

Perusahaan Umum Listrik Negara
Republic of Indonesia

STUDY
FOR
REHABILITATION OF HYDROPOWER STATIONS
IN
INDONESIA

FINAL REPORT
(MAIN REPORT)

September 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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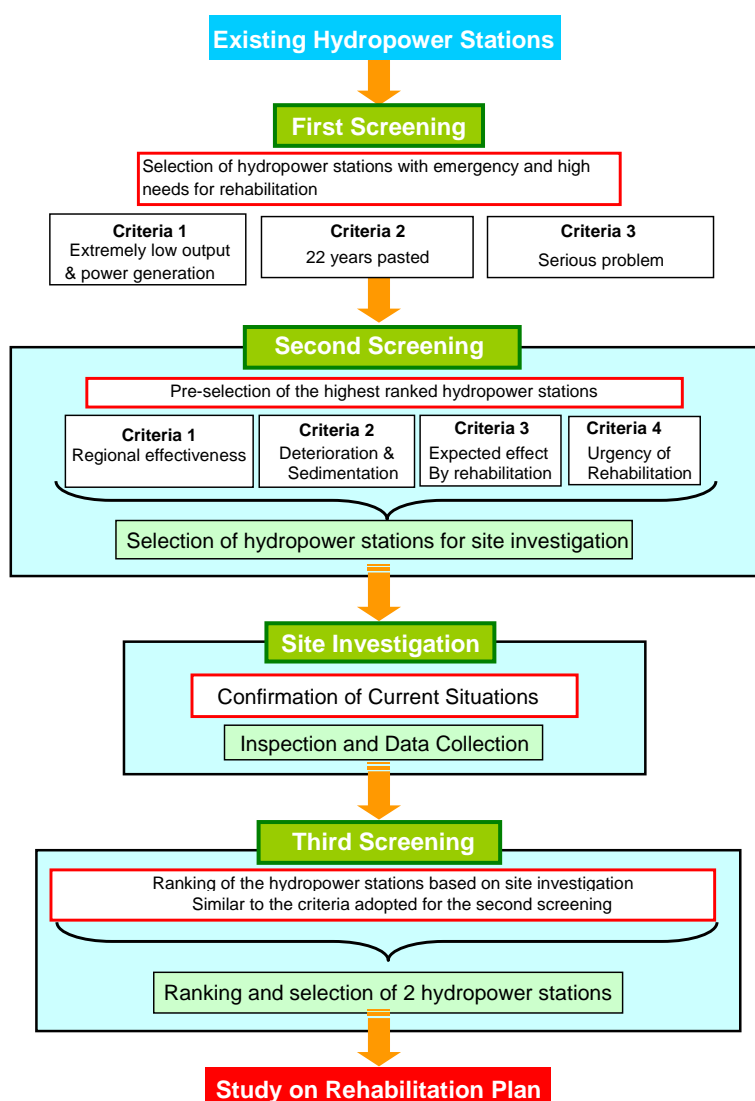
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Executive Summary

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Power demand in Indonesia is steadily increasing in proportion to the economic growth. To cope with the growing power demand, the power development has been implementing primarily with coal-fired thermal power plants. Moreover, the Government of Indonesia promotes conversion of the present generation system to non-oil based, which aims to develop a renewable energy such as hydropower and geothermal. Especially, for the hydropower which can be utilized for abundant domestic resources, the necessity of effective use of the existing hydropower stations have been increasing from the viewpoint of reduction of greenhouse gas emission. In consideration of the above circumstance, this study aims to analyze the current condition of the existing hydropower stations and formulate a possible rehabilitation project among the existing ones. In order to set priorities for the rehabilitation project, screening of the existing hydropower stations is carried out in accordance with the following flowchart.



Total 46 hydropower stations exist in the whole Indonesia excluding small-size, but information of 25 hydropower stations were presented by PLN for this study. As the results of the first and second screening, 4 hydropower stations located in Java Island as described below were selected with high priorities given based on the criteria of i) regional effectiveness, ii) degree of deterioration, iii) degree of sedimentation, iv) expected effect of rehabilitation, and iv) urgency of rehabilitation.

Consequently, site investigation for those hydropower stations was carried out to recognize the current situations. Observations under the site investigations are summarized as follows:

Sutami (Karangkates) Hydropower Station (105 MW) in East Java

Sutami has been operating for over 36 year since 1973. The existing generating equipment was designed based on the technology and practice in the 1970's, and major components such as turbine runner, generator windings and control and protection panel have not yet been rehabilitated to date. Corrosion of turbine runner by cavitations pitting was observed and residual life of the generator windings has been evaluated at 2~3 years. In addition, spare parts for the original equipment are difficult to find in the market.

Wlingi Hydropower Station (54 MW) in East Java

Wlingi has been operating for over 31 years as a cascade power station of Sutami since 1978. The existing generating equipment was designed based on the technology and practice in the 1970's, and major components such as turbine runner, generator windings and control and protection panel have not yet been rehabilitated to date.

Soedirman (Mrica) Hydropower Station (180.9 MW) in Central Java

Soedirman has been operating for 21 years since 1988. The reservoir is facing a serious sedimentation problem, but the power generation is not affected at the moment. The annual sedimentation to the reservoir with about 4.2 MCM, which is more than expected, has been experienced. IP has predicted that in 2014, 80% of the gross reservoir capacity will be buried and sedimentation will reach up to the HWL in 2021. Under these circumstances, watershed management is executing such as construction of sabo dams and campaign to residents on the present growing crop conversion. However, because of the huge amount of sedimentation, it is very questionable whether the watershed management countermeasures can solve the sedimentation problems or not.

The Soedirman (Mrica) Reservoir is utilized for downstream irrigation water supply (10,000 ha) and flood control besides power generation. Implementation of the radical countermeasures to solve the sedimentation problems should be carried out not only to keep function of water utilization but also to ensure flood control function of the Soedirman (Mrica) Reservoir.

Saguling Hydropower Station (700 MW) in West Java

Saguling has been operating for 24 years since 1985. Control system was replaced with the modern computerized system in 2002. Due to water quality with chemical contents, the cooling water system suffers from frequent cleaning of filters. Thus, the existing cooling water pipes including the existing governor system is scheduled to be replaced under the financial assistance of JBIC export credit line.

The annual sedimentation to the reservoir is observed at around 4 MCM. However, since the reservoir capacity is very large (875 MCM), it can still be functional for around 30 years from now. The problems at the moment are the reservoir water pollution and intruded waste materials from households. The study for the water resources management plan in the Citarum River basin including the reservoir watershed is now on-going under the technical assistance of ADB.

Result of Screening

Taking results of the site investigation into consideration, the following hydropower stations are selected to make a study for rehabilitation work or countermeasure as the highest ranked projects at the third screening.

- 1) Rehabilitation work for the generating equipment in Sutami Hydropower Station
- 2) Countermeasure for sedimentation in Soedirman (Mrica) Reservoir

In addition to the study for rehabilitation work of Sutami, a rehabilitation project combined with Wlingi is proposed to be made to enhance effectiveness of the rehabilitation because the both hydropower stations were constructed in the 1970's as cascade power stations in the Brantas River.

Results of the study for the rehabilitation project for Sutami and Wlingi, and countermeasure for Soedirman (Mrica) reservoir are summarized as follows

Rehabilitation Project in Sutami and Wlingi Hydropower Stations

Replacement of major components of the generating equipment is recommended and outline of the rehabilitation project is described as follows.

- 1) Scope of Rehabilitation Works

For Sutami Hydropower Station

Replacement of turbine runner, guide vanes, turbine bearing, inlet valve, governor, generator stator and rotor windings, thrust bearing, AVR and control and protection panels

For Wlingi Hydropower Station

Replacement of runner blade, runner hub, guide vanes, turbine bearing, governor, generator stator and rotor windings, thrust bearing and control and protection panels

- 2) Implementation Period for Sutami and Wlingi Hydropower Stations

Overall: 5 years including;

- Consultancy services: 1.5 years (including Consultant tender, design and preparation of Tender Documents)
- Tender for rehabilitation work: 0.5 years
- Manufacturing and delivery of equipment: 1.5 years
- Rehabilitation work at site: 1.5 years (unit by unit for Sutami and Wlingi)

3) Preliminary Project Cost

	FC (x10 ⁶ JPY)	LC (x10 ⁶ Rp)	Equivalent (x10 ⁶ JPY)
1.Sutami hydropower station	3,335	30,059	3,679
2.Wlingi hydropower station	2,561	22,742	2,821
3.Total	5,896	52,801	6,500

(Prepared by JICA Study Team)

4) Economic and Financial Analysis

Results of the economic and financial analysis are shown in Tables 1 and 2, which studied in comparison of “With project” and “Without project”. “With project” means the rehabilitation work set up immediately, while “Without project” means the power stations continue to operate without any rehabilitation. Moreover, “Without project” is assumed in 2 cases of Case-1 and Case-2 as noted in the table.

Rehabilitation work for Sutami is both economically and financially feasible, while rehabilitation work for Wlingi alone is not feasible in Case-2. However, it will be more feasible to execute the rehabilitation work for Sutami and Wlingi as one project.

Table 1 Economic Indices for Cases-1 & 2

	Case-1			Case-2		
	EIRR(%)	NPV(x10 ⁶ Rp.)	B/C	EIRR(%)	NPV(x10 ⁶ Rp.)	B/C
1.Sutami	28	938,928	5.8	18	121,776	1.6
2.Wlingi	15	130,801	1.9	4	-59,561	0.6
3.Sutami and Wlingi	24	1,069,730	4.1	12	62,215	1.2

Table 2 Financial Indices for Cases-1 & 2

	Case-1			Case-2		
	FIRR(%)	NPV(x10 ⁶ Rp.)	B/C	FIRR(%)	NPV(x10 ⁶ Rp.)	B/C
1.Sutami	35	1,606,755	9.2	23	203,117	2.0
2.Wlingi	14	218,062	1.8	3	-138,696	0.5
3.Sutami and Wlingi	25	1,824,815	4.8	12	64,422	1.1

- Note)
1. Case 1: “Without project”: The operation of the existing machines will come to a total stop in 2019 and no longer operated.
 2. Case 2: “Without project”: The operation of the existing machines will come to a total stop in 2019 and return to the service after the rehabilitation in 2024.
 3. EIRR include benefit of CO2 reduction, while FIRR exclude
 4. NPV and B/C was calculated at discount rate of 10%.

(Prepared by JICA Study Team)

5) Expected Effect of Rehabilitation

Sutami and Wlingi place high priority not only for power distribution to the regional area, but also for power supply of black start of Paiton thermal power plant (3,300MW) located in East Java. Upon renovating the major components, Sutami and Wlingi are expected to have an extended life of another 40 years, and thus Sutami and Wlingi continue to play an important function for reliable and stable power supply in the regional area.

Countermeasure for Sedimentation of Soedirman (Mrica) Reservoir

In order to solve the serious sediment problems in the Serayu River basin, the local government and IP have carried out lots of examination and countermeasures so far. Referring to actual examples of sediment countermeasures in Japan, The sediment countermeasures in the Serayu River basin from the sustainable sediment management point of view are examined and results of the study are summarized as follows:

1) Establishment of Target of Sediment Management by River Basin Area and Time Frame

In order to achieve effective sediment management, the target is recommended to set in terms of each river basin area (upstream river basin area, reservoir area, and downstream river basin area) and time frame (short-term, medium-term, and long-term).

2) Improvement of Sediment Balance

For sustainable sediment management, improvement of the sediment imbalance due to the large amount of trapped sediment (sedimentation) in the Soedirman (Mrica) Reservoir is required. Through this preliminary study, the sediment diversion weir and sediment bypass tunnel are recommended as an effective countermeasure to recover the reservoir storage volume. Capacity and layout of the structures is required to be examined based on the detailed investigation results to be executed in a further study.

3) Recovery of the Reservoir Storage Volume

As a result of this study, dredging in the reservoir is effective for the recovery of the reservoir storage volume. However, as regards the dredging volume and disposal method of the dredged materials, the appropriate scale and method shall be examined based on detailed investigation.

4) Execution of Environmental Monitoring in the Downstream Area and the Realization of the Sustainable Watershed Sediment Management

In order to execute the sustainable river basin sediment management, monitoring the environment in the downstream area is very necessary. Following the improvement of the river basin sediment balance, the main items to be executed are as follows:

- Impacts on water utilization in the downstream area,
- Impacts on the aquatic life (in particular, fishes) and aquatic plant,
- Impacts on riverbed fluctuation and coastal encroachment, and

- Impacts on the structures of the river and seashore.

Finally, the sustainable river basin sediment management adopt the PDCA cycle.

5) Future Vision of the Watershed Sediment Management

The future vision of the sustainable sediment management in the Serayu River basin (i.e., long-term target) is summarized in Table 3.

Table 3 Future Vision of River Basin Sediment Management

Area	Target of the Sediment Management	Countermeasures to be Implemented / Operation and Maintenance
Up-stream Basin Area	<ul style="list-style-type: none"> - Trapping of bed load - Reduction of sediment inflow 	<ul style="list-style-type: none"> - Sabo dams construction and the maintenance - Reforestation - River basin conservation countermeasure
Reservoir Area	<ul style="list-style-type: none"> - Passing the sediment inflow - Recovery of the reservoir storage volume 	<ul style="list-style-type: none"> - Construction of sediment bypass tunnel and appropriate operation and maintenance - Execution of dredging in the reservoir and appropriate disposal of the dredged material
Downstream Basin Area	<ul style="list-style-type: none"> - Improvement of sediment balance - Minimizing the negative impact in the downstream area and maximizing the positive impact in the whole area 	<ul style="list-style-type: none"> - Execution of the environmental monitoring - Execution of the sustainable sediment monitoring through the PDCA cycle

(Prepared by JICA Study Team)

6) Comprehensive Master Plan for the Watershed Sediment Management and Urgent Countermeasure

The comprehensive master plan for the watershed sediment management is recommended to execute first and then the road map for the appropriate sediment balance planning, sedimentation countermeasures, and Operation and Maintenance planning are prepared.

Based on the master plan, the urgent sedimentation countermeasures in the Serayu River basin are required.

Environmental and Social Considerations

In order to implement the above rehabilitation project or countermeasure, the following impacts are expected regarding environmental and social considerations.

Table 4 Expected Impact of Rehabilitation Work at Sutami and Wlingi Hydropower Stations

Expected Impact	Issues to be Considered Further
Oil leakage during rehabilitation work	Appropriate monitoring during operation
Waste (oil, steel, cable, etc)	Appropriate treatment according to Indonesian regulations
Noise and vibration, dust	Preparation of environmental management plan and environmental monitoring plan

(Prepared by JICA Study Team)

Table 5 Expected Impact of Sediment Countermeasure at Mrica Reservoir and Serayu River Basin

Expected Impact	Issues to be Considered Further
Impact on water use at downstream area	Confirmation of water use and land use at downstream area
Impact on aquatic environment	Examination of impact on fishery at downstream area
Possibility of land acquisition and involuntary resettlement due to construction of weir	Conduct of appropriate consultation with land owners
Impact on existing infrastructure due to change of river bed level	Examination of impact on existing infrastructure such as bridges or banks

(Prepared by JICA Study Team)

Conclusions and Recommendation

1) Rehabilitation Project in Sutami and Wlingi Hydropower Stations

The reliable life of hydropower plant prior to major rehabilitation is typically estimated between 30 and 50 years. Sutami and Wlingi hydropower stations were constructed in the 1970's and their operating years nearly reach their reliable lives. The opportune time for starting rehabilitation should be prior to the equipment experiencing frequent and severe problems with its major components. To avoid long term stoppage due to a severe problem and/or non availability of spare parts for damaged components, it is recommended that the appropriate time for rehabilitation for Sutami and Wlingi shall be initiated prior to shutdown by a severe problem of the major components later on in the near future, so as to minimize significant loss of revenue.

2) Countermeasure for Sedimentation of Soedirman (Mrica) Reservoir

For the sustainable sediment management in the Serayu River basin, the watershed sediment management is required to be planned and executed to maximize the whole benefit in the Serayu River basin. From this point of view, organization of the implementation and Operation and Maintenance for the watershed sediment management is recommended as follows:

- Establishment of the Organization for the Watershed Sediment Management
- Participation of the Residents in Decision Making, Planning, Operation and Maintenance - Initiation of Watershed Sediment Management with Financial Support
- Implementation of the Master Plan for Watershed Sediment Management in Serayu River basin.

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Study for Rehabilitaiton of Hydropower Stations in Indonesia

Final Report

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Abbreviations

ABB	:	Air Blast Type Circuit Breaker
AC	:	Alternating Current
ACSR	:	Aluminum Conductor Steel Reinforced
ADB	:	Asian Development Bank
AI	:	Annual Inspection
AMDAL	:	Analisis Mengenai Dampak Lingkungan Hidup
ANDAL	:	Analisis Dampak Lingkungan
AVR	:	Automatic Voltage Regulator
B/C	:	Benefit Cost Ratio
BBWS	:	Besar Balley Willya Sungai
BOD	:	Biochemical Oxygen Demand
BPS	:	Balai Penelitian Kehutanan Solo
CBM	:	Condition Based Maintenance
CFD	:	Computational Fluid Dynamics
CITES	:	Convention on International Trade in Endangered Species
COD	:	Chemical Oxygen Demand
CSR	:	Corporate Social Responsibilities
DC	:	Direct Current
DCS	:	Distributed Control System
DG	:	Diesel Generator
DDC	:	Drawdown Culvert
DO	:	Dissolved Oxygen
E/S	:	Engineering Services
EDG	:	Emergency Diesel Generator
EIRR	:	Economic Internal Rate of Return
EL	:	Elevation
ENPV	:	Expected Net Present Value
EU	:	European Union
FIRR	:	Financial Internal Rate of Return
FC	:	Foreign Currency
FNPV	:	Financial Net Present Value
G/E	:	Generating Equipment
GCB	:	SF6 Gas Circuit Breaker
GI	:	General Inspection
GIS	:	Gas Insulated Switchgear
Gol	:	Government of Indonesia
HPS	:	Hydro Power Station
HWL	:	High Water Level
ICB	:	International Competitive Bidding
IEC	:	International Electromechanical Commission
IP	:	Indonesian Power

IPP	:	Independent Power Producer
IUCN	:	International Union for Conservation of Nature and Natural Resources
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
LC	:	Local Currency
LFC	:	Load Frequency Control
LS	:	Lump Sum
LWL	:	Low Water Level
MEMR	:	Ministry of Energy and Mineral Resources
MO	:	Major Overhaul
MOD	:	Minutes of Discussion
NPV	:	Net Present Value
O&M	:	Operation and Maintenance
ODA	:	Official Development Assistance
OECF	:	Overseas Economic Cooperation Fund
P3B	:	Penyaluran Dan Pusat Pengatur Beban Jawa Bali (Jawa Bali Transmission and Load Dispatching Center)
PCDA	:	Plan, Do, Check and Action
PID	:	Proportional, Integral and Derivative
PJB	:	PT Java Bali Power Company
PJT I	:	Perusahaan Jasa Tirta I
PLC	:	Power Line Carrier
PLC	:	Programmable Logic Controller
PLN	:	Perusahaan Umum Listrik Negara Persero (Indonesia Electricity Corporation)
PMF	:	Probable Maximum Flood
PMG	:	Permanent Magnetic Generator
PST	:	Pumped Storage
RES	:	Reserver
RKL	:	Rencana Pengelolaan Lingkungan
ROR	:	Run of River
RPL	:	Rencana Pemantauan Lingkungan
RUKN	:	Rencana Umum Ketenagalistrikan Nasional
RUPTL	:	Rencana Usaha Penyediaan Tenaga Listrik (Electrical Power Supply Business Plan)
SCADA	:	Supervisory Control and Data Acquisition
SCF	:	Standard Conversion Factor
S/S	:	Substation
TBM	:	Time Based Maintenance
TDS	:	Total Dissolved Solids
TP	:	Total Phosphorus
UBP	:	Unit Bisnis Pembangkitan (Generation Business Unit)
VAT	:	Value-added Tax
WB	:	World Bank

Chapter 1
Introduction

CHAPTER 1 INTRODUCTION

1.1 Background

Power demand in Indonesia is steadily increasing in proportion to the economic growth. Moreover, according to the Review of Power Strategy in Indonesia published by the International Energy Agency in 2008, the increase rate of the power demand between 1997 and 2004 after the Asian monetary crisis, reached about 7% in yearly average.

