Chapter 5 Transmission Planning and System Analysis

In this chapter, various types of system analysis (power flow analysis, stability analysis, short circuit analysis, frequency analysis) are used and optimal transmission plans are developed to achieve the development of power stations.

Short-term transmission planning (approximately until 2007) is studied to verify the PLN transmission plan and to evaluate generation constraints caused by the transmission limit of the 500kV trunk lines for stability.

Mid- and long-term transmission plans for 2010 (approximately 25,000MW) and for 2015 (approximately 35,000MW) are studied in order to cope with the power development until approximately 2015. The study accounts for the various distribution patterns for the new power stations (balanced development, development mainly in West Java, development mainly in East Java, development heavily in East Java).

5.1 Current State of the Java Bali System

Java is a long and narrow island, and the length from east to west is almost 1,000km and so power must be transmitted over a long distance. To cope with this problem, a 500kV transmission system was introduced in 1984 and has since been expanded. In 1999, northern 500kV transmission lines, which consist of two circuits, were completed from the Suralaya Power Station in West Java to the Paiton Power Station in East Java.

As shown in Table 5.1.1, demand in West Java is high because of the high demand at Jakarta, which is located in this region. However, some of the large power stations, such as Paiton and Gresik, are located in East Java. Thus a lot of power flows from east to west through 500kV transmission lines, and power transmission is being restricted by stability considerations.

To remove this restriction, southern 500kV transmission lines are being constructed. The section from the Paiton Power Station to the existing Klaten substation in central Java will be completed in 2003, and the section from the Klaten substation to the new DepokIII substation in south Jakarta will be completed in 2004.

The one circuit of the transmission lines from Paiton to Klaten has already been in operation since April 2002, by bypassing the delayed Kediri substation.

Figure 3.1.1 shows the Java Bali 500kV system in 2001.

Table 5.1.1 Demand and supply balance of each area in the Java Bali system (2001)

	West Java (Area1, 2)	Central Java (Area3)	East Java (Area4)	Total
Demand (MW)	7,811 (60%)	2,057 (16%)	3,173 (24%)	13,041 (100%)
Supply (MW)	9,848 (53%)	1,755 (9%)	7,005 (38%)	18,608 (100%)

5.2 Transmission Planning (Short-term)

5.2.1 Programs and Conditions for System Analysis

(1) Programs

The following programs are used for system analysis.

Power Flow analysis	L method (Newton-Raphson method) (by Central Research Institute of Electric Power Industry)
Transient Stability analysis	Y method (by Central Research Institute of Electric Power Industry)
Short Circuit Capacity analysis	Program developed by CEPCO

(2) Conditions

The following are the conditions for system analysis.

Fault		3LG-O (3 phase ground fault: Criteria of P3B)
Fault Clearing time		100ms(500kV), 150ms(150kV)
Demand		Peak (Case 1)
Simulated Generators		500kV system: All power stations 150kV system: Large scale thermal power stations (Muara Karang, Tanjung Priok, Tambak Rolok, Gresik, Grati)
Parameters of Transmission lines and transformers		P3B data or manufacturer data (Partly standard data)
Generator data		P3B data or manufacturer data (Partly standard data)
	AVR	Standard data (Thyristor-type, Self-excitation)
	Governor	Standard data
	PSS	Not included

5.2.2 Results

(1) Transmission of the power stations in East Java and Tanjung Jati B

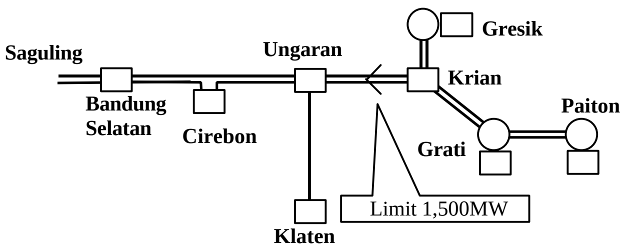
At present transmission of power generated by power stations in East Java, such as Paiton, is restricted due to stability problems.

System stability is studied every year up until the southern 500kV transmission lines are completed. Stability is also studied for the Tanjung Jati B Power Station, which is expected to be completed in 2005. The case in which there is a delay in completing the southern 500kV transmission lines is also studied.

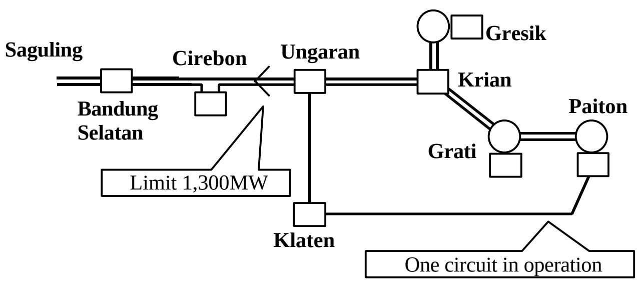
Figure 5.2.1 shows the results of the system analysis.

Figure 5.2.1 The results of transient stability analysis

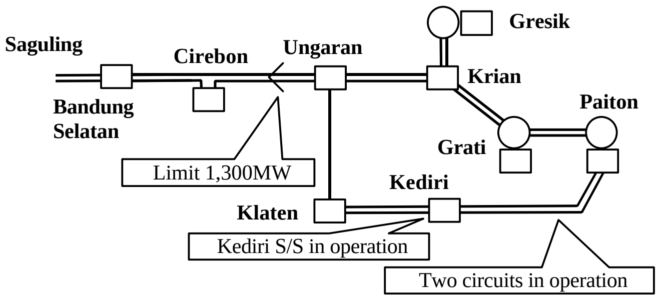
In 2002: No southern 500kV transmission lines



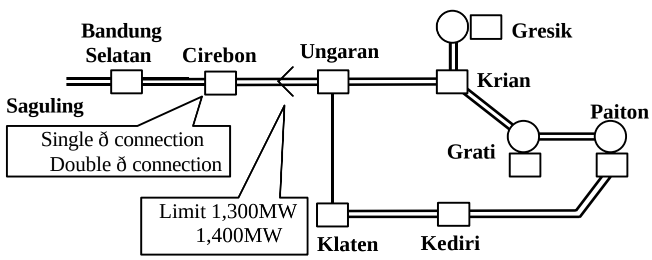
In 2002: Operation of one circuit between Paiton and Klaten



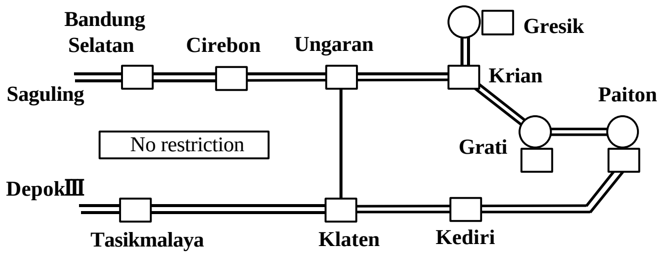
In 2003: Operation of two circuits between Paiton and Klaten



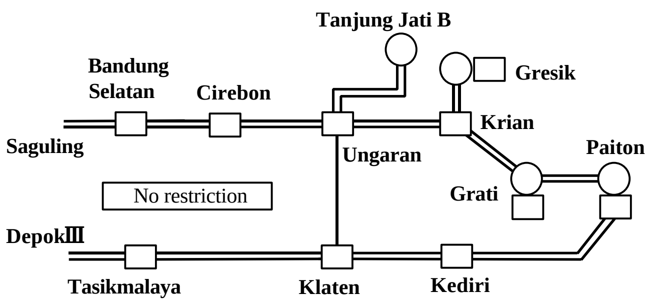
In 2003: After double ð connection at Cirebon



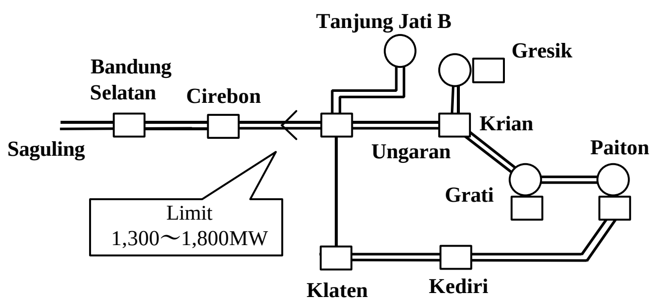
In 2004: Operation of entire southern 500kV transmission lines



In 2005: Operation of Tanjung Jati B



In 2005: Delay of southern 500kV transmission lines and operation of Tanjung Jati B



(2) Transmission planning for repowering at the Muara Karang Power Station

Transmission planning is studied for the Muara Karang Power Station (existing capacity: 1209MW) in northern Jakarta, where repowering (capacity increase: 420MW) is expected in 2006 and 2007.

Even though the power flow through the 150kV transmission lines between Muara Karang and Duri Kosambi (two routes), and between Duri Kosambi and Petukangan will be great at peak load, generation at the Muara Karang Power Station will not need to be restricted even when there is a fault with one circuit of the transmission lines.

However, during off-peak periods (the load is 70% of the peak load) generation at the Muara Karang Power Station will need to be restricted when there is a fault with one circuit of the transmission lines (see Figure 5.2.2 and Table 5.2.1).

(It has to be recognized that the amount of restriction depends largely on the demand forecast for that area. The demands of the substations for power flow analysis are forecasted based on the power flow diagram in "PENGUSAHAAN SISTEM JAWA BALI 2001" and the demand forecast for the entire Java Bali system (Case 1).)

The following measures can be considered for removing this restriction.

(A) Reinforcement of the existing 150kV transmission lines between Muara Karang and Duri Kosambi (2 routes), and between Duri Kosambi and Petukangan by reconductoring to sag suppression electric conductors (such as thermo-resistant ACSR, gap-type ACSR and extra thermo-resistant aluminum alloy conductor galvanized invar-reinforced series).

(Economical comparisons should be studied in detail to select the best type of sag suppression electric conductors.)

(B) Expansion of the 150kV system to increase the demand that is directly supplied from Muara Karang and Duri Kosambi along with the demand increase in Jakarta city.

(A) would be a drastic measure. (B) would be an efficient measure, if it were also used as a measure against the demand increase in Jakarta city. It is difficult to remove the entire restriction during off-peak only with (B). Therefore, it is more desirable to adopt (A) as a drastic measure.

However, in light of the following items, consideration should be given to reducing the amount of generation restriction with (B), and to cope with N-1 contingency by operational spinning reserve.

- There will be no restrictions at peak load, and no restrictions during off-peak without contingency.
- It will be possible to reduce generation at Muara Karang during off-peak periods, because it is a power station intended for middle and peak loads.

- The amounts of generation restrictions will decrease if periodic inspections and repairs are taken into consideration.
- The amounts of generation restrictions will decrease in accordance with the demand increase in the area.

The results of the stability analysis show that there will be no problems after the Muara Karang repowering. However, the stability will be severe in case of a transmission line fault between Muara Karang and Duri Kosambi, so loop operation between Tangerang and Jatake could be possible to improve stability.

After repowering of the Mura Karang Power Station, the situation will be very severe in the Gandul 150kV subsystem in terms of short circuit capacity. Therefore, a split operation of the 150kV system and upgrading of the facilities will be needed.

