Development and Operation in Indonesia. This study has been implemented by Chubu Electric Power Co., INC. and The Institute of Energy Economics, Japan from July 2001 to August 2002 based on the contract with your Agency.

This report presents the comprehensive proposal, such as the countermeasures against the power deficit anticipated for the near future, the Optimal Power Development Plan for the medium and long term considering political issues, Transmission Plan considering appropriate placement of power plants and measures from technical, organizational and institutional aspects in order to realize the above plans.

We trust that realization of our proposal will much contribute to sustainable development of electric power sector, and will contribute strengthening of economic fundamentals of Indonesia and improvement of the public welfare as well.

In view of the urgency to increase efficiency of power sector, we recommend that the Government of Indonesia implement our proposal by applying result of technology transfer in the study as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Energy and Mineral Resources, PT-PLN (Persero) and other authorities concerned of the Government of Indonesia for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

Akihisa Mizuno

Akihisa MIZUNO
Team Leader
Study on The Optimal Electric Power Development and Operation in Indonesia

Contents

Chapter 1 Preface

1.1 Background

Since the economic crisis in 1997, Indonesia has been regarded as needing reform in many fields. Structural reform has been under way in the electrical power sector to enable efficient electrical supply. This restructuring process was laid out in the "Power Sector Restructuring y the Indonesian government in 1998. It aimed to use deregulation of the power sector and the introduction of market mechanism through the creation of a competitive market in order to achieve electrical power supply of high quality and efficiency. The New Electricity Law is to be enacted as soon as possible as the legal basis of this policy. Within three years of the new law coming into effect, it is to establish Single Buyer (hereinafter referred to as SB) market within the Java – Bali system. Within seven years it is to completely liberalize the operation of the Java – Bali system in the Multiple Buyers/ Multiple Sellers market (hereinafter referred to as MB/MS).

In the SB market and the MB/MS market, private generation companies are expected to take part in power development than before. The Optimal Power Development Plan, reflecting the issues faced by the sector, is essential as a development indicator in order to reconcile future participation of the private sector in power development with efficient and stable power supply. On the other hand, government participation is needed for the attainment of public-interest goals such as environmental preservation, supply stability and the best mix of energy to make effective use of national coal and natural gas reserves. Therefore the government must also be capable of power development planning and policies.

As the economy recovers from the 1997 economic crisis, the power demand is growing steadily. Demand in the Java – Bali system grew by 8.8% on the preceding year in 1999, by 9.9% in 2000 and by 6.35% in 2001. Steady demand growth is expected in future, prompting concerns that the system could reach a power deficit by as early as 2003~04, without the construction of new power stations, or measures to rehabilitate existing power stations and ease restrictions on their operation. In this situation, the examination of the probability of power deficit and preparing short-term countermeasures are current urgent issues to be solved.

1.2 The Target Regions and Purpose of the Study

This situation prompted JICA to begin a "Study on the Optimal Electric Power Development and Operation in Indonesia" (referred to below as "the Study") in July 2001. The scope of the study was limited to Java and Bali. The purpose of the study is as follows;

- To examine the probability of the power deficit anticipated for the near future (around 2005) and prepare countermeasures.
- To examine the Optimal Power Development Plan for the medium and long term (to 2015), taking generation costs, the effective use of primary energy sources, environmental conservation and other issues, and a Transmission Plan considering appropriate placement of power sources.
- To examine measures from technical, organizational and institutional aspects in order to realize the above plans.
- To transfer to the Indonesian counterpart the technologies and know-how for implementing the optimal power development plan and transmission plan during the progress of the study.

1.3 Study Content

This study comprises the following two phases:

[1] Verification of the power deficit which is anticipated for the near future, and preparation of the necessary short-term measures

[2] Examination of the Optimal Power Development Plan and Transmission Plan for the medium and long term, and advice on the technical, organizational and systematic aspects in order to realize the plans

These phases are summarized below.

(1) Verification of the power deficit which is anticipated for the near future, and preparation of the necessary short-term measures

First, past trends in power demand will be analyzed to make a detailed demand forecast using an econometric model. The model will comprise demand functions using income (GDP), electricity tariff and household electrification rates as the explanatory variables. The characteristic feature of this examination is that pricing effects will be considered in the demand forecast, reflecting the trend in the period before 1997, in which power demand increased as the real price declined. The two forecast cases are as follows:

- The JICA/LPE Case 1 scenario, in which the power price is raised to the 6~7c/kWh level by 2005, approximately doubling the current nominal price.
- The JICA/LPE Case 2 scenario, in which the power price is tied to the inflation rate, thus maintaining the real price at the current level.

This examination is the first stage of a study intended to verify the power crisis. Therefore the forecast period extends to 2010.

Next, to verify the capacity of power supply, the study will confirm the development timing in the existing power development plan, the available capacity of existing power plants, and the restrictions on them, to review the supply capacity which can be anticipated in each year. The impact of transmission constraints of the southern 500kV transmission line is examined by system analysis. These studies will envisage a number of scenarios considering the operation schedule and practicability of power plants that are now in development or at the planning stage. The probability of power deficit will be verified for each scenario.

Short-term measures, which at present appear to include coordination of the repair schedules of thermal power generators, rehabilitation of those generators, and the utilization of captive power, will be examined and their anticipated effects gauged to estimate the impact of such measures on the power deficit.

(2) Examination of the Optimal Power Development Plan and Transmission Plan for the medium and long term, and advice on the technical, organizational and institutional aspects in order to realize the plans

The model constructed for the short-term demand forecast will be used as the basis for a medium and long-term demand forecast, extending the forecast period to 2015. For the medium and long-term Optimum Power Development Plan, WASP-IV will be used to study a minimum-cost plan taking into account policies for the stable and effective use of energy, environmental preservation and other issues. The minimum-cost power development as the base case will be analyzed for sensitivity to influences such as rising fuel prices, development lead time and environmental policies and evaluated from the point of view of primary energy supply. The issues identified in the above process will be examined, and then recommendations for the realization of the Optimal Power Development Plan will be presented.

For the Transmission Plan, to match the Optimal Power Development Plan by 2015, distribution scenarios of new power sources (balanced distribution, western bias, eastern bias) will be assumed. Then, power flow, stability and short-circuit capacity of each scenario will be examined by system analysis, and the Optimal Transmission Plan will be proposed.

In parallel with the above analyses, the technical, organizational and institutional issues and recommendations in order to realize the Optimal Power Development Plan and to contribute stable power supply will be examined.

On the technical side, based on the field study of thermal power plants, measures for improving the thermal efficiency of existing power plants will be analyzed in technical and economic terms, and effective measures will be proposed.

The current status of environmental measures will be studied. And environmental countermeasures to improve environmental conditions will be examined and further environmental measures in order to increase the utilization of coal in future will be proposed.

On the organizational and systematic side, measures from Indonesia and abroad which illustrate the realization of power development plans and stable power supply will be gathered and analyzed. Measures apparently applicable to Indonesia's current situation will be identified from these cases and analyzed.

Issues and recommendations will be examined for the utilization of DSM to contribute to stable power supply in the short, medium and long terms, and for the utilization of captive power, which are expected to have a large impact on Indonesia's Power Development Plan because of their large capacity.

Measures to assist the introduction of renewable energy, the introduction of CDM, and a power source bidding system with a view to the power supply composition will also be raised, with examples from overseas, as measures to support the optimal power development.

In addition, measures will be examined and proposals made on enhancement of the PLN's financial condition, which is most important to the realization of optimal power development plan, and on promoting private investment, which is the key to future power development.

1.4 Procedure of the Study

Procedures of this study are summarized as follows.

Procedure	Activities
Phase 1: Examination of probability of power deficit and planning of short-term countermeasures	
Review of power demand forecast	- Analysis of data and information - Review of existing short-term power demand forecast by using model
Review of power supply capacity	- Review of existing power development plan
Examination of the probability of power deficit and short-term countermeasures	- Verification of short-term demand and supply balance - Planning short-term countermeasures
Phase 2: Preparation of comprehensive and realistic medium-to-long term power development plan	
Long-term power demand forecast	- Analysis of long-term power demand forecast by using model
Drawing up the optimal power development plan	- Drawing up the optimal power development plan by using WASP-IV - Evaluation of energy available for power sector
Drawing up the power transmission plan	- Power flow analysis and stability analysis - Drawing up the transmission plan
Proposal to implement the plans on technical aspects	- Drawing up the rehabilitation plan for the existing thermal power plants
	- Review of the environmental policy - Examination of environmental measures
Proposal to implement the plans on institutional and organizational aspects	- Study for institutional and organizational recommendations for the optimal power development plan and stable power supply

Chapter 2 Electricity Demand Forecast in the Java-Bali Region

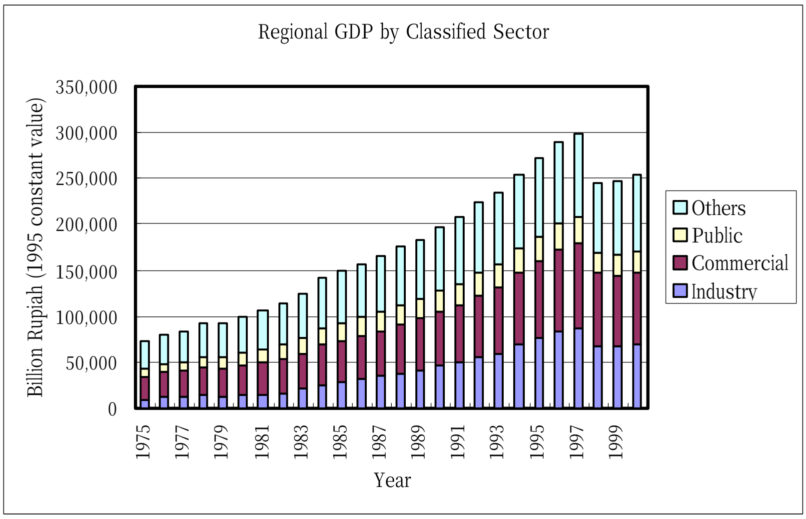
2.1 Historical Trend of Economic Activity and Electricity Demand

2.1.1 Historical Trend of Economic Activities (RGDP, Regional GDP)

The historical trend of RGDP in the Java-Bali Region shows a tendency similar to that of the GDP of the entire Indonesia. The Java-Bali Region has such characteristics that relatively compared to the entire country the share of the mining & quarrying sector is small, while the role of trade, restaurants and hotel is large. During the economic crisis in 1998 the real RGDP of the Java-Bali Region recorded a minus (-) 17.7 % growth. Afterwards, although the economy began to recover, to date the real RGDP has still not reached the level of 1995-1997. As for the structure of the RGDP component in the Java-Bali Region, the agricultural sector had decreased its share of the RGDP until 1997 when the share was 12 %. However, in 1998 the share recorded was 15 %. This implies that the agricultural sector did not suffer much from the impact of 1998's economic crisis. On the other hand, the share of the manufacturing industry was down from 29 % in 1997 to 27 % in 1998.

Figures 2.1.1 shows the historical trend of the RGDP classified by sector. In the figure, the classification of the RGDP corresponds to the electricity sector's category (except others). The "industry" in the electricity sector corresponds to the manufacturing industries, the "commercial" sector corresponds to the restaurants & hotel, banking & other finance intermediaries and the "public" sector corresponds to the public admin & defense and services. The share of the classified electricity sector (except others) accounts for about 67 % of the total RGDP in 2000.

Figure 2.1.1 Historical Trend of RGDP by Sector in the Java-Bali Region



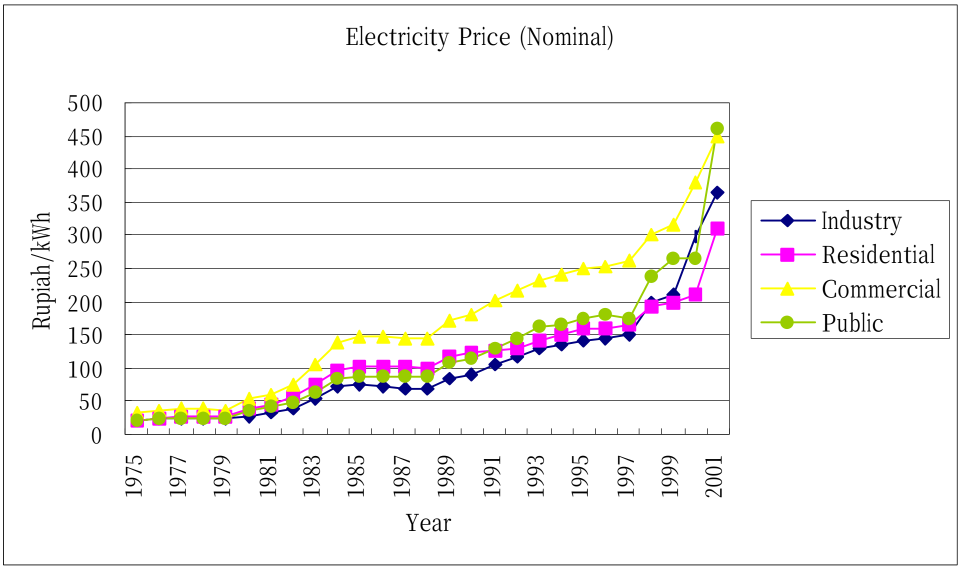
(Source) DGEEU and BPS

2.1.2 Electricity Price

Figures 2.1.2 (a) and (b) show the trends of electricity prices (nominal and real) in each sector since 1975 in the Java-Bali Region. The polygonal lines show prices for the commercial sector, the government/public sector, the industrial sector, and the residential sector. The nominal price rose during the period of 1980-1984 and after 1988. Average price of 88.7 Rupiah/kWh in 1988 increased by about 2.5 times by 1999 (222 Rupiah/kWh). Afterwards, the average price level reached 277 Rupiah/kWh in 2000 and 361 Rupiah/kWh in 2001.

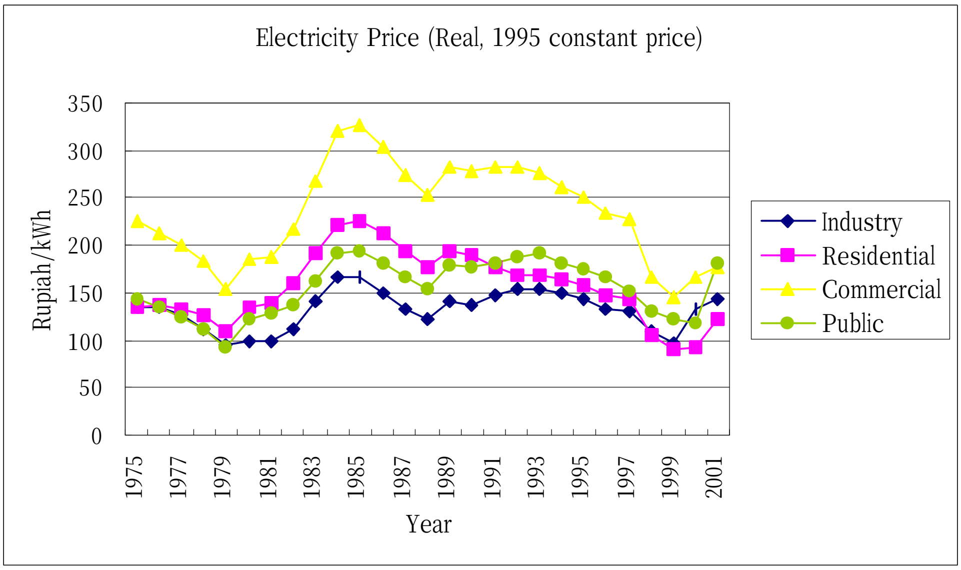
On the other hand, although the real prices increased during the period of 1979-1985, they have maintained a decreasing tendency since 1990 (See Figure 2.1.2 (b)). The reason is due to the result that nominal prices increased in the period of 1988-1999, however, the consumer price index (CPI, 1995=100) during 1988-1999 increased 3.8 times from 56.9 to 218.9. Although nominal prices rose in both years of 2000 and 2001, as of today real prices have not reached the price level of 1997 under the circumstances of the high inflation ratio.

Figure 2.1.2 (a) Historical Trend of Nominal Electricity Price



(Source) DGEEU and BPS

Figure 2.1.2 (b) Historical Trend of Real Electricity Price



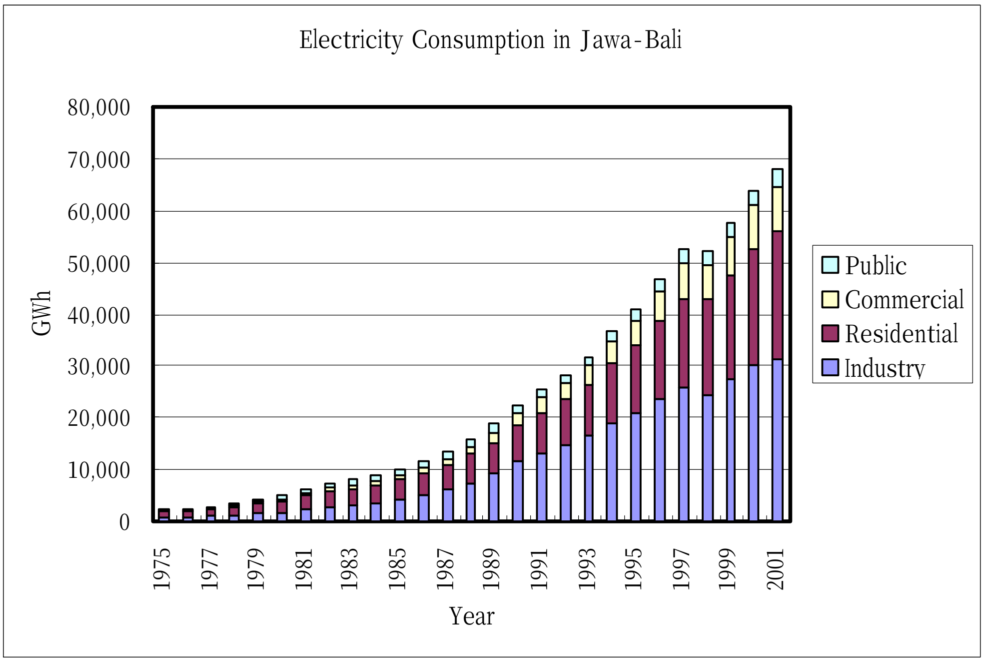
(Source) DGEEU and BPS

2.1.3 Electricity Demand

Figure 2.1.3 shows the historical trends of electricity demand by sector in the Java-Bali Region. Electricity demand in the Region has rapidly increased from 2,258.7 GWh in 1975, to 5,112.0 GWh in 1980, to 18,759.6 GWh in 1985, and to 63,871.8 GWh in 2000. The actual recorded value in 2001 was 67,927.2 GWh. Looking at the contribution by sector, the industrial sector, followed by the residential sector have pushed up the regional electricity demand. Annual average growth rates of electricity demand were 14.3 % in 1975-1980, 15.7 % in the 1980s and 11.25% in the 1990s. Each growth rate by consuming sector is shown in Table 2.1.1.

As for the demand structure, the industrial sector expanded its share from a level of a little over 30 % to a level of 50 % [level] in the 1980's. After the latter half of 1990s, however, the share of the industrial sector shrunk and the residential and the commercial sectors recovered that share. As for the share of the consuming sector, in 2001, the industrial sector accounted for 46 %, the residential sector for 36 %, the commercial sector for 3 %, and the government/public sector for 5 %.

Figure 2.1.3 Historical Trend of Electricity Demand by Sector (Java-Bali)



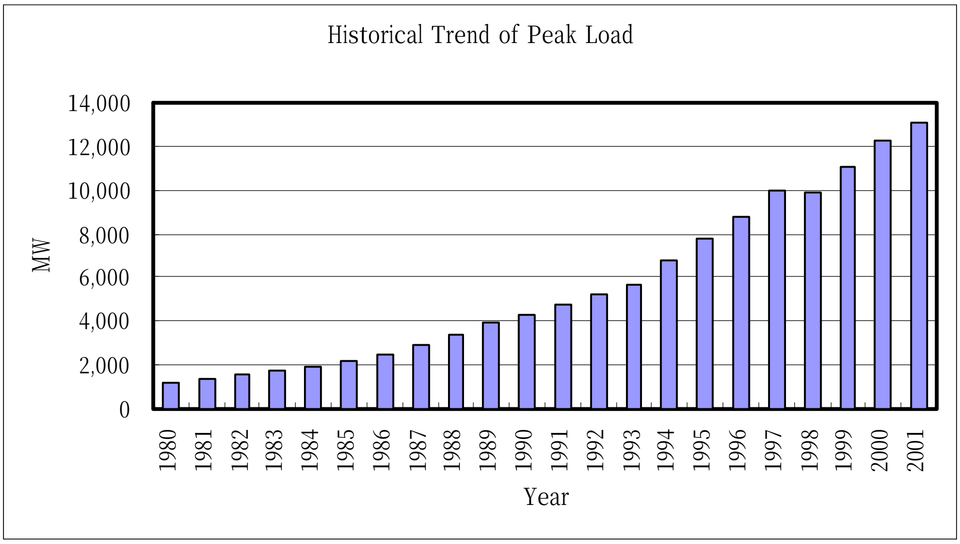
(Source) PLN

Table 2.1.1 Average Growth Rate of Electricity by Sector During Each Period

		1975-1980	1980-1990	1990-2000
Electricity Demand	Java-Bali Total	14.3	15.7	11.5
	Industry	15.4	21.6	10.5
	Residential	14.9	12.1	13.1
	Commercial	19.3	13.8	14.1
	Public	8.0	8.1	5.8
Peak Load	Java-Bali System		13.8	11.0

Historical trend of peak load is shown in Figure 2.1.4. Peak load (gross) has increased from 1,181 MW in 1980 to 7,777.3 MW in 1995, and to 12,231 MW in 2000. Annual average growth rate was 13.8 % in the 1980s and 11.0 % in the 1990s. In 2001, the peak load in the Region reached 13,041 MW.

Figure 2.1.4 Historical Trend of Peak Load in the Java-Bali System



(Source) PLN

Table 2.1.2 shows the historical trends of load factor and total losses in the Java-Bali system since 1990. Total losses are represented in terms of ratio (%), and include the plant own-use and transmission/distribution losses. As a recent trend, the plant own-use is about 4 %, and the transmission /distribution loss is about 12 %. Load factor is about 70 %.

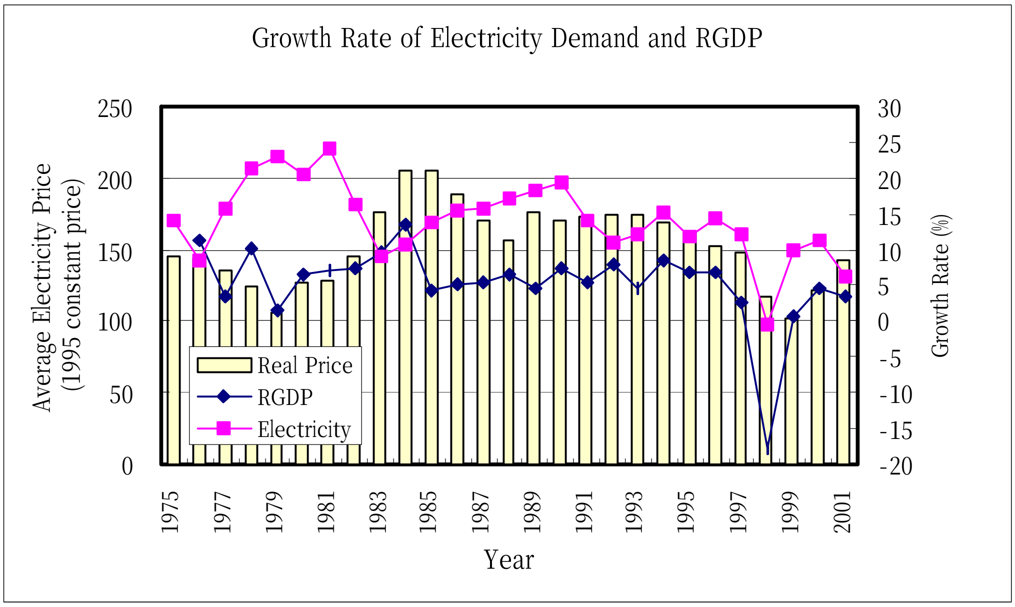
Table 2.1.2 Load Factor and Total Losses in the Java-Bali System (Unit: %)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Load Factor	70.2	72.8	78.0	79.7	70.2	70.5	68.4	70.7	71.9	70.3	69.9	71.1
Total Loss	19.9	18.1	16.5	16.2	15.8	16.1	15.7	15.5	16.6	16.2	15.1	16.4

(Source) PLN

Figure 2.1.5 shows the historical trend (1975-2001) of electricity demand and economic activities in the Java-Bali Region. In the figure, polygonal lines show annual growth rates of electricity demand ("Electricity" in Figure 2.1.5) and the RGDP respectively, and the bar graph shows the real price (at 1995 constant value) in each year. According to Figure 2.1.5, we can see the general characteristic that before 1997 the growth rate of electricity demand increases when the real price decreases. In 1998, the demand growth rate dropped drastically due to the economic crisis and it recorded minus growth. Although signs of recovery begin to appear after 1999, the economic driving force is still weak.