In consideration of the future economic growth in the country, it is necessary to immediately strengthen the power supply ability in order to meet the power demand which is expected to increase continuously in the future, especially in the islands of Java and Sumatra where major industries are concentrated. To cope with the growing power demand, the first crash program consisting of 10,000 MW coal fired thermal power plants has been implemented. Furthermore, a second crash program is on-going

The Government of Indonesia has announced in November 2008 the national electric power development plan (RUKN: Rencana Umum Ketenagalistrikan Nasional) to promote the conversion of the present generation system to non-oil based power generation. It aims to develop electric power by utilizing renewable energy including hydropower and geothermal energy in the future. Especially, needs of the hydropower development which can be utilized effectively for abundant own energy resources have been rising.

The necessity for the effective use of the existing hydropower station has also been increasing to meet the current power demand. It is also intended to urgently realize the use of "non-fossil fuel" for the present energy consumption structure, from the viewpoint of reduction of greenhouse gas emission.

The power system in Java-Bali is a developed system with share of 60% of the whole power system in Indonesia and hence, PLN (Perusahaan Umum Listrik Negara Persero) sets a higher priority on implementing the power development. However, some of the existing hydropower stations are facing problems such as less reliability, non-availability of spare parts and/or loss of performance due to deterioration and/or sedimentation. Under such circumstances, it is deemed effective to conduct investigation and study on the possibility of rehabilitating the existing hydropower stations.

In consideration of the above issues, this study analyzes the corrected data and information, and carries out review of the rehabilitation project to restore the original function and/or performance. This aims to establish an appropriate plan for said rehabilitation project, basically focusing on the existing hydropower station constructed under the financial assistance of Government of Japan.

The study was conducted in accordance with the Minutes of Discussion (MOD) between JICA and PLN signed on 18 February 2010 in Jakarta, Indonesia.

1.2 Purpose of Study

The purpose of the study is to formulate optimal rehabilitation plan or countermeasures to the current problem for the selected hydropower stations by screening the existing hydropower stations according to priority of needs for rehabilitation or countermeasure. This is intended to recover and maintain the initial functions of them especially in areas with high demand for power supply.

1.3 Study Team and Schedule

1.3.1 Study Team

Nippon Koei Co., Ltd. was awarded the contract to provide consulting services for the study. The study team consists of the following ten experts, and a coordinator:

Table 1.3.1-1 Member List of the Study Team

Name	Position/Expertise
MATSUSHIMA Noriaki	Team Leader / Hydropower Rehabilitation Planning
KAWASHIMA Motoyoshi	Hydropower Civil Engineering
TAGUCHI Shigehisa	Hydropower Mechanical Engineering
KIKUCHI Tatsuhiko	Hydropower Electrical Engineering
KUMASU Munenori	Transmission Line and Substation Engineering
MIYAZATO Tatsuya	Hydrological / Meteorological / Sedimentation Study
SATO Susumu	Geology
EGAWA Hitoshi / IWABUCHI Masahiro	Demand Forecast/Power System
ISHIZATO Hiroshi	Economic and Financial Analysis
OTA Tomoko	Environmental and Social Considerations
YAZAWA Kazumasa	Coordinator

(Prepared by JICA Study Team)

1.3.2 Study Schedule

The study team conducted site works in Indonesia from 18 March 2010 to 22 April 2010 which includes collecting information and data. During said period, site survey for the four hydropower stations namely, Sutami (Karangkates) in East Java, Wlingi in East Java, Soedirman (Mrica) in Central Java and Saguling in West Java were carried out to recognize the current situation by collecting data, through interviews with concerned authorities/personnel. Analysis of the collected data and preparation of draft final report was conducted in Japan. Consequently, the draft final report was presented to PLN in July 2010. The final report, which was revised based on PLN comments, was submitted to JICA in September 2010.

Chapter 2
Current Status of Power Sector

CHAPTER 2 CURRENT STATUS OF POWER SECTOR

2.1 Power Supply and Demand

2.1.1 Outline of Power Sector

(1) Installed Capacity

PLN is a national and sole power company that administers almost the whole of Indonesia as well as Java-Bali area. As of December 2008, PLN and subsidiary companies, i.e. Indonesia Power (IP), Java-Bali Power Company (PJB), PT PLN Batam and PT PLN Tarakan, manages a total capacity of 25,594 MW generating facilities. Out of this supply capacity, the generating facilities of 18,534 MW (72.4%) are located in Java-Bali region. Thermal power generation share 72% of the whole generation with steam (33%), combined cycle (29%) and gas turbine (10%). Following the thermal power, installed capacity for hydro (14%), diesel (12%) and geothermal (2%) is shared as shown in Figure.2.1.1-1.

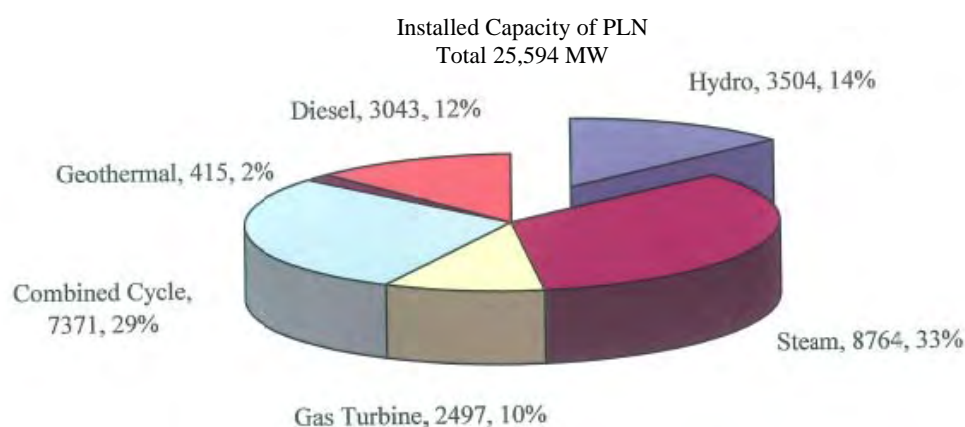


Figure 2.1.1-1 Installed Capacity of PLN as of 2008

(Source: PLN Statistics 2008)

According to PLN Statistics 2008, the installed capacity of PLN from 2000 to 2008 has been increasing with yearly rate of 2.8%. The total capacity increased by about 5,000 MW during the said periods and composition of type of generation for each year is shown in Figure 2.1.1-2. As seen the figure, the capacity of gas turbine generation is largely growing among the power generations, which increased double from 1,203 MW to 2,496 MW

On the other hand, the installed capacity of hydropower was increased by about 500 MW and its share on the total capacity has been constant to be about 15% from 2000 to 2008.

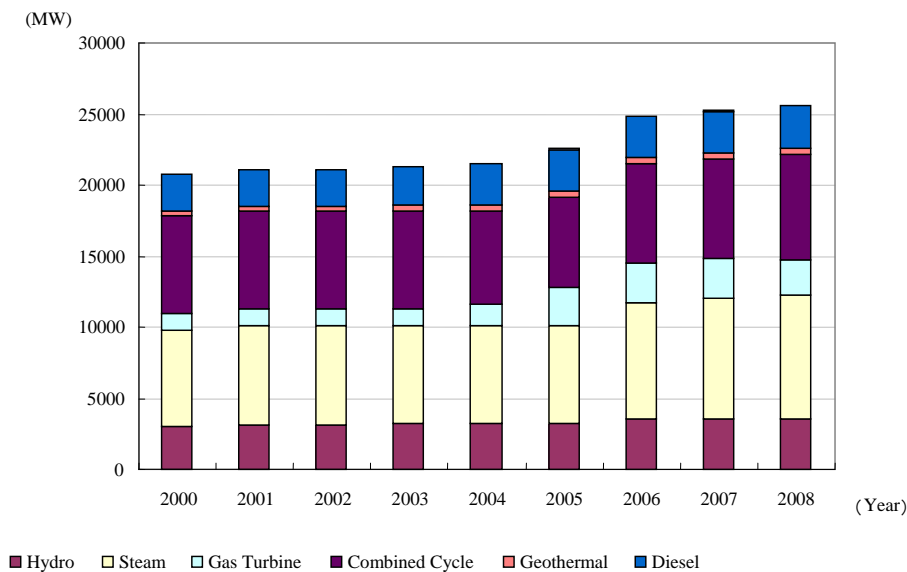


Figure 2.1.1-2 Installed Capacity in Indonesia (2000 ~ 2008)

(Source: PLN Statistics 2008)

(2) Available Capacity

Figure 2.1.1-3 shows relationship of the installed capacity and the available capacity of PLN generating facilities from 2000 to 2008. The available capacity means actual possible output for the power generation, while the installed capacity is the capacity written on the name plates. The available capacity has been reduced to about 80~90% of the installed capacity through the period, and in 2008 it was reduced to 21,580 MW (84.3%) against the installed capacity of 25,594 MW.

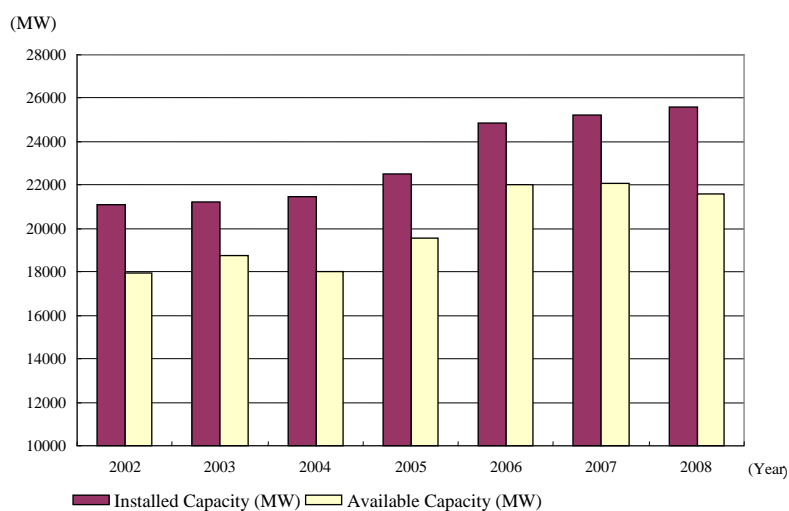


Figure 2.1.1-3 Installed Capacity and Available Capacity (2000~2008)

(Source: PLN Statistics 2008)

The relationship between installed capacity and available capacity in 2008 with type of the power generation is shown in Table 2.1.1-1.

Table 2.1.1-1 Installed Capacity and Available Capacity

Type	Installed Capacity (MW)	Available Capacity (MW)	Reduction (%)
Hydro	3,504	3,397	96.9
Steam	8,764	7,406	84.5
Gas turbine	2,496	2,173	87.0
Combined cycle	7,370	6,399	86.8
Geothermal	415	394	94.9
Diesel	3,020	1,796	59.4
Diesel gas	21	11	52.3
Wind	0.26	0.26	100
Total	25,594	21,580	84.3

(Source: PLN Statistics 2008)

As seen the table, the reduction of hydro was very few (96.9%), although any type of thermal power was reduced to the 85% against the installed capacity. Reason for the reduction on the thermal power might be considered several factors such as trouble and/or deterioration of equipment. On the other hand, it can be said that the hydropower is reliable power source and effectively operating and therefore it is highly expected to utilize the existing hydropower stations.

(3) Peak load

Peak load of the whole Indonesia in 2008 was recorded as 21,120 MW. In the meantime, in Java-Bali region, the peak load recorded was 16,307 MW, which accounts 77% of the total peak load in Indonesia. The peak load in Java-Bali was increasing by average yearly rate of 3.0%. According to a typical daily load curve in the whole Java-Bali power system, night time peak is higher than day time peak, while a daily load curve in West Java including Jakarta shows nearly same demands for day and night time demands. It is supposed that industrialization and commercialization in West Java have been developed.

(4) Power generation

The total power generation of PLN and subsidiary companies in 2008 was 118,047GWh, which shows 6.1% increase from that of 2007. Of the total power generation, PLN produced 36% and the remaining 64% was subsidiary companies.

Of the total power generation, thermal power share 79% of the whole power generation with steam (46%), combined cycle (32%) and gas turbine (5%). Following the thermal power, power generation for hydro (9%), diesel (5%) and geothermal (3%) is shared as shown in Figure.2.1.1-4.

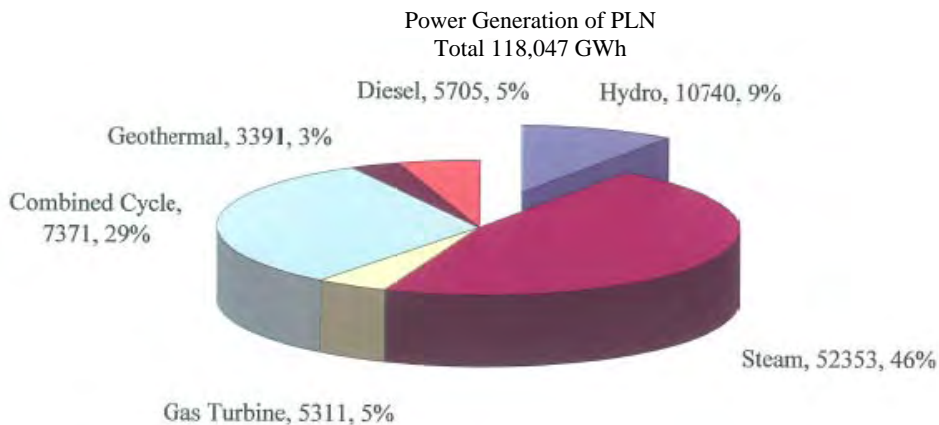


Figure 2.1.1-4 Power generation of PLN as of 2008
(Source: PLN Statistics 2008)

PLN has purchased the power from the external company accounts to 31,390GWh, and the total power generation in Indonesia including generation by external firms other than PLN amounted to 149,437GWh in 2008. The purchased power consists of 8,855GWh (28.2%) from PT Paiton Energy Co., followed by PT Java Power as among the firms with large power transactions.

Figure 2.1.1-5 shows power generation of PLN categorized by type of generation from 2000 to 2008. It is found that the power generation by steam generation is the largest among other sources of power generations. In particular, although the installed capacity of hydropower is about 14% of the total installed capacity, its power generation accounts for 9% of the total power generation.

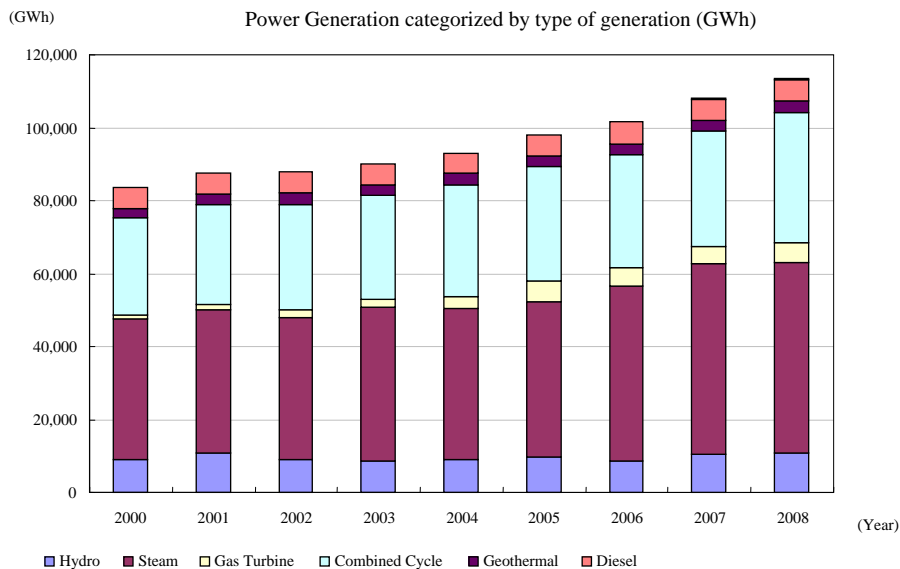


Figure 2.1.1-5 Power generation Classified by Power Source
(Source: PLN Statistics 2008)

2.1.2 Outline of PLN and Organization Structure

(1) Organization

PLN business components are shown in Figure 2.1.2-1.



Figure 2.1.2-1 PLN Business Components

(Source: PLN)

In Java-Bali and Sumatra regions, generation, transmission and distribution business components have been independently separated. In other area meanwhile, branch offices of PLN directly administer business operations as shown in Table 2.1.2-1.

Table 2.1.2-1 Services of PLN on Power Utility Classified by Region

Provided Services	Java-Bali	Sumatra	Other Area
Generation	IP PJB	Generation of Northern Part Generation of Southern Part	9 regional branch offices
Transmission	P3B Java Bali	P3B Sumatra	
Distribution and Customer Services	5 distribution offices	7 regional branch offices	“PLN associated companies”

(Source: PLN Statistics 2008)

As of March 2010, PLN has 36,649 employees. Figure 2.1.2-2 shows the organization chart of PLN as of March 2010.

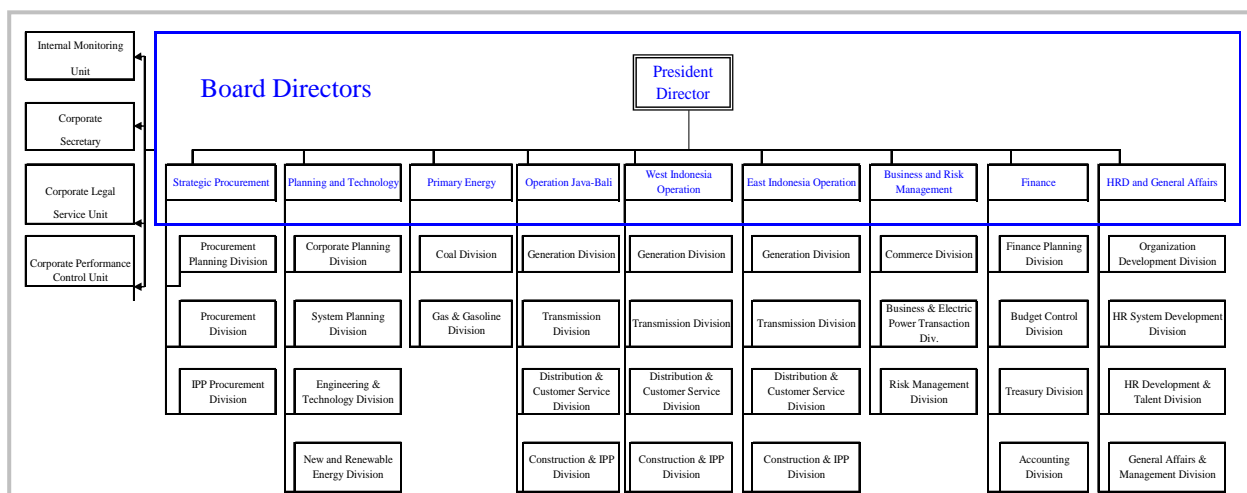


Figure2.1.2-2 Organization Chart of PLN
(Source: PLN)

(2) Power Tariff

Table 2.1.2-2 shows the transitional trend of average power tariff rate up to 2008. The average selling price of the power to consumers in 2008 was Rp 653.0 /kWh, which constantly maintained a price increase of about 7% on average from 2002 to 2008. Consecutively for a long time, loss margins have arisen due to high supply cost and reduction of subsidy to oil. According to data obtained from PLN, the supplying cost (generation cost) in Java-Bali region is about one third of that of Northern Sumatra since the former depends more on hydro generating power.

Table 2.1.2-2 Supply Cost and Power Tariff Rates (2002–2008)

	2002	2003	2004	2005	2006	2007	2008
Power Tariff Rate (Rp/kWh)	448	551	582	591	628	629	653
*Supply Cost (Rp/kWh)	601	618	597	710	954	883	1271
PLN Subsidy (Trillion Rp.)	4	4	3	13	36	44	82

*Supply Cost is used as generation cost in PLN Statistics 2008

(Source: PLN Statistics 2008)

Some of the consumers using private power shift to the power supply from PLN as the subsidy to the fuel has been reduced due to increasing oil prices, As a result, PLN is obliged to invest their budgets for the extension of their facilities. This has become one of the financial burdens of PLN, which leads to the trend of a more effective utilization of renewable energy, in terms of reducing operation and maintenance (O&M) costs. At the same time, the utilization of the existing hydropower station is highly expected in terms of the reduction of O&M costs and power tariff for consumers.