Figure 5.2.2 Normal condition (Off-peak in 2007)

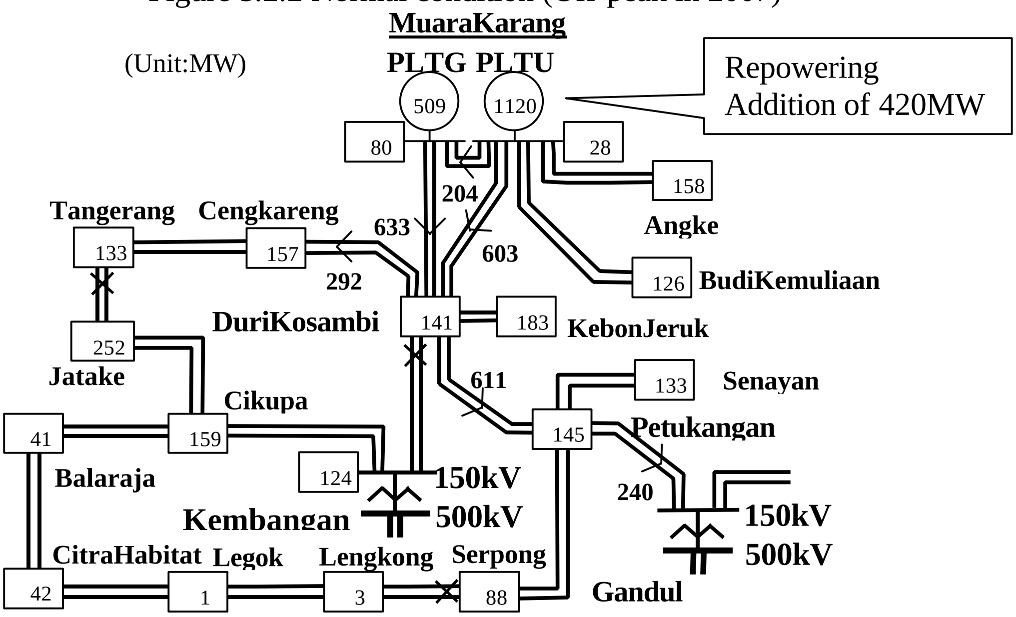


Table 5.2.1 Power flow in normal condition and with N-1 contingency (Off-peak in 2007)

Contingency	Transmission lines	Capacity (MVA)	Power flow (MW)	Availability Factor*1	Restriction of generation (MW)
Normal	M.K. PLTU-D.Kosambi	810 (2×405)	603	78%	0
	M.K. PLTGU-D.Kosambi	810 (2×405)	633	82%	0
	D.Kosambi-Petukangan	810 (2×405)	611	79%	0
M.K. PLTU -D.Kosambi 1cct-fault	M.K. PLTU-D.Kosambi	405 (1×405)	**400**	**104%**	**46**
	M.K. PLTGU-D.Kosambi	810 (2×405)	**837**	**109%**	**101**
	D.Kosambi-Petukangan	810 (2×405)	608	75%	0
M.K. PLTGU -D.Kosambi 1cct-fault	M.K. PLTU-D.Kosambi	810 (2×405)	**809**	**105%**	**59**
	M.K. PLTGU-D.Kosambi	405 (1×405)	**428**	**111%**	**130**
	D.Kosambi-Petukangan	810 (2×405)	608	79%	0
D.Kosambi -Petukangan 1cct-fault	M.K. PLTU-D.Kosambi	810 (2×405)	603	78%	0
	M.K. PLTGU-D.Kosambi	810 (2×405)	633	82%	0
	D.Kosambi-Petukangan	405 (1×405)	**608**	**158%**	**223**

*1: Calculated on the assumption that the power factor is 95%.

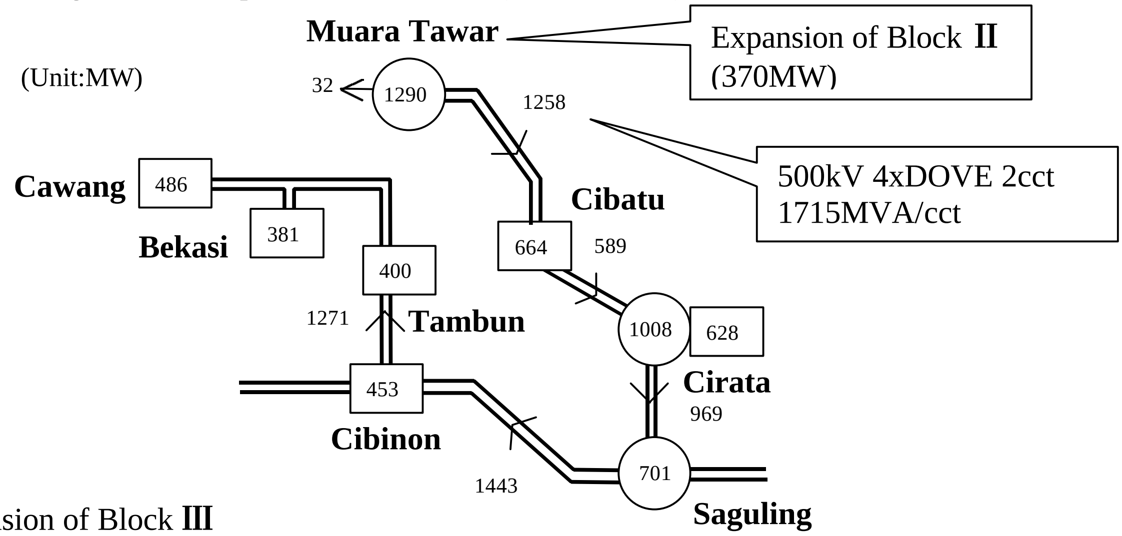
(3) Transmission planning for Muara Tawar Power Station

Transmission planning is studied for the Muara Tawar Power Station (existing capacity : 920MW) near Jakarta, where the expansion of Block Ⅱ (370MW) or the extension of Block Ⅲ(750MW) is expected in 2006 and 2007.

1) Expansion of Block Ⅱ

Figure 5.2.3 shows the expected power flow diagram at peak load in 2007 after expansion of Block Ⅱ(370MW). The power flow of each transmission line will be within the thermal capacity of one circuit, therefore there will be no overload even when there is a fault with one circuit. There will also be no problems in regard to stability.

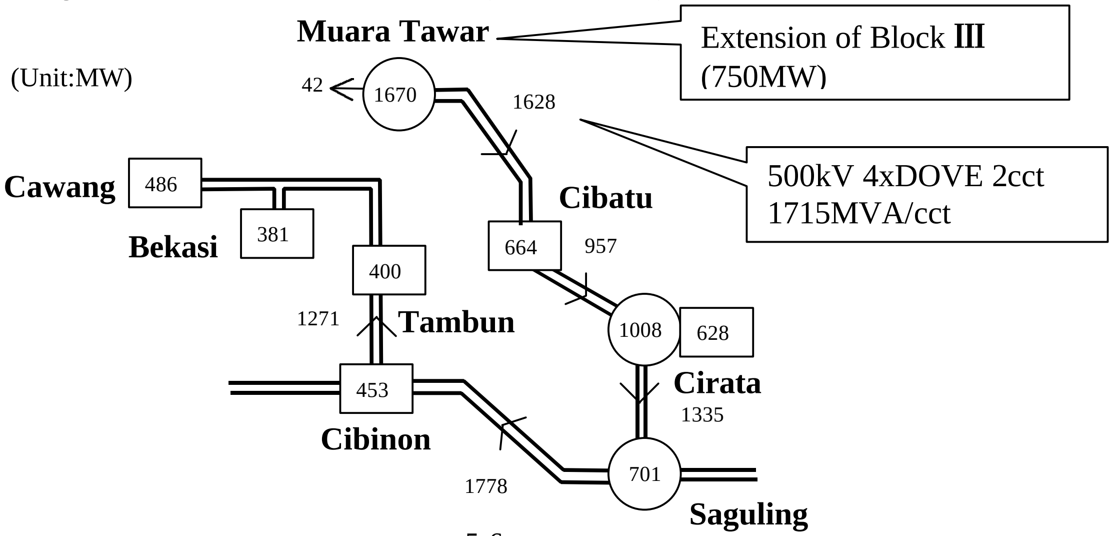
Figure 5.2.3 Expansion of Block Ⅱ(Peak in 2007)



2) Extension of Block Ⅲ

Figure 5.2.4 shows the expected power flow diagram at peak load in 2007 after extension of Block Ⅲ(750MW). The power flow of each transmission line will be within the thermal capacity of one circuit, therefore there will be no overload even when there is a fault with one circuit. There will also be no problems in regard to about stability.

Figure 5.2.4 Extension of Block Ⅲ(Peak in 2007)

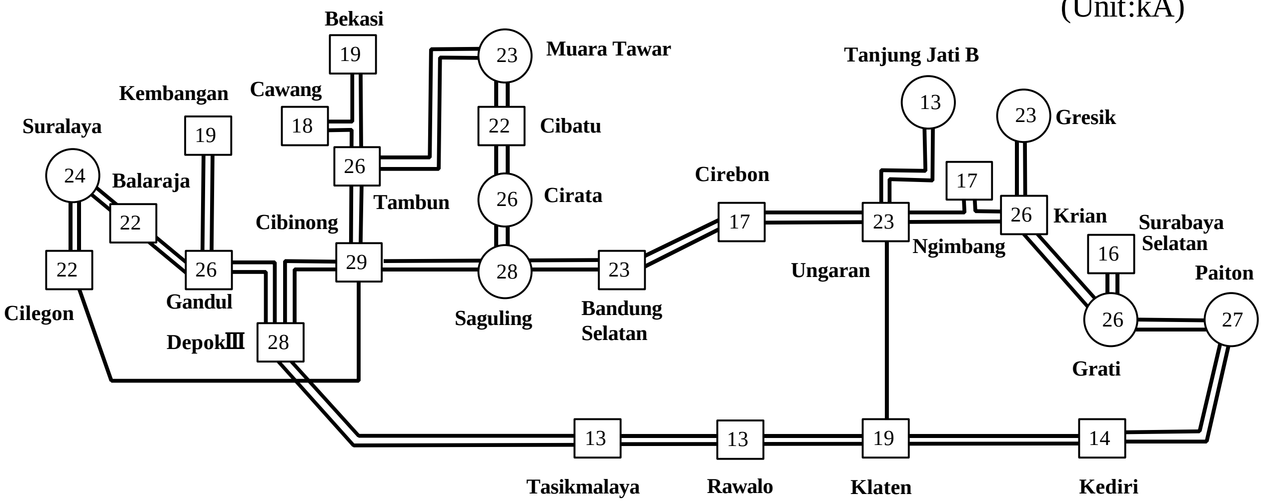


(4) Short circuit capacity

Figure 5.2.5 shows the result of a short circuit analysis in the 500kV Java Bali system in 2007. There will be no problem in terms of with short circuit capacity in the 500kV system.

Figure 5.2.5 Short Circuit Current (2007)

(Unit:kA)



(5) Frequency

By increasing the unit capacity of the generators, the benefit of economies of scale increases. But the larger the unit capacity of a generator becomes, the larger the drop in frequency and the amount of load shedding will be in the case of a generator failure.

At present, the largest unit in the Java Bali system is 615MW at Paiton. In 2005 the largest will be 660MW with the operation of Tanjung Jati B.

Through the least squares method and using the data of "EVALUASI OPERASI SISTEM TENAGA LISTRIK JAWA BALI 2000", the relation between the rate of generation loss (=(generation loss) /(system capacity)) and the drop of frequency in the Java Bali system is as follows:

$$\Delta f = 0.146 \times \Delta P$$

Table 5.2.2 shows the frequency drop that is calculated by this equation when the largest generator parallels out. It shows the amount of load shedding necessary for the frequency to recover to 49.5Hz.

