Ministry of Energy and Mineral Resources
The Republic of Indonesia

THE STUDY ON OPTIMAL ELECTRIC POWER DEVELOPMENT IN JAVA-MADURA-BALI IN THE REPUBLIC OF INDONESIA

FINAL REPORT

< SUMMARY >

December 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NEWJEC INC.
THE KANSAI ELECTRIC POWER CO., INC.

PREFACE

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

JICA selected and dispatched a study team, headed by Mr. Satoshi YAMAOKA of NEWJEC Inc., and organized by NEWJEC Inc. and The KANSAI Electric Power Co., Inc. four times from January 2008 to December 2008.

The Study Team held discussions with the counterparts concerned of the Government of Indonesia and State-owned Electric Power Company, PT. PLN (Persero), and conducted field surveys at the study area.

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

Finally, I wish to express my sincere appreciation to the counterparts concerned of the Government of Republic of Indonesia and PT. PLN (Persero) for their close cooperation throughout the Study.

December 2008

Seiichi NAGATSUKA
Vice President
Japan International Cooperation Agency

December 2008

Seiichi NAGATSUKA
Vice President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

We are pleased to submit to you the report of “the Study on the Optimal Electric Power Development in Java-Madura-Bali in the Republic of Indonesia”. This Study was implemented by NEWJEC Inc. and The Kansai Electric Power Co., Inc. from January 2008 to December 2008 based on the contract with your Agency.

This report presents the optimal power development plan to be proposed with comprehensive assessment of supply stability, reliability, economy and environment, based on current policies and plan, on various power sources and facility, and transmission line system. In addition, power source development, transmission line system, environmental measures and also investment promotion schemes for the power sector are proposed in order to realize the plans.

We trust that utilization of our proposal will much contribute to sustainable development in the electric power sector, which will contribute to the improvement of the public welfare in Java-Madura-Bali as well, and recommend that the Government of the Republic of Indonesia prioritize the implementation of our proposal by applying results of technology transfer in the Study.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Economy, Trade and Industry. We are also wish to express our sincere gratitude to Ministry of Energy and Mineral Resources, PT PLN (Persero), and other authorities concerned for the close cooperation and assistance extended to us throughout the Study.

Very truly yours,

Satoshi YAMAOKA
Team Leader,
The Study on the Optimal Electric Power
Development in Java-Madura-Bali
in the Republic of Indonesia

Abbreviation Table

Abbreviation	Full Description in English (Indonesian)
AC	Alternating Current
ACB	Air Blast Circuit Breaker
ACE	ASEAN Center for Energy
ADB	Asian Development Bank
AFC	Automatic Frequency Control
AH	Air Heater
AI	Annual Inspection
AMDAL	Environmental Impact Assessment
ANDAL	Environmental Impact Statement
AVR	Automatic Voltage Regulator
BAKOREN	Badan Koordinasi Energi Nasional (National Energy Coordination Committee)
BAPEDALDA	Badan Pengendalian Dampak Lingkungan Daerah (Regional Environmental Management Authority)
BAPETEN	Badan Pengawas Tenaga Nuklir (Nuclear Energy Regulatory Agency)
BAPPENAS	National Development Planning Agency (Badan Perencanaan Pembanguanan Nasional)
BATAN	Badan Tenaga Atom National (National Atomic Energy Agency)
BCFD	Billion Cubic Feet per Day
BEMS	Building and Energy Management System
BFP	Boiler Feed Water Pump
BLK	Block
BOD	Biochemical Oxygen Demand
BOP	Balance of Plant
BP	British Petroleum (BPS-Statics Indonesia)
BPMIGAS	Badan Pelaksana Kegiatan Usaha Hulu Minyak Dan Gas Bumi (Executive Agency for Upstream Oil and Gas Business Activity)
BPPT	Agency for the Assessment and Application of Technology
BPS	Badan Pusat Statistik
CB	Circuit Breaker
CBM	Coal Bed Methane
CDF	Computer Fluid Dynamics
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
CRT	Cathode Ray Tube
CWP	Circulating Water Pump
DAS	Data Acquisition System
DC	Direct Current
DCS	Distributed Control System
DGEED	Directorate General of Electricity and Energy Development
DGEEU	Directorate General of Electricity and Energy Utilization
DNA	Designated National Authority
DSM	Demand Side Management
DSS	Daily Start and Stop

Abbreviation	Full Description in English (Indonesian)
DEN	Dewan Energi Nasional
De-NOx	De-nitrification
De-SOx	De-sulfurization
DO	Dissolved Oxygen
DSM	Demand Side Management
ECR	Economical Continuous Rating
EE’C	Energy Efficiency and Conservation
EIA/AMDAL	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ESCO	Energy Service Company
EPC	Engineering Procurement Construction
FGD	Flue Gas Desulfurization
FIRR	Financial Internal Rate of Return
FOH	Forced Outage Hours
FOH (L)	Forced Outage Hours caused by power grid system
FOH(D)	Forced Outage Hours caused by power station
FW	Feed Water
GEF	Global Environment Facility
GF	Governor Free
GHG	Greenhouse Gas
GI	General Inspection
GIB	Gas Insulated Busbar
GIS	Gas Insulated Switchgear
GOV	Governor
GT	Gas Turbine
HHV	Higher Heating Value
HP	High Pressure
HRSG	Heat Recovery Steam Generator
HSD	High Speed Diesel Oil
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
IAEA	International Atomic Energy Agency
I & C	Instrumentation and Control
IDO	Intermediate Diesel Oil
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IGCC	Integrated Gasification Combined Cycle
IP	Intermediate Pressure
IPB	Isolated Phase Bus
IPP	Independent Power Producer
JBIC	Japan Bank for International Cooperation
JCC	Java Control Center
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency

Abbreviation	Full Description in English (Indonesian)
KA-ANDAL	Term of Reference for Environmental Impact Assessment
KEN	National Energy Policy
LFC	Load Frequency Control
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability
LP	Low Pressure
LRC	Low Rank Coal
LV	Low Voltage
MCR	Maximum Continuous Rating
MEMR	Ministry of Energy and Mineral Resources
METI	Ministry of Economy, Trade and Industry
MFO	Marine Fuel Oil
MHI	Mitsubishi Heavy Industries
MIGAS	Directorate General of Oil and Gas
MO	Major Overhaul
MOC	Ministry of Communications
MOE	Ministry of Environment (=KLH)
MOFo	Ministry of Forestry
MOH	Maintenance Outage Hours
MOI	Ministry of Industry
MOPS	Means of Plants Singapore
MS	Main Steam
NG	Natural Gas
ODA	Official Development Assistance
O&M	Operation and Maintenance
P3B	Penyaluran Dan Pusat Pengatur Beban Jawa Bali (Jawa Bali Transmission and Load Dispatching Center)
P3B UBOS	Penyaluran Dan Pusat Pengatur Beban Jawa Bali Unit Bidang Operasi Sistem (Jawa Bali Transmission and Load Dispatching Center)
PGN	PT Perusahaan Gas Negara (Indonesia Gas Corporation)
PJB	PT Java Bali Power Company
PLN	Perusahaan Umum Listrik Negara Persero (Indonesia Electricity Corporation)
PLTA	Hydro Power Plant
PLTD	Diesel Power Plant
PLTG	Gas Turbine Power Plant
PLTGU	Combined Cycle Power Plant
PLTM	Small Hydro Power Plant
PLTMH	Micro Hydro Power Plant
PLTP	Geothermal Power Plant
PLTU	Steam Power Plant
POH	Planned Outage Hours
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
RCC	Regional Control Center