2.2 Power Development Plan

According to Rencana Usaha Penyediaan Tenaga Listrik (RUPTL), which is a development plan published by PLN in 2008, the peak demand in Java-Bali region in 2018 is estimated to reach

43,600 MW. Meanwhile, the peak demand in Indonesia is projected to be 57,800 MW in 2018.

Figure 2.2.2-1 demonstrates the power demand projection and new power development plan for Java-Bali region from 2008 to 2018.

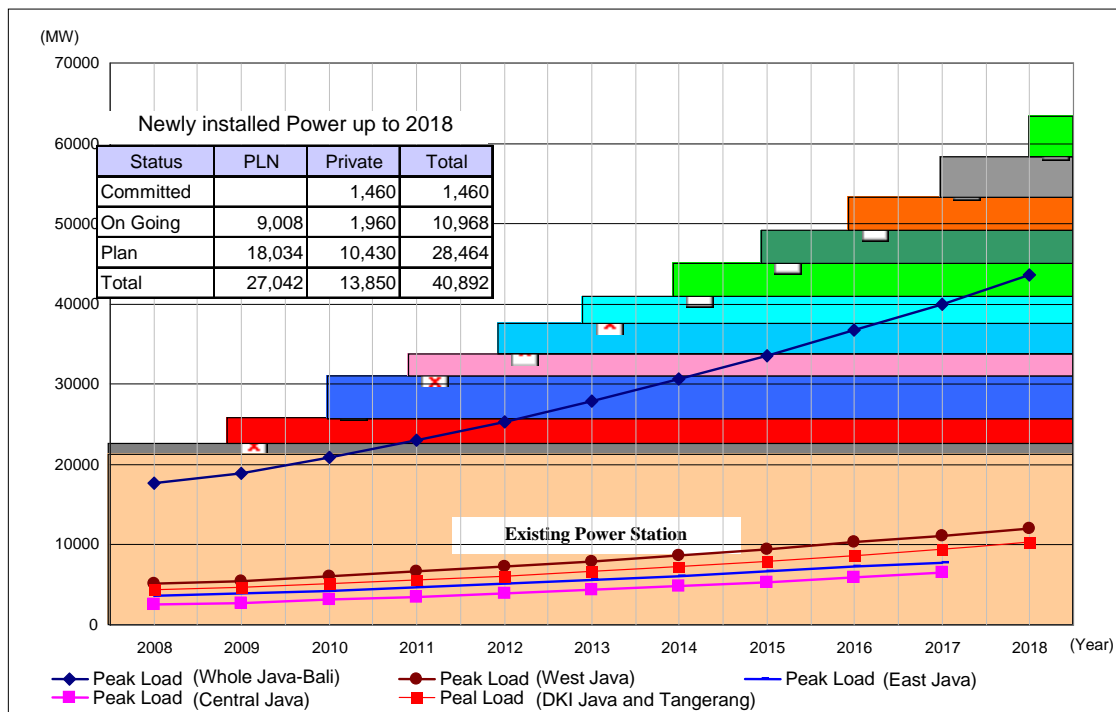


Figure 2.2.2-1 Demand Projection and Power Development Plan
 (Prepared by JICA Study Team based on RUPTL 2009-2018)

A development plan has been drawn up in order to meet the projected demand in the future. In particular, the future plan shown in the graph includes plans to be carried out by an independent power producer (IPP) of a private company, which highly relies on the thermal power station generated from the fossil fuel. Furthermore, in the latter half of 2010’s, there are several geothermal development plans to be carried out by IPP which are highly subjected to the economic circumstances.

Hydropower development also come under review in the second crash program being on progress as well as the geothermal development as a renewable energy and the study for update of hydropower potential resources is implementing. At present, hydropower potential capacity in Indonesia is estimated to be 42,853 MW and approximately 4,200 MW has already been developed to date, which is equivalent to only 10% of the whole potential capacity. Notwithstanding, in Java-Bali region, about 53% of potential hydropower energy equivalent to 2,400 MW has already been developed and the available output is reported to be 2,330 MW in 2008.

Due to the recent high increase in oil price and reduction of the subsidy to the oil, dependency on hydropower generation has gradually heightened. This tendency is particularly noted in Java-Bali region.

Based on a large-scale study conducted by the Ministry of Energy and Mineral Resources (MEMR) and PLN in the past 1990's, seven (7) hydropower developments shown in Table 2.2.2-1 was planned and included in RUPTL in order to make an effective utilization of the hydropower potential. However, development of the hydropower is actually difficult to be promoted due to social and environmental issues such as resettlement of residents, nature preservation etc. Although the new hydropower development plans existed in the RUPTL, implementation of the projects is anticipated to take a long time, therefore, it is extremely important to make the most use of the existing hydropower stations for stable and reliable power supply in sustainability by rehabilitating and improving the existing facilities, taking the fact that renewable energy especially hydropower is set as one of the promoting energy in the national policy into consideration.

Table 2.2.2-1 Power Development Plan of Hydropower

No.	Name	Owner	Type	Capacity (MW)	Operation Year
1	Upper Cisokan	PLN	PST	1,000	2014
2	Kalikonto	PLN	-	62	2016
3	Raiamandala	Private	ROR	30	2016
4	Kesamben	PLN	-	37	2017
5	Matenggeng	PLN	-	885	2017
6	Jatigede	Private	RES	110	2017
7	Grindulu	PLN	PST	1,000	2018
	Total			3,124	

(Source: RUPTL 2009-2018)

Chapter 3
Screening of Hydropower Stations

CHAPTER 3 SCREENING OF HYDROPOWER STATIONS

3.1 Methodology of Screening of Existing Hydropower Stations

3.1.1 Existing Hydropower Stations

The hydropower potential capacity in the whole Indonesia was estimated at 42,853 MW according to RUKN and approximately 4,200MW have been developed to date. The list of the major existing hydropower stations is attached in Appendix A. A total of 46 hydropower stations with total installed capacity of 4,187.5MW exist, excluding small-size hydropower stations and 56.4% of the total capacity is located in Java as shown in Figure 3.1.1-1. Figures 3.1.1-2 and 3.1.1-3 show the installed capacity and number of hydropower stations based on corresponding completion year, respectively. Hydropower stations constructed in the 1980's share half of the capacities. Among the developed hydropower, installed capacities owned by PLN amount to 3,504 MW as of 2008 according to PLN Statistics 2008.

Figure 3.1.1-1 Locations and Installed Capacity of Hydropower Stations

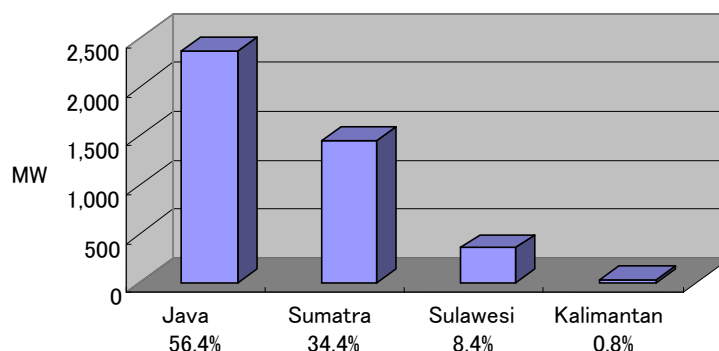


Figure 3.1.1-2 Completion Year and Capacity of Hydropower Stations

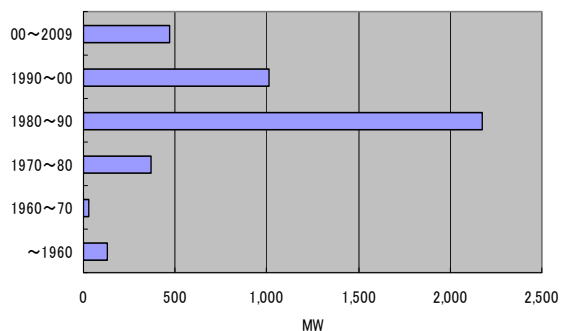
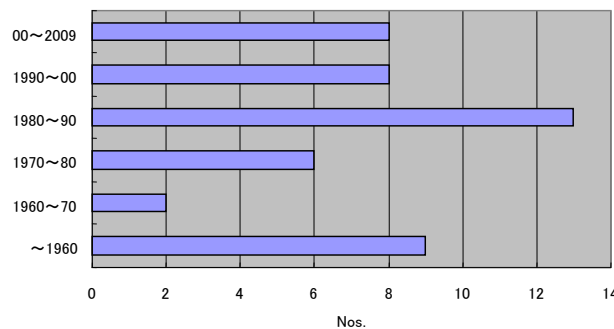


Figure 3.1.1-3 Completion year and Number of Hydropower Stations



(Figures 3.1.1-1 to 3.1.3: Prepared by JICA Study Team based on the data provided by PLN)

3.1.2 Methodology for the Screening of Existing Hydropower Stations

Screening of the existing hydropower stations was executed in accordance with the following procedures in order to set priorities for a rehabilitation plan. The flow chart for the screening process is shown in Figure 3.1.2-1.

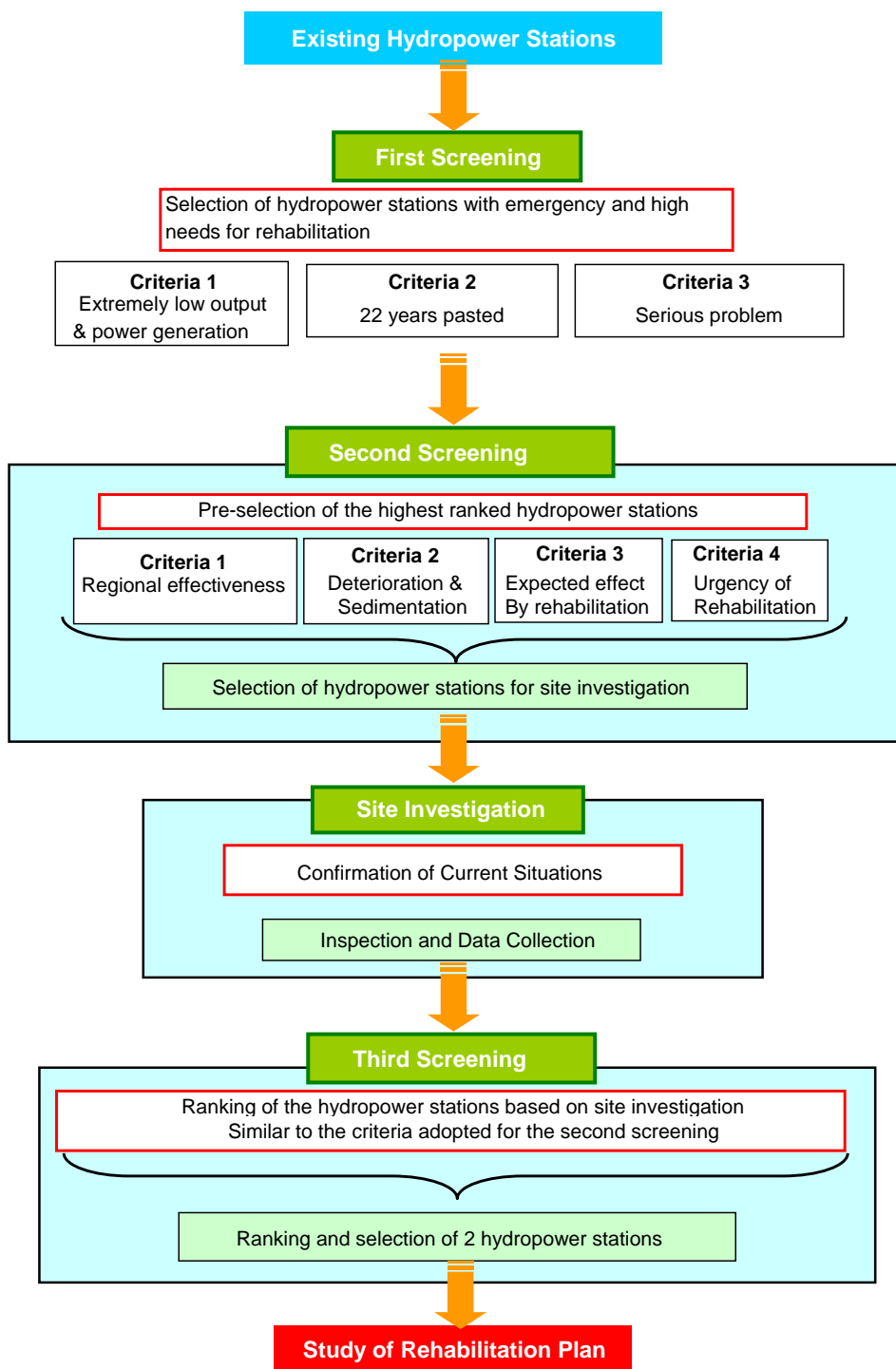


Figure 3.1.2-1 Screening Flow Chart
(Prepared by JICA Study Team)

- (1) First Screening: Selection of hydropower stations based on urgency and necessity of rehabilitation, from among the existing hydropower stations.
- (2) Second Screening: Selection of hydropower stations with higher priority for rehabilitation from among the selected hydropower stations in the first screening.
- (3) Site Investigation: Site investigation for the selected hydropower stations in the second screening.
- (4) Third Screening: Rehabilitation priority ranking of the hydropower stations selected in the second screening based on the results of site investigation, and selection of the two highest ranked hydropower stations

(1) First Screening

The first screening was focused on the following three criteria based on the existing data/information given by PLN. The concept of these criteria describe as follows:

- (i) Hydropower stations that exhibit remarkable decrease in the output and power generation
- (ii) Hydropower stations that are 22 years of service age or more since becoming operational
- (iii) Hydropower stations with serious problems on proper continuous operation

- (i) Hydropower stations that show remarkable decrease in output and power generation
Hydropower stations which have a remarkable reduction of generated output and power generation were screened in comparison with the designed value and the current data.
- (ii) Hydropower stations that are 22 years of service age or more since becoming operational
Legal lifetime of electrical and mechanical equipment related to hydropower station is set at 22 years in a guideline in Japan. There is a possibility that the equipment exceeding said legal lifetime have already deteriorated, causing large scale adverse impacts to the continuous operation of power station in near future. Procurement of spare parts for such equipment exceeding the legal life time may be impossible in the market.
- (iii) Hydropower stations with serious problems on proper continuous operation
Hydropower stations that presently have serious problems and concerns on continuous operation were determined through the review of data and information given by PLN

(2) Second Screening

The second screening was conducted to select hydropower stations which could be subjected to site investigation since verification of current conditions cannot be sufficiently carried out through review of data itself. Therefore, site investigation is an essential prerequisite of the final screening in order to identify proposed sites in the rehabilitation plans.

The second screening was focused on the following four criteria to prioritize the proposed rehabilitation projects.

- (i) Importance of the electricity system in the region
- (ii) Degree of equipment deterioration and sedimentation
- (iii) Effect of power recovery expected through the execution of the rehabilitation
- (iv) Urgency of rehabilitation

(i) Importance as the electricity system in the region

The functions of the hydropower station were considered as important in the regional power network.

(ii) Degree of equipment deterioration and sedimentation

The problems on power generation facilities are obtained from the first screening based on existing data e.g. feasibility studies and design reports, power generation operation records, and water depth of the reservoir survey records, etc. and hearing results from PLN. Causes to such problems were identified.

(iii) Effect of power recovery expected by execution of the rehabilitation

In relation to criteria (i), rehabilitation is intended to contribute in sustaining a stable and reliable power supply to the regional power network. Possible effects of the rehabilitation works include performance improvement, reliable and safety improvement, O&M cost reduction, etc.

(iv) Urgency of rehabilitation

Function and/or safety of hydropower station have to be sustained to realize stable power generation. If any of the hydropower stations is facing such a serious situation, urgent countermeasure is required to be taken.

(3) Site investigation

Site investigation was implemented for the hydropower stations selected in the second screening. This aims to confirm actual conditions of the current issues determined in the second screening, through visual inspections and interviews.

(4) Third Screening

Base on the collected data/information and interviews during the site investigation, priority ranking was conducted considering the same criteria adopted for the second screening. This is intended in to select two candidate rehabilitation plans.

3.2 First Screening

3.2.1 List of Hydropower Stations

At the kick-off meeting held on 21 March 2010 at the PLN head office, the study team requested PLN to present the current operating conditions of the existing hydropower stations for the purpose of first screening. However, it was confirmed that Wonogiri in CentralJava and Bakaru in Sulawesi were excluded from the objectives of this study, because study of their current problems is carrying out under Japanese Official Development Assistance (ODA).

List of the existing hydropower stations with respective current operating conditions given by PLN was shown in Table 3.2.1-1. As shown in the table, 25 hydropower stations were presented by PLN. Locations of these hydropower stations meanwhile are shown in Figure 3.2.1-1.

Table 3.2.1-1 List of Existing Hydropower Stations given by PLN

Area		Hydropower Station	Completion Year	Financial Source
East Java	1	Sengguruh	1988	ADB
	2	Sutami (Karangkates)	1973	JBIC
	3	Wlingi	1978	JBIC
	4	Lodoyo	1983	JBIC
	5	Tulungagung	1993	Austria Loan
	6	Wonorejo	2003	JBIC
	7	Selorejo (Kalikonto)	1973	JBIC
Central Java	8	Soedirman (Mrica)	1988	WB
	9	Jelok	1937	WB
	10	Tulis	2003	WB
West Java	11	Saguling	1985	JBIC
Sulawesi	12	Tonsea Lama	1950	Own fund
	13	Tanggari I	1987	ADB
	14	Tanggari II	1998	ADB
Sumatra	15	Tes	1991	ADB
	16	Musi	2006	ADB
	17	Batang Agam	1983	ADB
	18	Maninjau	1983	ADB
	19	Singkarak	1998	ADB
	20	Besai	2001	WB
	21	Batutegi	2002	JBIC
	22	Kotapanjang	1998	JBIC
	23	Sipansihoporas-1	2005	JBIC
	24	Sipansihoporas-2	2002	JBIC
	25	Renun	2005	JBIC

(Source: PLN)



Figure 3.2.1-1 Location Map Showing the Existing Hydropower Stations Presented by PLN

(Prepared by JICA Study Team)

3.2.2 Study of First Screening

- (1) Decrease of Output (MW) and Power Generation (GWh)

The current output and power generation of the hydropower stations were reported as shown in Table 3.2.2-1 and results of considerations were described as follows.

Table 3.2.2-1 Output and Power Generation of Existing Hydropower Stations

Area	Hydropower Station	Output (MW)			Power Generation (GWh)				
		Design	Present	% for design	Design	Plan (2009)	Actual (2009)	% for plan	% for design
East Java	Sengguruh	29	29	100	99	79	75	95	76
	Sutami	105	105	100	488	463	462	100	95
	Wlingi	54	54	100	167	153	144	94	86
	Lodoyo	4.5	4.5	100	37	40	39	98	105
	Tulungagung	36	36	100	184	131	121	92	66
	Wonorejo	6.5	6.5	100	32	19	20	105	63
	Selorejo	4.5	4.5	100	20	24	27	113	135
Central Java	Soedirman(Mrica)	180.9	180.9	100	580	652	479	73	82
	Jelok	20.48	20.48	100	97	97	94	97	97
	Tulis	12.4	6.0	52	15	15	10	67	67
West Java	Saguling	700	700	100	2156	2156	2295	106	106
Sulawesi	Tonsea Lama	10	10	100	58	50	44	88	76
	Tanggari I	18	18	100	90	63	64	102	71
	Tanggari II	19	19	100	92	66	70	106	76
Sumatra	Tes	17.6	17.6	100	87	152	96	63	110
	Musi	21.5	21.5	100	1120	1839	797	43	71
	Batang Agam	10.5	10.5	100	21	40	35	87	167
	Maninjau	68	68	100	270	218	205	94	76
	Singkarak	175	175	100	986	698	704	101	71
	Besai	90	90	100	804	804	646	80	80
	Batutegi	28.6	28.6	100	200	200	115	58	58
	Kotapanjang	114	114	100	542	542	489	90	90
	Sipansihoporas-1	33	33	100	135	142	65	46	48
	Sipansihoporas-2	17	17	100	69	72	55	76	80
Renun	41	41	100	618	616	566	92	92	

(Source: PLN)

1) Output (MW) of Hydropower Station:

The design and present outputs were shown in the above table. Only the present output of Tulis (12.4 MW) hydropower station in Central Java was reduced to half of the designed output. Consequently, it was confirmed that although Tulis had two units of generating equipment, one of which has been out of service due to alignment problem of the machines caused by the deformation of the civil structure. Meanwhile, the hydropower stations other than Tulis maintained their designed outputs.