Table 5.2.2 Frequency drop and load shedding

	2000		2005(Case1)	
	Peak	Minimum	Peak	Minimum
Load (MW)	12,231	3,936(32%)	16,185	5,179(32%)
Largest Unit (MW)	615(Paiton)		660(Tanjung Jati B)	
Frequency Drop (Hz)	△0.73	△2.28	△0.59	△1.86
Load shedding (MW)	203	497	109	500

5.2.3 Conclusions and Recommendations

(1) Removal of transmission restrictions in East Java

1) Completion of southern 500kV transmission lines

The entire southern 500kV transmission lines have to be completed to remove all the transmission restriction caused by system stability in East Java. Theses lines should be constructed as soon as possible.

The land acquisition problems near the Depok III substation should be solved as soon as possible in order to complete the entire southern 500kV transmission lines in 2004.

If the land acquisition problems are not solved, a temporary connection of the southern 500kV transmission line to the northern 500kV transmission line near Bandung Selaten or near Upper Cisokan should be studied.

2) Double π connection at Crebon substation

After completion of the section from Paiton to Klaten, the power flow between Ungaran and Cirebon will be restricted by stability considerations. Therefore, the connection of the 500kV transmission line at the Cirebon substation should be changed from a single π configuration to a double π configuration to alleviate the transmission restrictions.

(2) Transmission planning for Tanjung Jati B Power Station

To stably transmit the power of the Tanjung Jati B Power Station, construction of a new transmission line between Tanjung Jati B and Ungaran will be needed.

The entire southern 500kV transmission lines have to be completed to remove the generation restriction caused by stability considerations at the Tanjung Jati B Power Station. Therefore, the entire southern 500kV transmission lines should be constructed in 2004.

(3) Transmission planning for repowering at Muara Karang Power Station

After repowering of the Muara Karang Power Station, its generation will be restricted when there is a fault with one circuit of the transmission lines. To remove this restriction, it is desirable to reinforce the existing 150kV transmission lines between Muara Karang and Duri Kosambi (two routes), and between Duri Kosambi and Petukangan by reconductoring to sag suppression electric conductors (such as thermo-resistant ACSR, gap-type ACSR and extra thermo-resistant aluminum alloy conductor galvanized invar-reinforced series).

However, considerations should be given to expanding the 150kV system in order to increase the demand that is directly supplied from Muara Karang and Duri Kosambi in accordance with the demand increase in Jakarta city. Therefore, this alternative should be studied in detail, including demand forecast for this area.

With respect to short circuit capacity, after the repowering of the Muara Karang Power Station, the situation will be very severe in the Gandul 150kV subsystem. Therefore, a split operation of the 150kV system and upgrading of the facilities will be needed.

(4) Transmission planning for Muara Tawar Power Station

With respect to the expansion of Block Ⅱ (370MW) and the extension of Block Ⅲ (750MW) at the Muara Tawar power station, the power can be transmitted by the existing 500kV transmission lines with N-1 contingency as long as one of the plans is carried out.

(5) Improvement of system stability

1) Using PSSs

At present, the PSSs (Power System Stabilizer) are not used at some power stations. Therefore, the PSSs should be adjusted and used to improve stability.

2) Adoption of differential relay for trunk lines

At present, two sets of distance relays are adopted to protect each 500kV transmission line in the Java Bali system. Single-phase reclosing by using PLC (Power Line Carrier) has also been adopted. Distance relays have been technically established and their reliability is relatively high and so it is used in many countries.

Recently, optical fiber communications have been introduced in the Java Bali system, and so differential relays should be introduced to protect trunk lines in the future.

Differential relays have high reliability, and the fault clearing time can be shortened and multi-phase reclosing can be achieved by utilizing differential relays. In this manner stability can be improved.

(6) Largest generator unit in relation to system capacity

At present, the largest generator unit in the Java Bali system is 615MW at the Paiton Power Station. It is relatively large in comparison with the system capacity (13,041MW in 2001). Therefore, if a fault occurs at the largest generator, the frequency drops sharply and load shedding is needed.

There are plans to install two 660MW units at the Tanjung Jati B Power Station in 2005. If a larger capacity unit is installed, the amount of load shedding will increase. Thus, installation of a larger unit has to be carefully considered.

(7) Margin of the transmission stability limit

In this stability analysis, standard data are used for the generators. A 3-phase ground fault of one circuit is adopted, but generally a 1-phase ground fault for two circuits are stricter fault. Only the peak-load is studied, and not off-peak load or minimum load.

Therefore, a sufficient transmission stability margin should be kept for system operations.

5.3 Transmission Planning (Mid- and Long-term)

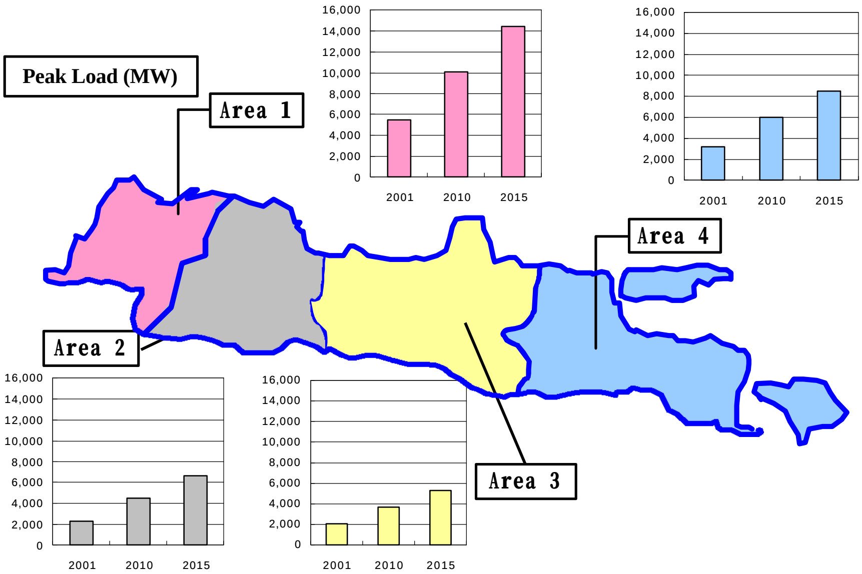
5.3.1 Demand Forecasts

For transmission planning, Case 2 for which the rate of increase is larger in comparison with Case 1, was adopted. The demand for each area is as follows.

Table 5.3.1 Demand forecast (Unit: MW)

	Area1	Area2	Area3	Area4	Total
2001	5,495 (42%)	2,316 (18%)	2,057 (16%)	3,173 (24%)	13,041 (100%)
2010	10,077 (41%)	4,543 (19%)	3,689 (15%)	5,988 (25%)	24,297 (100%)
2015	14,413 (41%)	6,601 (19%)	5,282 (15%)	8,504 (25%)	34,800 (100%)

Figure 5.3.1 Demand forecast in each area



5.3.2 Power Development Plan

In terms of the power development plan, the Base Case (Demand-JICA/LPE Case2) was adopted for transmission planning.

Table 5.3.2 Power development plan for transmission planning

	2001-2010	2010-2015	Total
Coal (600MW)	12	17	29
Combined Cycle (600MW)	6	1	7
Gas Turbine (120MW)	6	2	8
Pumped Storage (250MW)	0	6	6

5.3.3 Study Cases

The years 2010 and 2015 were studied for the transmission planning. The distribution of the new power stations is assumed as follows.

Table 5.3.3 Distribution patterns for the new power stations

Balance Case	The power stations are developed in accordance with the demand in each area
West Case	The power stations are developed mainly in West Java
East Case	The power stations are developed mainly in East Java
Heavy-East Case	The power stations are developed heavily in East Java

Table 5.3.4 Power development plan in each area (2001-2010) (Unit: MW)

			Area1	Area2	Area3	Area4	Total
Demand (2010)			10,077 (41%)	4,543 (19%)	3,689 (15%)	5,988 (25%)	24,297 (100%)
Generation	Existing (2001)		7,395 (40%)	2,373 (13%)	1,755 (9%)	7,005 (38%)	18,528 (100%)
	New	Balance Case	5,120 (**43%**)	3,600 (**31%**)	2,520 (**21%**)	600 (**5%**)	11,840 (100%)
		West Case	8,720 (**74%**)	1,200 (**10%**)	1,920 (**16%**)	0 (**0%**)	11,840 (100%)
		East Case	3,920 (**33%**)	2,400 (**20%**)	3,120 (**27%**)	2,400 (**20%**)	11,840 (100%)
		Heavy-East Case	2,720 (**23%**)	0 (**0%**)	3,720 (**31%**)	5,400 (**46%**)	11,840 (100%)

Note : With respect to existing generation, reduction by repowering is considered.
(Muara Karang : Δ80)

Table 5.3.5 Power development plan in each area (2001-2015) (Unit: MW)

			Area1	Area2	Area3	Area4	Total
Demand (2015)			14,413 (41%)	6,601 (19%)	5,282 (15%)	8,504 (25%)	34,800 (100%)
Generation	Existing (2001)		7,295 (40%)	2,373 (13%)	1,655 (9%)	6,905 (38%)	18,228 (100%)
	New	Balance Case	10,160 (**41%**)	6,300 (**26%**)	4,320 (**18%**)	3,600 (**15%**)	24,380 (100%)
		West Case	13,760 (**56%**)	5,100 (**21%**)	4,320 (**18%**)	1,200 (**5%**)	24,380 (100%)
		East Case	8,960 (**37%**)	5,100 (**21%**)	4,920 (**20%**)	5,400 (**22%**)	24,380 (100%)
		Heavy-East Case	5,360 (**22%**)	5,100 (**21%**)	5,520 (**23%**)	8,400 (**34%**)	24,380 (100%)

Note: The generators that will be removed by 2015 are excluded from the existing generation (Δ300).

5.3.4 Conditions

The conditions for the study are as follows.

- Based on the N-1 rule that is adopted by PLN, transmission planning is developed to ensure that there are no interruptions in the power supply when there is a failure involving just one piece of the equipment (a failure of one circuit in the transmission line).
  Transmission planning is developed to accommodate stability when there is a transmission fault (3LG-O: 3-phase short circuit).
- Transmission planning is studied at the peak demand.
- The programs for system analysis and other conditions are the same as those used for short-term transmission planning (cf.5.2.1 Programs and Conditions for System Analysis).
- With respect to the Balance Case, the ratios of periodic repair (PR) and balance stop (BS) of the generators in each area are the same. With respect to the West Case, the ratio of PR and BS is 10% in West Java, considering the dispersion of PR and BS. With respect to the East and Heavy-East cases, the ratio of PR and BS is 10% in East Java for the same reason.

5.3.5 Study Results

(1) Power flow diagram

Figures 5.3.2 shows the power flow diagrams for each case (Balance, West, East, and Heavy-East) for 2015.

(2) Summary

Table 5.3.6 shows the summary of the results.