Figure 2.1.5 Historical Trend of Electricity Demand and Real Price (Java-Bali)



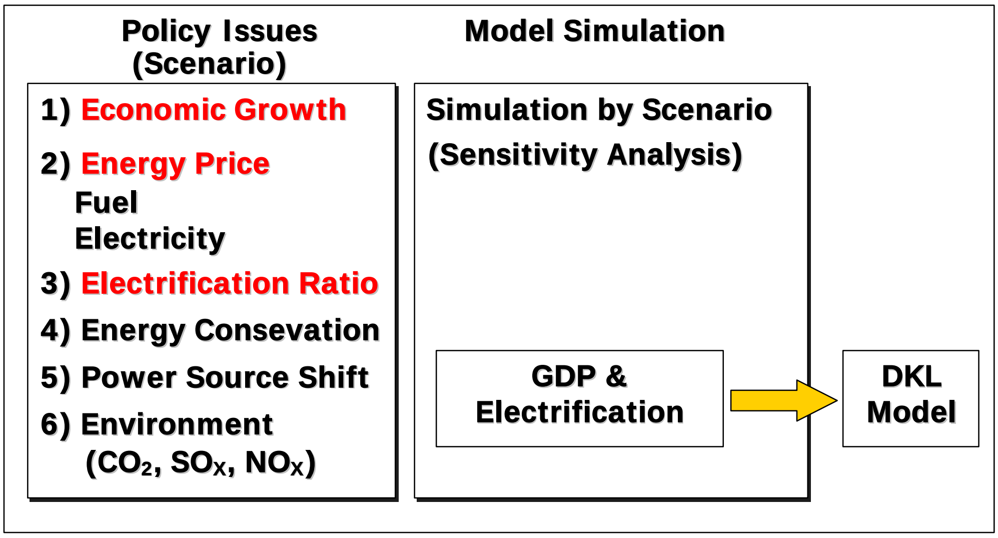
2.2 Electricity Demand Forecasting Model

2.2.1 Concept of Model

In this report, models were built focusing on economic growth (Regional GDP by sector) and electricity price. Demand function is expressed by Income (GDP) and Price based on econometrics principle. As shown in the following schematic diagram (Figure 2.2.1), models include functions for analyzing the impact of energy policy issues such as, electricity price and rural electrification.

Main scenarios related to policy issues can be applied to 1) economic growth (RGDP), 2) electricity price, 3) household electrification, 4) energy conservation, 5) power source shift (fuel shift), and 6) environmental constraints. In this report, 1) economic growth, 2) electricity price, and 3) household electrification are given as scenarios (external variables). Sensitivity analysis by simulation is focused on electricity price and, other analysis such as household electrification and energy conservation are added as applied.

Figure 2.2.1 Schematic Diagram of Proposed Model



2.2.2 Model Structure

(1) Electricity demand by sector

Figure 2.2.2 shows the framework of the end-use electricity sub-sector (electricity demand sub-sector). In this case, macro indicators consist of four items: (1) regional GDP by sector, (2) consumer price index, (3) electricity prices by sector and (4) household electrification ratio. In the electricity demand forecasting, the former items described above are treated as external variables in order to simulate the impact of price and GDP growth.

The end-use electricity demand sub-block comprising of each sector creates the system equations by sector and calculates both the sectoral demand and the total. The demand functions are estimated by regression analysis for each sectoral demand for the manufacturing, residential, commercial, and government/public sectors. The total demand is obtained by adding each of the sectoral demand.

Basically, system equations by sector were created as the following functional relations:

1) Industrial (manufacturing) sector

Electricity demand = f (GDP of industrial sector, Price for industrial sector)

2) Residential sector

Number of customers = f (Electrification ratio)

Electricity demand = f (Electricity consumption/Customer, Price for households, Number of customers, Previous year's demand)

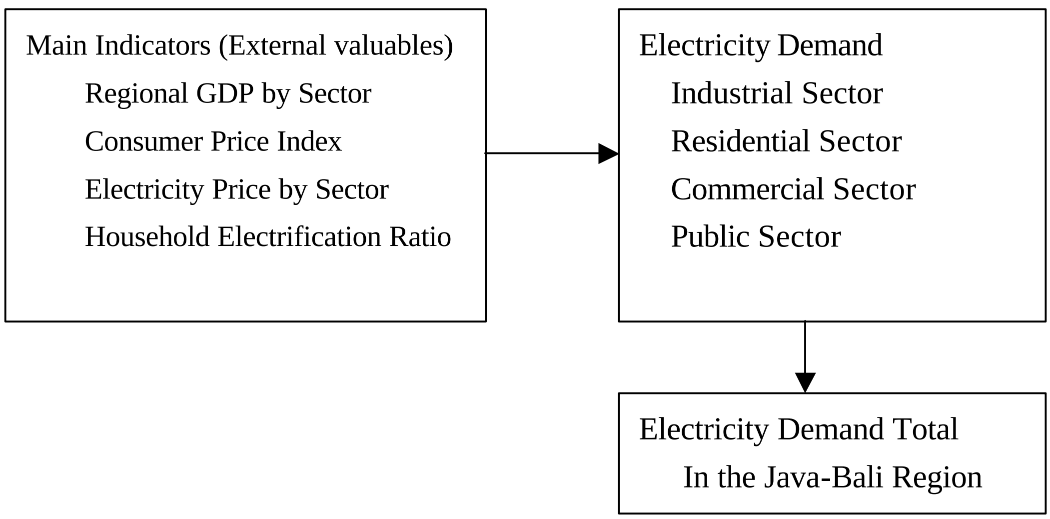
3) Commercial sector

Electricity demand = f (GDP of commercial sector, Price for commercial sector)

4) Government/Public sector

Electricity demand = f (GDP of public sector, Price for public sector, Previous year's demand)

Figure 2.2.2 Framework of Electricity Demand Sub-Block



(2) Power generation and peak load

In this sub-block, total electricity demand forecasted is received from the end-use electricity demand sub-block. Considering total losses (gross) by adding both the transmission /distribution (T/D) losses and own use (in plant use), the total electric power generation required is calculated. Peak load is calculated by use of a load factor.

In this simulation, total losses are handled as external variables (scenario). The load factor is calculated by the model itself, that is, by a structural equation by regression analysis. The load factor obtained by regression will increase with industrial demand and decrease with residential demand and, is as follows:

Load Factor = f (Industrial Demand, Residential Demand)

(3) Observation year

The base year and the observation year of the data for the model simulation are shown in Table 2.2.1. The base year is 2000, while the actual values for 2001 are input values of electricity demand, generated output and peak load..

Table 2.2.1 Base Year and Observation Year

Observation Year	1980 – 2000
Base Year	2000, Excluding electricity demand
RGDP applied	1980 – 2000
Electricity consumption, Generation and Peak Load	1980 – 2001, Input 2001 actual values

2.3 Forecasted Electricity Demand by Sector

In the first phase, electricity demand in the Java-Bali Region is forecasted until 2010, and the forecasted year is extended until 2015 in the second phase. Both forecasted results are the same until 2010. Electricity demand forecasting in the first phase was carried out for the purpose of preparing materials to examine whether power shortage is likely to happen in 2003 or 2004.

2.3.1 Scenario

Main points of the scenario (JICA/LPE) prepared are briefly shown in Table 2.3.1. GDP scenario is the same as PLN Low Case until 2010 with an annual average growth rate of 4.1 %. As for the price scenario, Case 1 raises the prices to the level of 6-7 cent/kWh (considering an exchange rate of Rp. 8000/ US$) until 2005, that is, nominal prices are doubled to current price levels. In Case 2, nominal prices are increased with inflation (consumer price index). Price scenario of Case 1 is shown in Table 2.3.2.

Table 2.3.1 Characteristics of Scenario (JICA/LPE)

		Scenario			
GDP Growth (%)		2000-2005	2005-2010	2010-2015	2000-2015
		3.8	4.3	4.5	4.2
Price	Case 1	Nominal prices increase based on the new pricing schedule.			
	Case 2	Real price constant (Nominal prices increase with inflation)			

Table 2.3.2 Price Scenario (JICA/LPE Case 1)

Price (Rupiah/kWh)		1999	2000	2001	2002	2003	2004	2005
Industry		210.3	299.6	365.2	429.3	480.8	533.7	587.1
	G.R (%)		42.5	21.9	17.6	12.0	11.0	10.0
Residential		197.7	210.9	311.0	395.1	442.5	486.8	535.4
	G.R (%)		6.7	47.5	27.0	12.0	10.0	10.0
Commercial		317.2	378.6	447.7	506.2	566.9	623.6	686.0
	G.R (%)		19.4	18.3	13.1	12.0	10.0	10.0
Public		265.8	265.8	460.6	507.1	568.0	624.7	687.2
	G.R (%)		0.0	73.3	10.1	12.0	10.0	10.0
Average		221.9	276.9	360.9	430.6	482.6	533.4	587.1
	G.R (%)		24.8	30.4	19.3	12.1	10.5	10.1

The detailed scenario is shown in Table 2.3.3. As just mentioned above, the GDP scenario is the same as PLN Low Case until 2010. Also, the growth rates of population and household electrification ratio were set as the same PLN scenario. Inflation is set between from 10 % to 8 %. In the Table 2.3.3, PLN scenario is also attached as a reference.

After 2011, the GDP growth rate is maintained at the 2010 level of 4.5 % and the price scenario adopts the real price constant case. Household electrification is set from 81 % in 2010 to 93 % in 2015, which is a time trend of annual average growth of 3 %. Inflation is set at 7 % per annum.

Table 2.3.3 Detailed Scenario (JICA/LPE and PLN))

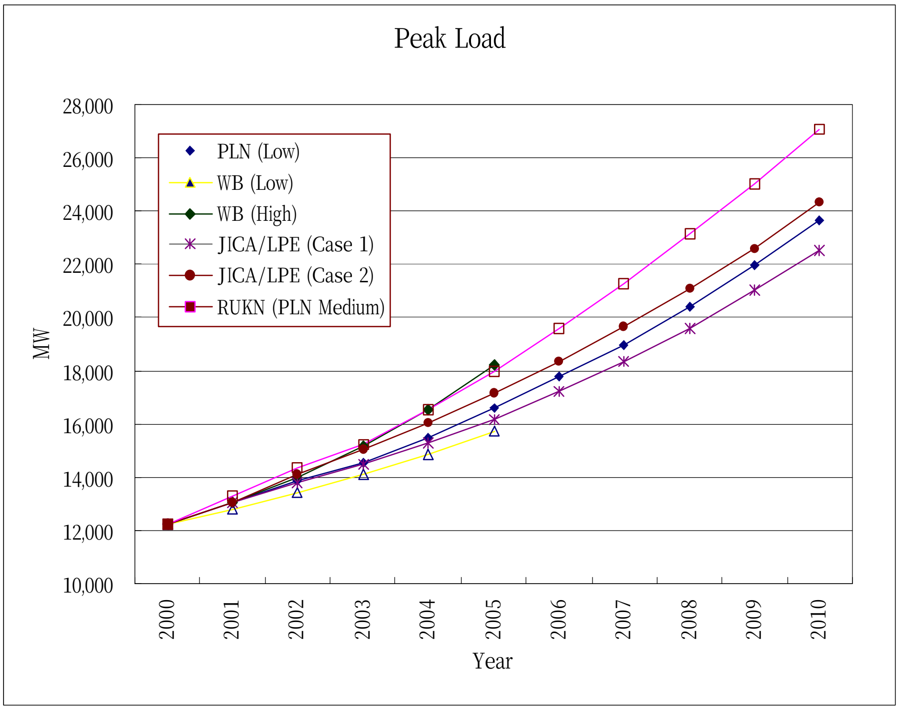
PLN			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP	Low	G.R (%)		3.4	3.7	3.7	3.9	4.1	4.2	4.2	4.3	4.5	4.5
	Medium	G.R (%)		3.8	3.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	High	G.R (%)		3.9	4.9	5.3	5.6	6.0	6.2	6.3	6.4	6.4	6.4
Population		G.R (%)	1.08	1.07	1.05	1.03	0.99	0.96	0.93	0.91	0.88	0.84	0.81
Electrification ratio		%	58.3	59.2	60.2	62.2	64.4	66.7	69.1	71.8	74.6	77.5	80.6
Total Loss		%	14.7	15.2	13.8	13.8	13.5	13.3	13.2	13.1	13.1	13.0	13.0

JICA/LPE			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP	Case 1	G.R (%)	4.7	3.4	3.7	3.7	3.9	4.1	4.2	4.2	4.3	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	Case 2	G.R (%)		the same as Case 1					the same as Case 1					Same to Case 1				
Price	Case 1	G.R (%)		18.3-73.3	11-27	12.0	10.0	10.0	Real value constant (the same as inflation)					Real value constant (the same as inflation)				
	Case 2	G.R (%)		Real value constant (the same as inflation)					Real value constant (the same as inflation)					Real value constant (the same as inflation)				
Population		G.R (%)	1.08	1.07	1.05	1.03	0.99	0.96	0.93	0.91	0.88	0.84	0.81	(Trend: Average 1.1% Growth)				
Electrification ratio		%	58.3	59.2	60.2	62.2	64.4	66.7	69.1	71.8	74.6	77.5	80.6	83.1	(Trend: Average 3% Growth			93.1
Inflation		%	3.7	10.0	10.0	10.0	10.0	10.0	9.0	9.0	8.5	8.0	8.0	7.0	7.0	7.0	7.0	7.0
Total Loss		%	14.7	13.2	13.8	13.8	13.5	13.3	13.2	13.1	13.1	13.0	13.0	13.0	13.0	13.0	13.0	13.0

2.3.2 Short-Medium Term Electricity Demand Forecasted Results (2001-2010)

Figure 2.3.1 shows the forecasted peak load until 2010. In the figure, examples of RUKUN, Low Case of PLN, and Low/High Cases of World Bank are also shown as references.

Figure 2.3.1 Forecasted Peak Load



2.3.3 Long Term Electricity Demand Forecasted Results (2001-2015)

According to the simulation results targeting the year 2015, the electricity demand is expected to rise at the average growth rates of 6.8 % in Case 1 and respectively, 7.2 % in Case 2 in the period of 2000-2015. Peak load would also increase at a 6.7 % growth rate in Case 1 and 7.2 % in Case 2 during the same period mentioned above. Table 2.3.4 shows the outline summarizing the simulation results over a five span.

Table 2.3.5 shows the actual values and the forecasted results of the peak load in the period of 2000-2015. The difference between the results of Case 1 and Case 2 is 985 MW in 2005, 1,758 MW in 2010, and 2,251 MW in 2015. In this simulation, the GDP scenario is only one example. In case that modelers change the GDP scenario, the difference is expected to become larger than the results shown.

Table 2.3.4 Outline of Simulation Results

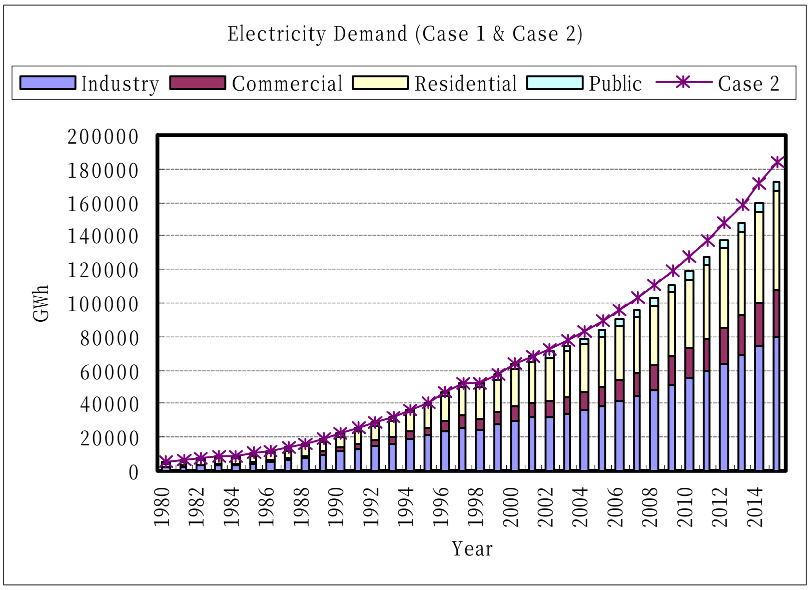
JICA/LPE		2000	2005	2010	2015	2000/2015
Java-Bali Case 1	Demand (GWh)	63,872	84,193	118,704	171,825	
	G.R (%)		(5.68)	(7.11)	(7.68)	(6.82)
	Generation (GWh)	74,901	97,087	136,410	197,455	
	G.R (%)		(5.33)	(7.04)	(7.68)	6.68)
	Peak Load (MW)	12,231	16,185	22,539	32,549	
	G.R (%)		(5.76)	(6.85)	(7.63)	(6.74)
Java-Bali Case 2	Demand (GWh)	63872	89,461	127,669	183,674	
	G.R (%)		(6.97)	(7.37)	(7.55)	(7.30)
	Generation (GWh)	74901	103,161	146,712	211,070	
	G.R (%)		(6.61)	(7.30)	(7.55)	(7.15)
	Peak Load (MW)	12231	17,170	24,297	34,800	
	G.R (%)		(7.02)	(7.19)	(7.45)	(7.22)

Table 2.3.5 Forecasted Peak Load (JICA/LPE)

	2000	2001	2002	2003	2004	2005	2006	2007
Case 1 (MW)	12,231	13,041	13,821	14,497	15,266	16,185	17,220	18,348
Case 2 (MW)	12,231	13,041	14,089	15,073	16,071	17,170	18,374	19,659
	2008	2009	2010	2011	2012	2013	2014	2015
Case 1 (MW)	19,612	21,000	22,539	24,225	26,058	28,048	30,208	32,549
Case 2 (MW)	21,075	22,612	24,297	26,099	28,040	30,131	32,380	34,800

Figure 2.3.2 shows the forecasted electricity demand of Case 1 (Bar Graph) and Case 2 (Polygonal Graph).

Figure 2.3.2 Electricity Demand by Sector (JICA/LPE Case 1 & Case 2)



(1) Simulation results of Case 1

Regarding the electricity demand by sector, demand for the industrial (manufacturing) sector is likely to increase from 30.0 TWh in 2000 to 55.1 TWh in 2010 and to 79.8 TWh in 2015 (up 6.7% per year during 2000-2015). Demand for the commercial sector is projected to climb from 8.3 TWh in 2000 to 17.9 TWh in 2010 and to 27.8 TWh by 2015 (up 8.4% per year). Demand for the residential sector will increase from 22.6 TWh (2000) to 40.9 TWh (2010) and to 58.9 TWh in 2015 (up 6.6 % per year). Public sector demand will increase from 2.9 TWh (2000) to 4.7 TWh and to 5.3 TWh in 2015 at the average growth rate of 4.0 %.

As for the demand structure, presently the biggest consumer of electricity is the industrial sector, followed by the residential sector. In 2001, the industrial sector accounted for 46.3 % of the total demand, the residential sector for 36.0 %, the commercial sector for 12.9 %, and the government/public sector for 4.8 %. The share of the commercial sector shows an increasing tendency, *i.e.*, 16.2 % in 2015 (Case 1), whereas the industrial sector maintains almost the same share, while the share of the residential and the public sectors will decrease slightly.

(2) Simulation results of Case 2

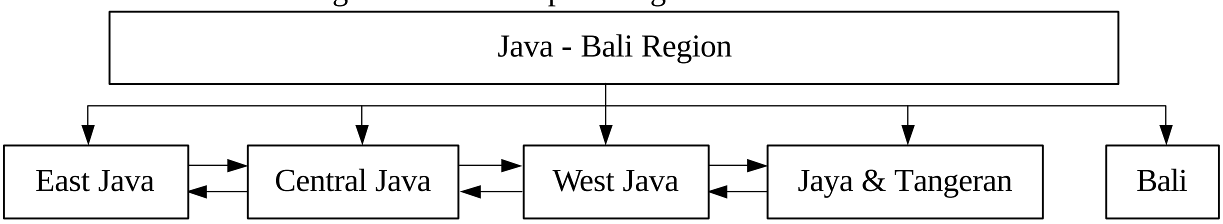
Demand for the industrial (manufacturing) sector is expected to increase from 30.0 TWh in 2000 to 59.2 TWh in 2010 and to 85.7 TWh in 2015 (up 7.2 % per year during 2000-2015).

Demand for the commercial sector is projected to climb from 8.3 TWh in 2000 to 18.5 TWh in 2010 and to 28.7 TWh by 2015 (up 8.7 % per year). Demand for the residential sector will increase from 22.6 TWh (2000) to 44.9 TWh (2010) and to 63.6 TWh (2015) at the growth rate of 7.1 %. The public sector will show a 4.5 % growth from 2.9 TWh (2000) to 5.0 TWh and to 5.7 TWh (2015). The share by sector in Case 2 showed similar results to Case 1, however, the share of the commercial sector in 2015 at 15.3 % is slightly lower than the results of Case 1.

2.4 Electricity Demand by Sub-Region

In this section, electricity demand in the Java-Bali Region is distributed into five (5) areas (sub-regions) taking into consideration the economic structure and electricity demand structure in each area. Each sub-region corresponds to the classification of PLN service area, which consists of Jakarta (Jaya & Tangeran), West Java, Central Java, East Java and Bali as shown in Figure 2.4.1. Figure 2.4.1 also shows the concept of regional economic activities and electricity demand shifts.

Figure 2.4.1 Concept of Regional Demand Shift



2.4.1 RGDP by Sub-Region (Area)

In this model, the RGDP by area is obtained by the following procedure:

1) the RGDP total in the Java-Bali Region is set by the economic scenario (See Table 2.3.3);

2) the sectoral RGDP, comprising of the manufacturing industry, the commercial, the public and others, which basically corresponds to the classification of the electricity demand sector, is distributed by taking into consideration the historical trends of economic activities in each targeted area; and

3) finally, the sectoral GDP is distributed to each area' GDP by sector using historical trend (logarithmic trend).

The annual growth rates of RGDP during 2001 – 2015 are projected at 4.2 % in the Jakarta area, 4.4 % in the West Java area, 4.2 % in the Central Java, 4.0 % in the East Java area and 4.5 % in the Bali area.