2) Power Generation (GWh) of Hydropower Station:

The design power generation as well as the planned and actual generation in 2009, were shown in the above table. Power generation of hydropower stations varies depending on several factors such as climate, water management, equipment trouble etc., aside from the deterioration of the power station. Thus, the annual power generation for each power station is planned every year taking said factors into considerations.

Therefore, the following hydropower stations with remarkable decrease in power generation as compared to the designed value were reviewed to determine the reasons.

Tulugagung in East Java:

Tulugagung hydropower station commenced the operation in 1993 with designed features of the output 36 MW (2x18 MW) and the annual power generation 184 GWh. The power station was constructed to use bypass-water of the existing Palit Agung canal between Brantas River and the diversion tunnel to Indian Ocean, which has a purpose of lowering the river water level particularly in wet season for prevention of flood in surrounding area. Under such situation, available water for the power generation is limited and dependent on the Brantas river water availability. It is supposed to be less river water availability to Tulugagung in 2009. This situation is also supposed by Wonorejo for which power generation was reduced due to more river water supplies for Surabaya city than power generation.

Wonorejo in East Java:

Wonorejo hydropower station commenced operation in 2002 with designed features of 6.5 MW (1x6.5 MW) output and annual power generation of 32 GWh. Wonorejo Dam has multipurpose functions such as to supply water to Surabaya City and to supply for irrigation and power generation. The water supply to Surabaya City is the highest priority and therefore, power generation was only initiated during cases when water discharge from the dam is available. Under such situation, power generation is nearly half the designed value, which is about 16 -20 GWh, from the initial operation.

Batutege in Sumatra:

Batutege Hydropower Station commenced operation in 2002 with designed features of 28.6 MW (2x14.3 MW) output and annual power generation of 200 GWh. Batutege Dam has multipurpose functions such as to supply water for irrigation and power generation. The power generation depends on water management conducted by PI which gives a higher priority on irrigation water rather than power generation. Since the damaged stator windings were repaired in 2009, the power generation in 2009 was reduced from the intended design value.

Sipansihoporas-1 in Sumatra:

Sipansihoporas-1 commenced operation in 2005 with designed features of 33 MW (1x33 MW) output and annual power generation of 135GWh. The power generation in 2009 was remarkably reduced to 48% of the design value. It was confirmed that the reduction caused by the long term outage of generator due to short circuit in the stator winding that occurred in 2009. After the repair of the damaged stator windings, the power generation is expected to recover the design value.

(2) Operating Years after the Project Completion

The following ten (10) hydropower stations are screened that have operated more than 22 years, counted from the completion year to year 2009.

Table 3.2.2-2 Hydropower Stations Operating for more than 22 Years

Area	Hydropower Station	Completion Year	Operating Years
East Java	Sutami	1973	36
	Wlingi	1978	31
	Lodoyo	1983	26
	Selorejo	1973	36
Central Java	Jelok	1937	72
West Java	Saguling	1985	24
Sulawesi	Tonsea Lama	1950	59
	Tanggari I	1987	22
Sumatera	Batang Agam	1983	26
	Maninjau	1983	26

(Prepared by JICA Study Team)

(3) Serious Problems for Continuous Operation

Current issues and past records of rehabilitation of hydropower stations were reported by PLN as shown in Table 3.2.2-3.

Table 3.2.2-3 Current Issues and Past Rehabilitations of Existing Hydropower Stations

Area	Hydropower Station	Current Issues	Past Record of Rehabilitation	
			Item	Year
East Java	Sengguruh	-Water quality of cooling system -Sedimentation	-Replacement of trash rake	1999
	Sutami	-Water quality of cooling system -Sedimentation	-Replacement of battery -Replacement of emergency DG -Repair of elevator -Replacement of circuit breaker -Replacement of governor motor	2008 2009 2009 2008 2009
	Wlingi	-AVR card model -Sedimentation	-Replacement of battery -Replacement of trash rake	2010 1999
	Lodoyo	-AVR card model -Governor	-Replacement of governor motor	2009
	Tulungagung	-Cooling coil of turbine bearing -Oil lubrication of bearing -Salting of electrical parts	-Replacement of heat exchanger -Replacement of battery -Modification of turbine bearing	2008 2008 2010
	Wonorejo	-GCB -Data logger	-Replacement of circuit breaker -Replacement of computer data logger	2010 2010
	Selorejo	-Oil cooler -Sedimentation	-Replacement of grease pump -Replacement of battery and rectifier	2009 2009
Central Java	Soedirman(Mrica)	-Sedimentation	-	
	Jelok	-Old of main equipment	-	
	Tulis	-Labile land influence generator operation	-	
West Java	Saguling	-Control system (No parts are available) -Governor (No parts are available) -AVR (No parts are available) -Corrosion of cooling water	-Replacement of control system -Replacement of cooling water system for #3 and #4 -Replacement of governor	2002 2009
Sulawesi	Tonsea Lama	-Inlet valve -Sedimentation	-	
	Tanggari I	-Card control	-	
	Tanggari II	-Generator Stator	-	
Sumatera	Tes	-	-	
	Musi	-	-	
	Batang Agam	-	-	
	Maninjau	-	-	
	Singkarak	-	-#1 Stator winding -#2 Stator winding	2008 2009
	Besai	-	-Rehabilitation	2002
	Batutegi	-Governor	-	
	Kotopanjang	-	-	
	Sipansihoporas-1	-Governor -Control system -Leakage of shaft seal -Gauging station -Seismograph -Intake and screen gate -Landslide of access road	-Short circuit in the stator winding	
	Sipansihoporas-2	-PLC -Warning station -Automatic gate control -Trash rake	-	
	Renun	-Telemeter -System computer -Service seal of inlet valve -Sedimentation	-	

(Source: PLN)

As seen in the table, most of the existing hydropower stations have been operating with some issues. However, it can be said that such issues could not seriously affect the continuous operation at the moment except for Soedirman (Mrica) Hydropower Station, as the result of the following considerations.

Hydropower stations in East Java

Hydropower stations constructed in the 1970's and the 1980's such as Sutami, Wlingi, Tulugagung and Wonorejo have undergone several rehabilitations in the recent years, and those rehabilitation works were replacement and/or repair for auxiliary equipment (battery, emergency diesel engine, governor motor etc), but not for major generating equipment such as turbine runner, generator etc. However, such frequent replacements even for the auxiliary equipment could be sign of deteriorations of equipment.

Hydropower stations in Central Java

According to information from IP, Soedirman (Mrica) is facing a serious problem on sedimentation and concern about operating continuance in the near future. The gross storage capacity of Mrica reservoir has been reduced to 65% of the original capacity due to sedimentation at an average rate of 4.2 MCM per year. If sedimentation will continuously occur at the same rate, the function of the reservoir will be terminated in 2014 according to IP evaluation. Furthermore, safety of dam itself could also be affected.

Hydropower stations in West Java

Saguling, which commenced the operation in 1985, made rehabilitation work for control and protection system that the old type analog system was replaced with new digital type in 2002. Saguling is facing a problem on cooling water system, but a rehabilitation work of cooling water system as well as governor is planned to be carried out under JBIC export credit line.

Hydropower stations in Sumatra

Singkarak, which commenced the operation in 1998, made rehabilitation works for stator winding of 2 units in 2008 and 2009 respectively.

Sipansihoporas-1, which was commenced the operation in 2005, has several issues for various components of generating equipment such as governor, control system etc., but considering that it commenced operation in 2005, it is supposed that such issues are not caused by the deterioration of equipment. Thus, post evaluation for Sipansihoporas-1 is recommended to recognize the current situation of the equipment.

3.2.3 Result of First Screening

Based on the above study for the first screening, twelve (12) hydropower stations were selected for further screening, as shown in Table 3.2.3-1. These include ten hydropower stations operating for

more than 22 years, plus Tulis and Soedirman (Mrica).

Table 3.2.3-1 Selected Hydropower Stations during First Screening

Area	Hydropower Station	Completion Year	Output (MW)	Operating Years	Decrease of Output/Energy Generation	Operation for more than 22 years	Serious problem for continuous operation
East Java	Sutami	1973	105	36		X	
	Wlingi	1978	54	31		X	
	Lodoyo	1983	4.5	26		X	
	Selorejo	1973	4.5	36		X	
Central Java	Soedirman(Mrica)	1988	180.9	21			X
	Jelok	1937	20.48	72		X	
	Tulis	2003	6.0	6	X		
West Java	Saguling	1985	700	24		X	
Sulawesi	Tonsea Lama	1950	10	59		X	
	Tanggari I	1987	18	22		X	
Sumatera	Batang Agam	1983	10.5	26		X	
	Maninjau	1983	68	26		X	

(Prepared by JICA Study Team)

3.3 Second Screening

3.3.1 Criteria

Second screening was conducted for the twelve hydropower stations selected in the first screening. The following four criteria were adopted in order to determine the hydropower stations highly prioritized for rehabilitation.

- 1) Importance of the electricity system in the region
- 2) Degree of deterioration of equipment and sedimentation
- 3) Expected effect through the execution of the rehabilitation
- 4) Urgency of rehabilitation

3.3.2 Evaluation of Second Screening

(1) Regional Significance

Power balance (MW) of PLN and its subsidiary companies in year 2008 is shown in Table 3.3.2-1.

Table 3.3.2-1 Power Balance (MW) in Year 2008

Area	Installed Capacity (MW)	Available Capacity (MW)	Peak Load (MW)	Reserve Margin (%)
Java	18,534	16,540	16,307	1.4
Outside Java	7,060	5,040	4,813	4.7
Total Indonesia	25,594	21,580	21,120	2.1

(Source: PLN Statistics 2008)

PLN owned and operated about 5,000 generating units with total installed capacity of 25,594 MW as of the end of 2008, of which 18,534 units (72.4%) were installed in Java. Reserve margin of the power system in Indonesia (2.1%) is quite on a low level, especially in Java being 1.4%. It is generally said that 8~10% of reserve margin is required so as not to affect a reliable power supply. Therefore, such small margin may cause an issue on unreliable power supply in the power balance of Indonesia. Considering such power balance especially in Java, hydropower stations located in Java (Saguling, Soedirman, Sutami and Wlingi) as shown in Figure 3.3.2-1, which have larger capacity than others, are highly prioritized for rehabilitation study.

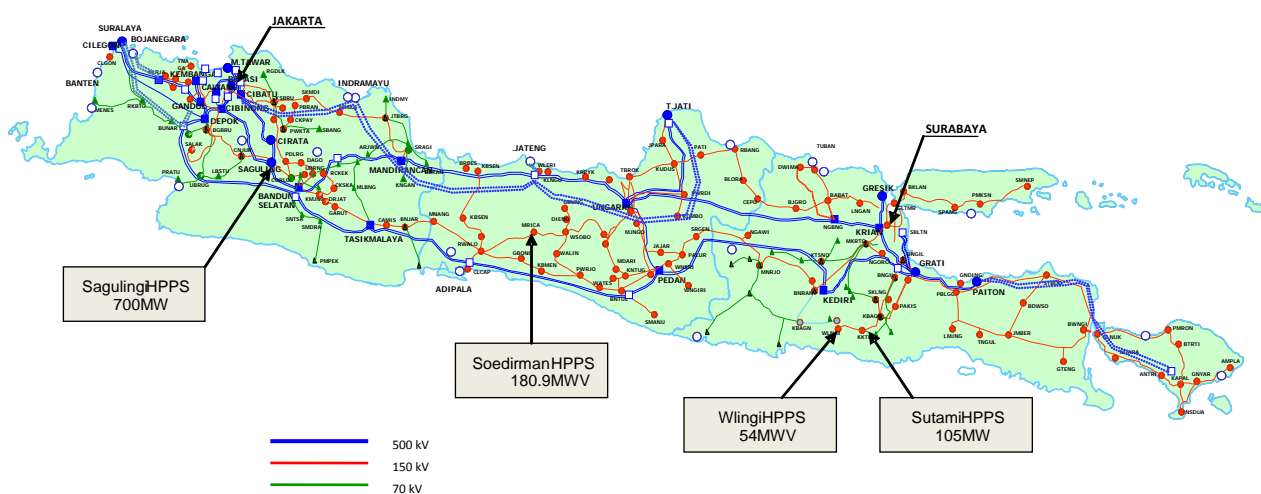


Figure 3.3.2-1 Power Network in Java Bali

(Prepared by JICA Study Team based on the network map provided by PLN)

(2) Degree of Equipment Deterioration and Sedimentation

Replacement of major generating equipment such as water turbine and generator of twelve hydropower stations have not been carried out. Meanwhile, replacement of auxiliary equipment such as battery, EDG, motor etc, have already been implemented. It is especially noted that Sutami and Wlingi hydropower stations in East Java, constructed in the 1970's, have been within the 30~50 years expected reliable lifetime of electrical and mechanical equipment related to hydropower station. Therefore, it is considered that these hydropower stations are at high risk of serious problems.

Problems on sedimentation and reservoir water pollution are very serious in Java and Kalimantan islands from characteristics of geology and soils point of view and also due to watershed management problems. In particular, Sengguluh, Sutami and Wlingi in East Java, and Soedirman in Central Java have big reservoirs, but their capacities are drastically decreased at present as compared to the planned volume. Also Saguling in West Java suffered from serious water quality problems. Meanwhile, significant volume of sediment flows to the reservoir due to effects of deforestation. However as the reservoir gross capacity is considerably huge (Gross: 875 MCM, Effective: 611 MCM), such sedimentation problem is not regarded as serious at present.

(3) Expected Effect of the Execution of the Rehabilitation

The major roles of hydropower station are to function during peak load operation of the power network and to serve water for irrigation and/or city use. It is considered that hydropower stations with large capacities are intended to provide effective power output and reservoir capacity, consequently ensuring a reliable and stable power supply to the region. Hence, hydropower stations such as Saguling (700 MW), Soedirman (180 MW), Sutami (105 MW) and Wlingi (54 MW) which have relatively large capacities are considered to produce remarkable effects through the extension of their service life. In addition, Saguling has a particular function to provide Load Frequency Control (LFC) of 500 kV power transmission network for stabilizing network frequency in case of sudden load change. On the other hand, the expected effect of rehabilitation with small hydropower station is comparatively low.

Based on the above standpoint, such hydropower stations with the output less than 50MW and the power generation less than 100GWh were excluded from the candidate hydropower stations during the second screening.

Table 3.3.2-2 Output/Generation of Candidate Hydropower Stations

Area	Hydropower Station	Output (MW)	Design Generation (GWh)	Operating Years
West Java	Saguling	700	2,156	24
Central Java	Soedirman(Mrica)	180.9	580	21
East Java	Sutami	105	488	36
Sumatera	Maninjau	68	270	26
East Java	Wlingi	54	167	31
Central Java	Jelok	20.48	97	72
Sulawesi	Tanggari I	18	90	22
Sumatera	Batang Agam	10.5	21	26
Sulawesi	Tonsealama	10	58	59
Central Java	Tulis	6.0	15	6
East Java	Lodoyo	4.5	37	26
East Java	Selorejo	4.5	20	36

(Prepared by JICA Study Team)

(4) Urgency of Rehabilitation

As evaluated in the first screening, urgent countermeasures against sedimentation problem of Mrica reservoir were considered to be taken so as to protect its reservoir function and dam safety.

3.3.3 Results of Second Screening

Taking the above assessments into consideration for the second screening, the four (4) high-priority hydropower stations were selected from the 12 hydropower stations that were left during the first screening.

From the view point of regional significance, the power network in Java has a significant issue because of a very small margin in the generation capacity against for the maximum power demand, and moreover the power network in the East Java has partly failed due to acting of the mud-volcano. The stable operation of hydropower stations in the East Java is so important to ensure the stable and reliable power supply to whole Java because the power supply to West Java depends heavily on the large-scale thermal power stations such as Paiton and Grati in East Java.

By the reason, Sutami and Wling which are relatively large-scale hydropower stations in the East Java were selected from the view points of the regional significant and the expected effect, whereas other hydropower stations of Lodoyo, Selorejo, Julok and Tulis located in Java were excluded during the second screening.

In addition to the above selection of Sutami and Wlingi, two more hydropower stations of Saguling and Soedirman were also selected by the following reasons.

- 1) Saguling, which is located in the West Java, was selected because Saguling has the largest output and annual generation so as to have a great impact to the power network by the LFC

function not only by its scale.

- 2) Soedirman, which is located in the Central Java, was selected because Mrica reservoir has a serious problem of sedimentation and an urgent countermeasure is required for cultivation, irrigation as well as for power generation.

On the other hand, hydropower stations located in Sulawesi (Tonsea Lama and Tanggari I) and Sumatra (Batam Agam and Maninjau) were set lower priority than the above hydropower stations

The selected hydropower stations by the second screening were shown in Table 3.3.3-1 for which set with higher priorities than others and to be subject to site investigation for further study.

Table 3.3.3-1 Selected Hydropower Stations Based on Second Screening

Area	Hydropower Station	Financial Source	Output	Completion Year	Operating Years
East Java	Sutami	JBIC	105 MW	1973	36
	Wlingi	JBIC	54 MW	1978	31
Central Java	Soedirman (Mrica)	WB	180 MW	1988	21
West Java	Saguling	JBIC	700 MW	1985	24

(Prepared by JICA Study Team)

3.4 Site investigations

3.4.1 Current Conditions of Sutami Hydropower Station

(1) Power Generation

The Sutami Hydropower Station is located 30 km away from Malang City in East Java province as shown in Figure 3.4.1-1.



Figure 3.4.1-1 Location Map of Sutami and Wlingi Hydropower Stations
(Prepared by JICA Study Team)

Principal features of Sutami Hydropower Station are shown in Appendix B-1.

Sutami Hydropower Station was constructed as a reservoir type hydropower in the upstream basin of Brantas River. It has three units of 35 MW generating equipment with a total installed capacity of 105 MW. It commenced its operation in 1973 for unit 1 and in 1976 for units 2 and 3. All of the equipment are handled and maintained by PT. Pembangkitan Java-Bali (PJB).

The power station was originally designed as peak load operation to serve the regional area including the demand of Surabaya City, via 150 kV transmission line. However, after a 500 kV power system was constructed in East Java, its demand center was moved to Malang City and its surrounding area. Sutami has the largest capacity and share with 37% of the total capacity, i.e., 281 MW of hydropower in East Java. In addition, Sutami has the role of supplying power to serve as black start for the Paiton thermal power plants in East Java.

Energy generation in the year 2009 was recorded at 462 GWh, which was 95% of the designed

value of 488 GWh.

(2) Hydromechanical Equipment (Gates and Penstocks)

Technical specifications and results of the site investigation of the hydro mechanical equipment are shown in Appendix C-1. Other than the equipment shown in the Appendix C-1, the dam is equipped with a spillway gate and river outlet facilities that are being operated by Perusahaan Jasa Tirta I (PJT I), and not by PJB. Hence, investigation and studies about the equipment undertaken by PJT I are excluded from this report.

The equipment has been maintained well since the completion of installation in 1972. Routine inspection and maintenance works have been conducted by the PJB's staff at the power station. It was found that there had been no serious troubles on operation, through interviews with personnel in charge at the power station. It was only reported that a small leakage was observed on the rubber seal of Intake Gate No. 1. This seal is scheduled to be replaced with a new one in the next maintenance period.

During the visual checking of equipment at the site, it was found that the model of the control system of intake gates was obsolete. The system does not conform to the requirements of the current safety regulations for electrical devices. Thus, it was evaluated that these control cabinets must be replaced with the ones that meet the current safety regulations. Furthermore, the colored lenses that cover the indicator lights on the local control cabinet were broken.

Steel surge tanks and steel penstocks have been maintained well and no significant defects such as heavy corrosion were observed.

Although it was observed the draft tube gate (tailrace gate) is fairly corroded, such corrosion does not influence the operating life time of the equipment.

(3) Generating Equipment (Water Turbines, Generators and Control System)

Technical specifications and results of the site investigation of the generating equipment are shown in Appendix C-1.

Unit 1 has been operating for over 36 years since its installation on 30 September 1973, while units 2 and 3 for over 33 years since 28 February 1976.