Abbreviation	Full Description in English (Indonesian)
REC	Regional Electricity Company
RH	Re-heater
RIKEN	Rencana Induk Konservasi Energi National (National Energy Conservation Plan)
RKL / UKL	Environmental Management Plan
RLA	Remaining Life Assessment
RPL / UPL	Environmental Monitoring Plan
RSH	Reserve Shutdown Hours
Rp.	Indonesian monetary unit (1 US$ = 9,000 Rp. in 2007 (Provisional))
PPA	Power Purchase Agreement
RIKEN	Runcana Induk Konsetvasi Energi National (National Energy Conservation Plan)
RUEN	Rencana Umum Energi National (National Energy General Plan)
RUKD	Rencana Umum Ketenagalistrikan Daerah (General Plan for Regional Electricity)
RUKN	Rencana Umum Ketenagalistrikan National (National Electricity General Plan)
RUPTL	Rencana Usaha Penyediaan Tenaga Listrik (Electrical Power Supply Business Plan)
SCADA	Supervisory Control and Data Acquisition
SH	Super Heater
SEDF	Social Electricity Development Fund
SH	Service Hours
ST	Steam Turbine
TDL	TARIF DASAR LISTRIK (Basic Tariff of Electricity)
TIT	Turbine Inlet Temperature
TOR	Terms of Reference
UBP	Unit Busnis Pembangkitan (Generation Business Unit)
UFR	Under Frequency Relay
USAID	U.S. Agency for international Development
VAT	Value Added Tax
WASP	Wien Automatic System Planning
WB	World Bank
WSS	Weekly Start and Stop
WW	Water Wall

Unit Table

Abbreviation	Unit
bbl	Barrel (1 bbl = 159 litter)
BCM	Billion Cubic Meter
BCT	Billion Cubic Feet
BOE	Barrels of Oil Equivalent
BSCF	10^9 Standard Cubic feet
BTU	British Thermal Unit (=0.251996 kcal)
dBA	Decibel Measured on the A Scale
DWT	Dead Weight Tonnage
GWh	Gigawatt-hour
Hz	Hertz
kJ	Kilo Joule
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour (1 kWh = 860 kcal) (1 kcal = 3.968 BTU)
MMCF	10^6 Cubic Feet (MM = 10^6)
MMBTU	10^6 British Thermal Unit (MM = 10^6)
MMSCF	10^6 Standard Cubic Feet (MM = 10^6)
MMSCFD	Million Standard Cubic Feet per Day
MMSTB	Million Stock Tank Barrel
MPa	Mega Pascal
MVA	Mega-volt-ampere
MW	Megawatt
MWh	Megawatt-hour
Nm^3	Normal Cubic Meter
pH	Potential of Hydrogen
ppb	Percent per Billion
ppm	Percent per Million
psi	Pound per Square Inch
rpm	Revolution per Minute
SBM	Setara Barrel Minyak (=BOE)
SCF	Standard Cubic Feet
STB	Stock Tank Barrel
TCF	Trillion Cubic Feet
TOE	Tons of Oil Equivalent (=10^7kcal)
VA	Volt-ampere

Table of Contents

List of Tables

List of Figures

1. PREFACE (BACKGROUND AND OBJECTIVES)

1.1. Background

The national medium-term plan from 2004 to 2009 in Indonesia proclaims that stable supply of electricity is one of fundamental issues that contribute to the improvement of public security and social welfare in addition to development of economy, society and politics. The overall national electricity plan (hereinafter referred to as "RUKN") states importance of formulating stable energy supply system and securing energy sources.

Java-Madura-Bali (hereinafter referred to as "Jamali") region is a center of politics, economy and industry in Indonesia. The population in Jamali region is 133 million, about 60% of Indonesian total population of 222 million as of 2006. The installed capacity of power plants owned and contracted by PLN is 24,846 MW in total and by type of power plant, steam plants take up 33.0% of the total, followed by combined cycle 28.3%, hydro 14.2%, diesel 11.8%, gas turbine 7.5% and geothermal 1.6%.

The total energy production including IPP was 123,370 GWh as of 2005, of which 79.5% was generated by PLN and 20.5% by IPP. PLN's energy production was 101,282 GWh of which 87% came from fossil fuel and 13% from other renewable energy, hydro and geothermal. In August 2005 a problem in Suralaya coal thermal plant units 5, 6 and 7 caused power supply shortage which resulted in black out in wide area of Jamali region.

The electricity power capacity in Jamali region is 16,355 MW as of 2005, 73% of total capacity 22,515 MW in Indonesia. Development of the capacity has not been catching up with the growth of demand. Many outages have occurred due to load control. The annual demand growth rate is assumed at 7% in Jamali region and this rate continuing for another 10 years requires extra capacity of about 1,500 MW. The present situation urges the power sector in Indonesia to make the best effort to increase reliable power sources.

In response to soaring world oil prices since 2005, the Ministry of Energy and Mineral Resources (herein after referred to as MEMR) decided to accelerate construction of new coal thermal power plants and set a target of the ratio of coal power plants to be raised from 42% (2006) to 71% (2010) in RUKN. Meanwhile, MEMR began to take specific actions to run a nuclear power plant by 2017 for stable power supply. In consideration of these situations, MEMR and PLN are required to update current power development plans immediately.

The previous JICA study in 2002 established the optimal power development plan and power system development plan which focused mainly on short term measures. Drastic economic and social changes since then bring about the need of revision to these plans. The construction of a southern high voltage transmission line, 500 kV from Paiton to Depok was completed in 2006. In addition, the electricity generated in southern Sumatra is now scheduled to be transmitted to Java by DC interconnection by 2012.

Because of insufficient power capacity, MEMR and PLN needed JICA's support to develop the twenty-year power development plan for Jamali region. JICA executed the project formation study in August 2007 and the S/W was signed between both governments. The main study was publicly announced in November 2007 and a consortium of NEWJEC Inc. and KANSAI Inc. was selected as a consultant through a proposal evaluation process in December 2007. This study was started in January 2008 and scheduled to be completed in December 2008.

The objectives of this study are:

1) To formulate the power development plan in Jamali region for 20 year period from 2009 to 2028; and
2) To transfer relevant knowledge and technologies to Indonesian counterpart.

The power development plan will incorporate current policies and past studies on various power sources and facility such as coal, natural gas, hydro, geothermal and nuclear and transmission line system. It will be optimized with comprehensive assessment of supply stability, reliability, economy and environment.

1.2. Objectives

(1) Optimal Power Development Planning in Java-Madura-Bali for the year from 2009 to 2028
(2) Technical transfers for the planning to the Ministry of Energy and Mineral Resources (MEMR) and the state-owned power company (PLN)

1.3. Flow of Overall Study

The study is comprised of the following three stages.

First Stage	Preparatory work
Second Stage	Study of the optimal scenarios
Third Stage	Proposal of optimal power development plan

2. CURRENT CONDITIONS IN JAMALI AND INDONESIA

2.1. Electricity Related Laws and Regulations, Policy and Organization

2.1.1 Electricity Related Regulations and Policy

To ensure a sound energy development a National Energy Policy that integrates the power sector with other sectors is formulated in consideration of rapid changes in national, regional and global environs. Laws and presidential decrees for national energy were established first and under these laws and decrees presidential instruction and ministerial decrees were announced to promote energy conservation activities and development of biomass or bio-fuel. Under this situation, regulations for renewable energy development and geothermal and ministerial decree to promote IPP were announced. Several presidential decrees are effective for implementation of Fast Track Program. New Electricity Law has been drafted and now is being deliberated in the national parliament.