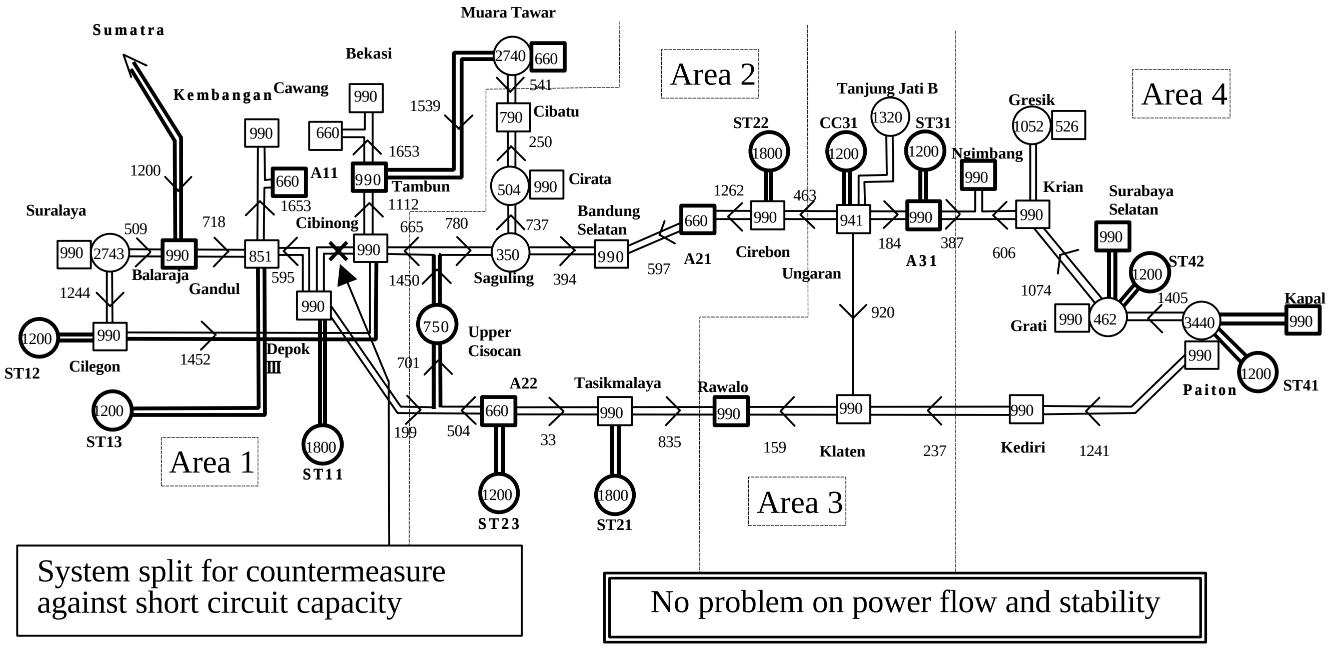
Table 5.3.6 Summary of result.

<table>
<tr><th colspan="2" rowspan="2"></th><th rowspan="2">Balance Case</th><th rowspan="2">West Case</th><th rowspan="2">East Case</th><th colspan="2">Heavy-East Case</th></tr>
<tr><th>(Without measure)</th><th>(With measure)</th></tr>
<tr><td rowspan="5">2010</td><td>Power flow</td><td>No problem</td><td>No problem</td><td>No problem</td><td>Generation interruption with a transmission fault</td><td>No problem</td></tr>
<tr><td>Stability</td><td>Stable</td><td>Stable</td><td>Stable</td><td>Unstable</td><td>Stable</td></tr>
<tr><td>Short Circuit</td><td>No problem</td><td>Need for Measure</td><td>No problem</td><td></td><td>No problem</td></tr>
<tr><td>Transmission Losses</td><td>Small</td><td>Medium</td><td>Large</td><td></td><td>Largest</td></tr>
<tr><td>500kV Third route</td><td>No need</td><td>No need</td><td>No need</td><td colspan="2">Needed</td></tr>
<tr><td rowspan="5">2015</td><td>Power flow</td><td>No problem</td><td>No problem</td><td>No problem</td><td>Generation interruption with a transmission fault</td><td>No problem</td></tr>
<tr><td>Stability</td><td>Stable</td><td>Stable</td><td>Stable</td><td>Unstable</td><td>Stable</td></tr>
<tr><td>Short Circuit</td><td>Need for Measure</td><td>Need for Measure</td><td>Need for Measure</td><td></td><td>Need for Measure</td></tr>
<tr><td>Transmission Losses</td><td>Small</td><td>Medium</td><td>Large</td><td></td><td>Largest</td></tr>
<tr><td>500kV Third route</td><td>No need</td><td>No need</td><td>No need</td><td colspan="2">Needed</td></tr>
</table>

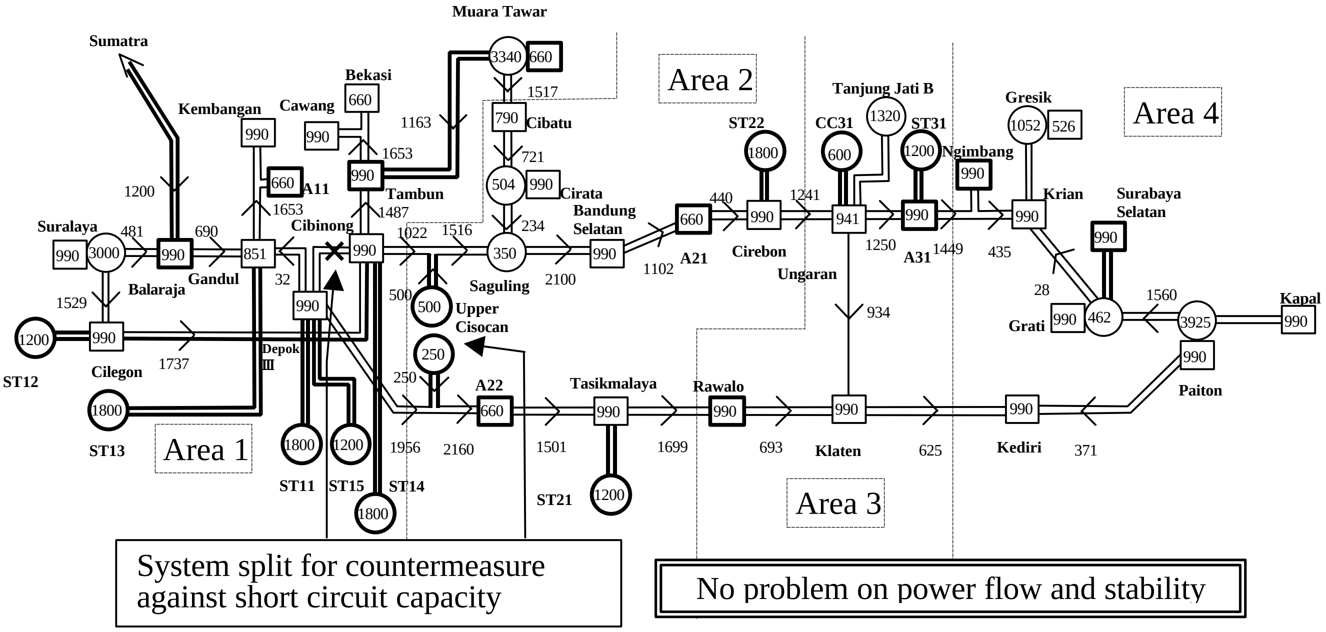
Figure 5.3.2 Java-Bali System Load Flow Diagram (In 2015)

Unit : MW
The circles show the power stations,
and the rectangles show the substations.
The thick lines show the new facilities after 2005
Blue color : Over stability limit
Green color : Over-load with one-circuit fault
Red color : Over stability limit and
over-load with one-circuit fault
power flow exceed one-circuit capacity