2.4.2 Electricity Demand by Sub-Region (Area)

Electricity demand by sector and by area in the Java-Bali Region is forecasted by the following procedure:

1) first, the model runs under the premise that the regional demand by sector simulated in section 4.3 is maintained, that is, the demand by sector in the Java-Bali Region is not changeable;
2) next, electricity demand by sub-region (area) is obtained from the relationship between RGDP by area and by sector and, electricity consumption by area and by sector. Intensities are applied for electricity demand projection. The intensities are not fixed for reflecting on the industrial structure change in each area; and
3) finally, peak load by area is distributed from the entire Java-Bali system to each area by use of historical trends of electricity demand and peak load by area in the past six (6) years, that is, the load intensity with respect to electricity demand that was adopted in each area. As described later, the area classification in the Java-Bali power system is based on P3B's service area.

Table 2.4.1 shows the electricity demand forecasted by sub-region (area) by sector and Table 2.4.2 shows the forecasted results in the Java-Bali Region by sector. Figure 2.4.2 also shows the historical trend and the forecasted result of Case 1 until 2015. It is shown that the West Java area expands its share and demand and the East Java area decreases its share. Regarding the share by area in 2015, Jakarta is expected to account for 29 %, West Java for 36 %, Central Java for 13 %, East Java for 19 %, and Bali for 2.8 %. As for growth rates of electricity demand by sub-region (area), the order is Bali, West Java, Jakarta, Central Java and East Java from the top of the list in both cases for Case 1 and Case2 (See Table 2.4.1).

Regarding the maximum demand (peak load), its area is classified into four (4) sub-region of areas 1, 2, 3, and 4 by the P3B service area, which is a little bit different from the PLN service area. Area 1 includes PLN service area of Jakarta and a part of West Java. Area 4 consists of East Java and Bali.

The forecasted results are shown in Table 2.4.3. Peak load by area for the year 2001 was 5,495 MW in Area 1, 2,316 MW in Area 2, 2,057 MW in Area 3, 2,827 MW in Area 4 (excluding Bali), and 346 MW in Bali. In Case 1, it is expected that Area 1 will be 9,393 MW, Area 2 will be 4,199 MW, Area 3 will be 3,401 MW, Area 4 (excluding Bali) will be 4,828 MW, and Bali will be 718 MW in 2010. In 2015, Area 1 will be 13,542MW, Area 2 will be 6,144 MW, Area 3 will be 4,919 MW, Area 4 (excluding Bali) will be 6,849 MW, and Bali will be 1,095 MW.

Figure 2.4.3 shows the historical trend and the forecasted results of peak load until 2015. In Figure 2.4.3, the bar graph shows the peak load by area for Case 1 and the polygonal graph shows the system peak load for Case 2. Peak load by area in the Java-Bali Region shows the characteristic that Area 1 accounts for a large share of about 40 %. In the case of adding Area 2 to Area 1, the share will reach 60 %.

Figure 2.4.2 Electricity Demand by Area (JICA/LPE Case 1)

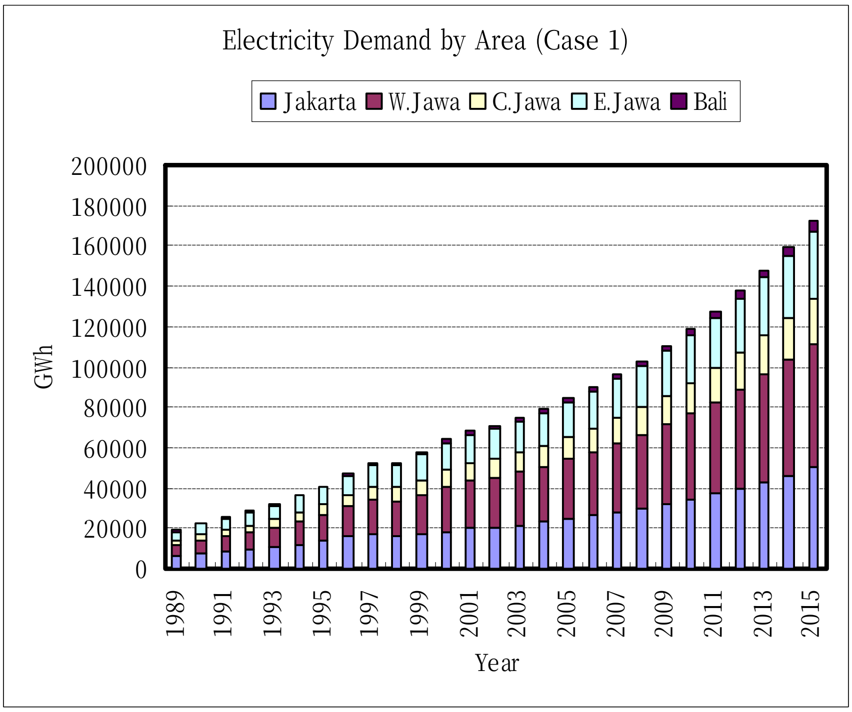


Figure 2.4.3 Peak Load by Area (JICA/LPE Case 1 and Case 2)

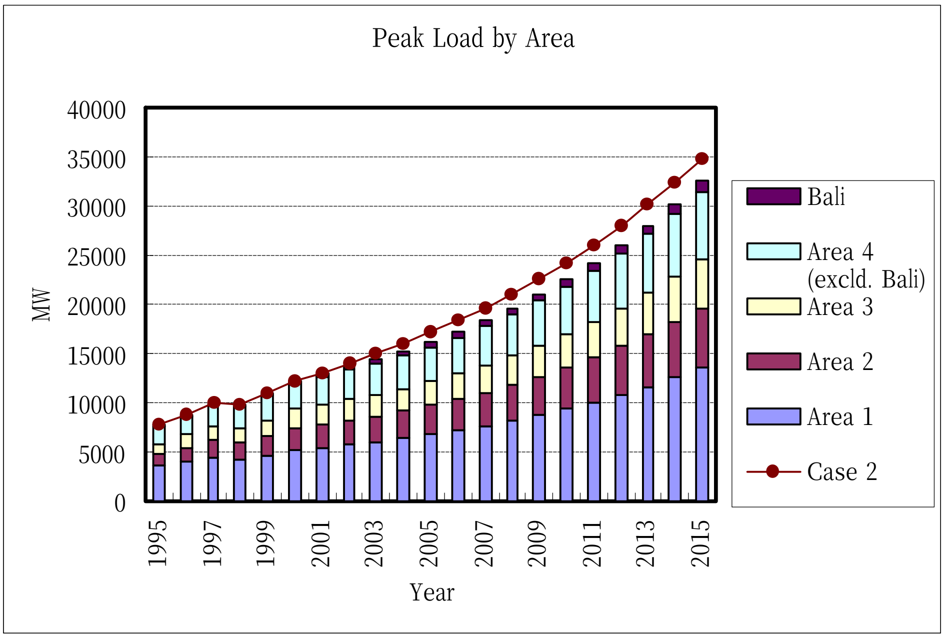


Table 2.4.1 Forecasted Electricity Demand by Sub-Region and by Sector

Demand by Sub-Region & Sub-Sector				1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2000/05	2005/10	2010/15	2000/15
Case 1	Jakarta	Total	GWh	16720	18510	19855	20823	21867	23156	24649	26292	28069	30021	32205	34577	37162	39964	43000	46288	49847	5.89	7.00	7.55	6.82
		Residential		5767	6252	6768	7270	7575	7933	8345	8813	9339	9926	10583	11312	12128	13026	14011	15087	16262	5.94	6.27	7.53	6.58
		Industry		5541	6281	6706	6766	7082	7404	7986	8533	9116	9751	10460	11218	12031	12901	13833	14831	15899	4.92	7.03	7.22	6.39
		Commercial		4158	4689	5021	5304	5639	6091	6602	7166	7777	8433	9219	10032	10958	11943	13015	14180	15446	7.08	8.77	8.97	8.27
		Public		1255	1295	1360	1483	1570	1647	1717	1780	1838	1892	1944	1995	2044	2094	2142	2191	2239	5.79	3.05	2.34	3.72
	West Java	Total	GWh	19721	22070	23613	24572	25893	27500	29418	31529	33814	36325	39127	42169	45480	49066	52948	57148	61689	5.92	7.47	7.91	7.09
		Residential		5601	6615	7159	7700	8036	8428	8879	9393	9970	10614	11335	12137	13036	14025	15112	16302	17603	6.06	6.45	7.72	6.74
		Industry		12759	13856	14690	14982	15845	16912	18218	19643	21171	22840	24701	26705	28860	31179	33675	36359	39247	5.63	7.95	8.00	7.19
		Commercial		913	1112	1198	1272	1359	1476	1607	1752	1910	2084	2282	2498	2734	2991	3271	3576	3909	7.65	9.23	9.37	8.75
		Public		448	487	566	617	653	685	714	740	764	787	808	829	850	870	891	911	931	7.96	3.04	2.33	4.42
	Central Jav	Total	GWh	7887	8709	8888	9371	9840	10400	11055	11779	12568	13438	14400	15468	16629	17893	19266	20757	22373	4.89	6.95	7.66	6.49
		Residential		3879	4319	4520	4853	5056	5294	5569	5883	6235	6628	7069	7558	8107	8711	9374	10100	10893	5.22	6.30	7.56	6.36
		Industry		2938	3202	3156	3218	3402	3630	3910	4214	4541	4898	5296	5724	6184	6680	7213	7786	8403	4.07	7.92	7.98	6.64
		Commercial		616	692	703	746	796	862	938	1021	1111	1211	1325	1448	1583	1730	1890	2064	2254	6.26	9.09	9.24	8.19
		Public		454	496	509	554	586	613	638	661	682	701	719	737	755	772	789	807	824	5.19	2.93	2.24	3.44
	East Java	Total	GWh	11849	13135	13941	14503	15164	15973	16933	17991	19135	20393	21795	23318	24977	26772	28714	30813	33080	5.21	6.61	7.24	6.35
		Residential		4182	4829	5280	5657	5880	6144	6449	6798	7191	7629	8120	8666	9278	9951	10689	11496	12376	5.96	6.09	7.39	6.47
		Industry		6292	6629	6844	6899	7215	7619	8123	8672	9257	9895	10606	11367	12181	13053	13987	14986	16055	4.15	6.95	7.15	6.07
		Commercial		854	1097	1077	1142	1120	1323	1440	1569	1709	1864	2040	2232	2441	2669	2918	3188	3483	5.59	9.16	9.31	8.01
		Public		521	579	741	805	849	887	921	951	979	1005	1029	1053	1076	1098	1121	1143	1165	9.71	2.71	2.05	4.77
	Bali	Total	GWh	1259	1441	1630	1748	1855	1988	2138	2306	2489	2692	2921	3172	3448	3750	4080	4441	4835	8.22	8.20	8.80	8.41
		Residential		519	613	710	765	800	840	886	939	998	1063	1137	1218	1309	1410	1520	1640	1772	7.66	6.56	7.79	7.34
		Industry		81	76	82	83	87	92	99	106	114	122	131	141	152	163	175	188	203	5.42	7.35	7.51	6.76
		Commercial		600	688	767	822	885	969	1063	1167	1280	1406	1550	1706	1878	2065	2271	2495	2740	9.09	9.93	9.94	9.65
		Public		59	64	71	78	82	87	91	94	97	100	103	106	109	112	115	118	120	7.12	3.26	2.52	4.28
Check	Jawa-Bali Total		GWh	57437	63872	67927	71017	74619	79017	84193	89896	96076	102868	110457	118704	127696	137446	148009	159447	171823				

				1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2000/05	2005/10	2010/15	2000/15
Case2	Jakarta	Total	GWh	16720	18510	19855	21279	22748	24327	26045	27900	29878	32025	34404	36968	39714	42672	45857	49285	52975	7.06	7.26	7.46	7.26
		Residential		5767	6252	6768	7269	7778	8307	8870	9476	10125	10825	11580	12417	13296	14244	15266	16365	17544	7.25	6.96	7.16	7.12
		Industry		5541	6281	6706	7118	7554	8038	8577	9164	9790	10473	11233	12048	12931	13855	14856	15928	17076	6.43	7.03	7.22	6.89
		Commercial		4158	4689	5021	5407	5822	6288	6816	7398	8028	8726	9517	10377	11312	12330	13436	14639	15946	7.77	8.77	8.97	8.50
		Public		1255	1295	1360	1484	1595	1693	1782	1862	1935	2002	2065	2126	2185	2242	2298	2354	2408	6.59	3.60	2.52	4.22
	West Java	Total	GWh	19721	22070	23613	25376	27218	29216	31405	33779	36322	39089	42156	45466	49017	52843	56965	61402	66178	7.31	7.68	7.80	7.60
		Residential		5601	6615	7159	7700	8251	8825	9439	10099	10809	11575	12412	13322	14290	15337	16466	17682	18991	7.37	7.13	7.35	7.28
		Industry		12759	13856	14690	15762	16900	18163	19566	21097	22737	24530	26529	28680	30995	33486	36166	39049	42150	7.15	7.95	8.00	7.70
		Commercial		913	1112	1198	1297	1403	1523	1659	1809	1971	2152	2356	2579	2823	3088	3377	3692	4035	8.33	9.23	9.37	8.98
		Public		448	487	566	618	663	704	741	774	805	832	859	884	909	932	955	978	1001	8.77	3.59	2.52	4.92
	Central Jav	Total	GWh	7887	8709	8888	9553	10237	10964	11750	12597	13501	14480	15560	16725	17970	19313	20759	22315	23989	6.17	7.32	7.48	6.99
		Residential		3879	4319	4520	4853	5192	5544	5920	6325	6759	7228	7740	8296	8887	9526	10214	10955	11751	6.51	6.98	7.21	6.90
		Industry		2938	3202	3156	3385	3629	3899	4199	4526	4877	5260	5687	6147	6642	7174	7747	8363	9025	5.57	7.92	7.98	7.15
		Commercial		616	692	703	760	821	890	968	1054	1147	1250	1368	1495	1634	1786	1951	2131	2327	6.94	9.09	9.24	8.42
		Public		454	496	509	554	595	631	663	692	718	742	764	786	807	827	847	867	886	5.90	3.47	2.42	3.95
	East Java	Total	GWh	11849	13135	13941	14884	15855	16894	18022	19238	20533	21934	23482	25147	26924	28833	30883	33084	35445	6.53	6.89	7.11	6.84
		Residential		4182	4829	5280	5656	6038	6434	6856	7310	7796	8320	8892	9513	10171	10882	11647	12469	13352	7.26	6.77	7.02	7.01
		Industry		6292	6629	6844	7258	7696	8183	8724	9314	9942	10627	11390	12208	13083	14019	15022	16095	17243	5.65	6.95	7.15	6.58
		Commercial		854	1097	1077	1165	1259	1366	1486	1620	1764	1924	2106	2304	2520	2756	3012	3291	3596	6.27	9.16	9.31	8.24
		Public		521	579	741	805	862	912	956	995	1031	1063	1093	1122	1150	1176	1202	1228	1253	10.53	3.26	2.24	5.28
	Bali	Total	GWh	1259	1441	1630	1768	1912	2068	2239	2426	2628	2849	3095	3363	3653	3969	4311	4684	5088	9.22	8.47	8.63	8.78
		Residential		519	613	710	765	821	880	942	1009	1082	1160	1245	1337	1435	1541	1656	1779	1912	8.99	7.25	7.42	7.88
		Industry		81	76	82	87	93	99	106	114	122	131	141	151	163	175	188	202	217	6.94	7.35	7.51	7.27
		Commercial		600	688	767	838	914	1000	1097	1205	1322	1452	1600	1762	1939	2132	2344	2576	2829	9.79	9.93	9.94	9.89
		Public		59	64	71	78	84	89	94	98	102	106	110	113	117	120	123	126	129	7.92	3.81	2.70	4.79
Check	Jawa-Bali Total			57437	63872	67927	72860	77969	83468	89461	95940	102861	110378	118697	127669	137278	147629	158774	170769	183674				

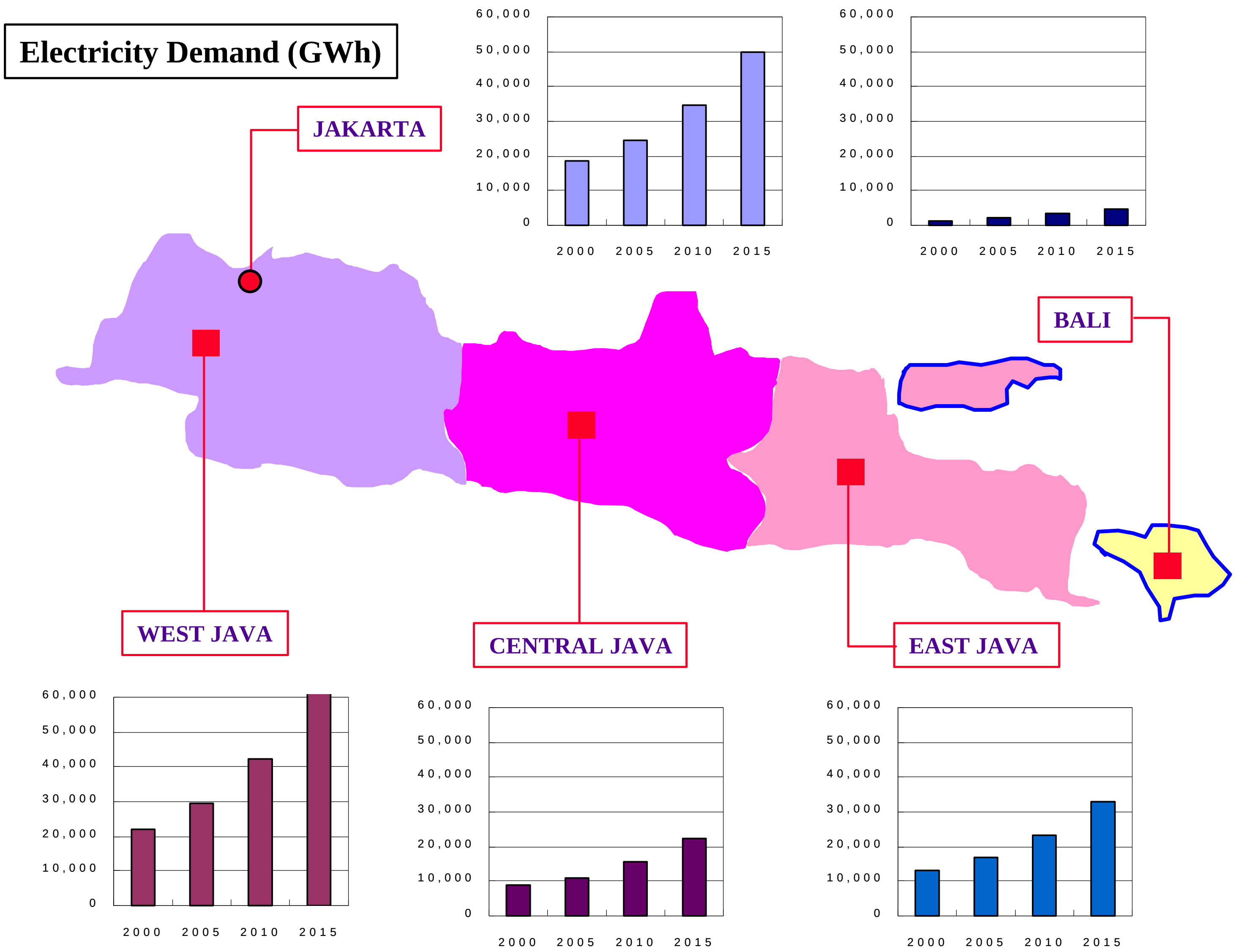
Table 2.4.2 Forecasted Electricity Demand by Sector

JICA/LPE				Actual			Forecast																	
				1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2000/05	2005/10	2010/15	2000/15
Case 1	Demand		GWh	57437	63872	67927	71017	74619	79017	84193	89896	96076	102868	110457	118704	127696	137446	148009	159447	171825				
			G.R.(%)			6.35	4.55	5.07	5.89	6.55	6.77	6.87	7.07	7.38	7.47	7.58	7.64	7.69	7.73	7.76	5.60	7.11	7.60	6.82
		Residential	GWh	19949	22629	24436	26245	27347	28639	30129	31826	33731	35860	38243	40891	43859	47124	50705	54624	58906	5.89	6.30	7.57	6.59
		Industry	GWh	27611	30045	31479	31948	33632	35738	38336	41169	44190	47506	51193	55154	59408	63977	68883	74151	79807	4.99	7.55	7.67	6.73
		Commercial	GWh	7141	8277	8766	9287	9899	10721	11649	12675	13787	15019	16416	17937	19594	21399	23364	25503	27833	7.07	9.02	9.18	8.42
		Public	GWh	2736	2921	3247	3537	3740	3919	4080	4226	4360	4484	4604	4721	4834	4947	5058	5169	5288	6.91	2.96	2.26	4.02
	Generation		GWh	67940	74901	78273	82386	86544	91328	97087	105543	110534	118348	126933	136410	146743	157947	170087	183230	197455				
			G.R.(%)			4.50	5.26	5.05	5.53	6.31	6.65	6.75	7.07	7.25	7.47	7.58	7.64	7.69	7.73	7.76	5.33	7.04	7.68	6.68
	Peak Load		MW	11032	12231	13041	13821	14497	15266	16185	17220	18340	19612	21000	22539	24225	26058	28040	30208	32549				
			G.R.(%)			6.62	5.98	4.89	5.31	6.02	6.40	6.55	6.89	7.08	7.33	7.48	7.57	7.64	7.70	7.75	5.76	6.85	7.63	6.74
Case 2	Demand		GWh	57437	63872	67927	72880	77969	83468	89461	95940	102861	110378	118697	127669	137278	147629	158774	170769	183674				
			G.R.(%)			6.35	7.26	7.01	7.05	7.18	7.24	7.21	7.31	7.54	7.56	7.53	7.54	7.55	7.55	7.56	6.97	7.37	7.55	7.30
		Residential	GWh	19949	22629	24436	26244	28079	29989	32020	34219	36570	39108	41878	44885	48079	51530	55249	59251	63551	7.19	6.98	7.20	7.13
		Industry	GWh	27611	30045	31479	33610	35872	38382	41172	44215	47468	51020	54981	59235	63804	68710	73979	79637	85712	6.50	7.55	7.67	7.24
		Commercial	GWh	7141	8277	8766	9467	10220	11068	12025	13085	14233	15505	16947	18517	20228	22091	24120	26328	28733	7.76	9.02	9.18	8.65
		Public	GWh	2736	2921	3247	3539	3799	4029	4235	4421	4590	4745	4892	5032	5167	5298	5426	5553	5678	7.71	3.51	2.45	4.53
	Generation		GWh	67940	74901	78273	84525	90430	96473	103161	110505	118340	126988	136402	146712	157754	169650	182457	196241	211070				
			G.R.(%)			4.50	7.99	6.99	6.68	6.93	7.12	7.09	7.31	7.41	7.56	7.53	7.54	7.55	7.55	7.56	6.61	7.30	7.55	7.15
	Peak Load		MW	11032	12231	13041	14089	15073	16071	17170	18374	19659	21075	22612	24297	26099	28040	30131	32380	34800				
			G.R.(%)			6.62	8.03	6.98	6.62	6.84	7.01	6.99	7.20	7.29	7.45	7.41	7.44	7.46	7.47	7.47	7.02	7.19	7.45	7.22

Table 2.4.3 Forecasted Peak Load by Sub-Region

Peak Load by Sub-Region																							
			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2000/05	2005/10	2010/15	2000/15
Case 1	Jawa-bali System	MW	11032	12231	13041	13821	14497	15266	16185	17220	18348	19612	21000	22539	24225	26058	28048	30208	32549	5.76	6.85	7.63	6.74
	Area 1		4602	5253	5495	5765	6047	6371	6754	7185	7653	8178	8754	9393	10092	10852	11677	12572	13542	5.15	6.82	7.59	6.52
	Area 2		1951	2164	2316	2494	2625	2774	2955	3158	3380	3627	3899	4199	4528	4884	5271	5690	6144	6.43	7.28	7.91	7.20
	Area3		1643	1905	2057	2099	2202	2316	2451	2605	2773	2962	3170	3401	3655	3932	4234	4562	4919	5.17	6.76	7.66	6.53
	Area 4 (excld. Bali)		2557	2593	2827	3060	3196	3349	3536	3747	3976	4233	4515	4828	5169	5540	5943	6378	6849	6.40	6.42	7.25	6.69
	Bali		279	316	346	403	427	456	488	525	566	611	662	718	780	849	923	1005	1095	9.10	8.82	8.80	8.64
Case 2	Jawa-bali System	MW	11032	12231	13041	14089	15073	16071	17170	18374	19659	21075	22612	24297	26099	28040	30131	32380	34800	7.02	7.19	7.45	7.22
	Area 1		4602	5253	5495	5863	6270	6682	7136	7633	8163	8747	9381	10077	10820	11622	12485	13414	14414	6.32	7.15	7.42	6.96
	Area 2		1951	2164	2316	2563	2730	2942	3154	3388	3638	3914	4214	4543	4896	5276	5685	6126	6601	7.83	7.57	7.76	7.72
	Area3		1643	1905	2057	2130	2283	2437	2605	2789	2985	3201	3434	3689	3962	4257	4574	4915	5282	6.46	7.21	7.44	7.04
	Area 4 (excld. Bali)		2557	2593	2827	3126	3330	3536	3763	4011	4275	4566	4880	5224	5591	5985	6408	6862	7350	7.73	6.78	7.07	7.19
	Bali		279	316	346	406	439	473	511	553	598	648	703	764	830	901	978	1062	1154	10.10	8.36	8.59	9.02

Figure 2.4.4 Forecasted Electricity Demand by Sub-Region



2.5 Examples of Model Application

2.5.1 Household Electrification

In JICA/LPE scenario, the electrification ratio is based on the governmental scenario of DGEEU and PLN until 2010, and afterwards, the electrification ratio in the Java-Bali Region is adopted at about three (3) % of the time trend (See Table 2.5.1) as an external variable (scenario). Needless to say, electrification is one of the integrated energy policies. In this section, we tried to simulate the electrification by itself by the use of macro indicators as a Reference scenario, that is, the electrification ratio is internalized as a function of government expenditure.