The energy policy has three missions; supply enhancement, diversification and energy conservation. To implement the energy policy, the Presidential Decree No.5/2006 introduced the targets to be satisfied as follows:

1) Energy Elasticity shall be less than 1.0 in 2025.
2) The Optimal Energy Mix shall be established by 2025: proportions of primary energy shall be as follows:
    - Oil fuel is less than 20%
    - Gas is more than 30%
    - Coal is more than 33%
    - Bio fuel is more than 5%
    - Geothermal is more than 5%
    - Other new and Renewable energy, such as bio-mass, nuclear, hydro, solar and wind power is more than 5%
    - Liquefied coal is more than 2%

As a campaign against nuclear power development at present is deemed to affect the presidential election in 2009, it is speculated that the current president will not sign the presidential decree on establishing the nuclear program study team before the election. In the road map of the nuclear development program, once the study team is formed, then a period of 10 years will be needed to start the commercial operation. Therefore, the first unit will presumably be able to start in 2018 or later.

2.1.2 Organization of Power Enterprise

Power enterprise and organization are defined in laws. Power supply enterprise is an enterprise which is in charge of generation, transmission and distribution of electricity. The authorized holder of electricity business (PKUK) is a state owned company, PLN to which the mission is devolved by the government.

MEMR had until recently assumed all the authorities related to the power supply enterprise, i.e., supervising the company, planning policies and regulating the sector. The role of supervising PLN was transferred to the Ministry of State of State-owned Enterprises. Policy-planning is the responsibility of Directorate of Electricity and Energy Utilization (DEEU) in MEMR. Power development plan is managed by the section of Electricity Supplying Program in Electricity Program Supervision Department. Fig.2.1-1 shows the organization chart of MEMR.

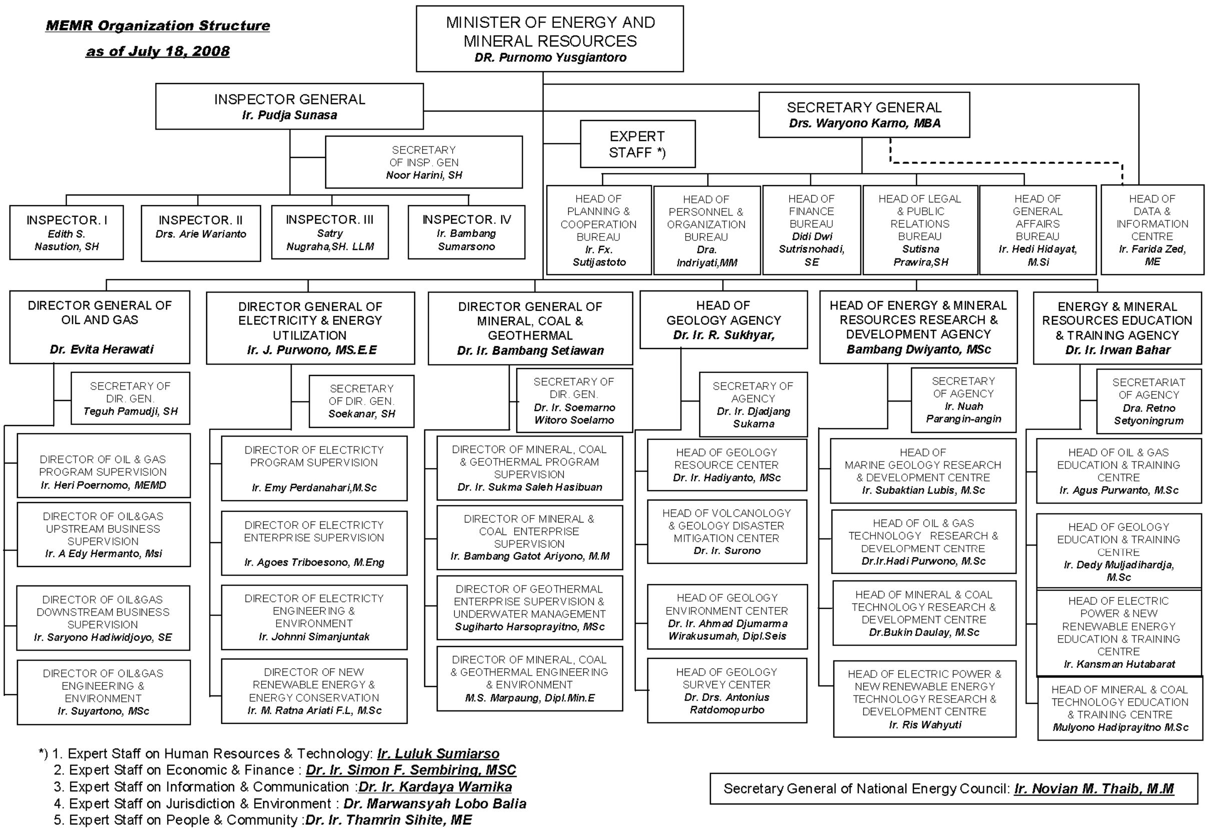


Fig.2.1-1 MEMR Organization Chart

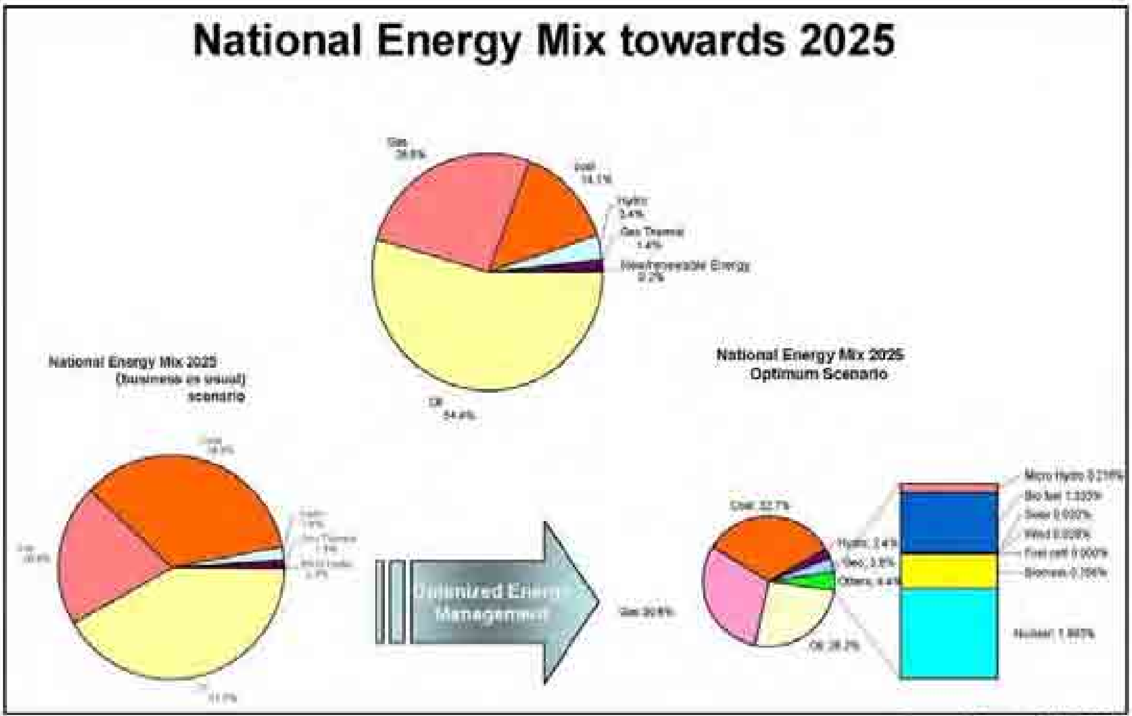
2.2. Energy Policies and Domestic Primary Energy Resources