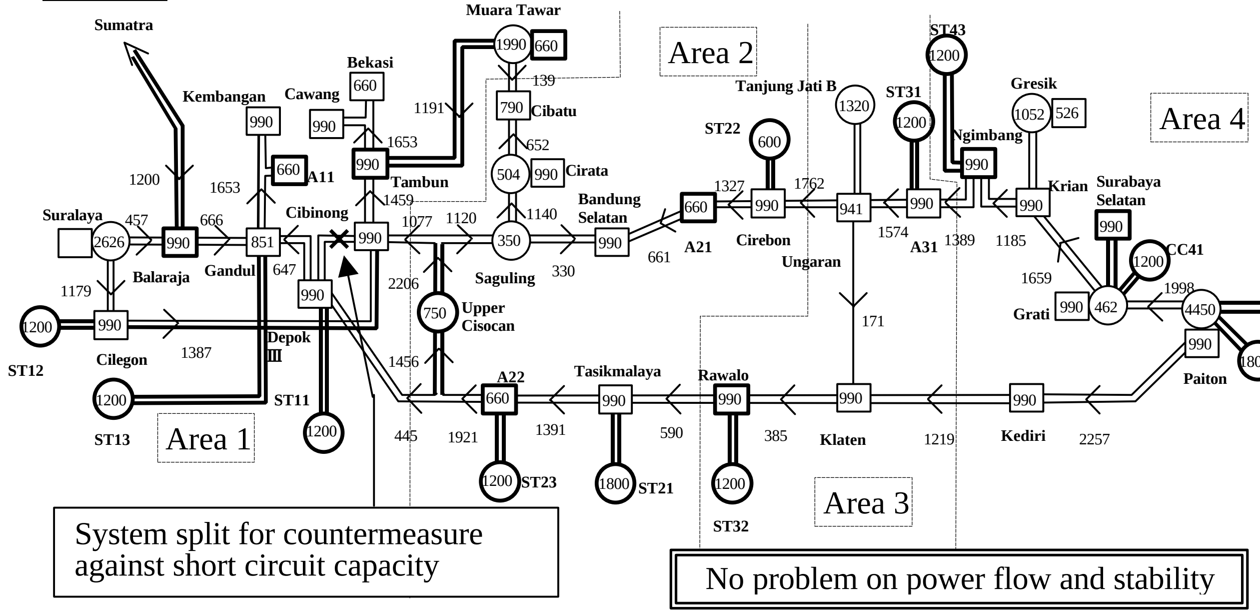
Balance case



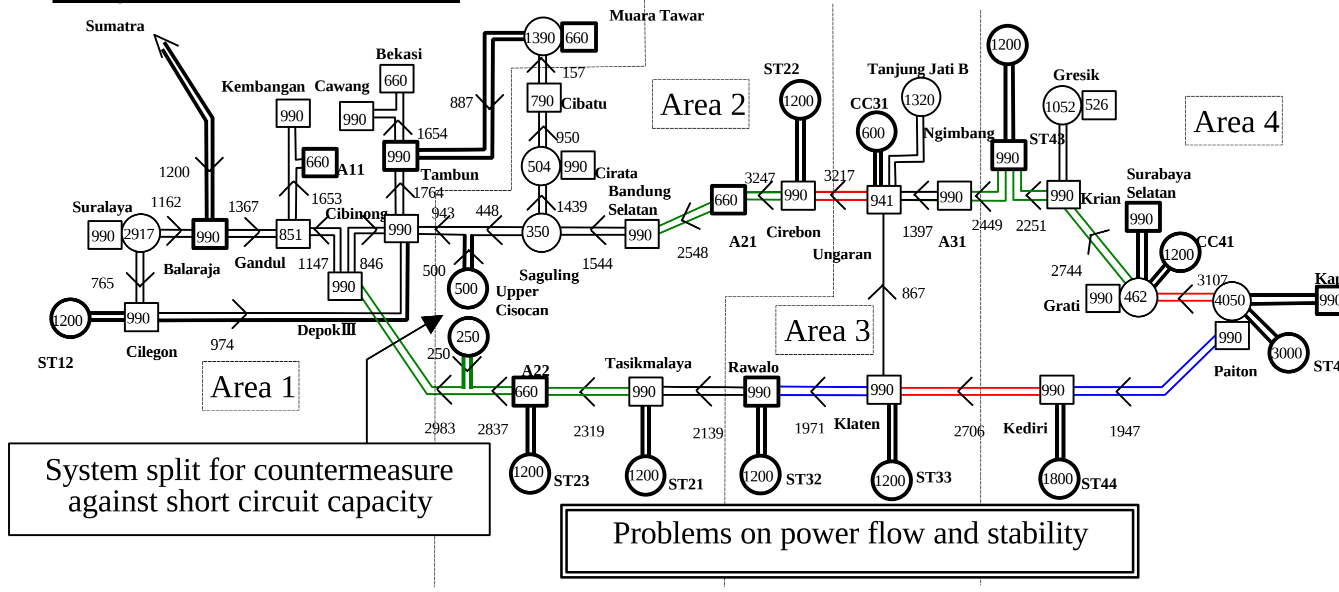
West case



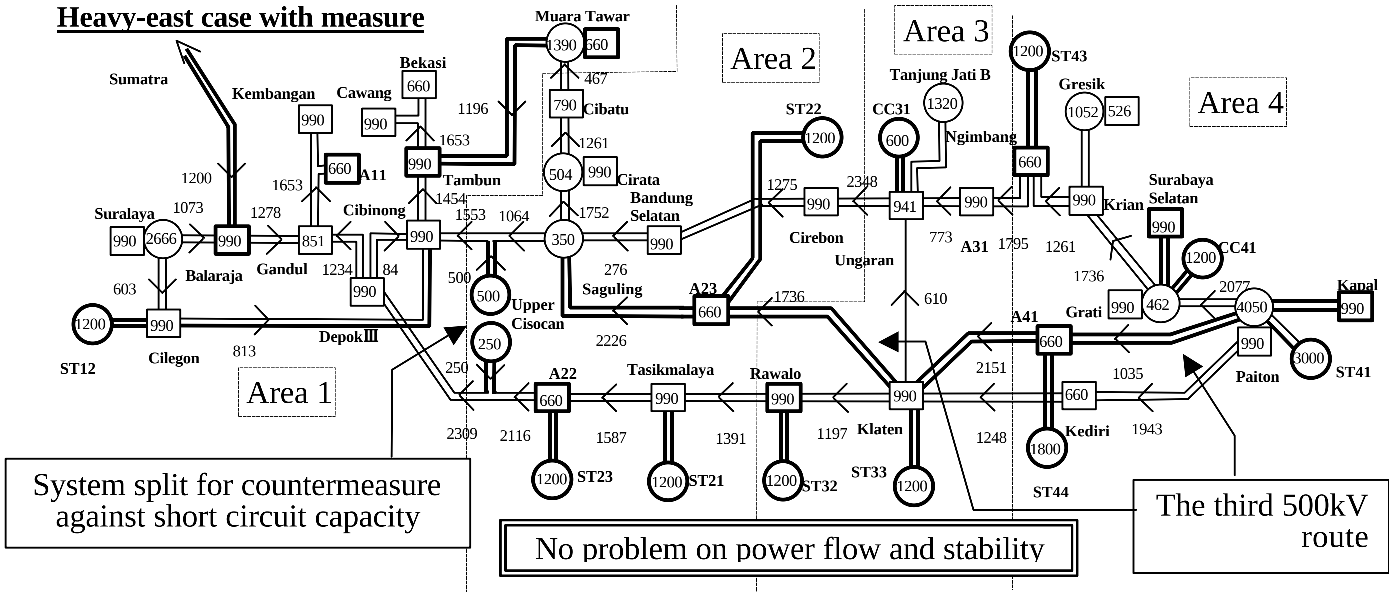
East case



Heavy-east case without measure



Heavy-east case with measure



5.3.6 Conclusions and Recommendations

(1) Distribution of new power stations

1) From the viewpoint of the transmission system, it is important to avoid the construction of new 500kV trunk lines and to avoid reinforcement of the existing 500kV trunk lines for power development.

Furthermore, it is desirable to minimize the power flows of the 500kV trunk lines to reduce the transmission losses.

Therefore, it is desirable to choose the sites of the new power stations to balance the generation with the demand in each area and to balance the power flows of the northern 500kV transmission lines with the power flows of the southern 500kV transmission lines.

- In area 1 (West Java), the generation is presently in balance with demand. However, the ratio of the area's demand to the total demand of the Java-Bali system is large (40%). Therefore, power development in coordination with the demand increase is desirable.
- In area 2(middle West Java), the demand exceeds the generation at present, and so it is desirable to promote more power development.
- In area 3 (central Java), though the demand exceeds the generation at present, construction of Tanjung Jati B will bring generation into balance with demand. Therefore, it is desirable to develop power in accordance with the increase in demand.
- In area 4 (East Java), the generation greatly exceeds demand at present, therefore it is desirable to develop power in other areas.

2) If power stations with capacities greater than 2400MW are developed in area 4 (East Java) and power stations with capacities greater than 3120MW are developed in area 3 (central Java) by around 2010, the power flows on the trunk lines will be heavy and power interruption will occur when there is a transmission fault, resulting in stability problems. Therefore, a third 500kV trunk line with a distance of almost 1,000km will be needed.

If power stations with capacities greater than 5400MW are developed in area 4 (East Java) and power stations with capacities greater than 4920MW are developed in area 3 (central Java) by around 2015, a third 500kV trunk line will also be needed.

Therefore, it is important to avoid the concentration of power development in East Java.

If construction of a third trunk line is needed, it could be a DC transmission line. Therefore, a detail study will be needed.

3) If the demand and the generation are not balanced in each area, partial reinforcement of the 500kV trunk lines or partial third 500kV trunk lines or 500kV transmission lines between the northern 500kV trunk line and the southern 500kV trunk line might be needed. Therefore, it is desirable to balance the demand with the generation in each area.

4) In terms of the new transmission lines from the new power stations to the existing 500kV system, it is desirable to shorten its distance as much as possible to reduce the construction costs and transmission losses and to improve transient stability. Therefore, it is desirable to choose the new sites as close to the demand (500/150kV substation) as possible when developing new power stations.

From the viewpoint of reliability, it is desirable to avoid concentration of power development at one site.

(2) Short circuit capacity

If power stations are developed heavily in West Java, there will be the problem of short circuits in the 500kV system. Therefore, a splitting of the system or other such measures (e.g. upgrading the equipment, current-limiting reactor) will be needed.

Measures against short circuit capacity should be determined by considering reliability and costs in comparison with the split of the system and other measures.

Chapter 6 Rehabilitation Plan of Thermal Power Plant

6.1 Summary

In this chapter, rehabilitation of the existing thermal power plants was planned. The following is the flow of the examination and summary of this chapter:

(1) Survey of the current status of the facilities

Operational status (year of commissioning, capacity factor, etc.), derated capacity and its reason, thermal efficiency, fuel cost per kWh, etc. were surveyed.

(2) Selection of focus of rehabilitation

From the survey results, it was decided to focus rehabilitation on thermal efficiency improvement of conventional steam power plants (PLTU).

(3) Selection of measures to improve thermal efficiency

From the result of the data and the interview during the site survey, the following items were selected as the thermal efficiency improvement measures to be examined in detail.

- Cleaning of feed water heater tubes
- Boiler chemical cleaning
- Improving high- and intermediate-pressure turbine blades
- Replacement of air preheater element and seal

(4) Examination of application of the thermal efficiency improvement measures

Efficiency improvement, cost, internal rate of return (IRR), net present value (NPV) and payback period were examined when the selected measures were applied to the target power plants. Table 6.1.1 shows the results.

Table 6.1.1 Application effect of thermal efficiency improvement measures (summary)

Power Station	Unit No.	IC (MW)	Age (year)	LP-HTR cleaning with sponge				HP-HTR cleaning with high pressure jet				Boiler chemical cleaning				Improvement of HP & IP turbine blades				Replacement of AH element & seal			
				Initial cost (x1000US$)	IRR (%)	NPV (x1000US$)	Payback period (year)	Initial cost (x1000US$)	IRR (%)	NPV (x1000US$)	Payback period (year)	Initial cost (x1000US$)	IRR (%)	NPV (x1000US$)	Payback period (year)	Initial cost (x1000US$)	IRR (%)	NPV (x1000US$)	Payback period (year)	Initial cost (x1000US$)	IRR (%)	NPV (x1000US$)	Payback period (year)
Suralaya	1	400	17	0.13	1,415	6	1	15	36	6	2	178	21	34	3	4,450	15	343	5	NA			
	2	400	17	0.13	1,415	6	1	15	36	6	2	178	21	34	3	4,450	14	216	6	NA			
	3	400	13	0.13	1,415	6	1	15	36	6	2	178	21	34	3	NA				NA			
	4	400	12	0.13	1,415	6	1	15	36	6	2	178	21	34	3	NA				NA			
	5	600	5	0.13	2,128	9	1	19	51	13	2	259	23	60	3	NA				NA			
	6	600	4	0.13	2,128	9	1	19	51	13	2	259	23	60	3	NA				NA			
	7	600	4	0.13	2,128	9	1	19	51	13	2	259	23	60	3	NA				NA			
Tambak Lorok	1	50	23	0.13	307	1	1	6	-17	-3	cannot pay back	43	17	5	3	3,910	NA	NA	NA	NA			
	2	50	23	0.13	307	1	1	6	-17	-3	cannot pay back	43	17	5	3	3,910	-1	-1,016	cannot pay back	NA			
	3	200	18	0.13	1,269	5	1	12	46	7	2	100	50	90	2	4,140	19	633	5	NA			
Muara Karang	1	100	22	0.13	628	3	1	7	10	0	3	62	36	33	2	3,990	11	-124	7	260	12	-2	6
	2	100	22	0.13	628	3	1	7	10	0	3	62	36	33	2	3,990	11	-56	7	260	12	-2	6
	3	100	21	0.13	628	3	1	7	10	0	3	62	36	33	2	3,990	11	-111	7	260	12	-2	6
	4	200	20	0.13	1,546	6	1	12	64	11	2	100	66	131	2	4,140	27	1,469	4	531	16	95	5
	5	200	19	0.13	1,546	6	1	12	64	11	2	100	66	131	2	4,140	26	1,406	4	NA			
Gresik	1	100	20	0.13	792	3	1	7	25	1	2	62	52	58	2	3,990	13	97	6	NA			
	2	100	20	0.13	792	3	1	7	25	1	2	62	52	58	2	3,990	13	63	6	260	18	64	5
	3	200	13	0.13	1,598	6	1	12	68	12	1	100	69	139	2	NA				531	17	116	5
	4	200	13	0.13	1,598	6	1	12	68	12	1	100	69	139	2	NA				531	17	116	5
Paiton	1	400	7	0.13	1,424	6	1	15	36	6	2	178	21	35	3	NA				NA			
	2	400	7	0.13	1,424	6	1	15	36	6	2	178	21	35	3	NA				NA			

Precondition: Capacity factor 70%   Exchange rate US$1=Rp9,000   Discount rate = 12%
Fuel price
Coal 207 Rp/kg (Suralaya), 210 Rp/kg (Paiton)
NG 2.45 US$/MMBTU (Muara Karang), 2.53 US$/MMBTU (Gresik)
MFO 710 Rp/liter

6.2 Conclusion

Rehabilitation should be carried out beginning with high IRR items. Therefore, rehabilitation items are prioritized as follows.

1) LP-HTR cleaning with sponge

This work is simple and does not require technical experience and know-how, and the cost is very small. Therefore, this can be carried out immediately by the Indonesian side alone. The targets are the last LP-HTRs of all steam power plants. This should be carried out every 8 years along with periodical inspection of LP-HTR.