The generating equipment has been maintained well by power station staff by implementing planned annual inspection, general inspection and major overhaul. It was observed during the site investigation that there were no serious problems that affect the continuous operation. However, the following observations were noted:

- 1) Water Turbine: Water turbine is of Francis type and a spare runner was provided at the same time as the completion of project. The spare runner was replaced by a used runner during major overhaul, which is carried out after 40,000 hours of operation. Damage or cavitations

found in the removed runner were repaired by welding at a workshop in Surabaya, and stored in the power station for further use during the next major overhaul. The existing runners have not yet been replaced with new ones since the initial operation.

- 2) Inlet Valve: Leakage from rubber seals of inlet valves were observed for all units due to gland packing degradation. The rubber seals have not been replaced since the installation of the respective units in 1973 and 1976.
- 3) Governor and Automatic Voltage Regulator (AVR): Governor and AVR, which have important functions such as speed and voltage control in response to fluctuation of the power demand, are of mechanical types with analog indicators. These are already obsolete considering that they were designed in the 1970's and thus, their spare parts are no longer available in the market.
- 4) Generator: Stator and rotor windings were inspected only by means of measuring the insulation resistance during major overhauls. According to the data for unit 2 during the major overhaul conducted in 2006, the insulation resistances were plotted in the range between 1.22 M-ohm and 136 M-ohm for stator windings, and between 83.6 M-ohm and 1,480 M-ohm for rotor windings. The insulation resistance values indicate a sign of deteriorating electrical insulation; however, it is very difficult to evaluate the degree of deterioration with such limited data. Moreover, the measured values were unbalanced and plotted in a wide range from small to large values. It is deemed that there is a potential insulation problem inside the stator and rotor windings. In 2004, Nippon Koei conducted inspection of the generating equipment using the testing equipment for stator windings. Subsequently, the estimated residual life of stator windings was assessed to be two years based on the calculated braking voltage of stator windings. The inspection report is attached in Appendix D of this report.
- 5) Supervisory and Control System: The supervisory and control system are of analog types designed in the 1970's, and replacement of any of said components has not taken place as of date. Operating apparatus on the operating desk such as the handle or knob was worn out. Moreover, all protection relays for the system protection including major components such as water turbine, generator and main transformer are of mechanical types and spare parts are no longer available in the market. Since it is not equipped with automatic data logger used for recording operating status and events, the operating staff takes records manually. Furthermore, data communication to Load Dispatch Center in Surabaya is very limited due to limited band of communication means at the Power Line Carrier (PLC), through the transmission lines.



Operation Desk (analog type)



Control Panel and Operation Desk

(4) Transmission Lines and Substations

1) 150 kV Substation Adjacent to the Power Station

PJB owns and manages two banks of main transformers and 150 kV associated circuit breakers and disconnecting switches for protection of main transformers, installed in the substation adjacent to the power station. Meanwhile, the other outdoor switchgear and outgoing 150 kV transmission line are owned and managed by P3B.

Air blast type circuit breakers (ABB) were replaced with SF6 gas circuit breaker (GCB) in 1990, due to the increase in system capacity. However, disconnecting switches operated by air have not yet been replaced since the disconnecting switches are used for maintenance of GCB without breaking current.

2) 150 kV Transmission Line

A 150 kV transmission line from Sutami Hydropower Station to Waru II Substation in Surabaya (total length 110km) was installed in 1972. Meanwhile, the 150 kV transmission line between Sutami and Wlingi Hydropower Stations (total length 23.6 km) was installed in 1978.

Following the completion of the second unit of Wlingi, another 150kV transmission line to Waru II substation was constructed in 1980.

Waru II was constructed in 1972 with 150 kV and 70 kV substations for supplying power to Surabaya. All circuit breakers in Waru II have been replaced with new ones in 1991, and 70 kV static condensers were removed.

As the construction of large scale thermal power stations were implemented, the network capacity was increased. Then, ABB was replaced with gas insulated system (GIS) including GCB. Waru II was renamed as Waru Substation under the control and operation by P3B. Load dispatching center (RCC4) is located in Waru and control the East Java power network.

The present power network in East Java with power flows in March 3, 2010 is shown in Figure 3.4.1-2.

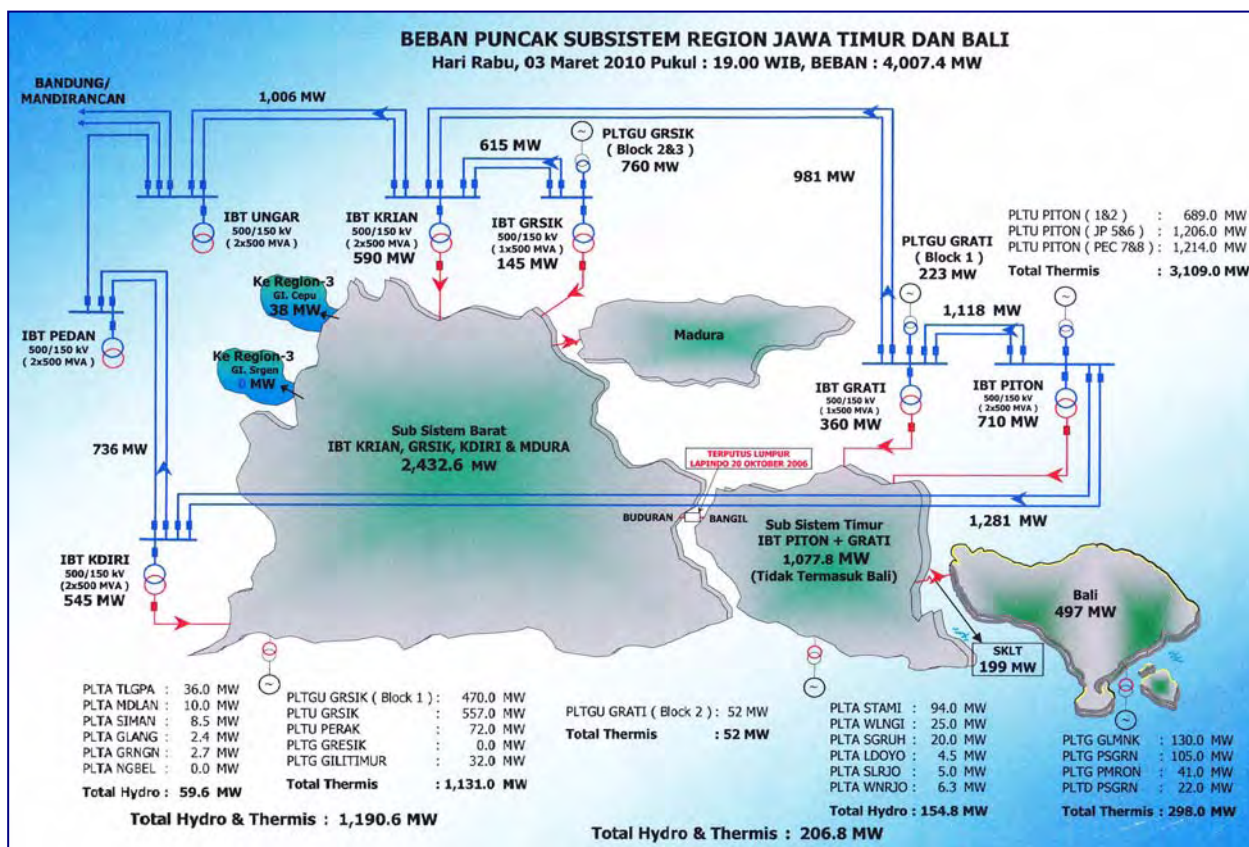


Figure 3.4.1-2 Power Network in East Java

(Source: PLN)

The 150 kV transmission lines from Sutami to Waru are now used only from Sutami to Bangil substations because about 27 km transmission lines between Bangil and Buduran substations has been interrupted in October 2006, due to Mud Volcano eruption in May 2006 at Porong and Sidoarjo districts, 30 km south of Surabaya City.

The Mud Volcano covers an area of about 6 km² and is still active. About 50,000 persons were evacuated from the area. A 15-m high dike was constructed around the volcano to prevent its further expansion.

Due to the eruption of Mud Volcano, the East Java power network was separated into two sub systems, namely, sub-system west and sub-system east. Sutami and Wlingi power stations are connected to the sub-system east including Paiton Thermal Power Station.

(5) Dams and the Appurtenant Civil Work Facilities

1) Organization for Operation & Maintenance (O&M)

The Sutami Dam was completed in 1972 and the Lahor Dam of which reservoir is connected to the Sutami Dam reservoir was done in 1977.

The Sutami Dam and the Lahor Dam including the watershed and the downstream of the dams are operated and maintained well by PJT I under the Ministry of the Public Works in Indonesia.

Meanwhile, the power generation facilities consisting of the power intake, the headrace tunnel, the penstock pipe, the powerhouse and the tailrace outlet are properly maintained by PJB.

2) Current Status of Sutami Dam and Lahor Dam

According to PJT I, behaviors of the measuring apparatus installed to monitor the movement of the dams and the appurtenant structures are generally normal. The ordinary and visual inspection reveal no abnormal phenomena in the dams and the appurtenant structures. The dam safety evaluation based on the measuring apparatus records are made twice per year and the results are then fully reported to the Dam Safety Committee in the Ministry of the Public Works.

The downstream training wall of the spillway in the Sutami Dam was repaired in 2007 under the financial assistance of Japanese ODA (Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project, JBIC Loan No. IP-510, hereinafter called as 'Brantas River Rehabilitation Project'). Subsequently no inconvenience in the dam operation was reported.

3) Current Status of Power Generation Facilities

According to PJB, no periodic inspection has been carried out for the civil structures of the power generation facilities. Nevertheless, it is evident from the observation that the structures are not exhibiting any defects.

4) Visual Inspection Results

The JCA Study Team has carried out the visual inspection of the civil structure focusing on settlement, deformation, leakage, and crack at the dams and power generation facilities. No serious defects have been observed. Results from the observation of the above facilities are shown in Appendix C1.

(6) Sedimentation in the Reservoir

1) Geology in the watershed

As shown in Figure 3.4.1-3, the Brantas River between the Sengguruh Dam and the Sutami Dam flows in the northern margin of the "Southern Mountains Zone" area. The area of the zone shows mountainous topography consisting of Tertiary Oligocene - Miocene volcanic rocks and sedimentary rocks. These rocks are soft to medium hard, and are considered generally to have sediment discharge ratios which are not so high. The tributaries of the Brantas River distributed in the Southern Mountains Zone area have very minor lengths compared to others. Accordingly, it is estimated that no large amount of sedimentation occurs in the area of these dams.

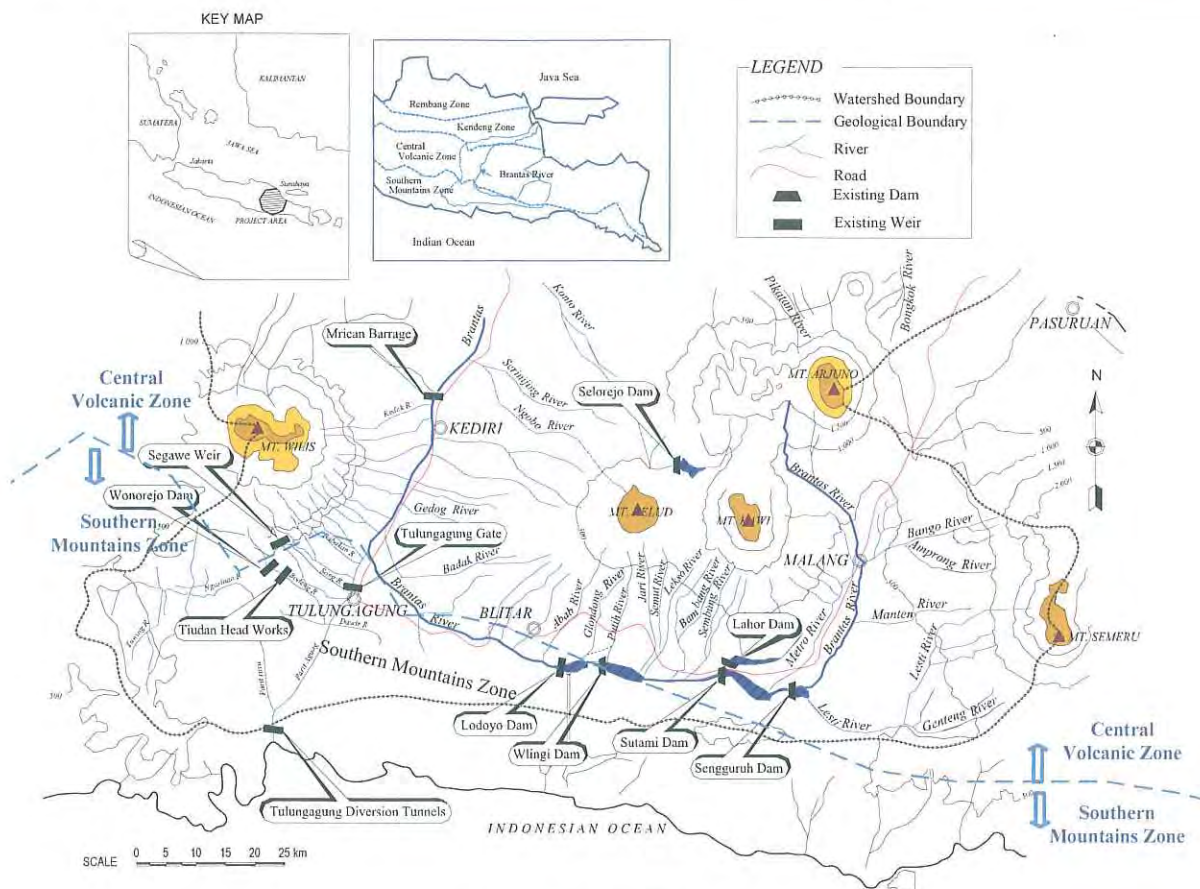


Figure 3.4.1-3 Basin Map of Brantas River
(Prepared by JICA Study Team)

The main source area of the sedimentations in both dams is estimated to be the Central Volcanic Zone area, which consists of mostly Quaternary Pleistocene to Holocene volcanic products, such as laharic deposits and volcanic ash fall deposits. Furthermore, in the Central Volcanic Zone area, many rivers, such as the Mario River, Brantas River, Lesti River and Genteng River, are flowing. Accordingly, it is estimated that the area has rather high sediment discharge ration in general.

Mt. Semeru, which is located in the eastern boundary of the Brantas River basin, is one of the most active volcanoes. Even though Mt. Semeru is continuously active, the mountain slopes in the Brantas River basin seems to be in general stable condition. This is due to the fact that in recent, only ash falls are seen in this basin area, and pyroclastic flows can be seen only in the southeastern slope of the mountain.

Rather large amount of sedimentations, which are mostly made up of fine materials, such as sand, silt, clay, are seen in the Sengguruh Reservoir. Such fine materials can be seen more along the Lesti River, Genteng River and Juog River than the Brantas River and Metro River. However, during heavy rains, it is estimated that all rivers bring the fine materials to the reservoirs in the form of wash and suspended loads. It can be estimated that the fine materials originate mostly from surface soil layers, such as vegetable fields and housing lands.

The surface soil layers consisting of rather old, highly weathered and semi consolidated volcanic

origin (probably ash falls) soil layers, are widely seen on the south – eastern slopes of Mt. Kawi and Mt. Arjuno. The Brantas River and Metro River flows in this area.

The west – southwest slopes of Mt. Semeru are covered by new ash fall deposits, which are fresh and rather coarse, and are very low consolidated. The Genteng River, Juog River and Lesti River flow in this area.



Just upstream of the newly constructed Sabo-dam in Lesti River. The reservoir is filled by fine materials, such as sand, silt, clay.



The Juog River, which is small tributary of the Genteng River. Sedimentation, such as sand, silt, is seen on the riverbed. Local people are gathering sand for constructions.

Sedimentation in the Lesti and the Juog River (Prepared by JICA Study Team)

A critical landslide related to sedimentations at the reservoirs is not reported and not found during the conduct of this study in the catchment areas and in the reservoir areas. However, because of the hilly / mountainous topography, small scale surface slope failures are commonly found in the catchment areas consisting of volcanic products, and even in the Tertiary rock areas. Such small scale slope failures will also produce sediments of the reservoirs.

2) Sedimentation in the Sutami Reservoir
 a) Current Situation of Reservoir Sedimentation

According to the water depth sounding survey at the Sutami Reservoir, PJT I has estimated the sedimentation (trapped sediment) in the reservoir as shown in Figure 3.4.1-4.

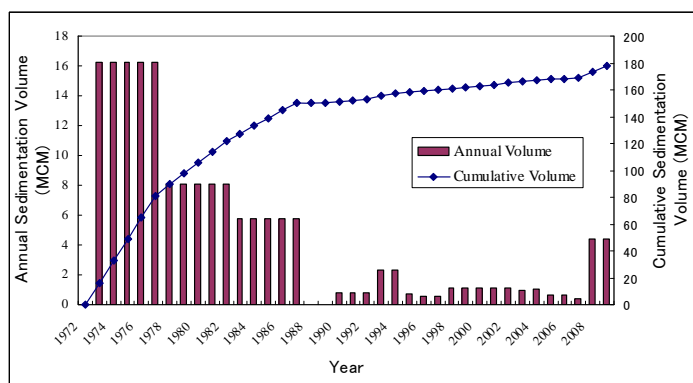


Figure 3.4.1-4 Sedimentation Record in Sutami Reservoir

(Source : JASA TIRTA I)

As shown in the figure, sedimentation in the Sutami Reservoir was reduced drastically. The main reason of the reduction is the construction of the Sengguruh Dam in 1989, which is located about 13 km upstream of Sutami Dam and about 25 km downstream of Malang city.

Layout plan and profile of the Sutami and Sengguruh power stations is shown in Figure 3.4.1-5.

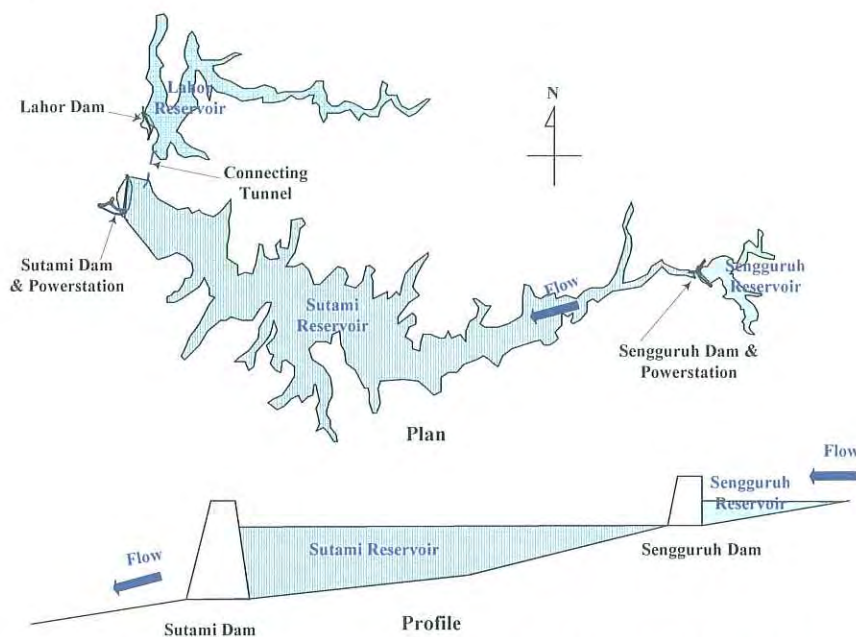


Figure 3.4.1-5 Layout Plan and Profile of Sutami and Sengguruh Power Station
(Prepared by JICA Study Team)

The above facts show that the Sengguruh Dam functions as sediment and garbage storage dam for the Sutami Dam.

PJT I and Besar Balley Willaya Sungai (hereinafter called as BBWS) carried out dredging operation and sabo-dam construction work from 2005 based on the recommendation under the Brantas River Rehabilitation Project. According to the observed sedimentation record, annual average sedimentation ratio in the reservoir from 2005 to 2009 is 1.984 MCM/year. On the other hand, the Brantas River Rehabilitation Project estimates an annual average sedimentation ratio of 0.822 up to 2055 taking into consideration the effectiveness of the sabo dams and the watershed conservation results.

Based on the above annual sedimentation ratios, remaining storage volume in 2055 has been estimated as shown in Table 3.4.1-1.