Energy related laws enacted and policies announced recently by the government are as follows:

- National Energy Policy 2003-2020 (KEN, March 2004)
- National Energy Management Blueprint (No.25/2005)
- Presidential decree on national energy policy (No.5/2006)
- Energy Law (No. 30/2007, established on August 10, 2007)

The vision set out in these policies is to guarantee energy supply in the national interests. Three missions are stated;

1) Guaranteeing a domestic energy supply:
2) Increasing the added values of energy sources
3) Managing sustainable sources of energy in an ethical and sustainable manner, focusing on conservation of environment



Source; Blueprint PEM 2005

Fig.2.2-1 National Energy Mix towards 2025

2.3. Economic and Social Status and Development Plans in Jamali Region

Long term National Development Plan 2005-2025 (Law No.17/2007) states that regional development in the Republic has issues such as the unregulated expansion of urban areas, imbalance between the cities in various sizes, job creation in areas outside Java and reduction of outflow of population thereof. Industrial policies are in the same line and aim at developing and nurturing small to middle scale industries in areas outside Jamali to make the economy in these areas healthy. Development policies regarding Jamali region are, in summary, mostly concerned not about developing new large industrial bases but about improving transport infrastructures and services in and between large cities, raising the levels of disaster prevention and preparedness, and alleviating negative impacts of urban development (urban sprawl and environmental degradation), in order to improve the efficiency and to fully exploit the potential of the existing industries.

Population of Jamali Region as a whole is 133 million in 2006, that is 60% of national population, while GDP of the region (GRDP) is 61% of national GDP, only slightly larger in proportion. Meanwhile, manufacturing, trade and finance sectors are larger in proportion than national GDP, revealing the fact that these sectors are concentrated in Jamali Region.

Table 2.3-1 Regional GDP by Industry and Growth Rate in Jamali (2002-2006)

Industrial Origin	Jakarta		West Jawa + Banten		Cent Jawa + DIY		East Jawa		Bali	
	GRDP	Growth	GRDP	Growth	GRDP	Growth	GRDP	Growth	GRDP	Growth
1. Agriculture, Livestock, Forestry & Fishery	292	-4.1%	39,732	2.3%	34,309	2.9%	46,476	3.0%	4,779	3.9%
2. Mining and Quarrying	933	-6.7%	7,079	-3.2%	1,804	7.6%	5,455	5.4%	138	3.8%
3. Manufacturing industry	53,647	5.2%	144,848	5.7%	50,670	5.1%	72,787	4.3%	2,098	4.5%
4. Electricity, Gas and Water Supply	2,076	5.8%	8,266	4.2%	1,409	6.3%	4,610	6.0%	330	4.4%
5. Construction	31,166	5.4%	9,775	9.4%	10,027	8.7%	9,030	2.2%	857	4.0%
6. Trade, Hotel & Restaurant	67,684	7.0%	62,088	5.9%	35,386	4.9%	81,715	9.0%	6,830	5.3%
7. Transport & Communication	26,609	13.2%	16,560	7.3%	9,213	6.4%	15,505	6.1%	2,323	4.0%
8. Finance, Real Estate & Business Services	94,281	4.0%	9,560	6.8%	6,991	4.6%	13,611	7.0%	1,674	5.8%
9. Services	36,012	5.1%	20,945	7.5%	18,408	7.6%	22,048	4.1%	3,155	5.5%
GRDP	312,700	5.7%	318,853	5.3%	168,218	5.1%	271,239	5.6%	22,185	4.8%
GRDP Without Oil and Gas	311,767	5.8%	310,128	5.6%	158,217	4.9%	270,554	5.6%	22,185	4.8%
Total Oil, Gas & Its Products	933	-6.7%	8,725	-3.3%	10,001	8.3%	684	4.5%	0	0.0%

In Jakarta, financial sector is particularly prominent. Besides, trade, services are larger than in other sub-regions, while manufacturing is less than 20%. In West Java sub-region, manufacturing is as large as 50% of total regional production showing that the region is the center of manufacturing. Central Java is characterized by rather large agriculture sector, which is 20% of regional production, as much as in Bali. East Java is similar to Central Java except that there is no oil and gas output and that trade is larger. Bali sub-region has smallest manufacturing sector (10%), largest agriculture (22%), trade (30%) and services sectors (14%) among five sub-regions.

Population in Jamali Region has been increasing. Among five sub-regions, West Java is growing fastest at more than 2% per annum, while Jakarta the lowest, at 0.17%.

Table 2.3-2 Population of Sub-region in Jamali

Year	1971	1980	1990	1995	2000	Growth R(90-00)
Jakarta	4,579,303	6,503,449	8,259,266	9,112,652	8,389,443	0.17
West Jawa	21,623,529	27,453,525	35,384,352	39,206,787	43,828,317	2.03
Cent. Jawa	24,366,496	28,123,702	31,433,697	32,570,045	34,351,208	0.94
East Jawa	25,516,999	29,188,852	32,503,991	33,844,002	34,783,640	0.70
Bali	2,120,322	2,469,930	2,777,811	2,895,649	3,151,162	1.31

2.4. Electricity Industry in Java-Madura-Bali

2.4.1 Power related Organization of PLN, P3B, Indonesia Power, PJB and IPP

The organization of PLN was restructured significantly during March and April 2008. It had been five years since previous large restructuring took place in 2003. The present organization structure of PLN is shown in Fig.2.4-1.

The new organization consists of six (6) main departments: planning and technology, strategic construction, Java-Bali-Madura, Outside Java-Madura-Bali, human resources and general affair, and finance. The planning and technology department is a counterpart to JICA, in charge of power generation equipment, power system, IPP, information technology and general technology. The department is also responsible for earlier part of the process of construction projects funded by JBIC and other donors, until loan agreement is signed. The strategic construction department is in charge of selection of external consultant, and procurement and supervision in construction. The responsibility for operation and maintenance of power plants after construction depend on the location of plants, and those in Jamali area are managed by Java-Bali- Madura department and those outside Jamali by Outside Java-Madura-Bali department.