2) HP-HTR cleaning with high-pressure jet

One set of high-pressure water jet equipment for common use for all power plants should be purchased first and it costs about US$140,000. And then, when the work is carried out, it costs only about US$2,000-4,000 per one HTR as the costs of transportation of the equipment, consumables such as nozzles, and labor.

Because this work requires technical experience and know-how, guidance from the experts of the water jet cleaning company should be received in the early stages of the introduction (e.g. for several months in total in several power plants).

The targets are the HP-HTRs of Suralaya PLTU 1-7, Tambak Lorok PLTU 3, Muara Karang PLTU 4-5, Gresik PLTU 1-4 and Paiton PLTU 1-2. This should be carried out every 4 years along with periodical inspection of HP-HTR.

3) Boiler chemical cleaning

Boiler chemical cleaning should be carried out at a proper time. Therefore it is necessary to determine whether or when this should be carried out following the detailed examination by the cutout test on the evaporation tube and operational state. The targets are the all steam power plants.

4) Improvement of HP & IP turbine blades and replacement of AH element & seal

IRR is not too high for the high investment cost. Especially for the improvement of HP & IP turbine blades, IRR is evaluated assuming that this improvement is carried out along with the inevitable replacement due to deterioration. Therefore it is necessary to determine whether this should be carried out following the detailed examination of the state of deterioration. In the detailed examination, manufacturers should participate to examine the applicable technology and the amount of efficiency improvement from the viewpoint of design.

The targets of the detailed examination for the improvement of HP & IP turbine blades are Suralaya PLTU 1-2, Tambak Lorok PLTU 3, Muara Karang PLTU 4-5 and Gresik PLTU 1-2.

The targets of the detailed examination for the replacement of AH element & seal are Muara Karang PLTU 4 and Gresik PLTU 2-4.

Chapter 7 Environmental Measures

In this chapter, an overview of the environmental regulations and measures in the thermal power plants and the proposals for promoting utilization of coals in the future are studied. The flow of examination and summary in this chapter is as follows.

7.1 Environmental Regulations and Standards

The whole environmental related regulations in Indonesia are investigated and the level of restriction, especially for air pollution standards, is evaluated.

Indonesia reviewed its emission standards in 2000 and tightened control by reducing the limit to 1/2 of existing level. As a result, while PM emission standard is a little lax, the SO_2 and NO_2 emission standards are nearly equal to the World Bank emission standards, so the level of restriction is same as developed countries.

7.2 Current Environmental Conditions and Countermeasures in Thermal Power Plants

The current gas emission from each thermal power plant by fuel type is surveyed and the proposals for environmental improvement are evaluated.

Table7.2.1 Current Environmental Conditions and Countermeasures

Fuel type	Current conditions	Countermeasures
Coal-fired (Paiton, Sularaya)	- P M: Some plants exceed the acceptable level (due to the damage of aging electrostatic precipitator) - SO_2: Emission of SO_2 is currently close to the allowable level	- PM: Replacement of the interior parts of electrostatic precipitator is planned. - SO_2: Difficult to purchase higher level coal. Consideration to the level of sulfur content
Oil-fired (Muara-karang)	- NO_2, PM: Good operation condition within acceptable level. - SO_2: Exceeding the acceptable level (due to using high sulfur contents Oil)	- SO_2: Conversion of fuel to natural gas Reduction of sulfur in Oil Installation of desulfurization facility （The conversion to natural gas is the most environmental friendly proposal for existing oil-fired power plants）
Natural gas-fired	- SO_2, NO_2, PM: Good operation condition within acceptable level.	—

7.3 Environmental Protection Measures to Promote Utilization of Coal in Thermal Power Plants

The coal reserves by coal type is shown in Table7.3.1. Consumption of lower-grade sub-bituminous coal and brown coal (lignite), which are abundant in coal reserves, are expected to increase in the future because they ensure better cost performance and energy security. To ensure ecological use of these types of coal, appropriate measures should be taken. In this chapter, environmental countermeasures for utilizing various type of coal and latest clean coal technologies (CCT) which are adaptable for Indonesia are studied.

Table 7.3.1 Coal reserves (%) by coal type

Type of coal	Amount of deposits (%)
Anthracite	0.36
Bituminous coal	14.38
Sub-bituminous coal	26.63
Brown coal	58.63
Total	100.0

(1) Measures to ensure environmental with lower-grade coal

a. Use of coal with lower calorific value requires:

- Construction of new coal mills in order to compensate for inadequate capacity of existing mills (for existing plants);
- Reinforced coal handling equipment to accommodate the expected increase in the volume of coal (for existing plants);
- Re-designed combustion equipment and ventilation system that can accommodate additional supply of fuel (for new and existing plants); and,
- Installation of coal mixing equipment to blend high-calorie and low-calorie coals (for new and existing plants).

b. Use of coal with high sulfur/ash content requires:

- Installation/addition of desulfurizers and dust disposal equipment (electrostatic precipitator) (for new and existing plants); and,
- Installation/addition of equipment to treat ash and by-product of desulfurization (for new and existing plant)

(2) Clean Coal Technology (CCT) that can be promoted to Indonesia

The increased use of coal for power generation in many countries has spurred innovation of diverse types of CCT technologies. The three main types of boilers that may apply to Indonesia are: supercritical boiler, brown coal (lignite) -fired boiler, and circulating fluidized bed combustion boiler.

Chapter 8 Institutional and Organizational Recommendation for the Optimal Electric Power Development Plan and Stable Power Supply

In this chapter, the following items were studied as the institutional and organizational measures contributing to realize the optimal power development plan and to ensure stable power supply.

(1) Lessons from the California Power Crisis to the power sector liberalization in Indonesia

In this section, the lessons from the California Power Crisis were examined to make use of the power sector liberalization in Indonesia from the viewpoint of stable power supply.

(2) System for power supply bidding with a view to power supply composition

This section will introduce Japan's wholesale electricity bidding system to implement the optimal power development plan by private investment in Single Buyer System.

(3) An approach to power development supporting system in line with energy policy

In this section, measures to support the power development in line with energy policy were examined from the viewpoint of realization of the optimal power development plan.

(4) Utilization of captive power

Captive power in Indonesia can affects stable supply of electric power. Therefore the demand trend of captive and the possibility to utilize as a short-term countermeasure against power deficit were examined.

(5) Utilization of Demand Side Management (DSM)

In this section, DSM was examined as a measure to ensure stable supply of electric power from the demand side.

(6) Financial enhancement of PLN

The financial situation of PLN which affects realization of the optimal power development plan was analyzed. And the required measures for enhancement of PLN financial condition were examined.

(7) Measures to promote private investment

The measures for promoting private investment necessary to realize the optimal electric power development plan were examined.

8.1 Lessons from the California Power Crisis to the Power Sector Liberalization in Indonesia

8.1.1 California Power Crisis

California's power sector reform started in 1996. Wholesale markets worked reasonably well for the first two years (1996-8) while the initial surplus of generating capacity disappeared. Then by 2000, when the demand surged and supply capacity cannot match the demand, rolling blackouts disrupted the state economy. This shortage of electricity was accompanied by the skyrocketing of the wholesale spot prices.

The immediate cause of the crisis is this mismatch of the demand and supply. The problem is said to be in the design of the wholesale market, which could not provide price signal of the users and/or the incentive for new power development to the wholesale market. Because initially the major private distribution companies were not allowed to buy outside of the spot market, they were exposed to the price volatility of the market. And the price signal of the users was not transmitted to the wholesale market due to the retail price cap system. This price volatility and the lack of interaction between the wholesale market and the retail market made market participants difficult to manage their risks.

8.1.2 Lessons for Indonesia

The purposes of liberalization are clearly different between the cases of California and Indonesia. California wanted to reduce the price by introducing competitive market. Indonesia wants to increase the private participants by liberalizing the market. Also in California crisis, the main concern was the establishment and regulation of a mandatory, wholesale power market based on spot pricing. But Indonesia's case is still far away from such an option.

Although there are such fundamental differences, there are also lessons to be shared.

a. The California case suggests the importance of the system to ensure new supply capacity in the competitive market. In other country, this function can be complemented by various means, namely a capacity obligation on distribution company's purchasing power in market, a parallel capacity market to the energy spot market, or a forward energy trading market whose prices signal expectations about future supply/demand balances. At the same time, the market rule has to be designed so that investors in new supply capacity do not face major barriers to entry to the wholesale power market. These barriers include uncertainty and expense in facing delays to the permitting process, regulatory uncertainties.

b. Indonesia like other developing countries should start with limited forms of competition that can evolve to full wholesale competition. The spot market should not be the priority until the sector can manage full competition.
c. Regulators should encourage and even require supplies to take measures for allowing large users to adjust their demand for power in real time, through smart metering and other means, since competition works properly only when both suppliers and users interact in the market.

8.2 System for Power Supply Bidding with a view to Power Supply Composition

This section will introduce Japan's wholesale electricity bidding system as an example for reference in connection with power procurement under the SBS system, which has yet to be clearly defined. Under the wholesale power system, the Japanese power companies play a role relatively similar to that of the single buyer, but the way they obtain new power sources would be of reference in the design of the SBS.

8.2.1 Problems in Past Invitations to IPPs in Indonesia

In 1992 Presidential Decree No.37 was promulgated as a measure to solve the power supply shortage foreseen by the Indonesian government. The decree strongly encouraged private sector participation in power source development projects. By the time of the Asian currency crisis in 1997, purchase contracts had been signed with a total of 27 IPPs. However, the economic depression which began with the Asian currency crisis led to most of the contracts being broken. Under the contracts which were not broken, the currency crisis led to a sharp drop in the value of the Rupiah, causing a severe back spread between the PLN's Rupiah-based electricity sale price and the US$-based unit prices for electricity under the contracts with IPPs (approximately 6c/kWh excess). This back spread drastically weakened the PLN's financial position, and it is now reviewing contract unit prices.

The plan to bring in IPPs in Indonesia was intended to use private sector funds to augment power supply development funds, even though they cost rather more, because there was no way to develop sufficient power sources to meet the growth in power demand from public sector funds alone. In order to attract private capital while simultaneously reducing power supply costs, the IPPs were offered attractive terms, but at the same time the IPPs involved had to be chosen with consideration for a balanced power supply composition.

8.2.2 Power Source Bidding System taking Power Source Composition into account

As described above, Indonesia's introduction of IPPs was intended to use private sector funds to augment power supply development funds, even though they cost rather more, because there was no way to develop sufficient power sources to meet the growth in power demand from public sector funds alone. In that sense, it differs from the nature of the Japanese IPP bidding system, which was intended to apply market principles to the power sector and reduce electricity charges. Therefore the methods of the Japanese system which appear to be applicable to the future design of the SBS will be summarized below in conclusion.

(1) Expansion of power sources using the power source bidding system

In Indonesia's past introduction of IPPs, the majority of power sources are applied to base load, and the system of soliciting sources from IPPs was certainly advantageous for base load sources. In future, if all power sources are to be developed by the SBS bidding system under the New Electrical Power Law, a bidding system will have to be introduced with methods that allow peak and middle power sources to compete effectively with base power sources.

Specifically, the power purchase prices will have to be set for the anticipated peak, middle and base power supply types (i.e. equipment usage rates) in order to encourage investment in power stations that will have lower equipment usage rates. Under such a method, there would be progress in expansion of peak and middle power sources.

(2) Power supply bidding system with consideration of power source combination

If peak, middle and base power sources are all targeted for investment under the power source bidding system, the volume solicited and the power purchase prices should be set for each equipment usage rate and fuel type in order to manipulate the power source combination while suppressing electricity charges. Therefore long-term targets for power source combination should be studied with a view to making effective use of primary energy and conserving the environment. It is important to clarify the direction of the nation's power source development in this way in order to provide information on which the private sector can base investment decisions.