Table 2.5.1 shows results of both the JICA/LPE scenario and the Reference scenario. Household electrification in the Java-Bali Region has been progressing from 8.6% in 1980, to 16.8 % in 1985, to 29.4 % in 1990, to 45.7 % in 1995 and to 58.3 % in 2000. Furthermore, DGEEU has a target that until 2010 Indonesia achieve the electrification ratio of 80.6 % in the Java-Bali Region. In the Reference scenario, the household electrification ratio is a little bit higher than in the JICA/LPE scenario until 2006, however, it is lower than the JICA/LPE scenario after 2007, as shown in Table 2.5.1.

Table 2.5.1 Scenarios of Household Electrification

	2001	2002	2003	2004	2005
JICA/LPE Scenario	59.2	60.2	62.2	64.4	66.7
Reference Scenario	59.2	62.6	64.9	66.8	68.4
	2006	2007	2008	2009	2010
JICA/LPE Scenario	69.1	71.8	74.6	77.5	80.6
Reference Scenario	70.0	71.4	72.9	74.3	75.7
	2011	2012	2013	2014	2015
JICA/LPE Scenario	83.1	85.6	88.1	90.6	93.1
Reference Scenario	77.0	78.4	79.6	80.8	81.9

The electrification ratio influences only the residential electricity demand. From the simulation results, the peak load by price scenario is summarized in Table 2.5.2. According to the Table, Case 2 will not create as much difference between the JICA/LPE scenario and the Reference scenario. In Case 1 the difference between both scenarios is 522 MW in 2010 and 1144 MW in 2015. In Case 2, the difference between both scenarios will be 51 MW in 2010 and 135 MW in 2015.

Table 2.5.2 Forecasted Peak Load by Scenario (Unit: MW)

Price Scenario (JICA/LPE)	Electrification Scenario	Year			
		2001	2005	2010	2015
Case 1	JICA/LPE Scenario	12,231	16,185	22,539	32,549
	Reference Scenario	12,231	15,904	22,017	31.405
Case 2	JICA/LPE	12,231	17,170	24,297	34,800
	Reference	12,231	17,183	24,246	34,665

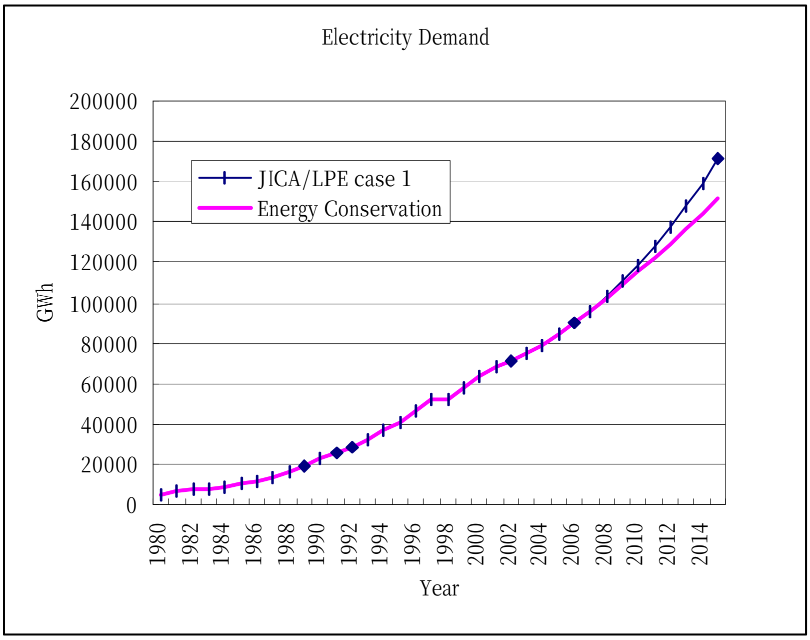
2.5.2 Energy Conservation Case

In this section, the developed model is applied to examine whether for policy making energy conservation policies and targets can be handled. The scenario is set as follows.

1) Residential sector: Energy saved from 2007 achieves energy savings of 10 % in 2015.
2) Industrial sector: Energy saved from 2008 achieves energy savings of 15 % in 2015.
3) Commercial sector: Energy saved from 2010 achieves energy savings of 10 % in 2015.

The results show that in 2010 it is expected that the electricity demand will decrease from 118,704 GWh to 115,447 GWh and the peak load from 22,539 MW to 26,912 MW. Further, in 2015, the electricity demand will decrease from 171,825 GWh to 151,906 GWh and the peak load from 32,549 MW to 28,867 MW.

Figure 2.5.1 Electricity Demand in the Java-Bali Region
(Case 1 and the Energy Conservation Case)



2.5.3 Captive Power

Traditionally, captive power, accounting for a relatively large share, has played an important role in Indonesia, especially Sumatra. As of December 2000, the installed capacity of captive power is15,220 MW, of which Java accounts for 7,325 MW and Bali for 65 MW (DGEEU annual Report, 2001). Actual capacity, however, is not grasped in statistics, which should include rated capacity, its reserve, and generated output, etc,. In this section, we tried to estimate the captive power generation for a model simulation, because consumer shift between PLN and Captive is supposed to depend on electricity prices and fuel prices in the near future.

(1) Estimation of power generation data

At this time, data is estimated from a published paper (Half-Day Joint Seminar on Captive Power in Indonesia, Development, Current Status and Future Role, PT PLN and The World Bank, Tuesday, July 6, 1999) and the DGEEU annul report. According to the estimation at this time, the utilization ratio (operation ratio) of captive power capacity is undergoing a change of about 36 % in recent years. The share of captive power generation in the Java-Bali Region is 30 % of the entire Indonesia.

(2) Scenario

In addition to the electricity price scenario, we prepared a fuel price scenario represented by diesel oil. The scenario applied to this simulation is summarized in Table 2.5.3. Electricity price scenario is the same as Case1 of the JICA/LPE scenario. Scenario setting for [of] population, GDP growth rate, inflation and household electrification ratio is based on the previous section (See Table 2.3.3). The aim of this scenario is to simulate the impact of fuel price.

Table 2.5.3 Scenario on Electricity Price and Fuel Price

	Electricity Price	Fuel Price
Scenario 1	Real price up (Same as Case 1 of JICA/LPE scenario, in which nominal price increase until 2005 as shown in Table 2.3.2)	Real price up (Nominal price increase the growth rate of 15 % until 2004)
Scenario 2	Real price up (Same as Case 1 of JICA/LPE scenario, in which nominal price increase until 2005 as shown in Table 2.3.2)	Real price constant (Nominal price increase with inflation)

(3) Model

In this model, a modification is done only to a system equation for the industrial sector. Electricity demand for industry is set as the sum of PLN (industrial demand) and captive power generation. The functional relationship is as follows:

Industrial demand total = f (Industrial GDP)

Captive power generation = f (Industrial GDP, Relative value of fuel price and electricity)

PLN's industrial demand = Industrial demand total   Captive power generation

PLN's electricity demand total = Residential demand + Industrial demand +Commercial demand + Public demand

(4) Simulation results

Captive power generation varies depending on price scenario. The result of Scenario 1, in which real fuel price increased until 2004, shows a drop in the generated output from Captive power. The difference between Scenario 1 and Scenario 2 is shown in Table 2.5.4. According to the results of this simulation, about 10 % of the captive power generation is shiftable and this in turn will affect PLN sales.

Table 2.5.4 Captive Power Generation by Scenario (Unit: GWh)

	2000	2005	2010	2015
Scenario 1	18,719	23,906	29,256	35,918
Scenario 2	18,719	26,276	32,159	39,479
Difference	0	2,370	2,901	3,561

Chapter 3 Probability of Power Deficit - Short and medium Term Development Plan -

3.1 Review of the Supply Capacity

Power plants can not always provide power at their installed capacity. Available capacities of hydro power plants decrease by the seasonal derating related to the seasonal water flow. Available capacities of thermal power plants decrease by the temporary defects of equipment or the operating condition of plants. Therefore, the available capacity of the system is influenced by these conditions.

Table 3.1.1 shows the items affecting the system available capacity. In this table, derated capacity is defined as the reduction of capacity related to the power sources, and constrained capacity is defined as the reduction of capacity related to other reasons.

Table 3.1.1 Causes of Constraint

Items	Causes	Peak Load Ratio(%)
Derated capacity covered by GRM	- Hydropower Seasonal Derating - Thermal Power Derating - Maintenance - Forced Outage - Essential Spinning Reserve	5% 2.7% 12% 6% 4.3%
Constrained capacity not covered by GRM	- Constraint due to transmission power flow limitation. - Long term outage - Special Contract Service	NA
Generation Reserve Margin (used in P3B)		30%

In order to evaluate the capacity deficit, we would like to study the operational reserve margin directly along the following procedure:

Study on Existing Power Plant	By studying the existing power planed, installed capacity by type is examined.
⇩	
Study on the Derated Capacity	By studying derated capacities, the validity of the system derated capacity is examined.
⇩	
Study on the Constrained Capacity	By studying constrained capacities, the validity of the system derated capacity is examined.
⇩	
Study on On-going / Planned Projects	By studying on-going and planned project, the commission schedule is studied.

3.1.1 Supply capacity of existing power units

Table 3.1.2 shows the installed capacity by the types of power source and their location in Java-Bali. This table shows the total installed capacity of PLN and IPPs. Captives and cooperatives are not included in the table.

We can see from Table 3.1.2 that the installed capacity of hydropower is 2,536MW (13.6% of the total installed capacity), thermal is 15,307MW (82.2%), and geothermal is 765 MW (4.1%). This means the main power source is thermal power. Conventional steam power units account for 8,450MW(45.4%) and combined cycle power units account for 5,985MW (32.2%).

Regarding location, Java- Bali Area is divided into four Areas: Area 1 (Jakarta and surrounding Areas), Area2 (West Java except Area 1), Area3 (Central Java), and Area4 (East Java and Bali). Most of the thermal power plants are located in Area1 and Area4. On the other hand, most hydropower plants are located in Area2. Most geothermal power plants are located in Area 1 and Area2.

Table 3.1.2 Installed capacity by type and Location (unit: MW)

Items	Areas				Installed Capacity Java-Bali	Capacity Percent %
	Area1	Area2	Area3	Area4		
Hydro	37	1,918	306	275	2,536	13.6
Thermal	7,108	80	1,389	6,730	15,307	82.2
Steam	(4,200)	(0)	(300)	(3,950)	(8,450)	(45.4)
C/C	(2,609)	(0)	(1,034)	(2,343)	(5,985)	(32.2)
GT	(300)	(80)	(55)	(361)	(796)	(4.3)
Diesel	(0)	(0)	(0)	(76)	(76)	(0.4)
Geothermal	330	375	60	0	765	4.1
Sub Total	7,475	2,373	1,755	7,005	18,608	100

Note: The capacity of IPPs is included

Table 3.1.3 shows the installed capacity by fuel. Coal fired power plants account for 6,650MW (35.7% of installed capacity). Natural gas fired power plants (4,749MW / 25.5%) and High Speed Diesel Oil (HSD) fired power plants (3,108MW / 16.7%) have the next largest capacity.

It is important to point out that many combined cycle power plants, which are designed to use natural gas, must operate as HSD fired power plants, because there is no natural gas supply. Muara-Tower thermal power plant (Block I, II), Grati thermal power plant (Block I), and Semarang thermal power plant (Block I, II) are examples.

Table 3.1.3 Installed capacity by fuel type (Unit: MW)

Item	Areas				Installed Capacity Java-Bali	Capacity Percent %
	Area1	Area2	Area3	Area4		
Hydro	37	1,918	306	275	2,536	13.6
Thermal	7,108	80	1,389	6,730	15,307	82.2
(Coal)	(3,400)	(0)	(0)	(3,250)	(6,650)	(35.7)
(Gas)	(2,388)	(80)	(0)	(2,281)	(4,749)	(25.5)
(HSD)	(920)	(0)	(1,089)	(1,099)	(3,108)	(16.7)
(MFO)	(400)	(0)	(300)	(100)	(800)	(4.3)
Geo thermal	330	375	60	0	765	4.1
Sub Total	7,475	2,373	1,755	7,005	18,608	100

Note: The capacity of IPPs is included

Table 3.1.4 shows the installed capacity by owner. Most of the generation capacity is owned by PLN (Indonesia Power, PJB). PLN owns 15,453MW of installed capacity (87% of the total) and IPP own only 3,155MW (17%).

Table 3.1.4 Installed Capacity by owner (unit: MW)

Item	Areas				Installed capacity Java-Bali	Capacity Percent %
	Area1	Area2	Area3	Area4		
Indonesia Power	5,031	1,035	1,695	100	7,862	42.3
PJB	2,128	1,008	0	4,454	7,591	40.8
IPP	315	330	60	2,450	3,155	17.0
Sub total	7,475	2,373	1,755	7,005	18,608	100

3.1.2 Review of the derated capacity covered by GRM

(1) Hydropower Seasonal Derating

Based on the investigation on the seasonal derating capacity of hydropower plants in 2000and in 2001,the maximum seasonal derating capacity is 5.4% of peak load in 2000 and 5.1% of peak load in 2001. Thus it is reasonable to assume that the hydropower seasonal derating is 5% of peak load.

(2) Thermal and Geothermal Power Plant Derating

Table 3.1.5 shows the derating capacity of the available capacity of thermal and geothermal power plants in February 2001. The derating capacity is reviewed every month. In February 2001, no geothermal power plant was derated.

Table 3.1.5 shows the derated capacity is 326MW, accounting for 2.5% of peak load. Thus it is reasonable to assume that the rate of derated capacity can be estimated at about 2.7% of peak load.

(3) Maintenance (Periodical / Planned Repair)

Based on the investigation of maintenance capacity in 2000 and 2001, Average maintenance capacities are 9.6% of peak load in 2000 and 11.3% in 2001. Thus it is reasonable to estimate that the rate of maintenance capacity is about 12% of peak load.

(4) Forced Outage (Unplanned Repair)

Forced Outage Capacity is the derated capacity by unpredictable accidents. P3B collects data of the forced outage rate of each type of thermal power plant and calculates the forced outage capacity. According the statistical data, it is reasonable to assume that the rate of forced outage is about 6% of peak load.

(5) Essential Spinning Reserve

Essential spinning reserve is the necessary capacity for the stable operation of the power system. Thus essential spinning reserve should be equal to or more than the capacity of the largest operating unit.

Currently, the maximum capacity in the Java- Bali system is 615MW of Paiton IPP-I which is about 4.7% of peak load in 2001. Therefore it would be reasonable to estimate the rate of essential spinning reserve at about 4.3% of peak load.

Table 3.1.5 Derated Capacity of Thermal Power Plants

Owner	Power Plant	Unit Type	Unit No.	Fuel	Start of Operation	IC (MW)	AC (MW)	Breakdown of (IC - AC) (MW)						
								Derated by				long-term outage	transmission constraint	others
								fuel	temp.	design	aging			
Indo-nesia Power	Suralaya	PLTU	1	Coal	1984	400	400							
			2	Coal	1984	400	400							
			3	Coal	1988	400	400							
			4	Coal	1989	400	400							
			5	Coal	1996	600	600							
			6	Coal	1997	600	600							
			7	Coal	1997	600	600							
	Tanjung Priok	PLTU	3	MFO	1972	50	0					50		
			4	MFO	1972	50	0					50		
		PLTGU	Block1	NG	1993, 94	590	575			15				
			Block2	NG	1994	590	575			15				
		PLTG	1,3,4,5	HSD,NG	1976-77	150	130				20			
	Tambak Lorok (Semarang)	PLTU	1	MFO	1978	50	45			5				
			2	MFO	1978	50	45			5				
			3	MFO	1983	200	200							
		PLTGU	Block1	HSD	1993, 97	517	494	23						
			Block2	HSD	1996, 97	517	501	16						
	Perak	PLTU	3	MFO	1978	50	45			5				
			4	MFO	1978	50	45			5				
	Grati	PLTGU	Block1	HSD	1996, 97	462	462							
		PLTG	Block2	HSD		302	0					302		
	Sunyaragi	PLTG	1-4	NG	1976	80	68				12			
	Cilacap	PLTG	1-2	HSD	1976	55	41				14			
	Pesanggaran	PLTG	1-4	HSD	1985-93	125	107				18			
		PLTD	1-11	HSD	1982	76	43				33			
	Gilimanuk	PLTG	1	HSD	1997	134	134							
PJB	Muara Karang	PLTU	1	MFO	1979	100	95				5			
			2	MFO	1979	100	95				5			
			3	MFO	1980	100	95				5			
			4	NG	1981	200	190				10			
			5	NG	1982	200	190				10			
		PLTGU		NG	1993, 95	509	470		39					
	Gresik	PLTU	1	NG	1981	100	95				5			
			2	NG	1981	100	95				5			
			3	NG	1988	200	200							
			4	NG	1988	200	200							
		PLTGU	Block1	NG	1992, 93	526	526							
			Block2	NG	1992, 93	526	526							
			Block3	NG	1993	526	526							
		PLTG	1-3	NG	1977, 84	61	54				7			
	Gilitimur	PLTG	1-2	HSD	1994, 95	40	36				4			
	Piton	PLTU	1	Coal	1994	400	400							
			2	Coal	1994	400	400							
	Muara Tawar	PLTGU	Block1	HSD	1997	640	605		35					
		PLTG	Block2	HSD	1997	280	270		10					
IPP	Piton 1	PLTU	5	Coal	1998	615	total 615						total 615	
			6	Coal	1998	615								
	Piton 2	PLTU	7	Coal	2000	610	total 610						total 610	
			8	Coal	2000	610								
	Cikarang List	PLTG	1-4	NG		150	0							150
Total						15,307	13,203	39	84	50	153	402	1,225	150
								326						

IC : Installed Capacity AC : Available Capacity

(6) Generation Reserve Margin

According to the result of the investigation on the generation reserve margin, each item of GRM adopted by P3B is almost adequate. However, essential spinning reserve at 4.3% against the forced outage of one Paiton unit is overlapping with forced outage at 6%. Therefore, by putting essential spinning reserve and forced outage into one, the new essential reserve margin can be set at 6%. Table 3.1.6 shows the proposed GRM in this report. It is reasonable to assume that GRM used for long term power development plan is about 25% in the condition that constraints are relieved.

On the other hand, some constraints, such as the power flow limitation of transmission line, is remaining in short term planning. Thus, supply capacity is evaluated by examining the operational spinning reserve directly in this report.

Table 3.1.6 Evaluation of GRM

Items	P3B	Proposed GRM	Bases
Hydropower seasonal derating	5%	3 - 5%	Same as P3B
Thermal power derating	2.7%	2.7%	Same as P3B
Maintenance	12%	12%	Same as P3B
Forced outage	6%	N/A	Included in essential spinning reserve
Essential spinning reserve	4.3%	6%	Same as forced outage rate of P3B
Total	30%	25%	—

(7) Summarize of Derated Capacity

Derated capacities used in this report is set at the figure in table 3.1.7.

Table 3.1.7 Derated capacity covered by GRM

Items	Capacity (MW)	Bases
(1) Hydropower seasonal derating	671MW	Planning data in 2001 (3-5% of peak load)
(2) Thermal power derating	326MW	Actual data in February 2001. (2.7% of peak load)
(3) Maintenance	Calculate yearly	10% of Operational capacity (12% of peak load)
(4) Essential spinning reserve	Calculate yearly	6% of peak load

3.1.3 Review of the constrained capacity not covered by GRM

(1) Long Term Outage Capacity

- Tanjung-Priok 3&4 (50MW x 2)

These units were rehabilitated in 1988. The turbine grand seal and super heating tubes were replaced in the rehabilitation work. However, the steam leakage from the boiler water wall occurred frequently a few years later. For this reason, these units are not now in use.

- Grati Block II (302MW)

PLN treats Grati block II as stand-by unit, actually on a long term outage. The first reason is no contract to provide natural gas, the second reason is the power system problem that Grati block II can not supply its full rated capacity.

(2) Special Contract Service

- Cikarang Listrindo (IPP/150MW)

Cikarang Listrindo is the IPP power plant located in the Cikarang industrial estate. Since the power is provided only to the industrial estate, the capacity can not be counted as a part of the supply capacity.

(3) Constrained Capacity

Figure 3.1.1.shows the Java-Bali system in 2001. The power demand in Java-Bali system is intensive in Jakarta, while some of large power sources such as Paiton are located in the east. Consequently, a lot of power flows occur east to west through a 500kV trunk line.

The amount of power flow on a trunk line is regulated by either the system stability or the thermal capacity of the transmission line. This limitation will be moderated as demand increases in the eastern area. However, the completion of a southern 500kV trunk line is required to remove this capacity constraint completely.