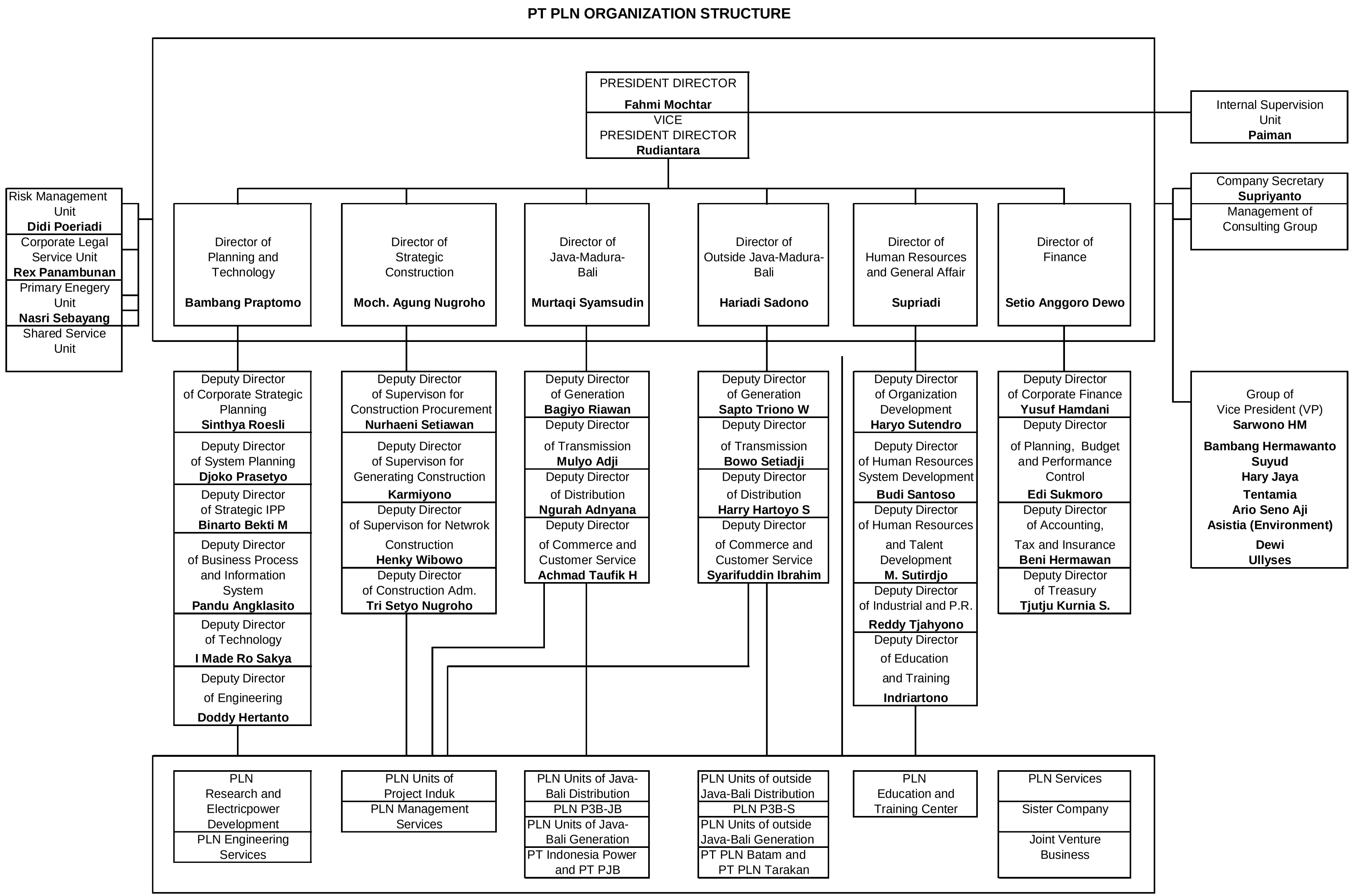
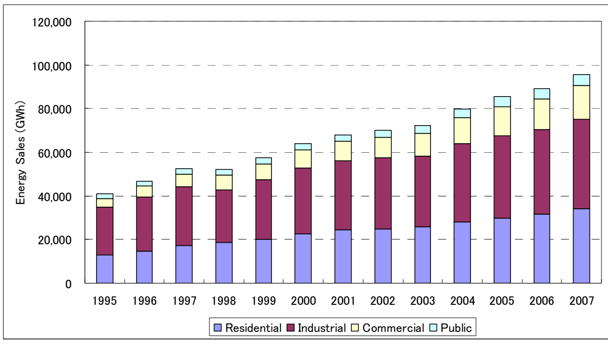


Fig.2.4-1 PLN Organization Chart (2008 April)

2.4.2 Demand and Supply

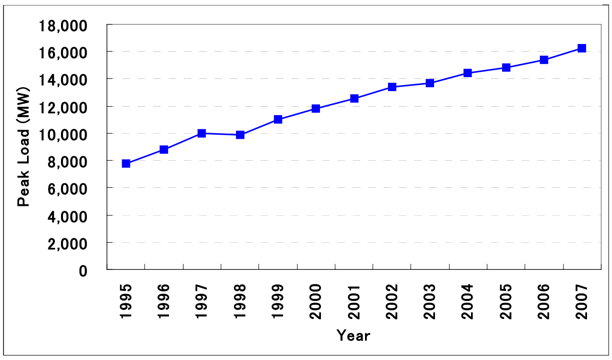
In Jamali region, electricity demand has been increasing in recent years reflecting social and economic growth. Transition of energy sales in Jamali region is shown in Fig.2.4-2. Although the growth of energy sales once recorded slowdown due to the economic crisis in 1997, steady growth has been recorded in recent years. The annual average energy growth rate from 2003 to 2007 was around 6.5%, and energy sales in 2007 reached 95,624 GWh.



Source : PLN

Fig.2.4-2 Energy Sales

Transition of the peak load in recent years is shown in Fig.2.4-3. The annual growth rate was more than 10% before the economic crisis, but it slackened after year 2000. The amount of peak load in 2007 was 16,251 MW.



Source : PLN

Fig.2.4-3 Peak Load

2.4.3 Existing Power Generation Facilities

Table 2.4-1 shows an overview of the existing power generation facilities in Jamali System. PLTP Drajat with installed capacity of 110 MW × 1 unit (IPP) was put into operation in June 2007.

Total installed capacity for 2007 in Jamali System is 22,421 MW, 82% by PLN and 18% by IPP, while rated capacity is 20,309 MW and about 10% less than the installed capacity. Gross production in 2006 was 104,775 GWh, 76% by PLN and the remaining 24% by IPP.

As of year 2006, energy generation by coal occupies 43% of the total PLN energy production, which has increased 5% than the previous year, while installed capacity of PLTU has increased its share by 3% than the previous year.

Table 2.4-1 Brief of Existing Power Generation Facilities in Jamali

Year	Installed Capacity		Rated Capacity		Total for Jamali	
	PLN	Out of PLN	PLN	Out of PLN	Installed Capacity	Rated Capacity
	MW	MW	MW	MW	MW	MW
Year 2005	16,356	N.A	14,225	N.A	N.A	N.A
Year 2006	18,416	3,895	16,990	3,837	22,311	20,827
**Year 2007	18,416	4,005	16,362	3,947	22,421	20,309

Year	Energy Production by Type of Fuel						PLN Total Production
	HSD	MFO	Coal	Natural Gas	Geothermal	Hydro	
	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Year 2005	18,880	7,133.0	29,439	12,902	2,870	6,247	77,471
Year 2006	16,575	7,717.0	34,526	13,434	2,975	4,682	79,909

Year	Energy Production Share by Type of Fuel						PLN Total Production
	HSD	MFO	Coal	Natural Gas	Geothermal	Hydro	
	%	%	%	%	%	%	%
Year 2005	24.4%	9.2%	38.0%	16.7%	3.7%	8.1%	100.0%
Year 2006	20.7%	9.7%	43.2%	16.8%	3.7%	5.9%	100.0%

Year	Installed Capacity (MW)						PLN Total Installed
	Steam	Gas Turbine	Combined C.	Geothermal	Diesel	Hydro	
	PLTU	PLTG	PLTGU	PLTP	PLTD	PLTA	MW
Year 2005	6,000	2,065.0	5,403	375	103	2,409	16,355
Year 2006	7,320	2,065.0	6,143	375	103	2,409	18,415

Year	Energy Production Share by Type of Fuel (%)						PLN Total Installed
	Steam	Gas Turbine	Combined C.	Geothermal	Diesel	Hydro	
	PLTU	PLTG	PLTGU	375	PLTD	PLTA	%
Year 2005	36.7%	12.6%	33.0%	2.3%	0.6%	14.7%	100.0%
Year 2006	39.8%	11.2%	33.4%	2.0%	0.6%	13.1%	100.0%

Note: * (75.65) is quoted from "Evaluasi Operasi System Jawa Bali 2007", P3B
** Source "Evaluasi Operasi System Jawa Bali 2007", P3B
Source : PLN Statistics 2005, 2006

2.4.4 Existing Power Development Plan

Table 2.4-2 shows the current power development plans listed in RUPTLs 2006 and 2007. As of February 6, 2008, five (5) projects have already started their commercial operation.