8.3 An Approach to Power Development Supporting System in line with Energy Policy

Under the Electric Power Policy, energy development in Indonesia is focused on reduction of use of fossil fuel to realize sustainable energy development. New and renewable energy sources are also being introduced as switches in energy use, for the sake of environmental preservation. In this section, electric power development supporting systems to introduce new and renewable energy and to introduce gas-fired power using CDM scheme are studied

8.3.1 Introduction of New and Renewable Energy Sources

We introduce, in this report, the measures for new and renewable energy promotion, which have introduced in foreign countries.

1) Obligation to purchase with fixed price
2) Obligation on the national electric power company to purchase by lump-sum bid
3) Quota and RPS (Renewable Portfolio Standard)
4) Self-regulated purchase system by the fixed price by Electric Power Companies

Clearly the key point of debate in system evaluations now used by each country is how to reconcile [1] expanded introduction of these energy types with [2] reduction of their costs. The existing systems in Germany and Britain emphasize [1] with legal regulations, and have gained a grasp of the issues involved in evaluation. The US RPS system gave more consideration to [2] through the introduction of market principles, but it is still too soon to produce an evaluation.

In order to identify the optimum system for Indonesia at this stage, it is important for the Indonesian government to clarify its priorities between points [1] and [2]. If it aims to expand the introduction of new and renewable energy sources in the short term, there will be an attendant fiscal burden, but legislative measures could be used to make the use of new and renewable energy sources mandatory. If it aims to reconcile expanded introduction of these energy types with cost reduction in the long term, it will have to await an evaluation of the RPS.

8.3.2 Introduction of Clean Development Mechanism(CDM)

The Ministry of Environment carried out a study in which the marginal abatement costs and the amount of reductions of green house gas emissions were calculated for the proposed power generation projects. Then the priorities were assigned to the various projects. Although large projects are not proposed in the study, the development of gas combined cycle, mini hydropower and cogeneration are given to high priorities for CDM and fuel diversification from coal to gas has been recommended.

According to the base case(JICA/LPE Case 2) in the optimal power development study using the least cost method, coal-fired power will have a dominating 57.0% of the installed capacity in 2015. CO_2 emissions are projected to increase to 156.4 million tons in 2015 from 39.6 million tons in 2001. The possibility of having the additional cost to replace coal-fired power with gas-fired power plants covered by the third countries or private companies, is going to be considered.

In the case that a project in which coal-fired power with a capacity of 600MW will be replaced with gas power in 2010, CO_2 emissions credit cost is estimated to 20.77US$/tons-$CO_2$

On the other hand, in Japan, marginal cost of CO_2 emissions in fuel conversion from coal to gas is 29.5 US$/tons-$CO_2$ considerably high and Afforestation Cost and Emission Trading cost have a wide range. It may provide competitive prices if the high CO_2 emission factor in Indonesia are improved.

There are a number of fundamental issues to be discussed for the implementation of CDM. For example, effective demand for CDM emissions offset, type of projects, the price of emissions credits, and credit distribution way between the countries are being discussed. Therefore further study on CDM is necessary.

8.4 Utilization of Captive Power

Captive power shares about 30% of installed capacity in Java-Bali system, which will make an impact on electric power development plan. In this section, present status and movement of captive power are studied for the electric power development plan

8.4.1 Present Status of Captive Power

There are two types of captive power: main power and supplementary power. Main power captive plants are not connected to PLN and supplementary powers are installed for back-up.

Table 8.4.1 Captive Power Installed Capacity in Java-Bali

	Installed Capacity (MW)
Main Power	1,835
Supplementary Power	5,958
Total	7,793

(Source：PLN Statistic 2000)

Consumers chose captives or PLN grid, depending on the reliability or price of electricity. Those who need reliability switch to PLN when the PLN supply becomes stable. Those who need low electricity prices switch to PLN when the PLN tariff is still low or fuel prices are high.

8.4.2 Cost Estimation of Captive Power

We will try to calculate the generating cost of captive power and compare it with the tariff of PLN. In case of new installation, the cost is higher than PLN's present tariff of Rp.371 for Industry (I-4), but it is relatively lower than the tariff which is scheduled to be doubled in 2005. On the other hand, in the case of existing captive which exclude investment costs, the costs are different and depend on the fuel price and tariff schedule.

Table 8.4.2 Comparison the costs between captive power and PLN (Rp./kWh)

Fuel price	Captive power cost		PLN Tariff(I-4)
	Newly installed	Existing	
Rp.1,110/L(with subsidy, present)	Rp.579	Rp.426	Rp.371(Present) Rp.742(Target in 2005)
Rp.1,830/L(without subsidy)	Rp.841	Rp.688	

As the movement of captive power will make an impact on electric power development, it is needed to conduct an actual operational condition survey, and to manage the data of fuel consumption and power generation, and power purchase conditions from existing captive powers. The stable power will be supplied by reflecting the movement of captive power to the electric power development plan.

8.5 Utilization of Demand Side Management (DSM)

In this report, DSM implementation issues will be analyzed by examining the power demand and DSM experience in Indonesia. Then institutional countermeasures for implementing DSM program in Indonesia will be proposed.

8.5.1 Characterization of Power Demand in Indonesia

(1) Daily load curve

Power demand in Indonesia has been increasing constantly, excluding the power crisis in 1991 and economic crisis from 1997 to 1998. Load factor as of 2000 remained at 69.9% which is comparable with the other ASEAN countries

Based on the result of analysis of peak demand over 1,000 hours, peak demand occurs in all months especially between July and December from the results for period of year. Based on the results for time-of-day, peak demand occurs only between 18:00-21:00. Based on the results for day of the week, peak demand of weekends is less than of weekdays. The results of time-of-day show a more conspicuous trend than the other results. Therefore the DSM options which decrease demand between 18:00-21:00 mainly caused by the electric lights are reasonable as a "Peak Cut" type of DSM. That is why DGEEU of MEMR is very keen to install the efficient type lamps in household.

8.5.2 Current Status in Indonesia

The DGEEU staff of MEMR, which is in charge of energy conservation, said that the previous DSM program was suspended after the economic crisis of 1997. Until now, although DGEEU appreciates the significance of DSM, it has not been able to implement substantial DSM programs because of financial issues in the GOI.

Given this situation, DGEEU is now planning or implementing following three programs,

- National awareness campaign in Yogyakarta through the mass media and workshops between local governments, universities and NGO's,
- TERANG program which aims to reduce demand by installing compact fluorescent lamps (CFL's) in household, and
- PJU program which aims to reduce demand by installing efficient lamps in public lighting.

8.5.3 Analysis of the Issues and Recommendations

The introduction of DSM could provoke several technical, financial and systemic issues. In this section, we are going to analyze these problems, focusing on common points among all DSM programs.

(1) Development of governmental organization and its capacity

In accordance with the restructuring of energy sector, PLN is going to be divided into generation, transmission and distribution sections. At this point, it can be assumed that the responsibility of government will increase as a leading organization in DSM in various ways.

For example, concerning the introduction of energy saving oriented DSM programs, parties such as the following are required:

1) Organizations which collect and administrate detailed data, such as load curves and the diffusion rates of electric appliances,

2) Specialists who analyze the data and formulate and evaluate plans for the introduction of DSM,

3) Organizations which support technical roles to formulate standards for electric appliances and examine and evaluate them

are required. In order to keep up with these additional functions, governmental organizations should be developed.

(2) Financial support for improvement of DSM

The introduction of energy saving oriented DSM programs, such as the introduction of highly efficient electric appliances, requires large initial costs for purchasing equipment.

However, in the case of Indonesia, both government and PLN could not afford financial support for the project. There are not any other effective organizations to subsidize it.

Considering these circumstances, it could be concluded that not only technical assistance to support organizational development, but also financial assistance such as 'soft loans', are necessary.

(3) Improvement of DSM after liberalization

In order to introduce a demand-control oriented DSM program such as Load Adjustment contract and Time-Of-Use contract, power suppliers are required to be responsible for the supply of power on the basis of contracts and systems. However, in the case of Indonesia, there is no power supplier who is capable of meeting that responsibility in the framework of liberalization.

In DSM developed countries such as US, investment towards DSM has been decreasing since the implementation of liberalization. Therefore, it may be necessary to discuss methods and actors to promote DSM programs at the formation of liberalization plans in Indonesia.

8.6 Financial Enhancement of PLN

8.6.1 Financial Analysis

We analyzed PLN's financial position based on the company's financial statements. The most remarkable point in the financial condition is the fact that PLN has suffered from chronic deficit since the economic crisis. This was caused by an expansion of USD-denominated expenses on heels of a decline of rupiah. It was found that increases in fuel cost and expenditure for electricity purchase from IPP are main factors for the current position in red ink, along with a rise in interest payment.

8.6.2 Revenue/Cost Analysis

We also analyzed income and expenses in order to study the impact they will have on the company's profits in the future. The income analysis results indicate that the tariff's impact is particularly important, although the income prospects will differ largely depending on such factors as electricity tariff, growth of demand, and expenses and their fluctuation. Compared to a simulation case of retaining the current rate at $0.04/kWh, another case of hiking the rate to $0.07/kWh from 2005 will boost the company's profit by Rp 40 trillion or so in 2010. As for expenses, power purchase from IPP is predicted to become the largest burden on management in the future rather than a rise of fuel cost.

8.6.3 Response of the Government of Indonesia and PLN

Actually, the Indonesian government and PLN has taken such measures as 1) revision of the electricity purchase contract with IPP, 2) debt-equity swap, 3) phased raise of tariff, 4) financial restructuring for PLN, in a bid to minimize an increase of expenditure triggered by the currency crisis and its adverse effects on PLN's financial position.

From the viewpoint of income and expenses, revision of the electricity purchase contract with IPP will reduce power purchasing cost, debt-equity swap will reduce interest payment by converting debts that obliges PLN to pay interest into shareholders' equity, and raise of tariff will boost revenues. PLN's financial restructuring intends to curtail cost from a management aspect to improve productivity, leading a decrease of expenses, as noted in its Efficiency Drive Program (EDP). These measures surely work well in improving financial statements for PLN in terms of income and expenditure, and the effects are likely to surface gradually. However, they will not improve the company's financial position that is exposed to the exchange risk. The same problem could arise in the future when the rupiah falls rapidly and largely again, even if the purchase price from IPP is set at a proper level, debts decrease, and tariff is lowered.

8.6.4 Structural Problem

The fundamental problem on PLN's financial structure is as follows; revenues from power sales are rupiah-denominated, while most of operating expenses are denominated in USD and other foreign currencies, which include fuel cost and electricity purchase cost, and fund raising by borrowing. In short, although revenues are rupiah-denominated, expenditure (fuel cost and electricity purchase cost) and debts are USD-denominated. As production costs and interest payments have climbed on the currency mismatch, the company has faced negative spread in which costs exceed revenues.

8.6.5 Proposals

Accordingly, PLN is required to study steps to clear the currency mismatch between revenues and expenses/fund raising in order to improve its financial structure.

The best solution of the currency mismatch is to introduce USD-denominated electricity tariff or tariff geared to USD rate movement for some users. A uniform tariff raise on a rupiah basis will temporarily erase the company's red ink, but it will not clear up the currency mismatch. The partial USD-denominated tariff system looks more feasible. Large-lot users such as major companies and part of rich people already hold USD accounts, in addition, paying tariff in USD would not much affect their production activities and everyday life. Setting tariff in USD is not unreasonable as long as the rates are around the average in a range seen in other ASEAN members.