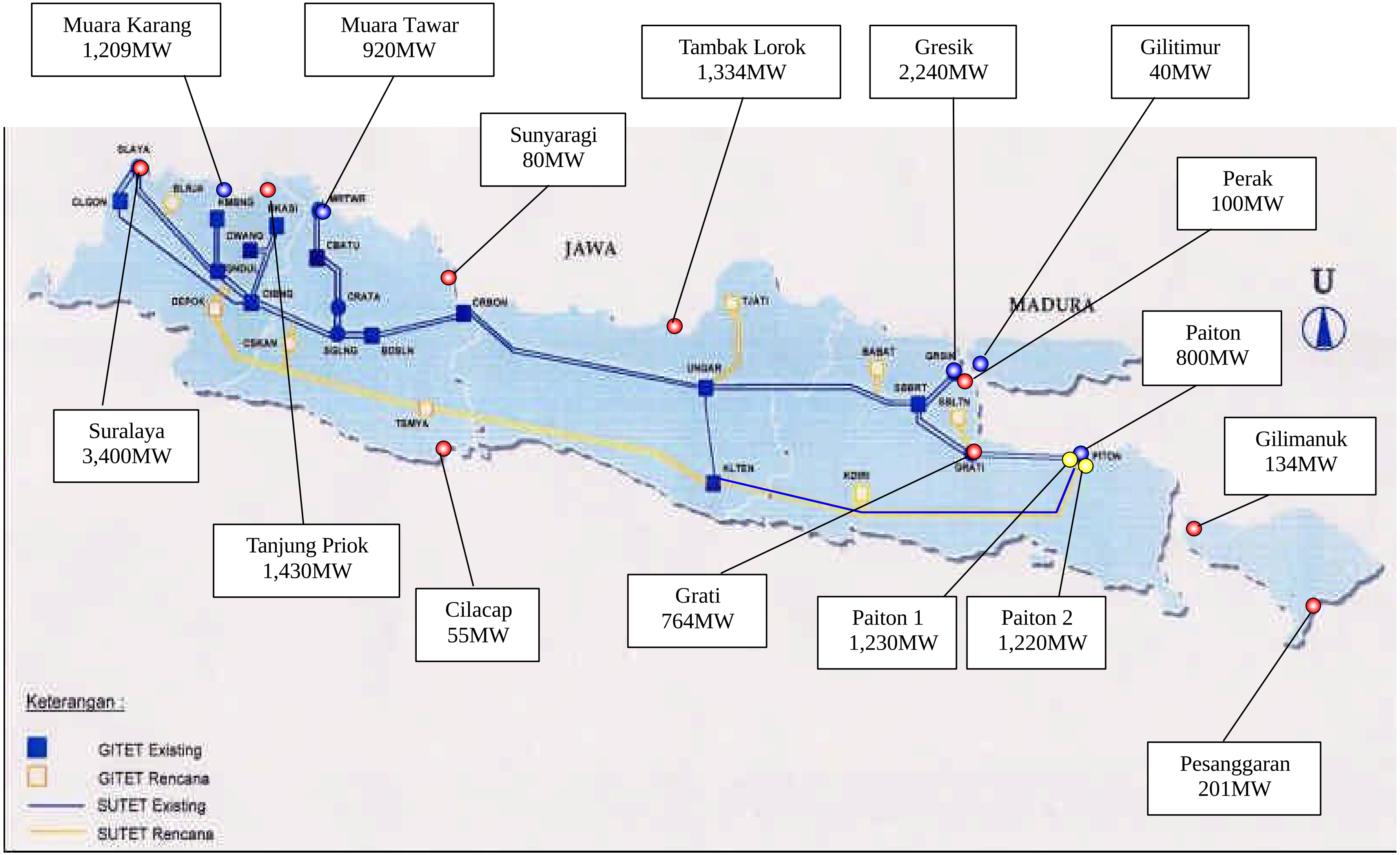
(4) Summarize of Constrained Capacity

Table 3.1.8 shows the constrained capacity used in this report.

Table 3.1.8 Constrained Capacity not to be covered by GRM

Items	Constrained Capacity	Remarks
(1) Long Term Outage		
a. Tanjung- Priok unit 3,4	100MW	*Refer to section 3.1
b. Grati BlockII	302MW	**To be removed in 2003-2004 by relieving the transmission constraint
(2) Special Contract Service Cikarang Listrindo	150MW	*Refer to section 3.1
(3) Constrained Capacity caused by transmission line.		
a. Constrained capacity at present condition	1,000-1,250MW	*Result of the system analysis
b. Commissioning of 500kV southern trunk line (Paiton-Klaten)		
- Tentative commissioning (2002)	500-600MW	*Result of the system analysis
- Complete commissioning (2003)	0 – 300MW	
c. Commissioning of 500kV southern trunk line (Klaten-Depok III) -Complete commissioning (2004)	0MW	*Result of the system analysis

Figure 3.1.1   The Java-Bali System in 2001



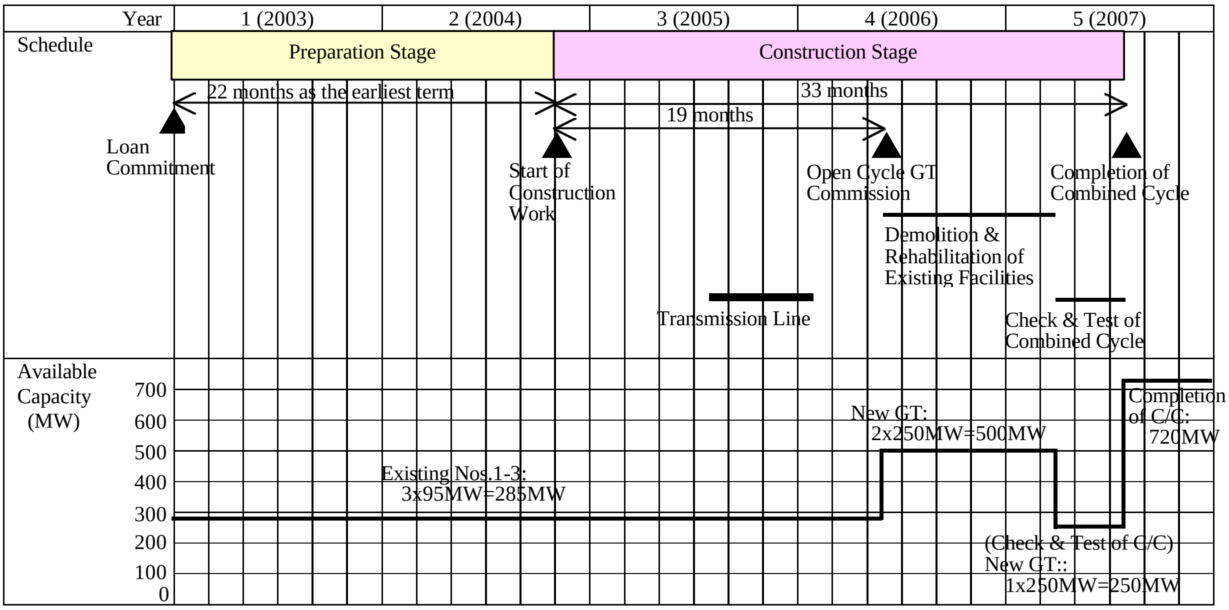
3.1.4 Ongoing / Planned Projects

(1) Repowering project for Muara-Karang unit 1-3 (2006-2007)

This project consists of a few phases. In the first phase, gas turbines (250MW x 2) will be installed without stopping the existing 1-3 units. In the next phase, the existing boilers will be demolished and new heat recovery boilers are installed, the existing steam turbines are combined with the new gas turbine in the last phase.

The schedule is shown in Figure 3.1.2. The feasibility study report indicates the new gas turbines will begin operating in 2006, thus the project can be completed in 2007.

Figure.3.1.2 Overall Project Schedule of Muara Karang Repowering

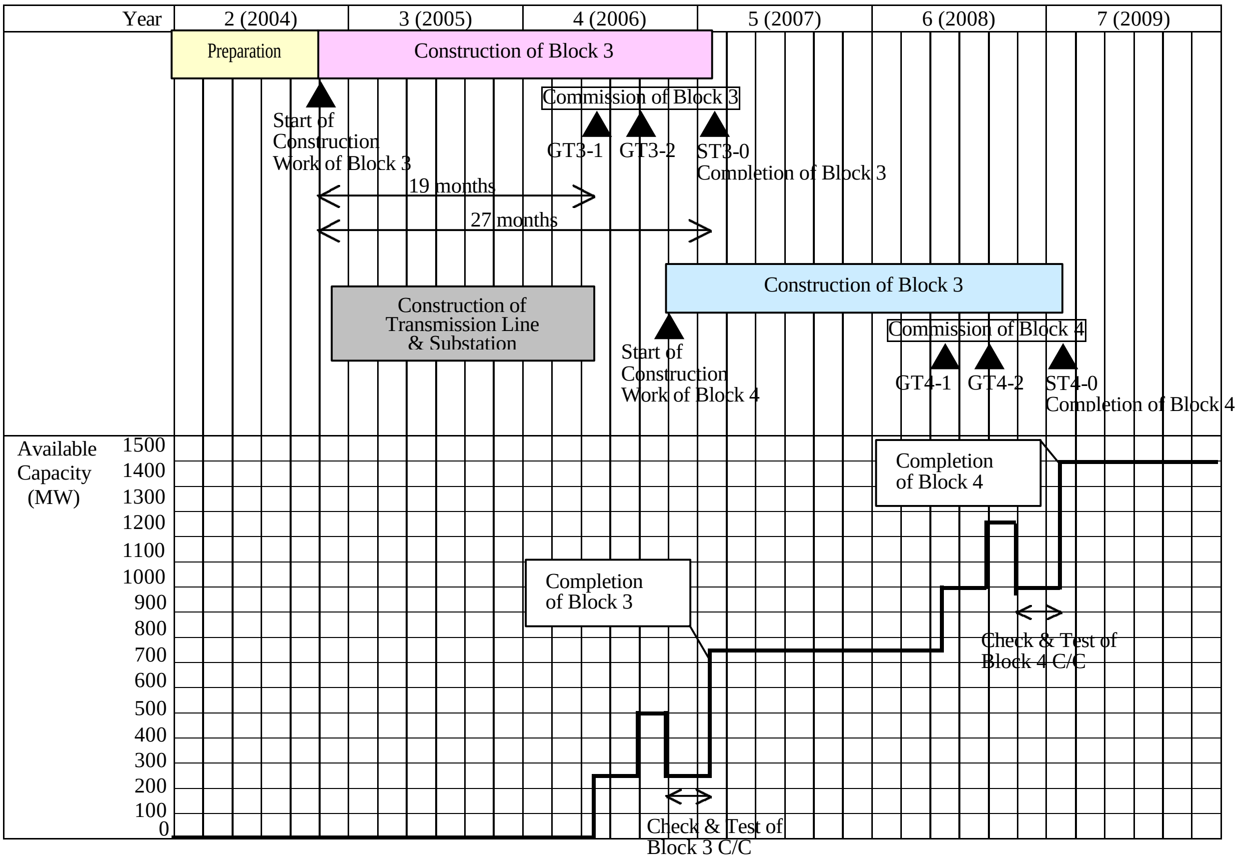


(2) Extension project of Muara-Tower Block III, IV thermal power plant (2006-2009)

There is space for extension power units (Block III and Block IV) at the site of Muara-Tower thermal power plant. In the present plan, a 750MW combined cycle facility consisting of gas turbines (250MWx2) and steam turbine (250MW) will be installed in each block. In total 1,500MW will be installed.

Figure 3.1.3 shows the project schedule based on the feasibility study report. In this case the commissioning of the first gas turbine will be in 2006. Meanwhile the present installed capacity of Muara- Tower power plant is about 1,000MW. After completing BlockIV, the total capacity of Muara-Tower power plant will be about 2,500MW. Since the total capacity of Muara-Tower power plant would be bigger than the heat capacity of single transmission line, it is necessary to investigate how to transmit power flow stably.

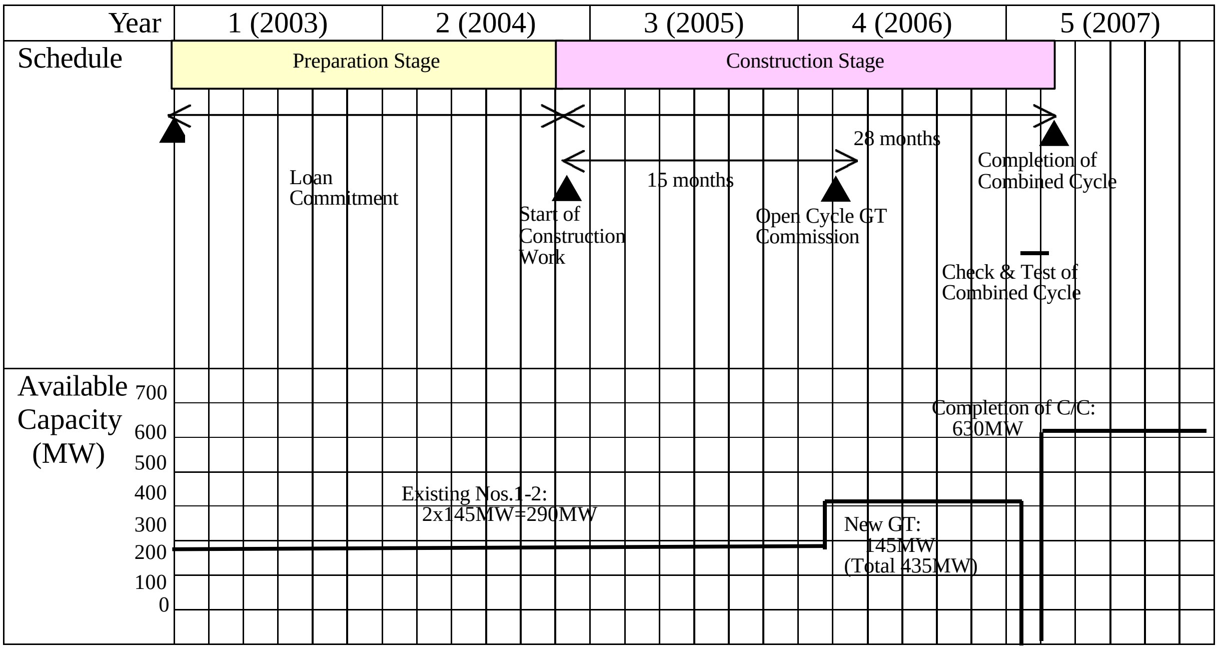
Figure 3.1.3 Overall Project Schedule of Muara-Tawar Extension



(3) Muara-Tower BlockⅡ Added on Project (2006-2007)

Since the feasibility study was completed by the end of Mach, 2002, the Muara-Tower Block Ⅱ Project is one of the candidate for the Japanese ODA loan. By installing a new gas turbine (145MW) and a new steam turbine (225MW), the existing open cycle gas turbines will become a combined cycle power plant. The total increased capacity is 370MW. Figure. 3.1.4 shows the project schedule estimated by reviewing the feasibility study report. The commissioning year of the gas turbine is expected to be in the beginning of 2006.

Figure. 3.1.4 Overall Project Schedule of Muara-Tawar Block Ⅱ Added on



(4) Tanjung-Priok thermal power plant repowering project

The feasibility study was completed by the end of Mach, 2002. The new combined cycle power plant consisting of two gas turbines (250MW x 2) and one steam turbine (250MW) will be installed after demolishing the existing No.3 and No.4 units (50MW x 2). Thus the increased capacity will be 650MW despite the total capacity (750MW). The further study on the transmission line and the sea water system should be required to realize this project. The total project cost will be estimated about US$455 million.

(5) Pemaron thermal power plant (2003&2004)

A new combined cycle power plant will be constructed by combining a new steam turbine with the gas turbines, which will be moved from Tanjung-Priok. The gas turbines (50MW x 2) will start operating in 2003 and completion (total 150MW) is expected in 2004. It is estimated that the installation work from design to commissioning requires at least two years. Since the procurement of the steam turbine and the heat recovery boiler are under negotiation, the commissioning of gas turbines will be in 2003 and the completion will be in 2004, according to the PLN. The project cost is expected to be about US$98million.

(6) Tanjung-Jati B (IPP: the second half of 2005)

According to the PLN, the PPA agreement between PLN and the owners is almost agreed. After completing the loan agreement between banks including the JBIC and the Indonesian government, the interrupted installation work will resume. The necessary construction period will 36 months for the No.1 unit and 39 months for the No.2 unit. According to the EPC contractors, the manufacturing of the equipment is about 70% completed. Some equipment is kept onsite, but most of it is kept in the manufacturer's storehouse. A new 500kV transmission line for Tanjun-Jati B is planned to connect to near the Purwodadi sub station of the existing northern 500kV trunk line. However, it is necessary to connect it with the Ungaran sub station directly because of the constraint of power flow.

(7) Upper Cisokan pumped storage power plant

The Upper Cisokan project is in the design stage by PLN, using a Japanese ODA scheme. The total capacity is 1,000MW. The operation of each plant is expected to start in 2009 (500MW) and 2010 (500MW).

(8) New 500kV trunk line (Southern route)

To reduce the power flow on the existing 500kV trunk line (Northern Route), a new 500kV trunk line (Southern Route) is expected to be commissioned in 2004.

*Paiton - Kediri - Klaten

The construction work for the Kediri sub station and Paiton GIL is behind the schedule due to funding problems. By commissioning this section, the constrained capacity of power plants in East Java would be relieved. Tentative commissioning is planed for the single transmission line in 2002, with completion slated for 2003.

*Klaten-Tasikmaralya- DepokIII

There are plans to commit a new trunk line between Klaten-Tasikmalaya-DepokIII in 2004. Since the acquisition of land around the DepokIII sub station is behind the schedule, the commission will be delayed for a few years. The commissioning of this section will completely remove the capacity constraints of the power plants in East Java.

3.1.5 Fuel supply Issues

(1) Coal Supply

The trouble caused by coal shortage occurs simultaneously multiple units in the same power plant, thereby causing a more serious effect, thus it is very important to prepare the infrastructure of the coal delivery. Table 3.1.9 shows the number of troubles in 2000 caused by the shortage of coal.

Table 3.1.9 Number of troubles by shortage of cal

	Total	Caused by Coal Supply	%
Number of Derating	652	183	28%

Source: P3B data

(2) Gas Supply

Table 3.1.10 shows the number of troubles caused by fuel shortage in 2000. A supply of fuel gas is very important in order to stabilize the power supply.

Table 3.1.10 Number of Troubles Caused by Gas Shortage in 2000

	Total	Caused by Gas Supply	%
Number of Forced Outage	529	5	1%
Number of Derated	652	112	17%

Source: P3B data

Figure. 3.1.4 shows the natural gas supply plan in Pertamina. The gas supply plan for the power sector calls for the provision of about 840-1050MMSCFD of fuel gas until 2015. It accounts for 330-380BSCF per year.

The contract for gas supply for Muara-Karang and Tanjung-Priok will be terminated in 2004, however, no procurement is done after 2004. Meanwhile, Muara-Karang No.1-3 units have the repowering plan. After repowering, the fuel consumption of the new unit requires an additional 700kton/year of natural gas. On the other hand, natural gas for the Muara-Tower thermal power plant is planned to be supplied through a future Java-Sumatra gas pipeline according to the Pertamina.

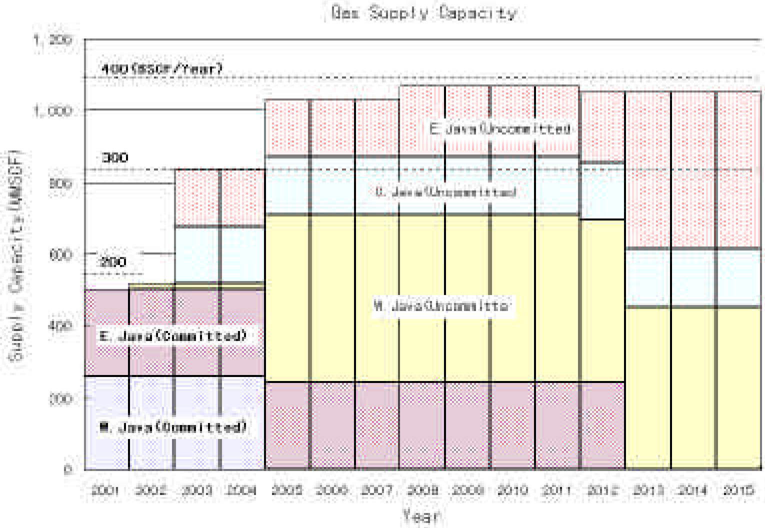


Figure. 3.1.4 Natural Gas Supply Plan in Pertamina

3.2 Probability of Power Deficit

3.2.1 Demand scenario

JICA/LPE_CASE 2 --- Real price constant scenario which is not required to take the price effect into account in determining the demand

JICA/LPE_CASE 1 --- Scenario which price effect is taken into account in determining the power demand. Planned price is taken is 2001 and 2002. Finally the price increases to about 7 cents / kWh.

3.2.2 Supply Scenario

The power deficit is studies based on the scenario shown in table 3.2.1.

Table 3.2.1 Development Scenarios (Sensitive Study)

Item ＼ Scenario		Normal Scenario					Slipped Scenario
Project Name	Capacity Increased (MW)	Base Case	Base + MTII Case	Base + MT III Case	MTII Added on Case	Limited Development Case	Slipped Base Case
Muara-Karang Repowering	420 (720)	2006&2007			NA		2007& 2008
Muara-Tower Block III Extension	750	NA		2006 &2007	NA		NA
Muara-Tower II Added On	370 (660)	NA	2006 &2007	NA	2006 &2007	NA	NA
Pemaron C/C	50 (150)	2003&2004					2003 &2004
Tanjung-Jati B	1,320	2005					2005
Southern 500kV Trunk line (Paiton- Klaten: Tentative Commissioning)	According to the	2002					2002
Southern 500kV Trunk line (Paiton-Klaten: Partial Complete)	system analysis	2003					2003
Southern 500kV Trunk line (Completion)		2004					2004

Schedule of Normal Scenario

*Muara-Karang repowering project	---	Review of the feasibility study report
*Muara-Tower Block Ⅲ extension project	---	Review of the feasibility study report
*Muara-Tower Block Ⅱ Added on project	---	Review of the feasibility study report
*Pesanggaran / Pemaron project	---	Not to count as the available capacity
*Tanjung-Jati B	---	Result of the 4th-work Indonesia
*500kV trunk line (Southern Route)	---	Result of the 4th-work Indonesia
*New Gas Turbine etc.	---	(Please Refer to Chapter 7)

(2) Method of Evaluation of Available Capacity.

Table 3.2.2 shows the demand-supply balance for base case. The operational spinning reserve will become smaller than the essential spinning reserve in 2003 and become negative from 2004. Therefor the short term countermeasures should be required for operating the system stably. The capacity deficit will reach 2,193MW in 2007.

Table 3.2.2 Demand- Supply Balance for Base Case - JICA/LPE Case 2- (Unit: MW)

Year	2001	2002	2003	2004	2005	2006	2007
a. Installed Capacity	18,608	18,608	18,608	18,658	19,978	20,178	20,398
• Existing capacity	18,608	18,608	18,608	18,608	18,608	18,308	18,308
• New capacity	0	0	0	50	1,370	1,870	2,090
b. Available capacity	14,292	15,082	15,572	15,900	17,088	17,268	17,466
•Hydropower seasonal derating	671	671	671	671	671	671	671
• Thermal power derating	326	326	326	326	326	326	326
• Maintenance	1,476	1,476	1,476	1,511	1,643	1,663	1,685
• Long term outage	462	402	402	100	100	100	100
• Special contract service	150	150	150	150	150	150	150
• Transmission constraint	1,231	501	11	0	0	0	0
c. Peak Load	13,041	14,089	15,073	16,071	17,170	18,374	19,659
• Essential Spinning reserve	782	845	904	964	1,030	1,102	1,180
• Operational Spinning reserve	1,251	993	*499	△171	△82	△1,106	△2,193
• LOLP (day / year)	0.1	1.4	5.5	NA	NA	NA	NA

* Years operational spinning reserves are smaller than essential spinning reserves.

The operational spinning reserve and the essential spinning reserve are calculated by the equations below:

*Operational spinning reserve = Available Capacity - Peak Load (MW)................. 3 - 1

*Essential spinning reserve = Peak load x 6%.. 3 - 2

The operational spinning reserve should be evaluated by the following equation.

*O.S.R. ≧ E.S.R. The power system can be operated stably.

*O.S.R. < E.S.R. The power system can be operated.
If a power plant stopped accidentally, some problems, such as black out of a limited area, would occur.

*O.S.R. ≦ 0 Since the power system can't be operated, counter measures, such as rotational black out, would be required.