(1) Fast Track Program (6,900 MW) in Jamali

The fast track program with total installed capacity of 6,900 MW of coal-fired thermal plants in Jamali is expected to start its commercial operation during 2009 and 2010. Fig.2.4-4 shows locations of ten (10) coal-fired power plants under the fast track program.

Table 2.4-2(1) shows the progress of the Fast Track Program as of February 2008 and Table 2.4-2 (2) shows the latest progress as of November 2008. According to the latest information, eight (8) projects out of ten (10) projects are under construction stage. However, concerning the three (3) projects out of eight (8) projects, their progress are slow because progress payments to EPC contractors are coming from the Advance Payment only at the moment. The remaining two (2) projects have not yet started the construction and their commercial operations are expected to be 2011 or 2012.

Table 2.4-2 (1) Existing Power Development Plans (As of February 6, 2008)

S.N	Power Plant/Project Name	Generation Type (PLTU, PLTG, PLTP, PLTGU, PLTA, PLTD, PLTN)	Installed capacity: U.Capacity MW	Installed capacity: Nos.of unit Nos.	Installed capacity: Total Capacity MW	Owner (IP, PJB, PLN, IPP)	Fuel (HSD, MFO, NG, Coal)	Location (WJ, CJ,EJ, Bali, Madura)	Expected Operation Year (of the 1st unit)	Financial Procurement: Already prepared	Financial Procurement: on-going	Financial Procurement: not yet planned	Financial Source (if already prepared)	Total Investment Amount (L/C and/or F/C): Local Currency Billion Rp.	Total Investment Amount (L/C and/or F/C): Foreign Currency Million USD	Construction and Land Acquisition: Already const. started	Construction and Land Acquisition: Already secured	Construction and Land Acquisition: on-going	Construction and Land Acquisition: Planned but not yet started	Construction and Land Acquisition: Not yet planned	EIA: Already finished	EIA: on-going	EIA: Not yet started	Approval of BAPEDALDA/Government: Already approved	Approval of BAPEDALDA/Government: on-going	Approval of BAPEDALDA/Government: Not yet submitted	RUPTL: Nov. 2006 (2006~10)	RUPTL: May 2006 (2006~16)	RUPTL: Aug. 2007 (2007~16)	Remark
Already Completed / Canceled Projects																														
1	Cilegon	PLTGU	740	1	740	PLN	NG	Banten	Op.2005																		■	■		Already start the operation in 2005
2	Tanjung Jati-B	PLTU	660	2	1,320	PLN	Coal	C.J	Op.2006																		■	■		Lease Project / Already start the operation in 2006
3	Cilacap	PLTU	300	2	600	IPP	Coal	W.J	Op.2006																		■	■		Already start the operation in 2006
5	Darajat #3	PLTP	110	1	110	IPP	Geo	W.J	Op.2007																		■	■	■	Already start the operation in 2007
4	Kamojang #4	PLTP	60	1	60	IPP	Geo	W.J	Op.2008																		■	■	■	Already start the operation in February 2008
5	~~Pemaron~~	PLTGU				PLN		Bali	Cancelled																		■	■		Canceled due to environmental restriction
On-going and Commited Projects (PLN & IPP)																														
6	Muara Karang	PLTGU	750	1	750	PLN	NG	Banten	2011				JBIC															■	■	
7	Muara Tawar	PLTGU	225	1	225	PLN	NG	Banten	2011				JBIC															■	■	
9	Tanjung Priok Extension	PLTGU	750	1	750	PLN	NG	Banten	2012				JBIC															■	■	
10	Suralaya Baru	PLTU	600	1	600	PLN	Coal	Banten	2009	APLN			China Exim Bank $330.8 Million	951	368	O					O			O			■	■	■	PLN signed a loan agreement on Jan. 30, 2008 (Jakata Post)
11	Labuhan	PLTU	300	2	600	PLN	Coal	Banten	2009	APLN			Bank Central Asia	1,538	373	O					O			O			■	■	■	International finace source has not yet prepared.
12	Teluk Naga	PLTU	300	3	900	PLN	Coal	Banten	2010	APLN				2,079	602	O					O			O			■	■	■	
13	Jabar Selatan/ Pelabuhan Baru	PLTU	300	3	900	PLN	Coal	W.J	2010	APLN				2,426	624	O					O			O			■	■	■	
14	Jabar Utara/ Indramayu	PLTU	300	3	900	PLN	Coal	WJ	2009	APLN			B. MANDIR, B. BNI, B.CA /	1,647	766	O					O			O			■	■	■	Syndicate of Banks consisting of Bank Mandir, Bank Negara Indonesia and Bank Central Asia
15	Rembang	PLTU	300	2	600	PLN	Coal	C.J	2009	APLN			B. MANDIR, B. BNI, B. CA /	2,474	339	O					O			O			■	■	■	Syndicate of Banks consisting of Bank Mandir, Bank Negara Indonesia and Bank Central Asia
16	Jatim Selatan/Pacitan	PLTU	300	2	600	PLN	Coal	E.J	2010	APLN				1,354	393	O					O			O			■	■	■	
17	Paiton Baru	PLTU	600	1	600	PLN	Coal	E.J	2009	APLN			China Exim Bank $284.0 Million	777	428	O					O			O			■	■	■	PLN signed a loan agreement on Jan. 30, 2008 (Jakata Post)
18	Tanjung Jati Baru /Cilacap	PLTU	600	1	600	PLN	Coal	C.J	2010	APLN							Bidding procurement					O					■	■	■	Under selection of EPC Contractor (Expected date of completion of EPC Contractor is the end of March
19	T Awar-awar	PLTU	300	2	600	PLN	Coal	E.J	2010	APLN							Bidding procurement				O						■	■	■	Under selection of EPC Contractor (Expected date of completion of EPC Contractor is the end of February
20	Patuha # 1, 2, & 3	PLTP	60	3	180	IPP	Geo	W.J	2010			O					O						O				■	■	■	Looking for investors
21	Wayang Windu #2	PLTP	110	1	110	IPP	Geo	W.J	2009	O			Sumitomo Shoji (Japan)			O					O						■	■	■	On schedule
22	Dieng #2 & 3	PLTP	60	2	120	IPP	Geo	C.J	2010			O															■	■	■	Looking for investors
23	Bali Utara / Celukanbawang	PLTU	130	3	390	IPP	Coal	Bali	2009	O						O					O						■	■	■	Behind schedule, year of commercial operation might be 2010.
24	Bedugul	PLTP	10	1	10	IPP	Geo	Bali	2010			O					O					O					■	■	■	Looking for investors, Ministry of Forest has not yet approved because the site locates in the National Park.
25	Cirebon ~~(Eks Cilegon)~~	PLTU	600	1	600	IPP	Coal	W.J	2010		O		JBIC and Korean Exim					O				O					■	■	■	Financial close is expected to be the mid of 2008.
PLN Planning Projects																														
26	Upper Cisokan	PLTA	500	2	1,000	PLN		W.J	2013		O		WB/JBIC					O				O						■	■	
27	LNG-1 (Bojanegara)	PLTGU			1,500	PLN	LNG	Banten	2014			O					O				O							■	■	EIA was already prepared in 2002 ~ 2003. However, due to postpone of the project, EIA regires to be re-
28	Kamojang #5	PLTP	60	1	60	PLN	Geo	W.J	2012																				■	
29	PLTU Baru																											■	■	
IPP Planning Projects																														
30	Cikarang Ext.	PLTGU	150	1	150	IPP	NG	W.J	2010			O					O						O					■		Still under negotiation with the original owner
31	Anyer	PLTU	300	1	300	IPP	Coal	W.J	2009			O					O						O					■	■	
32	Pasuruan	PLTGU	500	1	500	IPP	NG	E.J	2011			O								O			O					■		
33	Madura	PLTU	100	2	200	IPP	Coal	E.J	2011			O								O			O					■	■	
34	Tj. Jati A	PLTU	300	2	600	IPP	Coal	W.J	2014			O						O					O					■	■	Under negotiation with Developer
35	~~Tj. Jati C~~																											■		Tj. Jati C is closed out due to adaption of Financial Lease for Tj. Jati B # 1 & #2
36	~~Tj. Jati B3~~																											■		Tj. Jati B3 is the same project with Tj. Jati -B Ext.
37	Bali Timur	PLTU	100	2	200	IPP	Coal	Bali	2011			O								O			O					■	■	Bidding Procurement (selection of Developer) will start in March 2008
38	PLTU Jawa Tengah	PLTU	600	2	1,200	IPP	Coal	C.J	2014																				■	
39	Cikarang Listrindo	PLTG	150	1	150	IPP	NG	W.J	2012																				■	
40	Rajamandala	PLTA	47	1	47	IPP		W.J	2011																				■	
41	Mulut Tambang	PLTU			2,400	IPP		Sumatera	2012			O								O			O					■	■	The owner is changed from PLN to IPP in RUPTL Aug. 2007.
Potential Projects																														
42	LNG-2				2,250	PLN/IPP	LNG	Banten	2015								O											■		
43	Cilacap Ext. (III)	PLTU	600	1	600	IPP	Coal	W.J	2011			O							O				O					■	■	
44	Paiton Block III - IV	PLTU	800	1	800	IPP	Coal	E.J	2011			O					O						O					■	■	
45	Tanjung Jati-B Ext.	PLTU	660	2	1,320	IPP	Coal	C.J	2011	O			JBIC				O				O			O				■	■	
46	PLTGU Baru																											■		
47	PLTN		900 or 1,000			PLN			2018/19			O										O						■		EIA is almost finished but not yet submitted for approval.
Planning Projects by MEMR (Note: The Following projects are not listed in RUPTL.)																														
48	Telaga Ngebel	PLTP			120	IPP	Geo	E.J	2012			O								O			O							MEMR Projects announced by ESDM website saying "Government Ready to Tender 6 Geothermal Working Areas (Sep. 13, 2007). Provincial governments have already prepared Auction Committee and under preparation of Tender Documents. Tender Documents are expected be sold within this year. However, regional governments (smaller unit than the provincial government) have not yet prepared Auction Committee
49	Gunung Ungaran	PLTP			50	IPP	Geo	C.J	2012			O								O			O							
50	Gunung Tampomas	PLTP			50	IPP	Geo	W.J	2012			O								O			O							
51	Cisolok-Cisukarame	PLTP			45	IPP	Geo	W.J	2012			O								O			O							