Introducing rupiah-denominated expenses could be an option, in addition to leading the USD-denominated revenues. For instance, revising its USD-denominated purchase of fuel could be effective. The ongoing liberalization of energy market is expected to gradually hike fuel cost to the level of international trade. Differential fuel costs by user should be also considered. Fuel cost accounts for approximately 60% of electricity generation cost. Sales of fuel such as gas and oil are rupiah-denominated for individual consumption and USD-denominated for business use in principle. Although PLN buys fuel on a USD basis, all of its customers are not business- and industrial-users; there are also individual users. Nevertheless, if PLN buys fuel for household-use electricity generation on a USD basis, which is so-called lifeline of people, no one will enter in the household sector even after the electricity market is liberalized in the future. As for fuel cost that is controlled by the government policies, shifting supply to rupiah base from USD base could take effects in case PLN selects users on consideration for such policy elements as user base, income differentials, and re-distribution of wealth.

The reduction of the purchasing prices of fuels and electricity from IPP, however, has several problems. The reduction of fuel price is against the governmental decision to liberalize the energy sector, and may damage PLN's competitiveness in the long run. In the same context, re-negotiation with IPP and the reduction of power purchasing price from them could harm trustworthiness of the Indonesian electricity market, and have negative impact on the future prospect of the IPP. The Indonesian government has to balance short-term PLN rescue and long-term electricity market.

8.7 The Measures to Promote the Private Investment

8.7.1 Issues for the Promotion of Private Investment in Indonesia

Various methods have been discussed and studied on the investment in Indonesia. The measures are broadly classified into the following three categories: 1) the approach from the aspect of organizations and systems, 2) the finical assistance from abroad, and 3) the differentiation and separation of low risk consumers. The former two approaches do not necessarily reduce the credit risk. Regarding this, this section presents two business models based on the third approach.

8.7.2 Use of a Special-Purpose Company (SPC) and the Security Investment Collateralized by the Power Purchase Agreement

In this model a Special Purpose Company (SPC), which has generating facilities transferred from PLN, raises the fund by issuing its bond collateralizing generating facilities and the purchase agreement of electricity. In order for the model to function, the investor must be able to utilize the collateralized power plant effectively by himself. Then the foreign electric power companies that want to make inroad into Indonesia are expected to become the investors.

1) The procedure of the scheme is as follows:

(i) PLN establishes the special-purpose company (SPC) by its own fund or by a joint venture with other organization. The initial paid-in capital of a SPC will be usually very small. This is because the SPC is a kind of a dummy company that has no actual business activity.

(ii) PLN transfers a specific power plant (or plural) to SPC. In this case, the transfer means to sell the power plant. SPC pays PLN for the power plant by the fund raised by issuing its bond afterwards.

(iii) SPC that owns the transferred generation unit from PLN concludes the long-term purchase agreement of electricity (more than one year) with major electricity customers. SPC issues the bond to raise the fund collateralizing the purchase agreement. The fund is used to pay PLN for the transferred power plant.

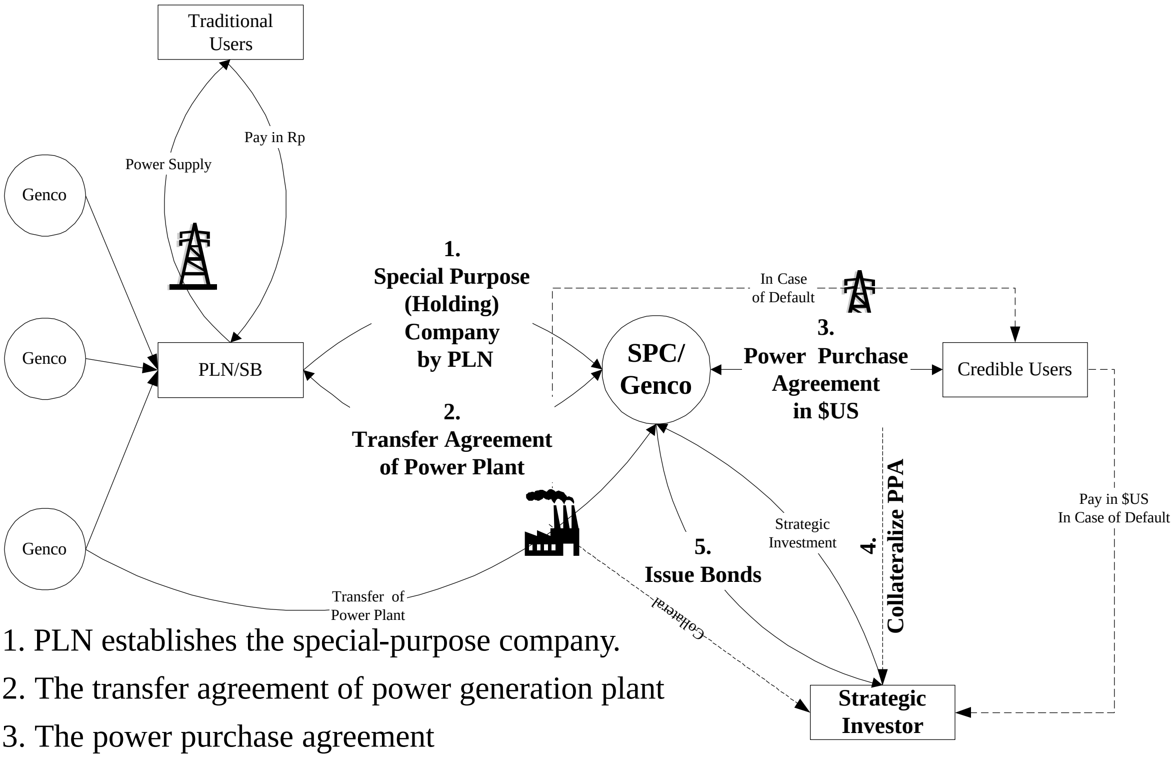
If SPC does not repay the interest and the principal of the bond, the purchaser of the bond (the investor) will receive the electricity charge directly from the major customers by exercising the security right (the right of pledge) set in the purchase agreement between SPC and the major customers. The purchaser can appropriate the money for the interest and the principal.

The purchaser of the SPC bond has the right of pledge on the demand right for electricity charge payment set in the purchase agreement of electricity.

If SPC fails to perform its duty of supplying electricity specified by the agreement due to bankruptcy, which forces SPC to discontinue the power generation, the bond purchaser (the investor) is allowed to perform the duty of supplying electricity by exercising the right of pledge on the SPC's power plant.

(iv) After PLN has received the cost of the transferred power plant, PLN is able to implement the building of a new power plant, the renovating, expanding and streamlining of the existing power plants by appropriating the cost received from SPC.

2) The above scheme is shown in the following figure.



1. PLN establishes the special-purpose company.
2. The transfer agreement of power generation plant
3. The power purchase agreement
4. The collateralizing of the power purchase agreement
5. The issuing of SPC bond

3) Position of Individual Parties

i) PLN: PLN will assign specific power plants for generating electric power consumed by foreign enterprises and transfer the plants to SPC. The arrangement will enable PLN to raise the new fund by collateralizing the purchase agreement with the foreign enterprises. PLN will continue to operate and maintain the power plants transferred to SPC based on the O&M agreement with SPC, so that there is no essential change in this regard except the ownership of the plants.

ii) Foreign Enterprises: JJC and foreign enterprises stationed at Jakarta are seriously concerned about the electric power problem. If a power cut occurs due to the shortage of power supply, the foreign enterprises will possibly loose their investment fund and may suffer a significant loss. They are willing to relieve PLN by accepting the electric power rate of 7 cents/kWh in advance. The current rate will be raised to 7 cents/kWh sooner or later.

In addition, the power plants of SPC are enabled to supply high-quality electric power through the technical assistance and technology transfer from the foreign electric power companies and they deserve to be paid by the foreign enterprises at the rate of 7 cents/kWh.

iii) Strategic Investor <the foreign electric power company>: The foreign electric power company invests in the SPC bond, secures the repayment of the interest and the principal of the bond and earns the profit by licensing the technology and know-how for the efficiency improvement of power plants. Here is the room for promoting the technology transfer through the cooperation between PLN and the foreign electric power company.

In this idea, the investor (the bond buyer) will take the credit risk of the foreign enterprises (the electricity purchasers), not that of PLN. If SPC fails to pay the interest and the principal of the bond, the investor will receive the electric power charges directly from the foreign enterprises, which will be appropriated to the interest and the principal of the bond. If SPC or PLN fails to perform the duty of supplying the electric power to the foreign enterprises and cannot pay for the interest and the principal of the bond by the loss of income, the investor is entitled to obtain the power plant by exercising the right of pledge for the plants. The investor, the electric power company at it home country, will start the power generation to supply electric power to the foreign enterprises that are the other parties of the sales agreement, and receive the electric power charge.

The primary concerns of foreign companies in Indonesia at present are how to prevent the occurrence of planned brown out caused by an electric power crisis in the near future. The stable supply of electric power is given priority over the electricity rate for continuing their operations in Indonesia. If they were supplied with stable and high quality electric power for a long period of time, they would accept the electric power charge on US$ basis.

4) When the above investment model is applied for the actual development, the following points must be reviewed.

- The consumption and its distribution of the consumption of PLN electricity by the foreign enterprises
- The selection of the power plants (PLN's plants) to supply electric power to the foreign enterprises (the power consumption and the distribution to be considered)
- The necessity of improving the legal system (the law of the special-purpose company, the laws related to electricity business etc.)

- The valuation of the assets for specified power plants
- Sounding the strategic investors about their intention
- The possibility of cooperation by the foreign governments (JBIC etc.)
- Sounding the Indonesian government

8.7.3 Investment into Power Generation Market (lifting the ban of the electric power generation in the industrial estate of foreign affiliates)

The current IPP model restricts the selling of electric power only to PLN, meaning that IPP is exposed to the credit risk of PLN. If private investment in the power generation market is to be promoted, the investor in power generation market should be allowed to sell electric power to consumers other than PLN. The most attractive consumer for the investor in power generation would be the industrial estate of foreign affiliates where the investor can supply electric power in the most efficient and safest way. If the Indonesian government decides to allow a partial liberalization of the power supply business to the foreign industrial estate, prior to the full liberalization in future, the investment in the power generation business would increase by the foreign electric power companies.

Followings are the reasons why the foreign industrial estate is focused on for inviting the investment in the market of electric power generation.

1) Few companies in the industrial estate would be forced in a position of nonpayment of electric power charge, because they have enough size to run manufacturing business in the estate. Then there would be no concerns about securing the return on the investment.
2) It is from the viewpoint of profitability. The investment in electric power generation requires selling electricity on the US$ basis and US$ payment in order to avoid the risk of foreign exchange fluctuations in particular by a heavy fall in rupiah. But the companies operating in the industrial estate would have the financial strength enough to pay on US$ basis.
3) It is the efficiency from the technical viewpoint. The transmission and distribution efficiency is higher if the consumers are concentrated in one area.

As for the investment in the power generation business in a leading industrial estate, there is the opinion that the Indonesian government and PLN would not agree with the investment because the investor will take only the excellent consumers. However, the financial problem of PLN and the shortage of electric power are in a serious condition. The introduction of the private investment at the earliest possible point will be the fast road to the sound public finance for PLN and then the state of Indonesia. This model is worthy to be considered as the fundamental plan for inviting the private investment.