**ESR: Essential Spinning Reserve, O.S.R: Operational Spinning Reserve............ 3 - 3

Meanwhile, there is another method to evaluate the system reliability, such as Loss of Largest Generating Unit Method. Table 3.2.3 shows the evaluation result of system reliability by the deference of evaluating method.

Table 3.2.3 Evaluation of Essential Spinning Reserve

Items	LOLP	Spinning Reserve (MW)	Loss of Largest Generating Unit Method (615MW)
E.S.R 6%	2 days / year	964 - 1,030MW	Largest Unit (615MW) + Old Unit (200MW)
E.S.R 8%	1 day / year	1,286- 1,374MW	Largest Unit x 2

3.2.3 Probability of Power Deficit

Table 3.2.4 summarizes the operational spinning reserve examined in the sensitive study.

(1) Effect of fluctuation of demand growth

・JICA/LPE CASE 2

The operational spinning reserve will be below the essential spinning reserve in 2003 and will be negative from 2004 in all cases. Therefore short-term countermeasures should be taken in order to operate the power system stably. The deficit of the Operational Spinning Reserve in 2004 and in 2005 will reach about △171MW and △82MW, thus the deficit capacity is contribute to estimate the necessary capacity for the short term countermeasures.

・JICA/LPE CASE 1

The operational spinning reserve will be below the essential spinning reserve in some years but the power system can be operated until 2005 in all cases. The power system can be operated until 2006 in the Base Case, the Base + Muara-Tower BlockⅡ and the Base + Muara-Tower BlockⅢ Case, and also can be operated untill 2005 in the Muara-Tower Added On Case, the Limited Case and the Slipped Base Case without short term countermeasures.

Table 3.2.4 Operational Spinning Reserve for All Development Scenarios (Unit: MW)

Year	2001	2002	2003	2004	2005	2006	2007
1. JICA/LPE CASE 2							
1) Peak Load	13,041	14,089	15,073	16,071	17,170	18,374	19,659
2) Essential Spinning Reserve	782	845	904	964	1,030	1,102	1,180
3) Operational Spinning Reserve							
・Base Case	1,251	993	*499	△171	△82	△1,106	△2,193
・Base+Muara-Tower Block II Case	1,251	993	*499	△171	△82	△975	△1,860
・Base+Muara-Tower Block III Case	1,251	993	*499	△171	△82	△656	△1,518
・Muara-Tower Block II Added on Case	1,251	993	*499	△171	△82	△1,155	△2,238
・Limited Development Case	1,251	993	*499	△171	△82	△1,286	△2,571
・Slipped Base Case	1,251	993	*499	△171	△82	△1,286	△2,391
2. JICA/LPE CASE 1							
1) Peak Load	13,041	13,821	14,497	15,266	16,185	17,220	18,348
2) Essential Spinning Reserve	782	829	870	916	971	1,033	1,101
3) Operational Spinning Reserve							
・Base Case	1,251	1,161	872	*634	*903	*48	△882
・Base+Muara-Tower Block II Case	1,251	1,161	872	*634	*903	*179	△549
・Base+Muara-Tower Block III Case	1,251	1,161	872	*634	*903	*498	△207
・Muara-Tower Block II Added on Case	1,251	1,161	872	*634	*903	△1	△927
・Limited Development Case	1,251	1,161	872	*634	*903	△132	△1,260
・Slipped Base Case	1,251	1,161	872	*634	*903	△132	△1,080

* Years operational spinning reserves are smaller than essential spinning reserves.

** Other Capacity to be Redacted ＝ Hydro power seasonal derating + Thermal Derating + Long Term Outage + Special Contract Service + Transmission constraint

(2) Effect of project development

The years in which the operational spinning reserve will become smaller than the essential spinning reserve are 2006 for the Base Case and 2005 for the Limited Development Case. The effect of project development is about one year for the Muara-Karang re-powering in JICA/LPE CASE 1. Since the operational spinning reserve will be negative from 2004, the project development will not influent on the years of power deficit in JICA/LPE CASE 2

(3) Effect of Project Slippage

The years in which the operational spinning reserve will be negative will be in 2007 in the Base Case and in 2006 in the Slipped Base Case, the effect of project slippage is only one years in JICA/LPE CASE 1. On the other hand, the project slippage will not influent on the year of power deficit in JICA/LPE CASE 2, since the operational spinning reserve will be negative from 2004.

3.3 Short -Term Countermeasures against Power Deficit

3.3.1 Items of Short - Term Countermeasures

Table 3.3.1 summarizes the items and effects of short-term countermeasures described in the previous section. All counter measures have to be reviewed carried out considering the cost performance.

Table 3.3.1 Effects of short-term countermeasures

Countermeasures	Estimated Effects	Policies
(1) Fuel Supply	-	Avoid generating troubles by securing fuel
(2) Reduction of the Forced Outage	-	Apply protection systems widely against common troubles
(3) Effective scheduling of periodic repair a. Shift of Periodical Repair	3% of operational capacity	*Reduction of Average maintenance rate(10%→7%) (refer to 5-1 and 5-2)
b. Shortening and strict observation the Periodical Repair on Schedule	-	Increasing the availability
c. Extended Operation	76MW	*Reduction of maintenance rate(7% →5%), of Muara-Karang 4,5 and Suralaya 1-7.
(4) Rehabilitation		
a. Muara-Karang unit 4,5	20MW	Exchange a HP Heater
b. Suralaya unit 1-4	80MW	Exchange turbine blades
(5) Improvement of Operation	N/A	Improve only the thermal efficiency
(6) Brown Out	188MW	Based on the analysis of P3B
(7) Rotational Black Out	N/A	-
(8) Buy out of Captives	Maximum 250MW	Based on the plan of PLN
(9) Request customers to Reduce Power Consumption	-	-
(10) Contract for Control of Demand – Supply Balance	-	-
(11) Control of Connection of New Customer to the System	-	-

3.3.2 Effect of the Short - Term Countermeasures

To confirm the effect of the short-term countermeasures described before, trial calculation for the improved capacities in Base Case and Slipped Base Case are carried out.

(1) Improved Capacity of the Countermeasures

Table 3.3.2 shows the maximum improved capacity by short-term countermeasures.

Table 3.3.2 Maximum Improved Capacity by Short - Term Countermeasures

Year	2001	2002	2003	2004	2005	2006	2007
(1) Rehabilitation							
• Muara-Karang 4 & 5	0	20	20	20	20	20	20
• Suralaya 1 – 4	0	0	80	80	80	80	80
(2) The Maintenance Shift							
*Base Case	246	246	442	453	492	498	505
*Slipped Base Case	246	246	442	453	492	492	498
(3) Extended Operation	0	0	76	76	76	76	76
(4) Brown Out	188	188	188	188	188	188	188
(5) Buy out of Captives	0	50	100	150	200	250	250
(6) Total Improvement A. Base Case							
• Counter Measures(100%)	434	504	906	967	1,056	1,112	1,119
• Counter Measures (50%)	217	252	453	483	528	556	559
B. Slipped BaseCase							
• Counter Measures(100%)	434	504	906	967	1,056	1,106	1,112
• Counter Measures (50%)	217	252	453	483	528	553	556

(2) Effect of Short Term Counter Measures

1) JICA/LPE_CASE 2

Table 3.3.3 shows the effect of the short - term counter measures

・Base Case

In the case that all (=100%) of the countermeasures are achieved, the time in which a power deficit is expected to occur will be delayed for three years. In the case that half (=50%) of the countermeasures are achieved, the time in which a power deficit is expected to occur will be delayed for two years. Thus, the short-term countermeasures should be carried out to avoid power deficits.

・Slipped Base Case

Countermeasures (=100%&50%) is expected to contribute to delay the time in which a power deficit is expected to occur for two years. Thus, the short-term countermeasures should be carried out to avoid power deficits.

Table 3.3.3 Operational spinning reserve after taking countermeasures

Year	2001	2002	2003	2004	2005	2006	2007
1. JICA/LPE CASE 2							
1) Peak Load (MW)	13,041	14,089	15,073	16,071	17,170	18,374	19,659
2) E.S.R (MW)	782	845	904	964	1,030	1,102	1,180
A. Base Case							
3) a Operational Situation before Countermeasures.							
・O.S.R (MW)	1,251	993	*499	△171	△82	△1,106	△2,193
・LOLP (Day / year)	0.1	1.4	5.5	NA	NA	NA	NA
4) a Effect of Short term countermeasures (100%)							
・Improved Capacity (MW)	434	504	906	967	1,056	1,112	1,119
・O.S.R after countermeasures (MW)	1,685	1,497	1,405	*796	*974	*6	△1,074
・LOLP (Day / year)	0.0	0.3	0.6	2.7	2.1	12.2	NA
5) a Effect of Short term countermeasures (50%)							
・Improved Capacity (MW)	217	252	453	483	528	556	559
・O.S.R after countermeasures (MW)	1,468	1,245	952	*312	*446	△550	△1,634
・LOLP (Day / year)	0.0	0.7	2.0	7.2	6.2	NA	NA
B. Slipped Base Case							
3) b Operational Situation before Countermeasures.							
・O.S.R. (MW)	1,251	993	*499	△171	△82	△1,286	△2,391
・LOLP (Day / year)	0.1	1.4	5.5	NA	NA	NA	NA
4) b Effect of Short term countermeasures (100%)							
・Improved Capacity (MW)	434	504	906	967	1,056	1,106	1,112
・O.S.R. after countermeasures (MW)	1,685	1,497	1,405	*796	*974	△180	△1,279
・LOLP (Day / year)	0.0	0.3	0.6	2.7	2.1	NA	NA
5) b Effect of Short term countermeasures (50%)							
・Improved Capacity (MW)	217	252	453	483	528	553	556
・O.S.R after countermeasures (MW)	1,468	1,245	952	*312	*446	△733	△1,835
・LOLP (Day / year)	0.0	0.7	2.0	7.2	6.2	NA	NA

* : The year operational spinning reserve is smaller than essential spinning reserve.

2) JICA/LPE_CASE 1

Table 3.3.4 shows the effect of the short - term counter measures

・Base Case

In the case that all (=100%) of the countermeasures are achieved, the time in which a power deficit is expected to occur will be delayed for a year. In the case that half (=50%) of the countermeasures are achieved, the operational reserves and LOLP from 2003 to 2006 will be improved.

・Slipped Base Case

In the case that all (=100%) of the countermeasures are achieved, the time in which a power deficit is expected to occur will be delayed for a year. In the case that half (=50%) of the countermeasures are achieved, the operational reserves and LOLP from 2003 to 2006 will be improved.

Table 3.3.4 Operational Spinning Reserve after taking countermeasures

Year	2001	2002	2003	2004	2005	2006	2007
1. JICA/LPE CASE 1 demand							
1) Peak Load (MW)	13,041	13,821	14,497	15,266	16,185	17,220	18,348
2) E.S.R (MW)	782	829	870	916	971	1,033	1,101
A. Base Case							
3) a Operational Situation before Countermeasures.							
・O.S.R (MW)	1,251	1,161	872	*634	*903	*48	△882
・LOLP (Day / year)	0.1	0.9	1.9	4.2	2.7	11.2	NA
4) a Effect of Short term countermeasures (100%)							
・Improved Capacity (MW)	434	504	906	967	1,056	1,112	1,119
・O.S.R after countermeasures (MW)	1,685	1,665	1,778	1,601	1,959	1,160	*237
・LOLP (Day / year)	0.0	0.2	0.1	0.3	0.2	1.4	9.0
5) a Effect of Short term countermeasures (50%)							
・Improved Capacity (MW)	217	252	453	483	528	556	559
・O.S.R after countermeasures (MW)	1,468	1,413	1,325	1,117	1,431	*604	△323
・LOLP (Day / year)	0.0	0.4	0.5	1.3	0.7	4.7	NA
B. Slipped Base Case							
3) b Operational Situation before Countermeasures.							
・O.S.R (MW)	1,251	1,161	872	*634	*903	△132	△1,080
・LOLP (Day / year)	0.1	0.9	1.9	4.2	2.7	NA	NA
4) b Effect of Short term countermeasures (100%)							
・Improved Capacity (MW)	434	504	906	967	1,056	1,106	1,112
・O.S.R after countermeasures (MW)	1,685	1,665	1,778	1,601	1,959	*974	*32
・LOLP (Day / year)	0.0	0.2	0.1	0.3	0.2	2.2	12.2
5) b Effect of Short term countermeasures (50%)							
・Improved Capacity (MW)	217	252	453	483	528	553	556
・O.S.R after countermeasures (MW)	1,468	1,413	1,325	1,117	1,431	*421	△524
・LOLP (Day / year)	0.0	0.4	0.5	1.3	0.7	6.6	NA

* shows the year operational spinning reserve is smaller than essential spinning reserve.

Chapter 4 Optimal Power Development Plan -Long Term Development Plan-

The optimal power development plan can be defined as a kind of the least cost development plan which contributes to continuous national development by providing stable power at affordable prices, taking environmental preservation and effective use of primary energy sources into account.

In the past, the PLN regarded the least cost development plan as the basis for investment decisions when they invest in new equipment. In the future, the power supply system will be changed in accordance with the liberalization of the power market moves forward. However, the fundamental policy of minimizing the necessary investment in the power market will not be changed. Thus, the least cost development plan described in this chapter will be applicable as the optimal power development plan even in the liberalized energy market.

The role of the government is to study the ideal state of the electricity market and show this to the private sectors in order to encourage the grater investment in the power sector. The present of the optimal power development plan to the public should serve as a guide when private sectors decide to invest in the power market.

1st Step: Screening Curve Analysis

Screening curve analysis estimates the optimal component ratio of power sources by using the levelized annual cost and the load duration curve. In order to understand the concept of the optimal component ratio and the results of the simulation analysis, it is greatly useful to analyze screening curve before using the WASP-IV.

2nd Step: Preparing the Optimal Power Development Plan simulated by WASP-IV

The least cost development plan is simulated using Wasp-IV. The least cost plan is prepared as a base case and is reviewed from the viewpoints of the lead time for construction and fuel supply constraints. The issues to be solved for the stable power supply is studied and the policies to realize the power development plan is proposed.

3rd Step: Review of Optimal Power Mixture

In order to put the index for the long-term power development plan, the component ratio of power sources to realize the least cost development is examined, assuming the limitation is relieved. Moreover, the trial calculation is done on the component ratio of power sources taking the environmental issues and energy effective use into account.

4.1 Screening Curve Analysis

4.1.1 Load Factor

Table 4.1.1 shows the load factors in the South-East Asian countries. The load factors of Java-Bali is moving around 70%, thus the component ratio of base load is likely to become larger than other power sources.

Table 4.1.1 Load Factors in the South - East Asian Countries (Unit: %)

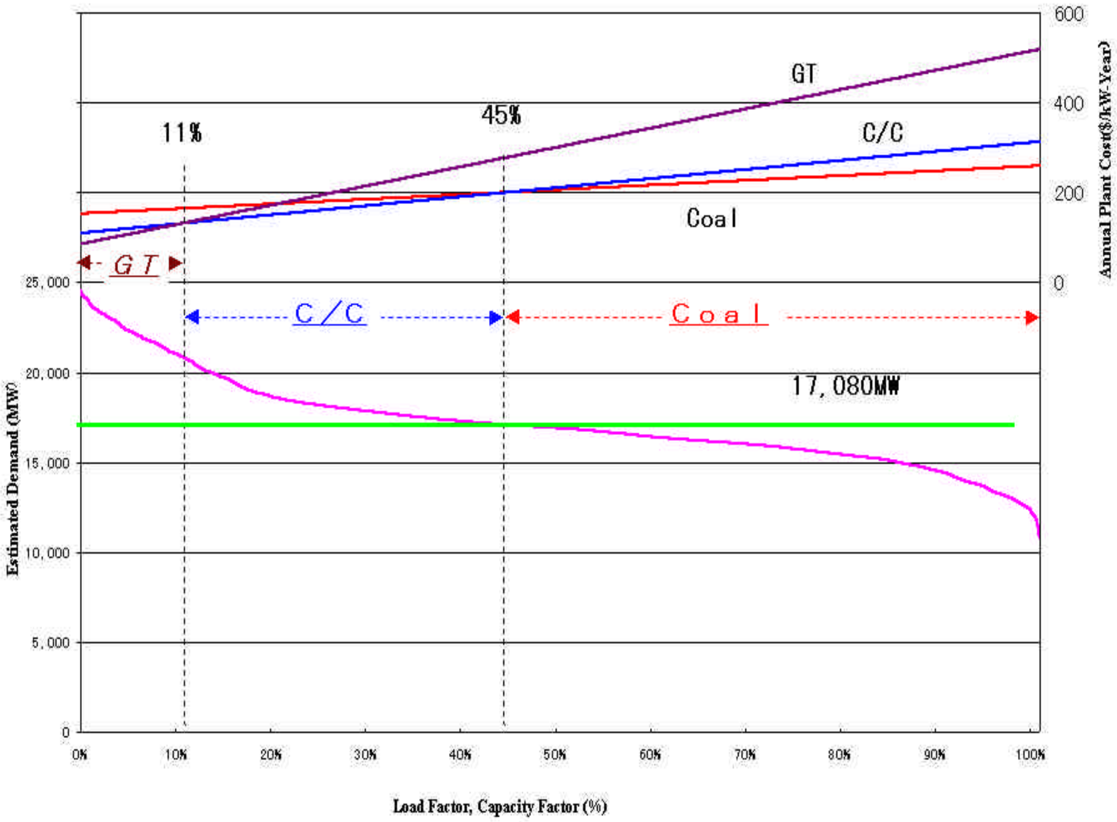
Country \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Indonesia (Java-Bali)	62.1	67.5	65.1	72.8	74.9	68.0	66.8	68.6	70.1	68.9	67.6
Thailand	68.8	70.4	71.7	73.6	74.4	74.5	75.1	73.1	71.3	71.9	74.4
Philippine	70.3	71.2	71.2	56.6	65.0	72.6	71.3	70.3	69.6	70.8	68.6

Source: Overseas Electric Power Industry Statistics/ Japan Electric Power Information Center, Inc. & PLN STATISTICS

4.1.2 Screening Curve Analysis

Figure 4.1.1 shows the screening curve of the power sources and the estimated duration curve in 2010. The upper curve shows the annual cost of each power source and lower curve shows the duration curve in 2010.

Figure. 4.1.1 Screening Curve Analysis



Source: PLN, P3B

Based on the result of screening curve analysis, the economical criteria of power sources are shown below:

Capacity Factor	Economical Order
11% >	Gas Turbine (Oil) is the most economical power source.
>45%, >11%	Combined Cycle System (Gas) is the most economical power source.
>45%	Steam Turbine System (Coal) is the most economical power source.

On the other hand, the present base load capacity is 9,950MW (Hydro: 2,536MW, Geothermal: 765MW, Coal: 6,650MW), the additional capacity of coal power unit would be about 7,000 MW (= 17,080MW - 9,950MW), assuming the necessary capacity is developed only by coal.

4.2 Optimal Power Development Plan

By using Wasp-IV, the optimal power development plan is examined. The study procedure is shown below:

a. Preparing the least Cost Power Development Plan (Base Case)	The least-cost power development plan is simulated by WASP-IV as base case.
⇩	
b. Examining the base case by Sensitive Study	Effects of limitations such as fuel price, environment issues etc., is examined from the viewpoint of effective use of primary energy.
⇩	
c. Examining the problem to be solved for stable power supply.	Taking the result of sensitive study, problem to be solved for stable power supply is made clear. The way to realize the power development plan is examined.

4.2.1 Base Case Study

(1) Condition

Base Case is defined as the least-cost power development plan with no limitation in and after 2006.

<u>a. Power projects to be considered as the fixed project</u>

Projects are determined based on "Base Case" mentioned in chapter 5. Model power sources are added to this scenario.

[JICA Limited Development Scenario 2]

* Pemaron C/C : Operation will start in 2003 (1000MW) / GT only
  In 2004 (150MW) / complete
* Tanjung-Jati B: Operation will start in 2004 (660MW), 2005 (660MW)
* Muara-Karang repowering: Operation will start in 2005 (500MW) / GT only
  In 2006 (720MW) / complete

<u>b. Electricity Demand</u>

Demand "JICA/LPE_CASE1 and JICA/LPE_CASE2", mentioned in chapter 2

c. Period studied

15 years

d. System Reliability

Criteria of the system reliability is set at on 1 day / year in LOLP after 2006

e. Discount rate

12%

f. Limitation of fuel supply

* Combined Cycle (Gas): Take-or-Pay contract is considered only to the existing unit.
Fuel conversion from HSD to Gas at Grati, Tamba-Lorok, Muara-Tower power stations are not considered.

g. Model Power Sources

Four kinds of model power source are considered in the simulation. Table 4.2.1 shows the characteristics of each model power source.

Table 4.2.1 Characteristics of the Model Power Sources

Unit Type	Steam Turbine Unit	Combined Cycle Unit	Gas Turbine Unit	Pump-Storage Unit
Abbreviation	ST	C/C	GT	PS
Fuel	Coal	Gas	HSD	-
Capacity (MW)	600	600 (150GT x 3 + 150ST x 1)	120	250
Construction Cost ($ / kW)	900	650	500	600
Life Time (Years)	25	20	15	50
Construction Period (Years)	4	3	2	5
Fuel cost (US$ / Gcal)	4.2	*8.7-10.1	14.5	-
Cycle efficiency for Pump Storage unit	-	-	-	70%
Heat Rate (kcal / kWh)	2380	2100	3100	-

* Depending on units / power plants

h. Commissioning Year

*Steam Turbine P/S (Coal) : On and after 2006, except for Tanjung-Jati B.

*Combined Cycle P/S (Gas): On and after 2006, except for Muara-Karang.

*Gas Turbine P/S (HSD) : On and after 2006

(2) Power Development Plan

Table 4.2.2 shows outputs of WASP-IV in case of JICA/LPE_CASE2 demand and JICA/LPE Case_1 demand.

Table 4.2.2 Simulation Output of WASP-IV (Base Case)

Year	Demand-JICA/LPE CASE 2					Demand-JICA/LPE CASE 1				
	Demand	ST	C/C	GT	P-S	Demand	ST	C/C	GT	P-S
	(MW)	Number of Units				(MW)	Number of Units			
2001	13,041					13,041				
2002	14,089					13,821				
2003	15,073					14,497				
2004	16,071			3) 1		15,266			3) 1	
2005	17,170	1) 2				16,185	1) 2			
2006	18,374	4	2) 2			17,220	3	2) 1		
2007	19,659		2			18,348		2		
2008	21,075		2	3		19,612	1	1		
2009	22,621	3		1		21,000	1	1	3	
2010	24,297	3		2		22,539	2	1		
2011	26,099	3		2	1	24,225	4			
2012	28,040	3	1			26,058	3			1
2013	30,131	3			2	28,048	2	1	2	1
2014	32,380	3			3	30,208	2		1	4
2015	34,800	5				32,549	5			
Total Number		29	7	9	6	-	25	7	7	6
Total Capacity (MW)		17,520	4,320	1,110	1,500		15,120	4,320	870	1,500

1) The Figure shows Tanjung-Jati B, 2) The figure includes the Muara-Karang Repowering

3) The figure shows the Pemaron C/C

a. Steam Turbine Power Unit (Coal-Fired)

The power development would rely on many coal-fired steam turbine units. This is coincident with the result of the screening curve analysis. The necessary capacity in 2015 is nearly 17,520MW in JICA/LPE_CASE2.

b. Combined Cycle Power Unit (Gas Fired)

The necessary capacity of combined cycle power unit is not so affected as coal-fired units by base load, because it is believed that certain capacity to meet middle / peak demand are necessary to operate power system stably.

c. Gas Turbine Power Unit (HSD Fired)

The necessary capacity is about 870MW-1,110MW, not so large, in both of JICA/LPE_CASE1 and JICA/LPE_CASE2.

d. Pumped Storage Power Unit

The number of required pumped storage power units depends on the component ratio of coal fired units which provide the surplus power to be pumped up, and it also depends on the gas turbines available to meet peak load demand. In both JICA/LPE_CASE 1 & 2, the 1,500MW of development should be introduced by 2015.