Table 3.4.1-1 Prediction of Sedimentation in Sutami Reservoir

Item	Estimated based on observed record from 2005 to 2009	Estimated in the Brantas River Rehabilitation Project	Remarks
Remaining Gross storage Capacity in 2009 (MCM) (1)	165.454* ¹⁾	165.454* ¹⁾	*1) Observed record in 2009
Annual Average Sedimentation (trapped sediment) Rate in the reservoir (MCM/Year) (2)	1.984 * ²⁾	0.822 * ³⁾	*2) Estimated based on observed record from 2005 to 2009. *3) Derived from Figure 3.15 of the Report on Engineering Studies for the Brantas River and the Bengawan Solo River Basins Volume 1 Summary
Dredging (MCM/Year) (3)	Included* ⁴⁾	0.3	*4) Effectiveness of the dredging has been included in the annual sedimentation rate obtained in *2)
Accumulated Sedimentation Volume in the Reservoir from 2010 to 2055 (91.264	24.012	(4)=\$((2)-(1)) x 46)
Remaining Gross Storage Capacity in 2055 (MCM)	74.190	141.438	((5)=(1)-(4))
Ratio of Remaining Storage Capacity between 2009 and 2055 (%)	45%	85%	((6)=\$((5) / (1)) x 100)

(Prepared by JICA Study Team based on the observation results by PJT I)

According to the Brantas River Rehabilitation Project, if the watershed conservation master (M/P) was implemented on schedule along with the maintenance dredging works of 300,000m³/year, the service time of the Sutami Reservoir will be extended up-to around 2055. However, if the expected results will not be obtained regardless of the watershed conservation, essential works, such as the large-scale dredging or the dam crest raising, shall be considered as the long-term countermeasures.

b) Current Situation of Sediment Management

In order to achieve the expected results of the Brantas Rehabilitation Project, PJT I and the Besar Balley Willya Sungai (hereinafter called as BBWS) under the Ministry of Public Works are actively conducting the following countermeasures in the reservoir and in the watershed under the financial assistance of Japanese ODA and through its his own fund.

b-1) Sediment Management of Sengguruh Reservoir

A large quantity of sediment and erupted materials from the Semer Volcano flow into the Sengguruh Reservoir from the Lesti River, left bank tributary of the Brantas River. Moreover a large quantity of waste materials from households flows from Malang city.



Sedimentation and Water Hyacinth in the Sengguruh Reservoir.



Sedimentation including waste garbage from Malang city.

Sedimentation in the Sengguruh Reservoir

(Prepared by JICA Study Team)

The sedimentation problem has been well managed by PJT I despite the large amount of sedimentation and garbage. Actual operation results for dredged sedimentation and garbage in 2008 is listed below.

Annual dredged sediment volume in 2008: 273,000 m³

Annual dredged garbage volume in 2008: 76,000 m³

b-2) Sediment Management of Sutami Reservoir.

The sediment and the waste materials from households flowing out of the Sengguruh Reservoir in the above manner are dredged from Sutami Dam. According to the Brantas Rehabilitation Project, the planned annual dredging volume is 300,000 m³. Actual annual dredging volumes in the recent five (5) years by JASA TIRTA I are as follows:

Table 3.4.1-2 Annual Dredging Volume in Sutami Reservoir

Year	Actual dredging volume (m ³)
2005	401,390
2006	450,273
2007	300,750
2008	303,910
2009	315,445

(Prepared by JICA Study Team)

b-3) Reservoir eutrophication of Sengguruh and Sutami Reservoirs

Due to severely untreated waste water from households in Malang city that flows into the Sengguruh Reservoir, eutrophication phenomena have occurred in both reservoirs of Sengguruh and Sutami dams.

3) Watershed Management Plan in Upper Brantas River

The watershed management plan in the upstream of the Brantas River was planned under the Brantas Rehabilitation Project. In addition to the existing sabo dams, new construction of six

sabo dams in the upstream of the Brantas River and of three sabo dams along the Lesti River in the eastern slope of the Sengguruh Reservoir are on-going under supervision of the BBWS. These sabo dams will contribute in reducing the sediment inflow to the Sengguruh Reservoir. The sediment control plan in the Upper Brantas River prepared under the Brantas Rehabilitation Project is shown in Figure 3.4.1-6

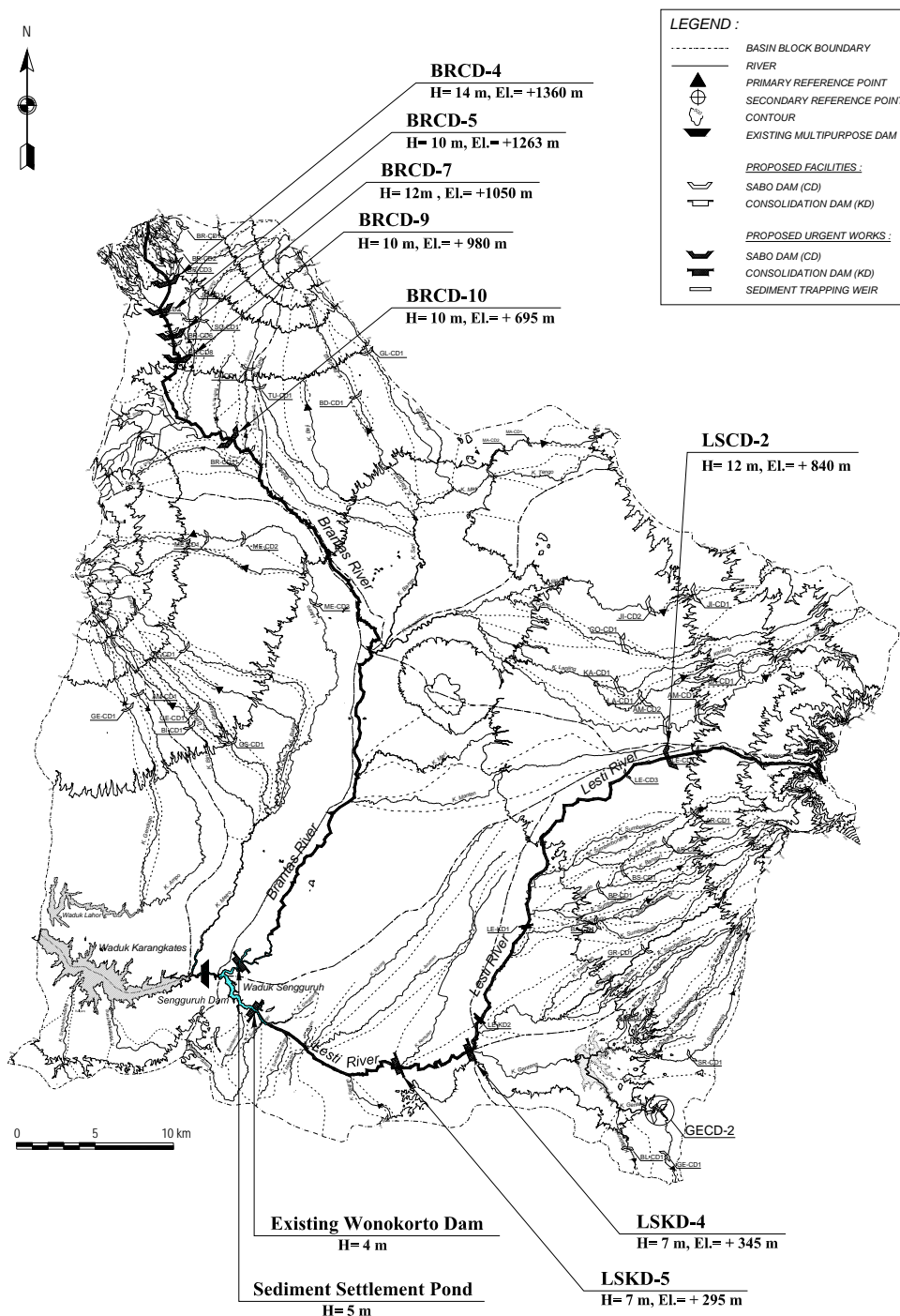


Figure 3.4.1-6 Sediment Control Plan in the Upper Brantas River
(Source: Report on Engineering Studies for the Brantas River and the Bengawan Solo River Basins)

4) Conclusion for Current Sediment Management of Sutami including Upper Brantas River

In conclusion, after the completion of the above 'Brantas River Rehabilitation Project' under Japanese ODA, the sedimentation problem in the Sutami Reservoir will be settled for a few decades. Further in Malang city and the surrounding area, a number of the treatment facilities for the waste materials from households shall be increased to mitigate the troublesome dredging works and cleaning of the trash rack which form part of the intake facilities of the Sengguruh Dam and Sutami Dam. Moreover, modernization or new construction of sewage treatment plants is recommended to improve the reservoir water quality management.

3.4.2 Current Conditions of Wlingi Hydropower Station

(1) Power Generation

Wlingi Hydropower Station is a run-of-river type and located about 30 km downstream of the aforesaid Sutami Dam along the Brantas River.

Principal features of said hydropower station are shown in Appendix B-2.

Wlingi Hydropower Station has two units of 27 MW generating equipment with a total installed capacity of 54 MW. Unit 1 and Unit 2 of the station commenced operation in 1978 and 1980, respectively. The power station is interconnected with Sutami through 150 kV transmission line. The generating equipment are handled and maintained by PJB.

Wlingi has the same role as Sutami, namely, to function during peak load operation to serve the regional area as a cascade hydropower station in the Brantas River. However, its continuous operation as a base load is also taken into consideration as long as water is available.

The energy generation in the year 2009 was 144 GWh/year, which is 86% of the designed value of 167 GWh.

(2) Hydromechanical Equipment (Gates and Penstocks)

Results of the site investigation of the hydro-mechanical equipment are shown in Appendix C, together with the technical specifications. Other than said equipment, the dam is equipped with spillway gate and irrigation intake gates which have been handled by PJT I, and not by PJB. Therefore investigation and studies about the equipment undertaken by PJT I are excluded from this report.

The equipment has been maintained well since the completion of the project in 1978. Routine inspection and maintenance works have been conducted by PJB staff for the power station. It was found that there had been no serious troubles about operation through interviews with personnel in charge at the power station.

During investigations at the site, water hyacinth was observed on the surface of the reservoir. These grasses and rubbish trapped on the trash racks have been removed using two sets of trash

removing system, whenever required. Any reduction of the power generation due to choking of trash racks with water hyacinth and materials was not shown in the data log book.

(3) **Generating Equipment (Water Turbines, Generators and Control System)**

Results of the site investigation of the generating equipment are shown in Appendix C-2 together with the technical specifications.

Unit 1 has been operating for over 31 years since its completion in 1978, while unit 2 remained operational for over 29 years since its completion in 1980.

The generating equipment has been maintained well by power station staff by implementing planned annual inspection, general inspection and major overhaul. Recent major overhaul was carried out in 2006 and 2008 for unit 1 and unit 2, respectively.

It was observed during the site investigation that there were no serious problems that affect the continuous operation. However, the following observations were noted.

- 1) AVR: Output of unit 1 is restricted up to 70% of the rated value due to failure of AVR. The existing AVR is an old model with analog indicators which has been used since the beginning of the operation. PJB plans to replace it with a new one in 2010 using its own fund.
- 2) Governor: Governor is of mechanical type with analog indicators. This type of governor is obsolete considering that it was designed in the 1970's and thus its spare parts are no longer available in the market.
- 3) Generator: Stator and rotor windings were inspected only by means of measuring the insulation resistance during major overhauls. According to the data for unit 2 during the major overhaul conducted in 2008, the insulation resistances were plotted in the range between 235 M-ohm and 1.03 G-ohm for stator windings, and between 253 M-Ohm and 1.74 G-ohm for rotor windings. The measured values were randomly plotted in a wide range from a small one to large one. It is considerable to have tendency of potential insulation problem inside stator and rotor windings. Thus, the insulation resistance values indicate a sign of deteriorating electrical insulation; however, it is very difficult to evaluate degree of deterioration with such limited data.
- 4) Supervisory and Control System: The supervisory and control system was of analog type designed in the 1970's, and replacement of any of said components has not taken place as of date. Operating apparatus on the operating desk such as the handle or knob was worn out. Moreover, all protection relays for the system protection including major components such as water turbine, generator and main transformer are of mechanical types with spare parts which are no longer available in the market. Since it is not equipped with automatic data logger used for recording operating status and events, the operating staff takes records manually. Furthermore, data communication to Load Dispatch Center in Surabaya is very limited due to

limited range of communication means at the PLC, though the transmission lines.

(4) Transmission Lines and Substations

PJB owns and manages the main transformers of 30 MVA and 150 kV associated disconnecting switches for protection of main transformer, installed in the switchyard adjacent to the power station. Meanwhile, other outdoor switchgear and 150 kV transmission line to Sutami constructed under the financial assistance of OECF in 1978 are owned and managed by P3B.

Air blast type circuit breakers (ABB) were replaced with SF6 gas circuit breaker (GCB) in 1990 due to the increase in system capacity. However, disconnecting switches operated by air have not yet been replaced since the disconnecting switches are used for maintenance of GCB without breaking current.

(5) Dams and the Appurtenant Civil Work Facilities

1) Organization for Operation & Maintenance

Wlingi Dam was completed in 1976 while the Wlingi Power Station became operational in 1979.

In the same manner as other hydroelectric power stations existing in the Brantas River basin, the dam including the watershed and its downstream of the dam is operated and maintained well by PJT I while the power station is also properly maintained by PJB.

2) Current Status of the Wlingi Dam

Thirty three years have passed since the completion of the dam and the power station. According to PJT I, behaviors of measuring apparatus which have been installed to monitor the movement of dams and the appurtenant structures are generally normal and the ordinary and visual inspection results also reveal no abnormal phenomena in the dams and the appurtenant structures. The dam safety evaluation based on the measuring apparatus records are made twice per year and the results are then fully reported to the Dam Safety Committee in the Ministry of the Public Works.

Mt. Kelud erupted on a large scale on February of 1990. Consequently, Wlingi Reservoir was filled fully with the erupted volcanic materials. In order to immediately restore the reservoir function, dredging works in the reservoir and various sabo works have been undertaken under the financial assistance of OECF between 1990 and 1995. Afterwards, in order to prevent the intrusion of the erupted volcanic deposits from the southern slope of Mt. Kelud into the reservoir, Mt. Kelud sabo project was initiated. However the progress of the project implementation was only 50 % by 1996.

3) Current Status of Power Generation Facilities

According to the PJB, no periodical inspection has been carried out for the civil structures of

the power generation facilities. Nevertheless, it is evident from the observation that structures are not exhibiting any defects.

4) Visual Inspection Results

JICA study team has carried out the visual inspection of the civil structure focusing on settlement, deformation, leakage, and crack at the dams and power generation facilities. No serious defects have been observed. Results from the observation of the above facilities are as shown in Appendix C2.

(6) Sedimentation in the Reservoir

1) Geology in the Watershed (Refer to Figure 3.4.1-1 of Sub-section 3.4.1)

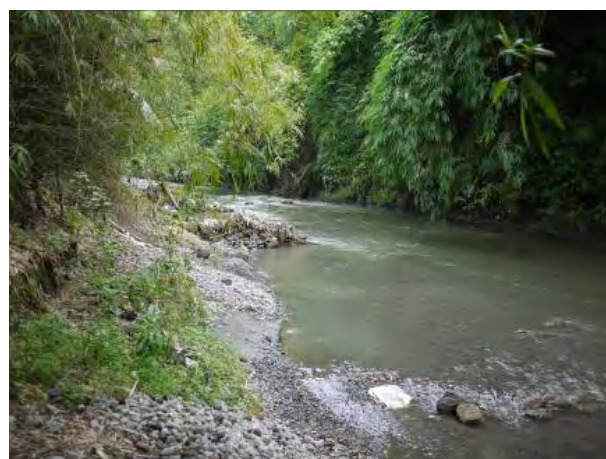
As discussed in Sections 3.4.1 regarding Sengguruh Dam and Sutami Dam, the main source of sedimentations in the Wlingi reservoir is estimated to be the Central Volcanic Zone area, which consists of mostly Quaternary Pleistocene to Holocene volcanic products, such as laharic deposits, and volcanic ash fall deposits.

The riverbed sediments materials of the tributaries of the Brantas River (such as Lekso River, Jari River), distributed on the southern slope of Mt.Kelud are coarser materials than those in the upper reaches of the Brantas River and its tributaries (such as Lesti River, Genteng River). This is due to Mt.Kelud eruptions. Mt.Kelud remains very active until now. The volcanic products from the mountain are made up of pyroclastic flow and ash fall.

After its eruptions, lahars (volcanic mud flows) are produced and flow during heavy rains along the existing rivers such as Lekso River and Jari River. Due to its recent eruption the Wlingi Reservoir has been almost filled with sediments.



Middle reaches of the Merawu River, near Desa Sijeruk, in which landslide has occurred in 2006. Terrace deposits are distributed in both banks. The riverbed is covered by deposits of sand, gravel and boulders. Mountain slopes in this area are mostly covered by forest, and seem to be generally stable at present.



Lower reaches of the Jari River. Riverbed deposits are sand, gravel and some boulders, which are originated from laharic deposits

Sedimentation in the Lekso and the Jari Rivers (Prepared by JICA study team)

Consequently, the most critical sediments that discharge to the Wlingi Reservoir deemed to be materials from the tributaries of the Brantas River, distributed on the southern slope of Mt. Kelud.

The southern mountainous area of the Wlingi Reservoir consists of tertiary volcanic / sedimentary rock formations of the southern mountains zone. Due to very short tributaries of the Brantas River distributed in this area and the geological condition mentioned above, the sediment discharge ratio in such area is estimated to be very low in general.

The sediments discharged from the upstream of the Brantas River are also estimated to be very minimal due to the existence of the Sutami Dam and Sengguruh Dam in the upstream of the Wlingi Dam.

A critical landslide related to sedimentations to the reservoir is not reported and not found in this study in the catchment areas and in the reservoir area during the field reconnaissance study. However, due to the hilly/mountainous topography, small scale surface slope failures are commonly found in the catchment areas consisting of volcanic products, and even in the tertiary rock area. Such small scale slope failures will also produce sediments in the reservoir.

2) Current Situation of Sediment Management in the Wlingi Reservoir

Under the above circumstances, in order to maintain the reservoir function of the Wlingi Dam, BBWS is actively conducting the following countermeasures in the reservoir and in the watershed under the financial assistance of Japanese ODA and through its own fund

a) Sediment Control Plan around Southern Slope of Mt. Kelud.

As shown in Figure 3.4.2-1 several sabo projects in the western and southern slopes of Mt. Kelud are presently ongoing.

In particular in order to mitigate the intrusion of sedimentation to the Wlingi Reservoir, construction of bypass channel is necessary to flush out sediments from the branching rivers such as the Putih River, Jari River, Semute River and Lekso River discharging into the downstream of the Lodoyo weir (See Figure 3.4.2-2).

This bypass channel is not completed as of date. The lowering of the riverbed in the middle and the lower reaches of the Brantas River causes serious impacts, thus the construction of this bypass channel will be essential to mitigate the situation.