APLN means Already Prepared for PLN Portion.

Working Area does not specify the development site. The development site is to be determined by IPP

Source : PLN Project and Crash Program (PLN system Planning Division), IPP Project (PLN Primary Enrgy Division), Crash Program (PLN Coal Fired Steam Power Plant 10,000 MW Fast Track Project)
Planning projects by MEMR are informed by Investment Development Section (Geothermal and Coal) in MEMR.

Table 2.4-2(2) Latest Progress of the Fast Track Program

(As of November 06, 2008)

S.N	Power Plant/Project Name	Expected Operation Year (of the 1st unit)	Financial Procurement			Progress of Construction
			PLN Advance Payment	Foreign Bankers	Local Bankers	
Fast Track Program (6,900 MW Crash Program in Jamali)						
10	Suralaya Baru	2009	Already Paid	Finance Close (China Exim Bank)	Finance Close	Under construction
11	Labuhan	2009	Already Paid	No Foreign Bankers	Finance Close (Bank Central Asia)	Under construction
12	Teluk Naga	2010	Already Paid	Under negotiation with Bank of China (Interest and Government concerned)	Determination of loan amount by foreign bankers first, then negotiation with local bankers.	Under construction but progress is slow due to the progress payment is covered by Advance Payment.
13	Jabar Selatan/ Pelabuhan Baru	2010	Already Paid	Looking for foreign bankers	Determination of loan amount by foreign bankers first, then negotiation with local bankers.	Under construction but progress is slow due to the progress payment is covered by Advance Payment.
14	Jabar Utara/ Indramayu	2009	Already Paid	Finance Close (Bank of China)	Finance Close (B. MANDIR, B. BNI, B.CA)	Under construction
15	Rembang	2009	Already Paid	Finance Close (Barclays Bank)	Finance Close (B. MANDIR, B. BNI, B. CA)	Under construction
16	Jatim Selatan/Pacitan	2010	Already Paid	Under negotiation with China Exim Bank (waiting signing and governments approval)	Determination of loan amount by foreign bankers first, then negotiation with local bankers.	Under construction but progress is slow due to the progress payment is covered by Advance Payment.
17	Paiton Baru	2009	Already Paid	Finance Close (China Exim Bank)	Finance Close	Under construction
18	Tanjung Jati Baru /Cilacap	2011/12	Not yet	Looking for foreign bankers	Not yet proceeded	Not yet start construction due to waiting for the official approval for EPC Contract
19	T Awar-awar	2011/12	Not yet	Looking for foreign bankers	Not yet proceeded	Not yet start construction due to waiting for the official approval for EPC Contract