(3) Installed Capacity

Table 4.2.3 shows the installed capacity and its component ratio. The component ratio of coal fired power units is increased to about 55% in 2015. The total base load capacity including hydro and geothermal power units exceeds to about 60%. Figure .4.2.1 shows the installed capacity from 2001 to 2015 in JICA_CASE2.

Table 4.2.3 Installed Capacity (Base Case)

Demand:JICA/LPE CASE 2 (UNIT:MW,%)

	2001		2005		2010		2015	
Hydro	2,536	13.6%	2,536	12.7%	2,536	8.4%	2,536	6.0%
P.S.	0	0.0%	0	0.0%	0	0.0%	1,500	3.5%
Coal	6,650	35.7%	7,970	39.9%	13,970	46.4%	24,170	57.1%
Gas	4,749	25.5%	4,649	23.3%	8,369	27.8%	8,969	21.2%
HSD	3,108	16.7%	3,258	16.3%	3,978	13.2%	4,218	10.0%
MFO	800	4.3%	800	4.0%	500	1.7%	200	0.5%
GEO	765	4.1%	765	3.8%	765	2.5%	765	1.8%
Total	18,608	100.0%	19,978	100.0%	30,118	100.0%	42,358	100.0%

Demand:JICA/LPE CASE 1 (UNIT:MW,%)

	2001		2005		2010		2015	
Hydro	2,536	13.6%	2,536	12.7%	2,536	8.4%	2,536	6.4%
P.S.	0	0.0%	0	0.0%	0	0.0%	1,500	3.8%
Coal	6,650	35.7%	7,970	39.9%	12,170	40.4%	21,770	54.8%
Gas	4,749	25.5%	4,649	23.3%	8,369	27.8%	8,969	22.6%
HSD	3,108	16.7%	3,258	16.3%	3,618	12.0%	3,978	10.0%
MFO	800	4.3%	800	4.0%	500	1.7%	200	0.5%
GEO	765	4.1%	765	3.8%	765	2.5%	765	1.9%
Total	18,608	100.0%	19,978	100.0%	27,958	92.8%	39,718	100.0%

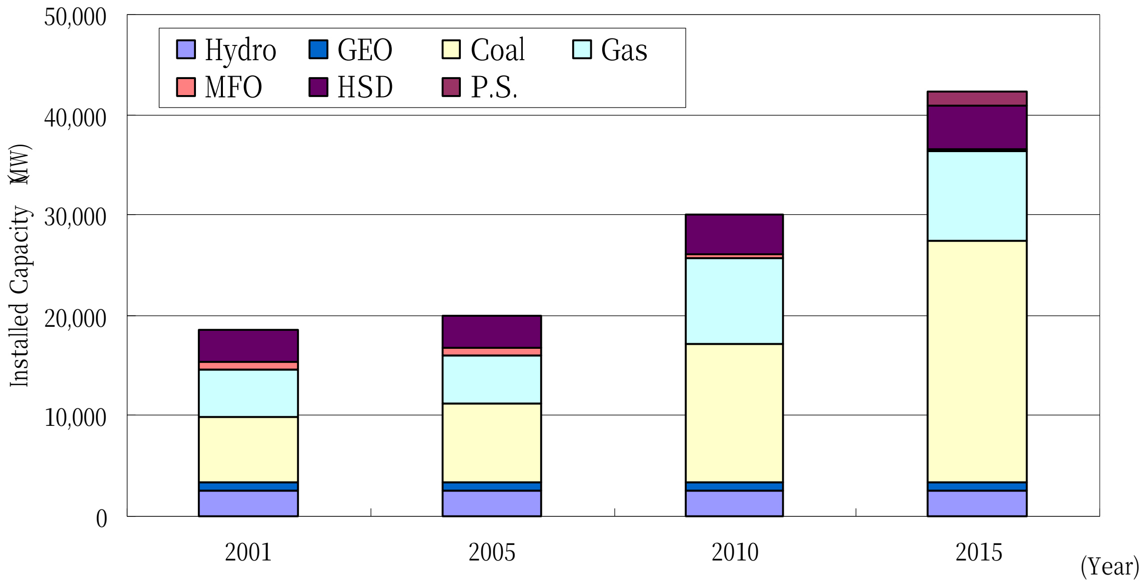


Figure 4.2.1 Trend of Installed Capacity (Demand: JICA_CASE2)

(4) Power Production

Table 4.2.4 shows the generation and its component ratio. Coal fired power units generate over 70% of the electricity in both cases in 2015. Figure 4.2.2 shows the trend of power production and Figure 4.2.2 shows the duration of power generation in2015.

Table 4.2.4 Power Generation (Base Case)

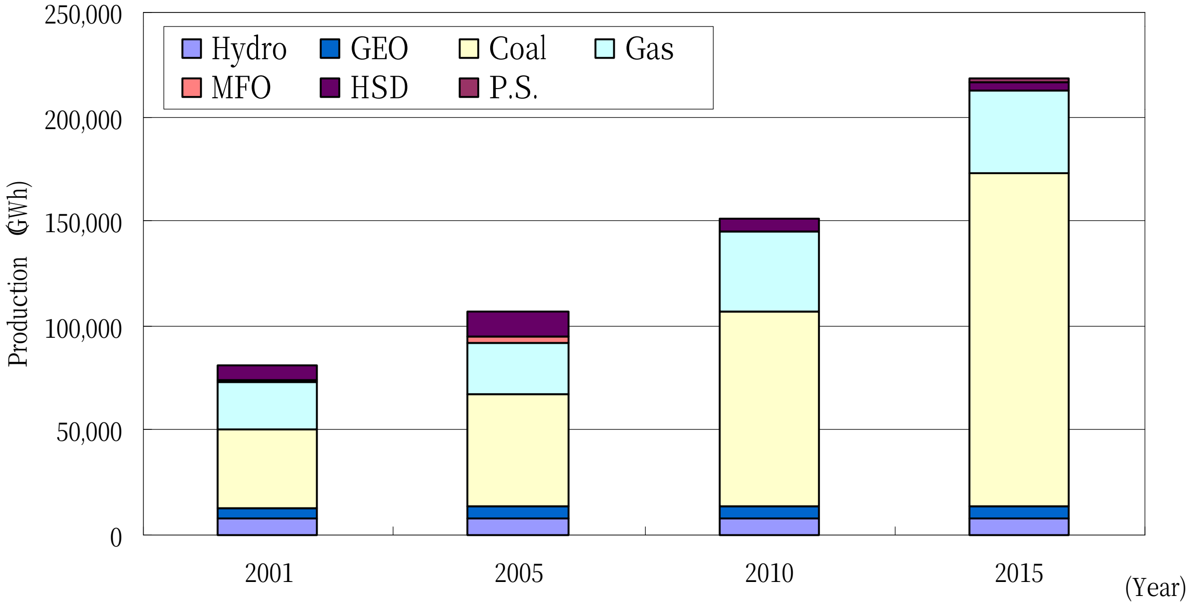
Demand:JICA/LPE CASE 2 (UNIT:GWh,%)

	2001		2005		2010		2015	
Hydro	7,719	9.5%	7,719	7.2%	7,719	5.1%	7,719	3.5%
P.S.	0	0.0%	0	0.0%	0	0.0%	1,500	0.7%
Coal	37,577	46.2%	53,776	50.5%	92,893	61.6%	159,187	72.9%
Gas	21,965	27.0%	24,805	23.3%	38,332	25.4%	39,694	18.2%
HSD	6,880	8.5%	11881	11.2%	5,230	3.5%	4,054	1.9%
MFO	1,717	2.1%	2510	2.4%	833	0.6%	377	0.2%
GEO	5,402	6.6%	5,864	5.5%	5,864	3.9%	5,864	2.7%
Total	81,260	100.0%	106,555	100.0%	150,871	100.0%	218,395	100.0%

Demand:JICA/LPE CASE 1 (UNIT:GWh,%)

	2001		2005		2010		2015	
Hydro	7,719	9.5%	7,719	7.7%	7,719	5.5%	7,719	3.8%
P.S.	0	0.0%	0	0.0%	0	0.0%	1,209	0.6%
Coal	37,577	46.2%	52,169	51.8%	81,560	58.3%	143,922	70.5%
Gas	21,965	27.0%	23,141	23.0%	38,488	27.5%	40,294	19.8%
HSD	6,880	8.5%	9,629	9.6%	5,504	3.9%	4,608	2.3%
MFO	1,717	2.1%	2,243	2.2%	879	0.6%	385	0.2%
GEO	5,402	6.6%	5,864	5.8%	5,864	4.2%	5,864	2.9%
Total	81,260	100.0%	100,765	100.0%	140,014	100.0%	204,001	100.0%

Figure 4.2.2 Trend of Power Production (Demand: JICA/LPE_CASE2)



(5) Fuel Consumption

Table 4.2.5 shows the fuel consumption. As power generation increases, coal consumption increases until 2015 and reaches about 72,000kT in JICA_CASE2. It is nearly four times as much as the current consumption. Gas consumption increases to about 340 BSCF in both cases, and it is nearly two times as much as current consumption.

Table 4.2.5 Fuel Consumption (Base Case)

Demand:JICA-CASE2 (UNIT:KT,BSCF,kl)

	2001	2005	2010	2015
Coal	17,016	24,352	42,065	72,085
Gas	192	216	327	337
HSD	1,682	3,013	1,316	1,035
MFO	478	699	233	100

Demand:JICA-CASE1 (UNIT:KT,BSCF,kl)

	2001	2005	2010	2015
Coal	17,016	23,624	36,933	65,172
Gas	192	202	328	343
HSD	1,682	2,412	1,374	1,160
MFO	478	625	246	102

(6) Investment

Table 4.2.6 shows the necessary investment cost. The necessary investment cost to implement the development plan until 2010 is about US$9.4 billion in JICA/LPE CASE1 and about US$7.6 billion in JICA/LPE-CASE2.

Table 4.2.6 Necessary Investment (Base Case)

Demand:JICA/LPE CASE 2 (UNIT:Million US$)

	2001-2005	2006-2010	2001-2010	2011-2015	Total
Coal	1,188	5,400	6,588	9,180	15,768
Gas C/C	0	2,355	2,355	390	2,745
HSD	98	360	458	120	578
P-S	0	0	0	900	900
Total	1,286	8,115	9,401	10,590	19,991

Demand:JICA/LPE CASE 1 (UNIT:Million US$)

	2001-2005	2006-2010	2001-2010	2011-2015	Total
Coal	1,188	3,780	4,968	8,640	13,608
Gas C/C	0	2,355	2,355	390	2,745
HSD	98	180	278	180	458
P-S	0	0	0	900	900
Total	1,286	6,315	7,601	10,110	17,711

4.2.2 Sensitive Studies

(1) Sensitive Study on Fuel Price - Fuel Price Increase Scenario -

The impact of the fuel price increase on the power development plan is examined. The scenarios studied are shown in Table 4.2.7.

Table 4.2.7 Fuel Price Increase Scenario

Case / Item	Base Case	Gas Price Increase		Coal Price Increase	
		Case1	Case2	Case1	Case2
Coal ($/ton)	20	20		25	30
Gas ($/MMBTU)	2.5	3.0	3.5	2.5	
HSD oil ($/Gcal)	14.5				

① Power Development Plan

Table 4.2.8 shows the output of WASP-IV in each case. In the Gas Price Increase Case, the capacity of the combined cycle power plants to be developed will decrease if the gas price increases, while the capacity of coal power plants will increase. In the Coal Price Increase Case, the capacity of the coal power plants will decrease if the coal price increases, while the capacity of the combined cycle power plants will increase.

Table 4.2.8 Power Development Plan by Wasp-IV(Fuel Price Increase Scenario)

Case		Base Case				Gas Price Increase Case 1				Gas Price Increase Case 2				Coal Price Increase Case 1				Coal Price Increase Case 2			
Gas Price		2.5$/MMBTU				3.0$/MMBTU				3.5$/MMBTU				2.5$/MMBTU							
Fuel Price		20$/ton				20$/ton								25$/ton				30$/ton			
Year	Demand	ST	C/C	GT	PS	ST	C/C	GT	PS	ST	C/C	GT	PS	ST	C/C	GT	PS	ST	C/C	GT	PS
	(MW)	Number of Units				Number of Units				Number of Units				Number of Units				Number of Units			
2001	13,041																				
2002	14,089																				
2003	15,073																				
2004	16,071			3) 1				3) 1				3) 1				3) 1				3) 1	
2005	17,170	1) 2				1) 2				1) 2				1) 2				1) 2			
2006	18,374	4	2) 2			5	2) 1			5	2) 1			2	2) 4			1	2) 4	3	
2007	19,659		2			1	1	1		2		1		1	1			1	1	1	
2008	21,075		2	3			2	3		2		4		1	1	3		1	2		
2009	22,621	3		1		2	1			1	2			3		1		3			
2010	24,297	3		2		3			1	2	1		1	2	1	2		2	1	1	
2011	26,099	3		2	1	2	1	4		2	1	3		3		2	1	3		2	1
2012	28,040	3	1			4				3	1			4				4			
2013	30,131	3			2	2	1		2	2			4	3			2	2	2	3	
2014	32,380	3			3	4			1	4			1	3	1		1	2			4
2015	34,800	5				4		2	1	5				3	1	1	1	3	1	3	
Total Number		29	7	9	6	29	7	11	5	30	6	9	6	27	9	10	5	24	11	14	5
Total Capacity (MW)		17,520	4,320	1,110	1,500	17,520	4,320	1,350	1,250	18,120	3,720	1,110	1,500	16,320	5,520	1,230	1,250	15,120	6,720	1,710	1,250

1) The figure shows Tanjung-Jati B, 2) The figure includes the Muara-Karang Repowering

3) The figure shows the Pemaron C/C

② Gas Consumption

Figure 4.2.3 shows the trend of gas consumption in each case. IF gas prices increase, the amount of gas consumption will decrease. This trend will emerge clearly in 2008. The amount of necessary gas in 2008 is about 330BSCF/year in the Base Case, while 290BSCF/year at a price of 3.0US$/MMBTU, and 220BSCF at 3.5US$/MMBTU. On the other hand, if coal prices increase, the amount of gas consumption will increase. The amount in 2015 will reach 390BSCF/year at a price of 25US$/ton, and 450BSCF/year at 30US$/ton, while 340BSCF/year in the Base Case. Thus, the gas consumption will go above the present supply plan.

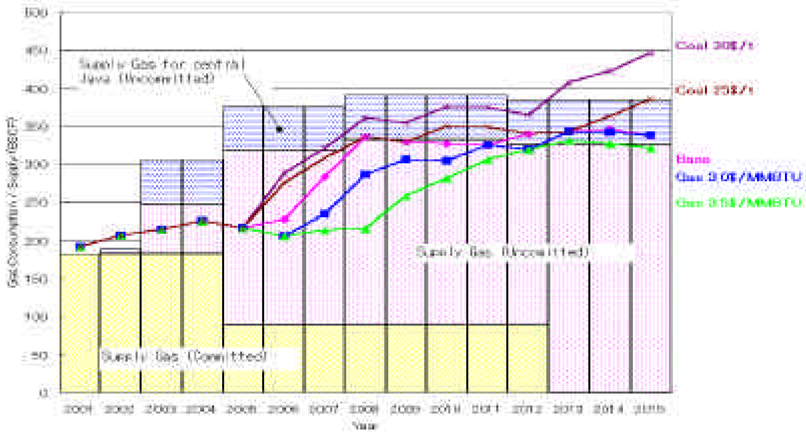


Figure 4.2.3 Trend of Gas Consumption

③ Coal Consumption

Figure 4.2.4 shows the trend of coal consumption in each case. If coal prices increase, the amount of coal consumption will decrease. The amount in 2007 will fall down to 30,000kton/year at a price of 25US$/ton, and 28,000kton/year at 30US$/ton, while 31,000kton/year in the Base Case. On the other hand, if gas prices increase, the amount of coal consumption will increase. The amount in 2008 will reach about 34,000kton/year at a price of 3.0US$/MMBTU, and 38,000kton at 3.5US$/MMBTU, while 32,000kton/year in the Base Case.

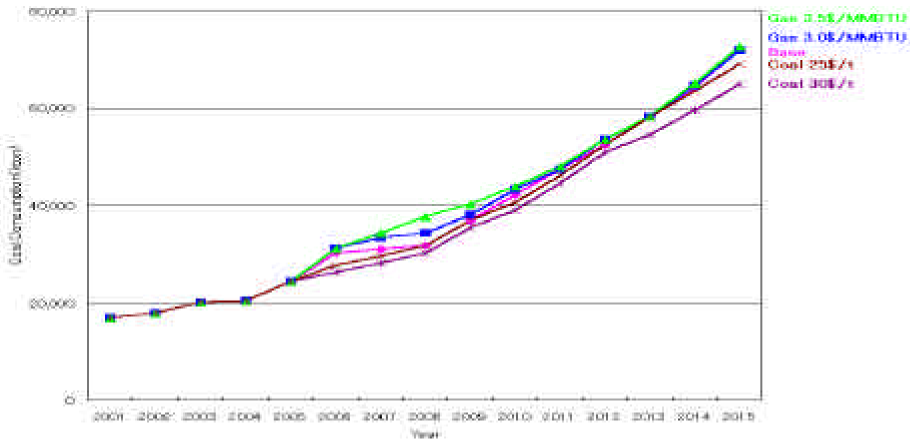


Figure 4.2.4 Trend of Coal Consumption

(2) Sensitive Study on Power Development Limitation - Limited Development Scenario-

The impact of limitation to the lead-time of construction and to the capacity itself is studied. The concept of case studied is as follows:

・No Coal Power Plant Case

Since Base Case is the least-cost power development plan in the calculated period, the output consists of coal power plant mainly because of its low fuel price. Since the necessary investment for coal power plant is expensive, investors in captive powers and IPPs are likely to construct combined cycle or gas turbine power plant that is cheaper in investment and can be constructed in shorter period in place of coal power plant, as is shown in other countries introducing market mechanism. No Coal Power Plant Case is the case which no coal power plant will be developed until 2010 except for Tanjung-Jati B.

・Coal Power Plant Limited Case

Taking the lead-time into account, Coal Power Plant Limited Case is the case that the commissioning year of coal power plant should be in and after 2008. Moreover, the number of coal power plant to be developed until 2010 are limited only two units per year.

・Combined Cycle Limited Case

Regarding the effective use of natural gas, power plant should be developed in cooperating with gas infrastructure. Combined Cycle Limited Case is the case that the number of combined cycle power plant to be developed are limited only three until 2010, except for Muara-Karang repowering.

・ Pumped Storage Limited Case

The candidate of pump storage power unit is only Upper Cisokan pumped storage power plant (Total 1,000MW) now. Thus, Pumped Storage Limited Case is the case that the capacity of pumped storage power plant is limited at 1,000MW.

In these cases, limitations would be relieved from 2011 assuming the environment for the large investment by private sectors is prepared. Table 4.2.9 shows the condition of each case.

Table 4.2.9 Power Development Limited Scenario

<table>
<tr><th>Case</th><th>Base Case</th><th>No Coal Power Plant Case</th><th>Coal Power Plant Limited Case</th><th>C/C Power Plant Limited Case</th><th>P.S. Power Plant Limited Case</th></tr>
<tr><td>1) Demand</td><td colspan="5">JICA/LPE CASE 2</td></tr>
<tr><td>2) Fixed Project</td><td colspan="5">• Pemaron C/C: 2003 (100MW) - GT Commissioning
2004 (50MW) - Complete
• Tanjung-Jati B: 2005 (660MW x 2)
• Muara-Karang Repowering: 2006 (500MW) - GT Commissioning
2007 (720MW) - Complete</td></tr>
<tr><td>3) Model Power Sources
• Coal Power Plant</td><td>In and after 2006</td><td>In and after 2011</td><td>In and after 2008
2 units / year
(2008-2010)</td><td colspan="2">In and after 2006</td></tr>
<tr><td>• Combined Cycle Plant</td><td colspan="3">In and after 2006</td><td>In and after 2006 (Maximum 3 units until 2010)</td><td>In and after 2006</td></tr>
<tr><td>• Gas Turbine</td><td colspan="5">In and after 2006</td></tr>
<tr><td>• Pumped Storage Plant</td><td colspan="4">In and after 2008</td><td>In and after 2008 (Maximum 4 units)</td></tr>
<tr><td>4) LOLP</td><td colspan="5">• Not to take into account until 2005
• 1day / Year in and after 2006</td></tr>
</table>

① Power Development Plan

Table 4.2.10 shows the power development plan for Power Development Limited Scenario. In the No Coal Power Plant Case and the Coal Power Plant Limited Case, combined cycle power plants are developed in place of coal power plants. However, since coal power development will increase after relieving the limitations, the total number of coal power plants until 2015 in the Coal Power Plant Limited Case will decrease only by 3 units as compared to the Base Case. In the No Coal Power Plant Case, the number of coal power plants will decrease by 7 units because of the limited development until 2010.

Similarly, in the Combined Cycle Power Plant Limited Case, coal power plants are developed as alternative power sources. However, more combined cycle power plants are developed after 2010, so that the total capacity to be developed until 2015 is the same as that of the Base Case.

Taking this into account, the component ratio needed to realize the least-cost power development will be at the same level, even though the development year is different.

Table 4.2.10 Power Development Plan by WASP-IV (Power Development Limited Scenario)

Case		Base Case				No Coal Power Plant Case				Coal Power Plant Limited Case				Combined Cycle Power Plant Limited Case				Pumped Storage Power Plant Limited Scenario			
Year	Demand (MW)	ST	C/C	GT	P-S	ST	C/C	GT	P-S	ST	C/C	GT	P-S	ST	C/C	GT	P-S	ST	C/C	GT	P-S
		Number of Units				Number of Units				Number of Units				Number of Units				Number of Units			
2001	13,041																				
2002	14,089																				
2003	15,073																				
2004	16,071			3) 1				3) 1				3) 1				3) 1				3) 1	
2005	17,170	1) 2				1) 2				1) 2				1) 2				1) 2			
2006	18,374	4	2) 2				2) 5	3			2) 5	3		4	2) 2			4	2) 2		
2007	19,659		2				2				2				2				2		
2008	21,075		2	3			2	4		2	1			2		4			2	3	
2009	22,621	3		1			3			2	1			3		1		3		1	
2010	24,297	3		2			3			2	1	1		3		2	1	3		2	
2011	26,099	3		2	1	4				3		3	1	1	2	1		3		2	1
2012	28,040	3	1			4				4				3	1			3	1		
2013	30,131	3			2	4			1	3			2	3			2	3			2
2014	32,380	3			3	4		1		3		2	2	3			3	4			1
2015	34,800	5				4		2	1	5				5				5			
Total Number		29	7	9	6	22	15	11	2	26	10	10	5	29	7	9	6	30	7	9	4
Total Capacity (MW)		17,520	4,320	1,110	1,500	13,320	9,120	1,350	500	15,720	6,120	1,230	1,250	17,520	4,320	1,110	1,500	18,120	4,320	1,110	1,000

1) The figure shows Tanjung-Jati B, 2) The figure includes the Muara-Karang Repowering

3) The figure shows the Pemaron C/C

② Gas Consumption

Figure 4.2.5 shows the trend of gas consumption in each case. In the Base Case, Combined Cycle Power Plant Limited Case and Pumped Storage Power Plant Limited Case, gas consumption will move in accordance with the gas supply plan. However, in the No Coal Power Plant Case and the Coal Power Plant Limited Case, the gas consumption will be bigger than that which is stipulated in the gas supply plan. Especially, in the No Coal Power Plant Case, gas consumption will reach 600BSCF / year.