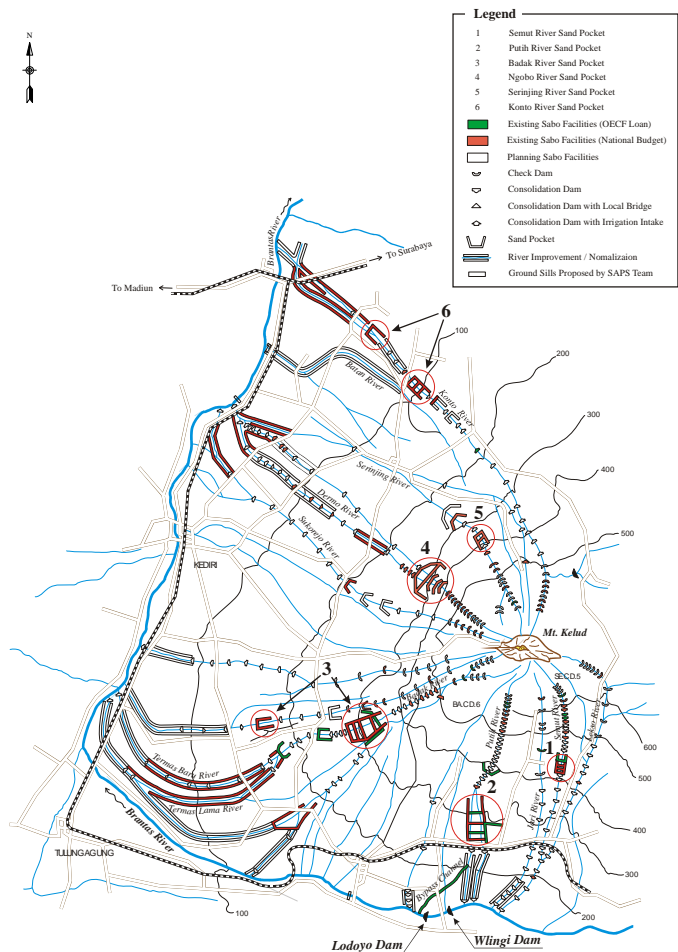


Figure 3.4.2-1 Sediment Control Plan in Mt. Kelud Area

(Source: Report on Engineering Studies for the Brantas River and the Bengawan Solo River Basins)

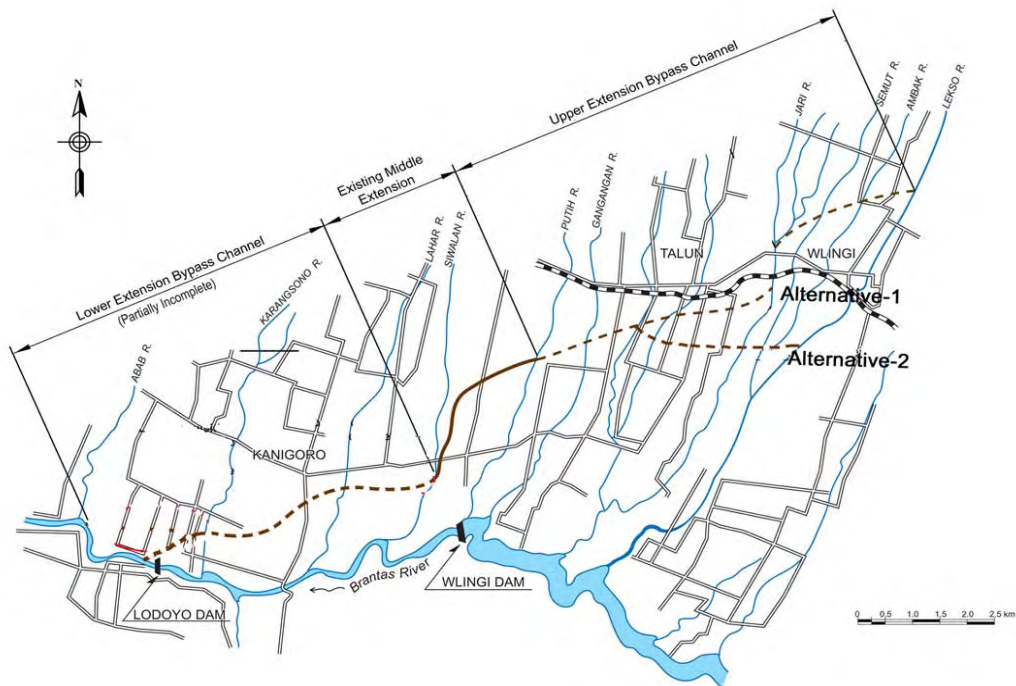


Figure 3.4.2-2 Bypass Channel Detail in Mt. Kelud Area

(Source: Report on Engineering Studies for the Brantas River and the Bengawan Solo River Basins)

b) Dredging Work and Sediment Flushing Operation for Wlingi Reservoir

As shown in the photos below, large scale continuous dredging in the Wlingi Reservoir and sand flushing through the spillway gates, are being carried out, several times per annum. Sand flushing operation to flush out the sedimentation in the Wlingi Reservoir and Lodoyo Weir reservoir into the downstream of the Lodoyo Weir in the Brantas River, is executed in the following manners:



Wlingi reservoir, Reservoir dredging works



Wlingi dam, Existing spoil bank

Dredging Works for Wlingi Reservoir (Prepared by JICA study team)

- Making Wlingi and Lodoyo reservoir perfectly empty, and
- Discharging the reservoir water from the Sutami dam, upstream of Wlingi dam and Lodoyo weir.

The annual dredging volume and the annual sand flushing volume in the Wlingi reservoir proposed by the aforesaid ‘Brantas Rehabilitation Project’ are as follows:

Planned annual dredging volume: 200,000 m³

Planned annual sand flushing volume: 400,000 m³

On the other hand, actual annual dredging volume and sand flushing volume in the last five (5) years are shown in Table 3.4.2-1.

Table 3.4.2-1 Annual Dredging and Sand Flushing Volume (Unit: m³)

	Actual dredging volume	Actual sand flushing volume
2005	115,502	935,498
2006	80,258	356,555
2007	150,630	459,179
2008	150,100	395,480
2009	175,626	145,514

(Prepared by JICA study team)

Consequently, the effective reservoir volume of Wlingi Dam was kept to more or less 2.0 MCM on Dec. of 2009, which is 38% of the planned effective reservoir volume of 5.2

MCM.

- c) Lots of waste materials from households are mixed with the sediment likes in the reservoir such as Sengguruh Dam located upstream of Sutami dam. In order to mitigate the troublesome dredging works and cleaning of the trash rack which form part of the intake facilities, campaign for the river environmental conservation to the local residents in the river basin are being conducted. It will however take time to realize the effects of said campaign.
- 3) In conclusion, sedimentation problems in the Wlingi Dam will be resolved upon completion of construction of the abovementioned bypass channel and by actively campaigning for river environmental conservation.

3.4.3 Current Conditions of Soedirman Hydropower Station

(1) Power Generation

Soedirman Hydropower Station is located on the Serayu River flowing near Banjarnegara City in the Central Java province in Central Java as shown in Figure 3.4.3-1.



Figure 3.4.3-1 Location Map of Soedirman Hydropower Station

(Prepared by JICA study team)

Principal features of Soedirman Hydropower Station are shown in Appendix B-3.

Soedirman Hydropower Station was constructed as a reservoir type hydropower in the Serayu

River for the purpose of irrigation and power generation. It commenced operation in 1988 and all the equipment including the associated civil structures are managed and maintained by Indonesia Power (IP).

The power station has three units of 60.3 MW generating equipment with a total installed capacity 180.9 MW. The generated power is transmitted to Wonosobo and Rawalo through 150 kV power network. The total installed capacity of Central Java (Region 3) is 4,510 MW which is obtained from 4,166 MW thermal (steam and gas), 309 MW hydro and 35 MW geothermal. The capacity of Soedirman Hydropower Station shares 4.0 % of the total installed capacity, and 58% of the hydropower in the Central Java.

The operating pattern of Soedirman is quite different between rainy and dry seasons due to the availability of reservoir water and the balance of irrigation water. As a typical daily operating pattern in the rainy season, 120 MW was continuously generated through the day plus 180 MW peak load operation from 17:00 to 22:00 hrs, recorded in Jan, 2009. On the other hand, only 5 hours peak load operation was recorded in the dry season of Nov. 2009, since supplying irrigation water to the downstream is given priority over power generation. The average energy generation in the past 5 years was 450 GWh/year, which is 77.6% of the designed value of 580 GWh.

(2) Hydromechanical Equipment (Gates and Penstocks)

Results of the site investigation of the generating equipment are shown in Appendix C-3 together with the technical specifications.

The equipment has been maintained well since the completion of project in 1988. Routine inspection and maintenance works have been conducted by IP staff at the power station. It was found that there had been no serious troubles about operation through interviews with personnel in charge at the power station.

During the visual checking of equipment at the site, a small leakage was found from the rubber seal on the gate leaf of spillway gate no. 3. The rubber seals have not been replaced since 1988 but are scheduled for replacement in the next maintenance period.

It was reported that minor leaks of hydraulic fluid were observed at the upper flange of the guard gate of lane no. 1 of drawdown culvert gate during the closing operation of the gate. The gasket at the upper flange is also scheduled for replacement in the next maintenance period.

Small seepage water was observed at the upstream end of the guard gate lane no. 2. The O&M staff reported that this seepage between concrete and bonnet of the gate was found recently. It was advised that grouting of the gap is necessary to stop water seepage to avoid the gate from heavily corroding.

It is reported that all the hydraulic fluid for all the hydro-mechanical equipment in this power station have not been completely replaced since the completion of the project. Thus, the concerned

staff were advised to check the quality of the fluid and to replace them periodically, so as to avoid pressure oil unit and piping from clogging due to scales.

(3) Generating Equipment (Water Turbines, Generators and Control System)

Results of the site investigation of the generating equipment are shown in Appendix C-3 together with the technical specifications.

The three units have been operating for over 21 years since the project completion in 1988.

The generating equipment has been maintained well by power station staffs by implementing planned annual inspection, general inspection and major overhaul. It was observed during the site investigation that there have been no serious problems that affect the continuous operation. However, the following observations were noted:

- 1) Inlet Valve: Small leakage was found on the rubber seal of the inlet valve No. 3. The rubber seals have not been replaced since 1988 but are scheduled for replacement with new ones in August 2010.
- 2) Governor and AVR: Governor and AVR, which have important functions such as speed and voltage control in response to fluctuation of the power system, were rehabilitated in 2006 by means of replacement to digital type electric apparatus since the original parts were not available in the market.
- 3) Control and Protection System: The control and protection system have been replaced in 2006 with modern system with computers. Hence, all data for operation and status can automatically be monitored and controlled in display of the computers.

(4) Transmission Lines and Substations

Main transformers of 70 MVA and 150 kV associated outdoor switchgears including circuit breakers and disconnecting switches and 150 kV transmission lines which were constructed under the WB funds in 1988 are controlled, operated and maintained by P3B of subsidiary company of PLN. All outdoor switchgear is operating without any trouble.

(5) Dams and the Appurtenant Civil Work Facilities

1) Organization for Operation & Maintenance

Some dams used for the operation of the hydroelectric power station owned by IP, are the property of the Ministry of the Public Works. However, for Soedirman Hydropower Station, all facilities including dam is owned and managed by IP.

2) Current Status of the Mrica Dam

Although IP itself has no regulation on the management of the dam, it carries out monitoring and periodical maintenance in accordance with the regulation of the Ministry of Public Works.

The monitoring and maintenance activities carried out by IP are summarized in Table 3.4.3-1.

Table 3.4.3-1 Maintenance and Monitoring Activities for the Dam and Civil Structures

Maintenance and Monitoring Category	Check Item
A. Regular monitoring and maintenance	
A-1 Weekly monitoring	Visual inspection of structures
A-2 Monthly monitoring	Environment, geotechnical, hydrological monitoring. Measurement of civil structure
A-3 Quarterly maintenance	Clearing of weeds
B. Annual inspection	Inspection of measuring device for the power intake, the main dam, spillway, powerstation, drawdown culvert.
C. Special inspection	The inspection is conducted when a specific incident occurs.
D. Inspection	The inspection is conducted when the monitoring results indicate extraordinary values, such as extraordinary displacement of main dam due to earthquake. However, such inspection has not been carried out yet.

(Prepared by JICA study team)

Twenty years have passed since the completion of the dam and the power station. According to IP, behaviors of measuring apparatus which have been installed to monitor the movement of the dam and appurtenant structures are generally normal. Moreover the regular and visual inspection results did not reveal any abnormal phenomena in the dam and the appurtenant structures. Dam safety evaluation based on the measuring apparatus records are conducted twice per year. Results are then fully reported to the Dam Safety Committee in the Ministry of the Public Works.

3) Current Status of Power Generation Facilities

According to IP, there were no evident defects found in the civil structures for the power intake, the waterway and the power-house.

4) Visual Inspection Results

JICA study team has carried out a visual inspection of the civil structure focusing on settlement, deformation, leakage, and crack at the dams and power generation facilities. No serious defects have been observed. Results from the observation of the above facilities are shown in Appendix C3.

(6) Sedimentation in the Reservoir

1) Geology in the Watershed

The main source of sedimentations in Soedirman (Mrica) Reservoir is estimated to be the Central Volcanic Zone area, which consists of mostly Quaternary Pleistocene to Holocene volcanic products, such as laharic deposits and volcanic ash fall deposits. Furthermore, many rivers, such as the Serayu River, Merawu River, Tulis River and Begaluh River, are flowing in the area (see Figure 3.4.3-2). These rivers seem to have rather high sediment discharge ratio in general.



S1, S2 and S3: Serayu River.
 S4: Garung HydroPower Station
 M1, M2 and M3: Merawu River.
 T1: PLTA Tulis Dam in Tulis River.
 B1: Typical land use, such as corn, potato.

Figure 3.4.3-2 Location Map of Soedirman (Mrica) Dam

(Prepared by JICA study team)

The slopes of the upper reaches area of the Serayu River and its tributaries, which are covered by volcanic products, are cultivated widely. The slopes of both banks in the area of middle to upper reaches of said river are mostly covered with paddy fields. However, those of the Merawu River and Tulis River are mostly covered with dry fields, such as maize, potato and vegetables. During heavy rains, surface soil erosion may occur widely and rather strongly in the dry field areas in the Merawu River and Tulis River basins.

The riverbed sediment materials, even in the lower reaches of the Serayu River and its tributaries, are mostly coarser than those in the Soedirman (Mrica) reservoir observed at present. During heavy rains, significant volumes of fine materials, such as clay, silt, sand, appear to be discharged more to the Soedirman (Mrica) reservoir than the coarse materials in the form of wash and suspended loads. Consequently, it is estimated that the fine materials which originated from surface soil layers is the largest source of the sedimentation in the Soedirman (Mrica) reservoir.



Serayu River just upstream of the Mrica reservoir. Sedimentation, sand and gravel with boulders, is seen on the riverbed.



Lower reaches of the Merawu River. The riverbed is covered by many sand, gravel and boulders

Sedimentation in the Serayu and the Merawu Rivers (Prepared by JICA study team)

A critical landslide related to sedimentations of the reservoir is not reported and not found in the catchment area in this field reconnaissance study. However, because of hilly/mountainous topography, small scale surface slope failures are commonly found in the area consists of volcanic products area, even in Tertiary rock areas. In the catchment area, the landslides in the area of the middle to lower reaches of the Merawu River, such as Sijeruk landslide, are also reported. Such landslides and small scale slope failures will also produce sediments of the reservoir.

2) Sedimentation in the Mrica Reservoir

The Mrica Dam watershed area is 1,069.71 km². The population in the watershed is 860,000 and the major industry is agriculture. The main rivers that branch to the Serayu River are the Lumajang River, Merawu River and Songgoluang River. Significant volume of sediment and waste material from households are intruding into the Mrica reservoir at present. It is noted that the annual average trapped sediment volume is estimated to be 4.2 MCM.

According to interview with IP, the situation are as follows:

a) Serious Sedimentation in the Reservoir

Based on the monitoring records of the actual sedimentation in the reservoir, IP predicts that the sedimentation will reach up to 80% of gross reservoir capacity in 2014 causing difficulties to the normal operation of the power station. According to the prediction based on this fact, the reservoir will be fully filled with the sediments in 2021, which may reach the high water level.



Sedimentation in the Mrica Reservoir.
(Prepared by Indonesia Power)

b) Large Amount of Sediment Flushing Operation in Near Future

In the Mrica Dam, the drawdown culvert for the reservoir water level lowering and the sand flushing is provided at the elevation below the power intake inlet facility. The water intake for the power generation is not seriously influenced so far. However, IP estimated that 4.2 MCM/year of sediment flushing operation from 2014 will be required to maintain the function of the power intake. At that time not only lots of sediment discharge but also

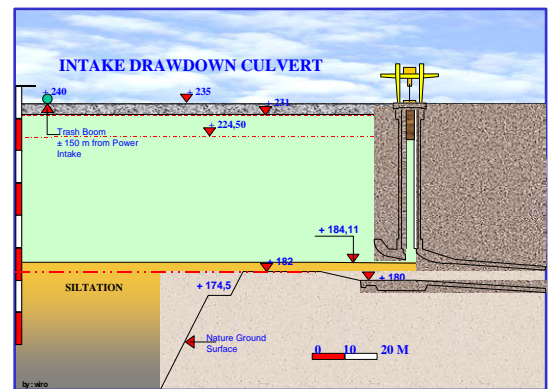


Figure 3.4.3-3 Profile of Drawdown Culvert
(Prepared by Indonesia Power)

stoppage of the power generation will be forced due to the flushing operation.



Sediment Flushing Operation from Mrica Dam
(Prepared by Indonesia Power)

c) Small Scale Dredging and Sediment Flushing Operation for Recovery of Reservoir Volume

In order to further restore the normal function of the Mrica Reservoir, small scale dredging and sand flushing from the river outlet have been conducted. As this rate is significantly small compared to the annual average sedimentation of 4.2 MCM/year, the dredging and the sand flushing could not restore the reservoir function and prolong the service life of the reservoir.



Small Scale Dredging Work and Material Utilization

(Prepared by Indonesia Power)

d) Watershed Sediment Management to Reduce Sediment Inflow

In order to mitigate the sediment production/inflow from the watershed, the government of the Central Java province and IP are jointly implementing the Mrica Dam watershed management countermeasures. These include campaigns to prevent residents in the watershed from destroying forest resources due to agricultural land reclamation, and to advocate environmental conservation and others concerns. Among the methods introduced to prevent considerable sediment intrusion into the reservoir is in stead of cultivation of the potato, introduction of alternative crops such as mini papaya “carica” and flower cultivation.

e) Improved Reservoir Operation

In the Mrica reservoir, water supply to the downstream irrigation of 10,000 ha was prioritization while the surplus reservoir water can be utilized for the power generation. As the reservoir capacity is decreasing in recent years due to sedimentation, the operational water level for the power generation for the rainy season is lowered to EL.228.0 m, which is 3m below the high water level of EL.231.0m, so as to minimize the spilled out water volume from the reservoir.

f) Deterioration of Water Quality

Lots of sewage water and waste material from households in Wonosobo and

Banjaranegara are dumped into the Mrica reservoir. Therefore the water quality has deteriorated with waste materials drifting in the reservoir and with thick mats of water hyacinths being formed at present. However, the serious affection to the reservoir operation and the power generation have not occurred so far.

g) Consideration of Downstream River Basin

There exists the Bendung intake weir is intended to supply the irrigation water to 20,000 ha, located at Kebasan about 100 km downstream of the Mrica Dam. On the way to the intake weir, small fishery business and small scale of sand mining activities are observed.

There are presently no report on damages in the downstream of the Mrica dam and complains from the river user and the residents along the river due to the abovementioned sediment flushing operation in the Mrica Dam.

3) Recommendation for the Sediment Problem

Regardless of the above practices by the local government and IP, there were no essential improvements achieved due to the small scale countermeasures compared to the huge amount of the sediment inflow.

Under the above circumstances, a mass sedimentation in the Mrica reservoir is considered serious causing social problems to the region. IP as well as PLN intends to mitigate the severe sedimentation problem and thus. IP requests the Government of Indonesia for a financial assistance to execute an effective sediment countermeasure. However, the financial assistance has been pending and no practical measures have been executed at present.

Therefore, it is strongly recommended that the sediment mitigation measure for the Mrica reservoir as well as for the Serayu River basin should be initiated as a practical solution with definite financial support.

3.4.4 Current Conditions of Saguling Hydropower Station

(1) Power Generation

Saguling Hydropower Station is located in the middle reach of the Citarum River flowing near Bandung City in the West Java province. Meanwhile, Cirata and Jatiluhur dams are located at the middle and lower reaches of the Citarum River as shown in Figure 3.4.4-1.

Principal features of Saguling Hydropower Station are shown in Appendix B-4.

Saguling Hydropower Station is about 30 km away from Bandung. Operation of the power station commenced in 1985 and all of the equipment have been managed and maintained by IP.

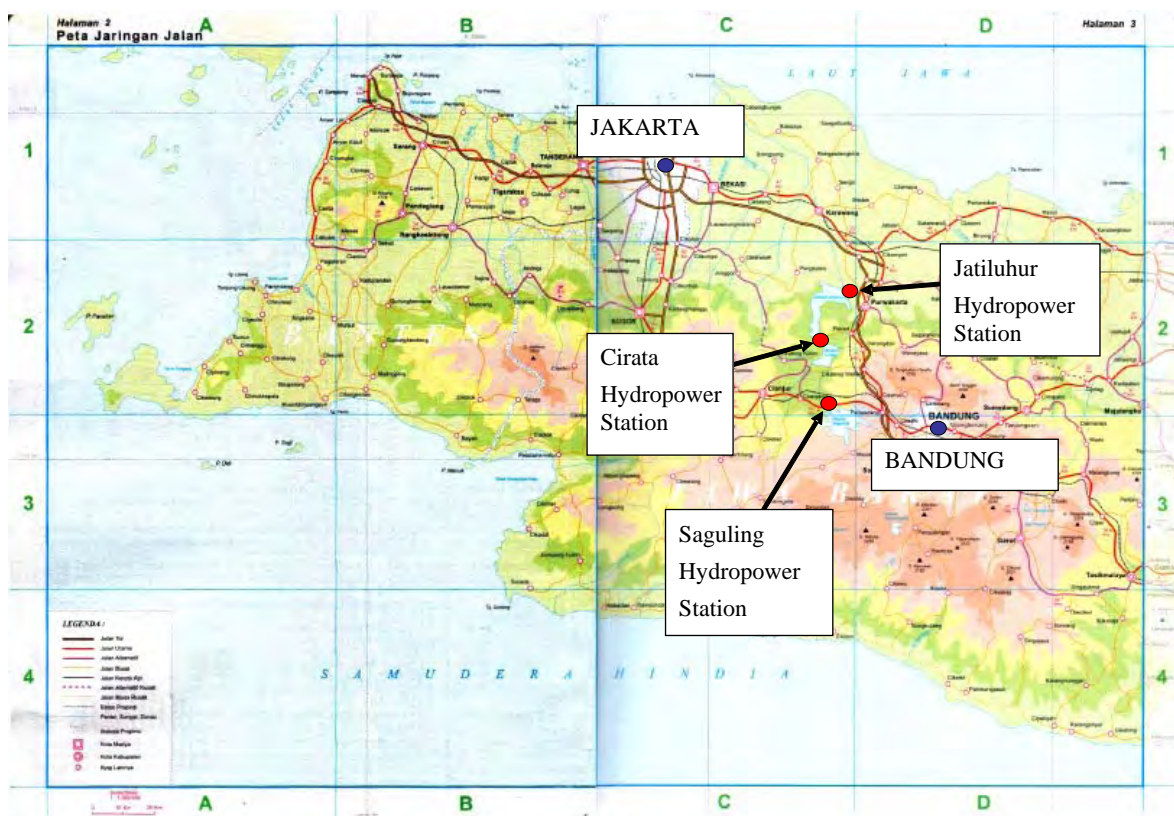


Figure 3.4.4-1 Location Map of Saguling Hydropower Stations

(Prepared by JICA Study Team)

The power station has four units of 175 MW generating equipment. The power station (700 MW) has a function of providing base load operation via 500 kV transmission line to the region area, mainly to Jakarta, the largest demand center in Indonesia. Saguling has a load frequency control (LFC) function to stabilize the power system frequency.

Its energy generation in the year 2009 was recorded as 2,295 GWh, which was 106 % of the designed value of 2,156 GWh.

(2) Hydromechanical Equipment (Gates and Penstocks)

Results of the site investigation of the generating equipment are shown in Appendix C-4 together with the technical specifications.

The equipment has been maintained well since the completion of the project in 1986. Routine inspection and maintenance works have been conducted by IP staff at the power station.

It was found that there had been no serious troubles on operation through interview with personnel in charge at the power station.

It was reported that water spilled out from the open spillway of Saguling Dam on March 21, 2010 due to heavy rains. It was noted that flooding occurred in Karawang City, at the downstream of Citarum River basin, due to discharge from not only Saguling but also from Cirata and Jatiluhur dams, as their water level reached the full level.

(3) Generating Equipment (Water Turbines, Generators and Control System)

Results of the site investigation of the generating equipment are shown in Appendix C-4 together with the technical specifications.

Unit 1 and unit 2 have been operating for over 24 years since its completion in 1985, while unit 3 and 4 have operational for 23 years 1986.

The generating equipment has been maintained well by power station staff by implementing planned annual inspection, general inspection and major overhaul. It was observed during the site investigation that there have been no serious problems that affect its continuous operation. However, the following observations were noted:

- 1) Water Turbine: Water turbine is of Francis type and a spare runner was provided at the time the project was completed. It was replaced by a used runner during the major overhaul in 2004. Damage or cavitations appeared in the removed runner were repaired by power station staff. It is then stored in the power station for futures use in the next major overhaul. It is noted that the existing runners have not yet been replaced with new ones from the time of initial operation.
- 2) Inlet Valve: Leakage from valve bearing was observed in unit 3.
- 3) Governor: Governor is of analog PID type which is already obsolete and none of its parts are available in the market. It is planned to be replaced with new ones through the financial assistance of JBIC export credit line.
- 4) Cooling water system: Cooling water system has been corroding due to chemical contents in the river water being polluted by drainage water from industrial factories at the upper reach of the river in Bundung City. Under such circumstance, PLN was requested to replace the embedded pipes of the cooling water system through the assistance of JBIC export credit line in 2006. The contract for the replacement has been signed by the supplier and PLN in 2009.
- 5) Supervisory and Control System: The supervisory and control system originally provided with analog type has been replaced with computerized system in 2002, through IP's own fund. Automatic data logger is equipped with control system and operating status to monitor events displayed on the generating equipment.

(4) Transmission Lines and Substations

Two units of main transformers with 412.2 MVA are installed adjacent to the power station belonging to IP. Meanwhile, all 500 kV outdoor switchgear and 500 kV transmission lines constructed under the financial assistance of OECF in 1985 are controlled, operated and maintained by P3B. Moreover, Six 500 kV transmission lines are connected from Saguling Switchgear to the 500 kV power transmission network in Java-Bali. Presently, all outdoor switchgears are operating without any trouble.

(5) Dams and the Appurtenant Civil Work Facilities

1) Organization for Operation & Maintenance

Saguling Dam and Saguling Power Station were completed in 1986. The dam has been utilized for supplying water for power generation and irrigation water downstream. The dam and the power station are operated and maintained well by IP.

2) Current Status of the Saguling Dam

Twenty three years have passed since the completion of the dams and the power station. According to IP, behaviors of the measuring apparatus installed to monitor the movement of dam and the appurtenant structures are generally normal. Moreover, regular and visual inspection results did not reveal abnormal phenomena in the dam and the appurtenant structures. Dam safety evaluation based on the measuring apparatus records are conducted twice per year and the results are then fully reported to the Dam Safety Committee in the Ministry of the Public Works.

3) Current Status of Power Generation Facilities

According to IP, there were no evident defects found in the civil structures in the power intake, the waterway and the power station.

4) Visual Inspection Results

The JCA Study Team has carried out a visual inspection of the civil structures focusing on settlement, deformation, leakage, and crack at the dams and power generation facilities. No serious defects have been observed. Results from the observation results of the above facilities are shown in Appendix C4.

(6) Sedimentation in the Reservoir

There exists Bandung city of which population is 2,500,000 people within the watershed of the Saguling reservoir, and due to the affection of Bandung city, the pollution of the reservoir water becomes deteriorated gradually. According to IP, the present situation is as follows:

1) Current Situation of Reservoir Sedimentation

Annual average sedimentation including waste material from households and factories to the Saguling reservoir is estimated about 4.0 MCM. According to IP, as the gross reservoir capacity is 875 MCM and very large, the operation of the Saguling reservoir can be made as scheduled for about 30 years from now.

2) Water Pollution Problem of Reservoir

The reservoir water pollution is caused by lots of sewage/waste material from households and factories in Bandung city. Intrusion of lots of polluted water and garbage to the Saguling reservoir is caused by poor sewage treatment facilities, bad manner of surrounding residents such as throwing garbage and limits of garbage collection capacities by the local government.

Campaign regarding the garbage problem to the residents will be helpful to ease this problem.

According to IP, intrusion volume of sewage/ waste material from households and factories are as follows:

Intrusion of polluted water volume 250,000 m³/year

Intrusion of waste material volume 2.5 ha/day



Garbage in the Saugling reservoir



Disposal operation of water-hyacinth in Saguling reservoir

Garbage and Water-hyacinth in Saguling Reservoir (Source: Indonesia Power)

Due to the sewage / waste material from households and factories in the above, reservoir water quality has worsened from C to D class. Therefore the restriction for using the reservoir water is enforced. Presently metal corrosion of the cooling water pipes in the Saguling Power Station has accelerated and the corrosion damages of the wire net intended to form a fish pond has occurred. Fish breeding in the reservoir is prohibited now.

In addition, the reservoir eutrophication with growth of water hyacinth has also been observed around the upstream of the reservoir, due to the water pollution.

3) Current Study for the Problems in the Citarum River Basin

The solution for the problems in Citarum River basin is an urgent matter in the region. The study for the water resources management plan in the Citarum River basin including the Saguling reservoir watershed is now ongoing under ADB. The water quality and the sedimentation problems in the Saguling reservoir shall be addressed as one of the main components in the ADB study.

3.5 Third Screening

3.5.1 Criteria

Based on the results of site investigations carried out from April 4 to April 13, 2010, the third screening was conducted for the four hydropower stations selected from the second screening. The following allocated weights for the criteria were considered in the evaluation. The same criteria as the second screening was applied, but the criterion for 'Degree of deterioration and sedimentation' was separated into 2 criteria as 'Degree of deterioration of equipment' and 'Degree of sedimentation' and then total numbers of criteria becomes five.

Criteria	Weight
1) Regional effectiveness	: 0.5
2) Degree of deterioration of equipment	: 1.0
3) Degree of sedimentation	: 1.0
4) Expected effect by execution of the rehabilitation	: 0.5
5) Urgency of rehabilitation	: 1.0

3.5.2 Evaluation of Third Screening

Ranking of priority made in the third screening of the four hydropower stations based on evaluation for each criterion is shown in Table 3.5.2-1. The ranking was made by evaluation as A, B and C, which means A is High, B is Middle and C is Low with points of 5, 3 and 1 respectively.

Table 3.5.2-1 Results of Third Screening

Criteria	(1) Regional Effectiveness	(2) Deterioration of Equipment	(3) Sedimentation	(4) Expected Effect	(5) Urgency	Score	Rank
(Weight)	(0.5)	(1.0)	(1.0)	(0.5)	(1.0)		
Sutami	A	B	B	A	B	14	2
Wlingi	B	B	C	A	B	11	3
Soedirman	A	C	A	A	A	15	1
Saguling	A	C	C	A	C	8	4

Note: A= High with 5 points, B= Middle with 3 points, C=Low with 1 point

(Prepared by the Study Team)

The evaluations of A, B and C for the hydropower stations shown in the above table were made by the following considerations.

(1) Regional Effectiveness

The regional effectiveness for each hydropower station was evaluated as follows.

1) Sutami

The installed capacity of Sutami is 105 MW, which is 37% of the total hydropower capacity of 281 MW in East Jawa. Sutami has an inevitable role and regional significance with the following two functions;

- i) To facilitate peak load operation to the regional area including Malang and Blitar cities
- ii) To provide a black-start function for Paiton Thermal Power Plant located in East Java.

Paiton is a coal-fired thermal power plant with a total installed capacity of 3,300 MW, connected to 500 kV Java-Bali power network. Paiton's significant role is to serve as base load supply on the Java-Bali power network.

At the present, the power network in the East Java is facing problems due to interruption of 150kV transmission line by Mud-Volcano occurred in 2006 as described in Clause 3.4.1 (4). After this accident, the power network has been divided into two sub-systems, namely east and west area.

According to power flows in March 3, 2010 in the east area where Sutami and Wlingi are located is indicated in Table 3.5.2-2.

Table 3.5.2-2 Power Flow in East Area in East Java (March 3,2010)

No.	Power Source	Type	Power Flow
1	Paiton	Coal-fired	710 MW
2	Grati (Block 1)	Combined Cycle	360 MW
3	Grati (Block 2)	Combined Cycle	52 MW
4	Sutami (Karangkates)	Hydro	94 MW
5	Wlingi	Hydro	25 MW
6	Sengguruh	Hydro	20 MW
7	Lodoyo	Hydro	4.5 MW
8	Selorejo	Hydro	5 MW
9	Wonorejo	Hydro	6.3 MW
Total			1,276.8 MW

(Source: P3B)

Under the influence of the volcano accident, power flow from Sutami and Wlingi accounts for 9.3% out of total power sources (1,276.8MW) for the east area. As the mud-volcano is still acting and no anticipation is made when it is stopped, and then recovery of the interrupted transmission line is also not scheduled. Under such situations, Sutami and Wlingi become more important power sources in the regional area than before.

2) Wlingi

Wlingi has the installed capacity of 54 MW, which is a half of that of Sutami. Wlingi operates using the discharge water from Sutami, which means that the functions of both power

stations are closely related. Major function of Wlingi is peak load operation to serve the power to the regional area as described in the above for Sutami, however, as far as water is available, Wlingi is forced to be operated continuously.

3) Soedirman (Mrica)

Soedirman has installed capacity of 189 MW and facilitate peak load operation to the regional area and also has two major regional functions other than the power generation. Firstly, it supplies water for irrigation while the second is to serve as flood control facility. Mrica supplies water for irrigation purposes to serve an area of 10,000 ha and functions as a water-refilling facility across 20,000 ha downstream.

Furthermore, Mrica Reservoir highly contributes to the reduction and prevention of flood damages at the downstream area.

Under this present status, the Serayu River with Soedirman Hydropower Station is expected to give impacts to water utilization and safety of residents in the Serayu River basin if functions of the water utilization and the flood control deteriorate in the near future.

4) Saguling

Saguling is a large-scale hydropower station with 700 MW, which is the largest hydropower station of PLN. The generated power is directly connected to 500 kV Java-Bali power transmission network. Saguling was originally designed for 6 hours peak load operation, but presently, it is utilized for base-load operation of 24 hours as long as water is available.

Saguling has an important function in the power transmission network, which is one of the few power stations that can keep and provide 20 MW to the load frequency control (LFC) to the power system.

From the above assessment, Sutami, Soedirman and Saguling were evaluated as A while Wlingi as B, in terms of regional effectiveness.

(2) Degree of Equipment Deterioration

The generating equipment of all four hydropower stations have been maintained by power station staff by conducting regular maintenance (annual inspection and general inspection) and periodic major overhaul. At present, no serious damages or accidents have been reported based on the recent operation records.

Although maintenance works for Sutami and Wlingi hydropower stations were properly executed, the working lifetime of their electrical and mechanical equipment have been exceeded considering that the facilities were constructed in the 1970s. Therefore, it is deemed that these hydropower stations are subject to high potential risk in continuing their reliable and stable operation.

For Soedirman and Saguling hydropower stations, rehabilitation works for the supervisory and control system have been done through own fund. As a result, the system was modernized and

has been equipped with automatic data logger, which allows monitoring of the operating status of generating equipment through the display monitor. Rehabilitation of governor and embedded pipes for cooling water supply system in Saguling has been initiated under the financial assistance of JBIC export credit line.

Meanwhile control system including governor and AVR at Sutami and Wlingi hydropower stations are obsolete, along with the analog indicator. Said facilities do not have automatic data logger for their control system. PJB, which operates 12 hydropower stations including Sutami and Wlingi along the Brantas River, intends to rehabilitate the control system of all the 12 hydropower stations in the future. This should enable the hydropower stations to be controlled, operated and monitored by only one control center.

From the above assessment, Sutami and Wlingi were evaluated as B, while Soedirman and Saguling as C, in terms of degree of deterioration of equipment.

(3) Degree of Sedimentation

Degree of sedimentation of each of the hydropower station was determined from the results of the site investigation as follows:

Appropriate sediment managements has been carried out for the Sutami Reservoir and the Wlingi Reservoir by PJT-I regardless serious sedimentation problem in the reservoirs. Furthermore, BBS undertakes the construction of sabo dams in the upstream area and construction of sediment bypass channel for the Wlingi Reservoir. Hence, long-term countermeasures against the sedimentation problem in the Wlingi Reservoir has been carried out.

For the Soedirman (Mrica) Reservoir, watershed management works are being undertaken by IP, local government and other agencies. Small scale sediment dredging and sediment flushing operation in front of the power intake, through the drawdown culvert gate are carried out periodically. However, this seems ineffective since the countermeasures are relatively small scale comparing with the significant sediment inflow into the reservoir.

For the Saguling Reservoir, the overall study on the water resources management in the Citarum River basin is on-going. The main concerns for the reservoir however are the polluted water and waste material intrusion. Since the Saguling Reservoir has large capacity comparing with the sediment inflow into the reservoir, the sedimentation problem does not significantly affect the reservoir function at the moment.

(4) Expected Effect by Execution of the Rehabilitation

Main roles of the four candidate hydropower stations for power network are summarized in Table 3.5.2-3.

Table 3.5.2-3 Main Roles of Candidate Hydropower Stations

Hydropower Station	Output (MW)	Operating Years	Main Roles for Power Network
Sutami	105	36	Power supply for the peak load in the eastern region in East Java Power supply for the base load Black start of Paiton Thermal Power Station
Wlingi	54	31	Power supply for the peak load in the eastern region in East Java Power supply for the base load
Soedirman (Mrica)	180.9	21	Power supply for the Central Java (during rainy season) Power supply for peak load (during dry season)
Saguling	700	24	Power supply for base load for West Java (Jakarta)

(Prepared by the Study Team)

The purpose of rehabilitation works is to extension of equipment's life and restoration of functions. Since the expected life time for the hydro-mechanical and electrical equipment is generally explained 30 to 50 years, all the four hydropower stations are faced with a possibility for suddenly losing important functions.

From the above assessment, all the four hydropower stations were evaluated as A in terms of expected effect by execution of rehabilitation.

(5) Urgency of Rehabilitation

It was confirmed by the site investigation that urgent countermeasures for sedimentation problem of Mrica dam was considered to be taken as the highest priority so as to protect its reservoir function and dam safety. Therefore, Soedirman was evaluated as A, while Sutami and Wlingi as B taking account of the operating years beyond 30 years. Saguling was evaluated as C because of the reason mentioned in the subsequent paragraph.

(6) Rehabilitation Work under JBIC Export Credit Line

In addition to evaluations of the above criteria, the rehabilitation work under JBIC export credit line was considered in this study. The JBIC export credit line is used to give a financial assistance to procure Japanese goods for rehabilitation work in the existing generating power plants in Indonesia. In order to utilize the export credit line, PLN considered rehabilitation works of the existing hydropower stations as well as thermal power, and consequently proposed Saguling and Sutami to be subject to said works. However, it was finally decided by PLN to nominate only Saguling together with Muara Karang, Suralaya and Paiton for thermal power operations. The request for the rehabilitation work of Saguling includes (i) replacement of governors and (ii) improvement of embedded cooling water pipes. Contract for the rehabilitation work for Saguling has been concluded in 2008 between the supplier and PLN. Execution of said contract is in progress.

Saguling was evaluated with higher priority than Sutami at that time, although Sutami is ten years

older than Saguling. The high priority rating for Saguling was based on evaluation results as follows: (1) Saguling has a large capacity, (2) Saguling is located close to Jakarta which is the biggest demand center in Indonesia and (3) Saguling has an LFC function and (4) Saguling faces problem on cooling water system due to water quality.

The above evaluation results have been considered in this study considering regional effectiveness and other expected effects. However, the urgency was rated as C because the rehabilitation of Saguling has already been committed for execution under JBIC export credit line. On the other hand, the urgency for rehabilitation work for Sutami was evaluated as B, which set higher priority than Saguling since no rehabilitation work has been committed.

3.5.3 Results of Third Screening

In accordance with the results of the third screening, Soedirman was ranked as the highest priority hydropower station for rehabilitation. Soedirman is required to make a countermeasure for the sedimentation problem, while the generating equipment is not required to be rehabilitated at the moment because the deterioration is not so serious and the replacement of major equipment such as control and protection panel, AVR etc. has been done.

Sutami was ranked as the second priority hydropower station for rehabilitation. Sutami is required to take considerations for rehabilitation of the generating equipment because rehabilitation for major equipment such as turbine runner, generator, control and protection panel etc. have not yet carried out although the operating years are nearly 40 years. On the other hand, Sutami is facing sedimentation problem, but a countermeasure are being undertaken by BBWS. Therefore, a countermeasure for the sedimentation is not taken in this study.

Based on the above, the following two rehabilitation works were considered to be studied in the next stage:

- 1) Rehabilitation work for the generating equipment in Sutami Hydropower Station
- 2) Countermeasure for sedimentation in Soedirman (Mrica) Reservoir

In addition to the rehabilitation work for Sutami, it is proposed to be combined with the rehabilitation works for Wlingi to enhance the expected effectiveness. This was considered since both power stations were constructed in the 1970s as cascade power station in the Brantas River, and rehabilitation works for Wlingi generating equipment have not yet been done so far.