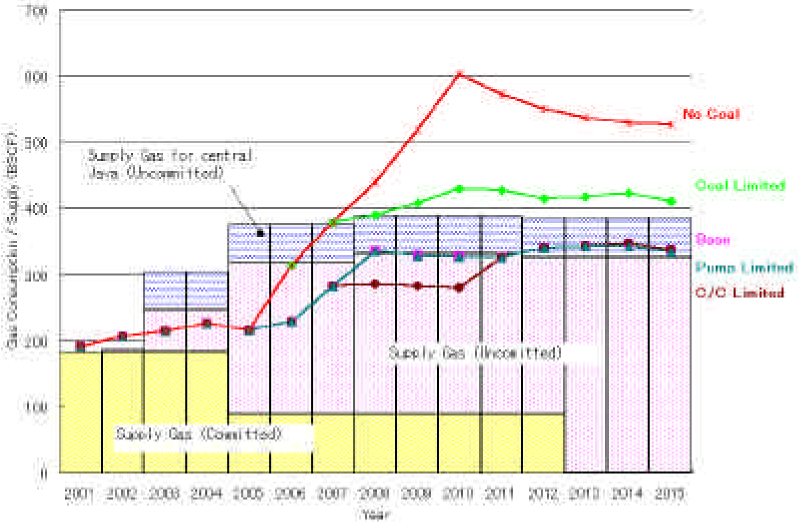


Figure 4.2.5 Trend of Gas Consumption

③ Coal Consumption

Figure 4.2.6 shows the trend of coal consumption in each case. Coal consumption is about 20,000kton / year in 2001, and will become 60,000 – 70,000kton / year in 2015 in all cases.

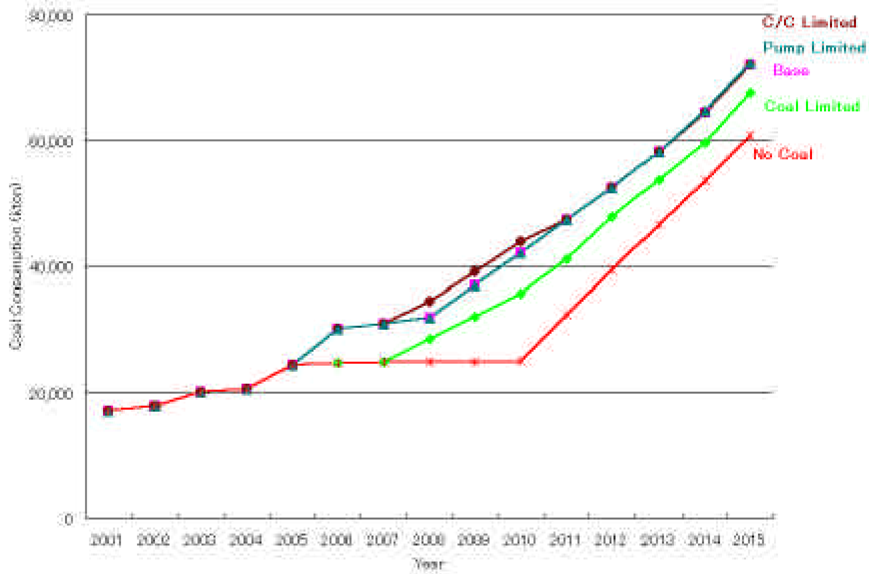


Figure 4.2.6 Trend of Coal Consumption

(3) Sensitive Study on Environmental Issues -Environmental Scenario-

As mentioned before, the power development plan of Base Case consists of coal power plant mainly. On the other hand, since grovel warming issue is discussed all over the world, the issue has to be taken into account in this report. In this section the case using the renewable energy effectively and the case keeping the CO_2 emission / kWh at present level are examined. Table 4.2.11 shows conditions of each case.

Table 4.2.11 Environmental Scenario

Item	Renewable Energy Effective Use Scenario	CO_2 Emission Limited Case
Renewable Energy Power Plant	Refer to Table 4.2.12	
Combined Cycle Power Plant	Calculated by WASP-IV (Least cost planning)	Adjusted to keep CO_2 emission at the present level
Coal Power Plant		
Gas Turbine		Calculated by WASP-IV (Least cost planning)
Pumped Storage Power Plant		

Although the renewable energy is developed by national policy, the investment should be in a certain economic level. Thus, the candidate is chosen by construction cost / kW, specifically 2,000US$ / kW. Table 4.2.12 shows the amount of renewable energy treated in this scenario. These power plants are assumed to start operating from 2011.

Table 4.2.12 Amount of Renewable Energy

Unit Type	Number of Plant	Number of Unit	Total Capacity
Hydro Power Plant	8	-	1,697MW
Geothermal Power Plant	8	17	990MW

① Power Development Plan

Table 4.2.13 shows the power development plan for Environmental Scenario. In Renewable Energy Case, the number of coal power plant will decrease, since the base power plants, such as run off river type hydro and geo thermal power plant, are developed. The number of reduced units is about 4.

To keep CO_2 emission / kWh at present level, the number of coal power plant should decrease, in contrast the number of combined cycle power plant should increase. The number of unit to be developed until 2015 is 12 for coal power plant and 24 for combined cycle power plant. Thus, it is necessary to develop combined cycle power plant twice as many as coal power plant.

Table 4.2.13 Power Development Plan By WASP-IV (Environmental Scenario)

		Base Case				Renewable Energy Case						CO2Emission Limited Case					
Year	Demand (MW)	ST	C/C	GT	P-S	ST	C/C	GT	P-S	Hyd	Geo	ST	C/C	GT	P-S	Hyd	Geo
		Number of Units				Number of Units						Number of Units					
2001	13,041																
2002	14,089																
2003	15,073																
2004	16,071			[3] 1				[3] 1						[3] 1			
2005	17,170	[1] 2				[1] 2						[1] 2					
2006	18,374	4	[2] 2			4	[2] 2						[2] 5	3			
2007	19,659		2				2						2				
2008	21,075		2	3			2	3				1	2				
2009	22,621	3		1		3		1				1	2				
2010	24,297	3		2		3		2					3				
2011	26,099	3		2	1	1		1	1	2	2			3	2	2	2
2012	28,040	3	1			2		1		2	2	1	1			2	2
2013	30,131	3			2	3			1	2	2	2	1		1	2	2
2014	32,380	3			3	2		1	3	2	2	2	2			2	2
2015	34,800	5				5		1				3	2				
Total Number		29	7	9	6	25	6	11	5	8	8	12	20	7	3	8	
Total Capacity (MW)		17,520	4,320	1,110	1,500	15,120	3,120	1,350	1,250	1,697	990	7,320	12,120	870	750	1,697	990

Hyd: Hydro Power Plant, Geo: Geothermal Power Plant

1) The figure shows Tanjung-Jati B, 2) The figure includes the Muara-Karang Repowering

3) The figure shows the Pemaron C/C

② Gas Consumption

Figure 4.2.7 shows the trend of gas consumption in each case. In Renewable Case, gas consumption is not so different from Base Case because the amount of renewable energy is not so much. However, in CO_2 Emission Limited Case, the gas consumption will move over 700BSCF/year.

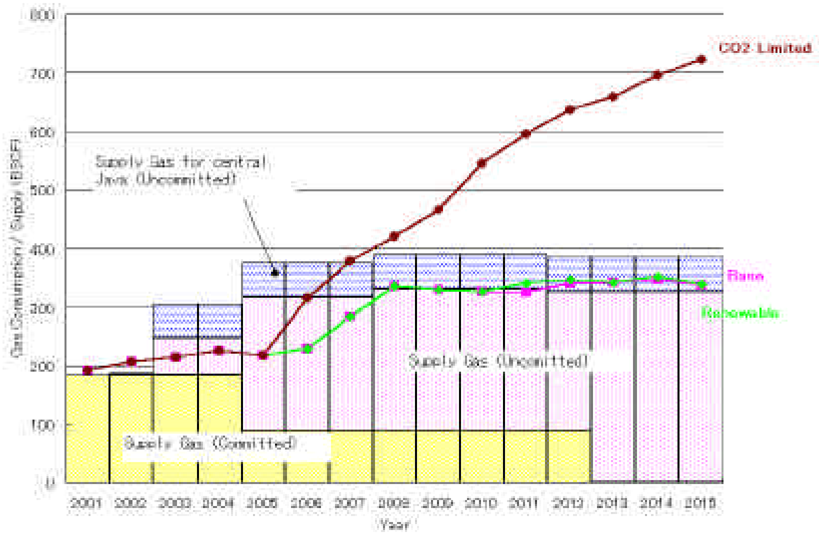


Figure 4.2.7 Trend of Gas Consumption

③ Coal Consumption

Figure 4.2.8 shows the trend of coal consumption in each case. In Renewable Case, coal consumption is not so different from Base Case because the amount of renewable energy is not so much. However, in CO_2 Emission Limited Case, coal consumption will move not more than 40,000kton / year.

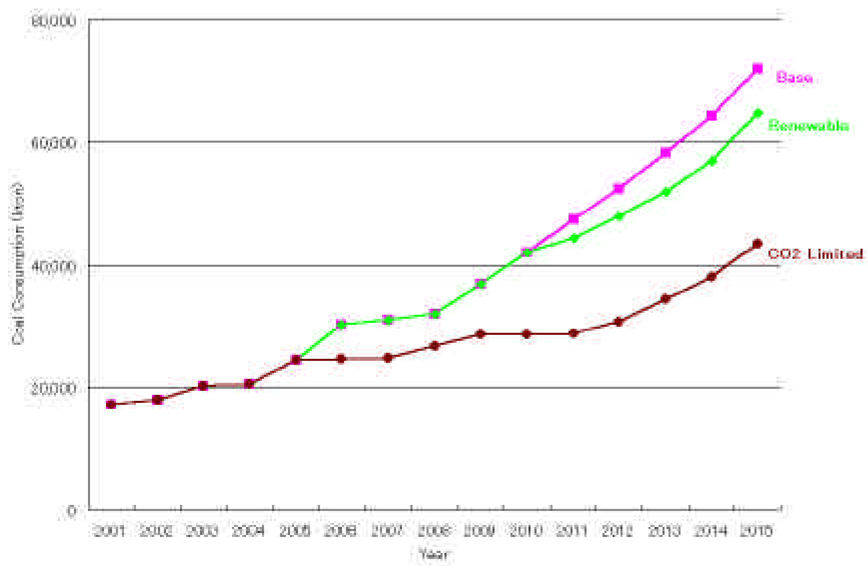


Figure 4.2.8 Trend of Coal Consumption

Table 4.2.14 shows fuel consumption and CO_2 emissions for each case in 2015. By using the renewable energy effectively, CO_2 emission will decrease from 0.820kton-CO_2/kWh to 0.764kton-CO_2/kWh in 2015, however, the CO_2 emission cannot be maintained at the present level (0.661kton-CO_2/kWh). In the CO_2 Emission Limited Case, CO_2 emission can keep within the 0.660kT-CO_2, while the gas consumption will jump up.

Table 4.2.14 Fuel Consumption and CO2 Emission

Fuel Consumption (UNIT:KT,BSCF,kl)

Year	2001	2015		
	Base	Base	Renewable	CO2 Limited
Coal	17,016	72,085	64,795	43,433
Gas	192	337	339	722
HSD	1,682	1,035	2,288	2,473
MFO	478	100	129	130

CO2 Emission (UNIT:kT)

Year	2001	2015		
	Base	Base	Renewable	CO2 Limited
Coal	36,925	156,423	140,604	94,251
Gas	11,271	19,828	19,930	42,474
HSD	4,113	2,532	5,595	6,047
MFO	1,432	298	387	390
Total	53,742	179,082	166,517	143,161
GWh	81,260	218,395	218,039	217,020
kg-CO2/kWh	0.661	0.820	0.764	0.660

4.2.3 Issues to be addressed for the Power Development Plan

Sensitive studies on fuel price, limitation of power development and environmental policy has been made and the impact of these conditions on power development plan was examined. This section will propose some of the issues that need to be addressed for the power development plan.

(1) Issues to be solved for realizing the power development plan

1) Investment

- For providing power stably, necessary capacity to be developed will reach 24,500MW and required investment will reach US$ 20 billion until 2015.
- Since it is difficult to procure this investment by government, investment by private sector can not but be expected.
- Taking the suspense of development and re-negotiation of purchase price with IPPs, it is not in the situation for foreign investors to invest the IPP project in Indonesia.
- Therefore, to make clear the organization which has the responsibility to provide power to the system under the new electricity law, and to introduce the private capitol to power sector, are very important.

2) Type of power sources

- The output of WASP-IV is the least cost plan to minimize the operation cost and levelized investment cost. Since Indonesia has the high load factor at about 70%, the simulation result becomes the development plan consisting of coal power plants mainly.
- Private investors are likely not to invest on the coal power plant because of its high investment caused by high construction cost per kW and great capacity per unit. Consequently, the gas turbine or combined cycle power plant using fuel gas is likely to be the objective of investment because of lower investment and shorter construction period.
- Therefore, to introduce the private capitol, it should be the urgent matters to construct the gas infrastructure and to provide fuel gas stably at low cost. Thus, gas infrastructure for the private sector should be constructed under the responsibility of the government for the time being.
- For the long-term development, energy policy regulating the amount of available gas for power sector and taking the effective use of coal should be required from the viewpoint of primary energy resources. Therefore, the government should study the optimal ratio of power sources, taking the effective use of primary energy and environmental issues into account.

3) Gas supply

- The amount of gas consumption is greatly influenced by fuel price and the development of coal power plant. Thus, In order to provide the necessary gas at necessary time, fuel supply plan should be prepared periodically with taking the situation of demand and power development into account.
- Amount of minable resource of gas in west Java is limited and no gas project is expected to be developed except for the gas pipeline between Java and South Sumatra. Therefore, gas consumption for power sector it is likely to be limited.
- Gas consumption in middle term is considered to move at about 380BSCF
- In long term, new gas projects, such as Tanguh project in Irian Jaya, are expected to be developed. The project scale of Tanguh would be about 300BSCF / year. Considering the gas for other sectors, gas supply for power sector can not but be a part of this project.
- In order to reduce the impact on environment, power sources should be developed by fuel gas. In this case, since the gas consumption jumps up, the capacity to be developed should be set deliberately, with considering the environmental policy and energy policy.

4) Coal supply

- In the least cost plan at JICA/LPE case 2, the coal consumption will reach 70million ton / year in 2015. On the other hand, mineable reserve of coal in Indonesia is about 4,928million ton. The amount ratio of the bituminous coal and sub bituminous coal for electric power is estimated to be 40%. Moreover, amount of confirmed resources is about 11,569million ton, thus leaving the export, consumption in other sector and use in outer island, the fuel coal for power sector in Java-Bali is enough to supply. Therefore, coal should be used from the point of primary energy in Indonesia.

Table 4.2.15 Mineable Resources on Coal (UNIT: million T)

Mineable Reserve	Amount of Resources		
	Confirmed	Expected	Total
4,928	11,569	27,306	38,875

Source: Directorate of Coal, "Indonesian Coal Yearly Statistics, Special Edition 2000"

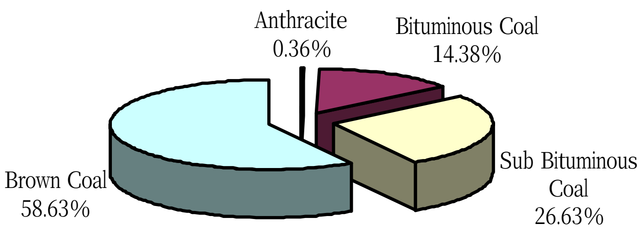


Figure 4.2.9 Composition of coal reserve by type.

- In case of coal power plant can not be developed sufficiently, gas power plant would be developed instead of coal power. Thus the gas consumption will jump up beyond the capacity of infrastructure. In order to control the gas consumption, a certain capacity of coal power plant should be developed.
- Despite the enough resources, fuel coal circulating in the market is rather short. This means the shortage of infrastructure from mining to the market. Thus the infrastructure of coal should be developed in accordance with the development of power sources with forecasting the coal consumption periodically.

5) Lead time for construction.

- In the case of a coal fired power unit, it requires four years for the actual construction period, and six to seven years including the environmental impact assessment. Considering the above, it seems very difficult to commitment in 2008. Therefore, the coal power plant should be developed by government policy or encourage of investor should be done by the favorable treatment.

(2) Suggestion to realize the power development plan

- In order to develop power sources by using private capital, the environment for investment should be prepared for developing gas turbines or combined cycle power plant requiring the small investment. Actually it is necessary to provide the fuel gas stably at low cost by constructing the infrastructure. In case that the necessary infrastructure is not prepared, the fuel gas for power sources can not be supplied, thus the infrastructure of fuel gas should be developed under the responsibility of the government.

- Taking the mineable reserve of coal and the amount of available gas for power sector, coal power plant should be developed in a certain extent from the viewpoint of primary energy. Since coal power plants require the big investment, the private capital is not likely to introduce to coal power plant. Therefore, the coal power plant should be developed by government policy or encourage of investor should be done by the favorable treatment.

- In order to meet power development plan, fuel infrastructure and environmental policy, national energy-environmental policy is required. In order to make full use of private capital, it is important to provide the information to the private investors for making clear the direction of the national development and the information for judging to the investment.

4.3 Study on Optimal Power Component Ratio

The concept of a power mix used in Japan includes energy security and environmental impact, since Japan does not have enough primary energy resources. Considering the power mix in Indonesia, the concept of effective use of the country's own primary energy and environmental factors should be considered. In this section, trial calculation of long term power mix is made taking the method of using the private sector, effective use of natural gas for environment, the upper limit of the amount of natural gas and effective use of coal and other considerations into account

4.3.1 Component Ratio to Realize the Least Cost Development

Figure 4.3.1 shows the component ratio of installed capacity and power production realizing the least cost development.

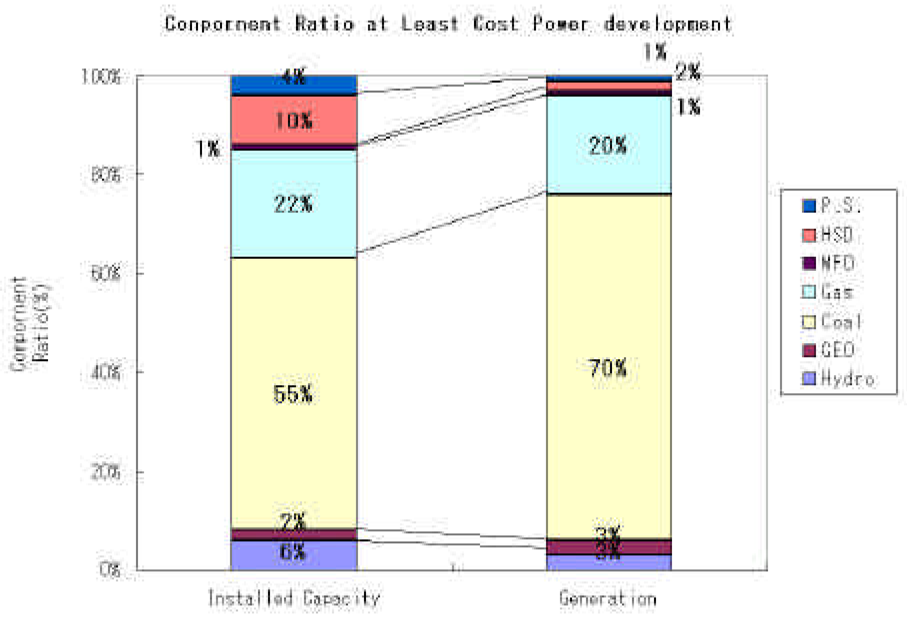


Figure4.3.1 Component Ratio to Realize the Least Cost Development

a. In the event the limitations are relived, component ratios of installed capacity and power generation realizing the least cost development will converge to the ratios shown above.

b. The load factor in Japan is about 60% (average of 10 power companies) and the component ratio of base load power plant, such as hydro, geothermal, nuclear and coal fired power plant, is 40% in installed capacity and 60% in power generation.

c. The component ratio of base load power sources, such as hydro, geothermal and coal-fired power plant, exceeds 60% in installed capacity and 75% in power generation. The high load factor (=70%) in Indonesia is likely to contribute this.

4.3.2 Trial Calculation of Target Power Mixture in Long Term

A trial calculation of the target power mixture for long-term was prepared, taking the method of using private sector, effective use of the natural gas for environment, the upper limit of the amount of natural gas, the effective use of coal and other considerations into account.

(1) Conditions

When adopting the CO_2 Emission Limited Case as the original case, the amount of gas consumption is adjusted to about 500–550 BSCF / year in the future, based on the following concept.

The amount of natural gas to be supplied
= The amount of present plan + 1/2 of gas supply by * new project
= 380 BSCF/year + 150 BSCF/year (300BSCF x 1/2)
= 500 – 550 BSCF / year

* Expected amount from Tanguh project in Irian Jaya.

Table 4.3.1 Scenario of Trial Calculation on an Optimal Power Mixture

Type of Power Source	Effective Use of Primary Energy	CO_2 Emission Limited Case (Listed Again)
Renewable Energy Power Plant	Refer to Table 4.2.12	
Combined Cycle Power Plant	Adjust the Upper limit of Gas Consumption at about 550BSCF/ year	Adjust the CO_2 emission at about the present level
Coal Power Plant		
Gas Turbine	Calculated by WASP-IV (Least Cost Planning)	

(2) Component Ratio of Power Sources over the Long-Term.

Figure 4.3.2 shows the results of a trial calculation of a target power mixture over the long-term. It is important to show the figure to the private investors, so that private capitol can actually be put to use.

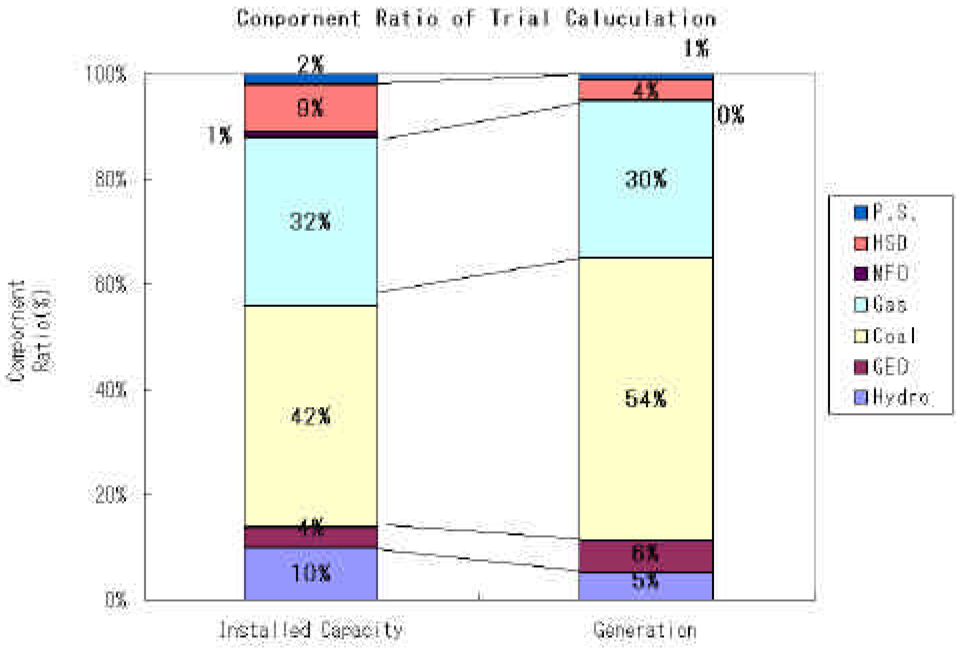


Figure. 4.3.2 Component Ratio of Power Sources in Long-Term (Trial Calculation)