Source: PLN

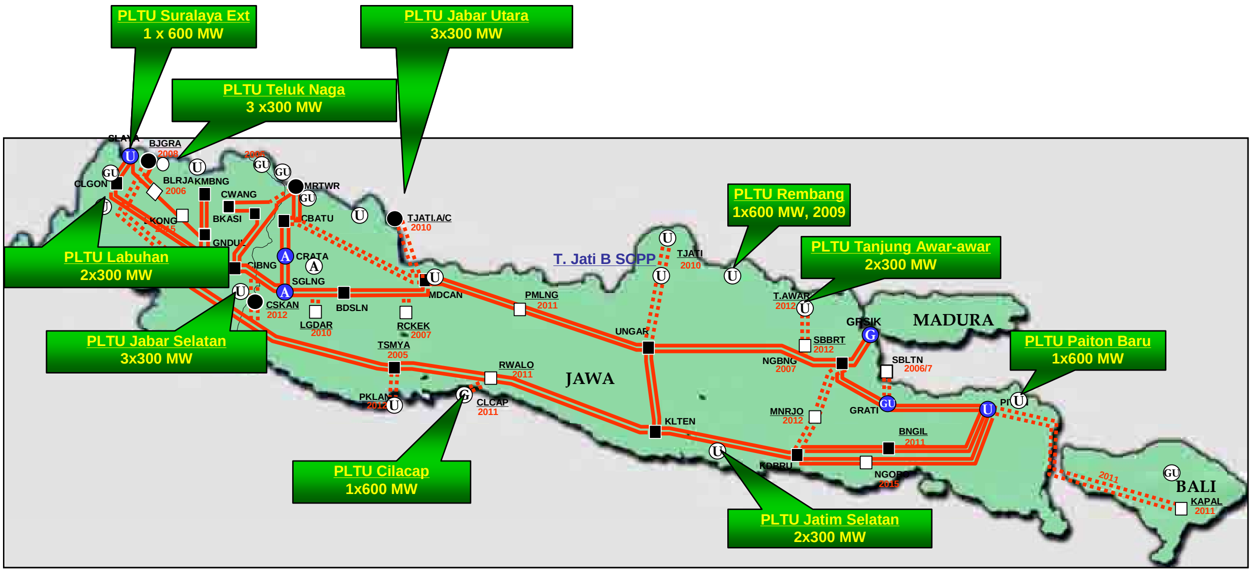


Fig.2.4-4 Location of Fast Track Program (6,900 MW) in Jamali

(2) Geothermal (PLTP) Development

Drajat unit 3 (110 MW, IPP) and Kamojang unit 4 (60 MW, IPP) were put into operation in June 2007 and February 2008, respectively.

Four (4) geothermal power plants are already committed or under construction start their commercial operations in 2009 and 2010. However, two (2) out of 4 projects are still looking for investors. All geothermal power development will be implemented by IPP. Apart from

RUPTL, MEMR is planning under its own initiative[1] to develop four (4) geothermal power plants of 265 MW in total capacity in Jamali, with expected commercial operation from 2012[2].

(3) Combined Cycle Thermal Power Plant (PLTGU) Development

Development of combined cycle thermal power plants by IPP, such as Cikarang Extension (150 MW) and Pasuruan (500 MW), has been eliminated from the latest development plan (RUPTL in 2007). Future development plan of combined cycle thermal power plants is only by LNG-fired PLTGU (Bojanegara, 2 × 750 MW, PLN) except for the on-going projects under JBIC Loan.

(4) Hydropower (PLTA) Development

Due to the limited potential sites for hydroelectric power development in Jamali, especially for reservoir-type hydroelectric power development, only Upper Cisokan Pumped Storage Power Plant (2 × 500 MW) with expected commercial operation from 2013, is planned. If PLN wishes to start its commercial operation as originally schedule, its construction meets to start in 2008, construction of Upper Cisokan Power Plant requires 5 years. However, its finance since has not been fixed even though World Bank and other international financial institutions show their intention to provide funding. Considering the progress of financial arrangement, its commercial operation seems to delay for 2 years (2015).

(5) Nuclear Power (PLTN) Development

Development of PLTN has been under way even though it is not mentioned in the latest plan (RUPTL 2007). The Indonesia Government has not fixed its location yet.

2.4.5 Power System Reinforcement Plan

The overall power system reinforcement plan in Indonesia is divided into two parts, one for Java-Madura-Bali and the other for the remaining areas, and they are carried out respectively. This power reinforcement plan will be conducted in the next decade. Its accomplishment will be in cooperated to RUPTL and the plan will be revised annually.

(1) Current Situation of Java-Madura-Bali System

The present major power transmission system in Java Island is a 500 kV system extending to all areas of the island.

The 500 kV system is comprised of the north and south corridors that go through Java Island for about 900 km from east to west, and comprised of interconnection lines that connect these 2

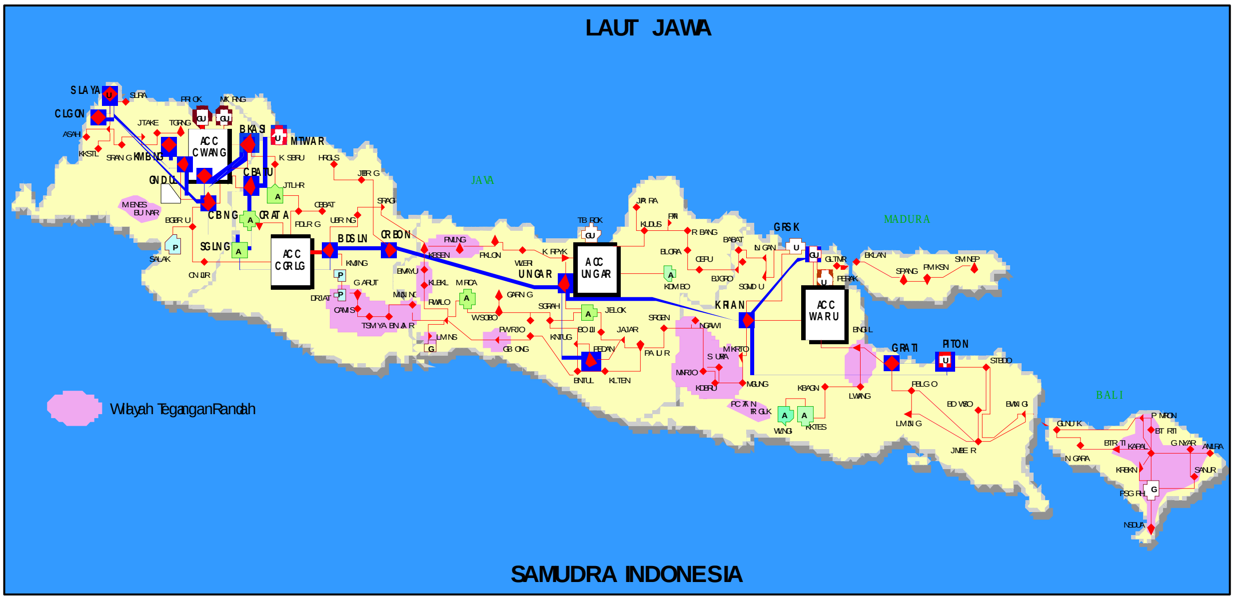
[1] System Planning Section of PLN has not been informed by MEMR as of Feb. 6, 2008.
[2] According to the Jakarta Post of June 7, 2006, Tampomas (50 MW), Cisolok Sukarame (45 MW) and Tangkuban Perahu (220 MW) have been bided and their operation are expected in 2011.

corridors. The system in Bali Island is connected to the Java system with 150 kV submarine cables, and the Java and Bali systems are operated integrally and they configure Java-Bali system.

The Java-Madura-Bali system has following main characteristics of power flow and system configuration:

- The power system is configured by long-distance northern and southern 500 kV transmission lines which are connected from Paiton P/S in the eastern edge to a load center in the western edge of Java.
- A large-scale demand area, such as Jakarta, is located in the west side.
- Many large power plants, such as Paiton P/S, are located in the east side.
- The connection between the Java and Bali systems is not so strong (150 kV submarine cables with transmission capacity of around 200 MW)
- Substantial dependence of the Bali system on power supply from the Java system

The power system has a heavy power flow from the east side to west side, and elasticity problem seems to be keen issued in transmission system.



Source ; Sistem Tenaga Listrik Jamali, Jawa-Madura-Bali, PLN

Fig.2.4-5 500 kV Bulk Power Network of the Java-Madura-Bali System

(2) Plan to Reinforce Power System

Power system reinforcement is conducted with cooperation between PLN Head Office and PLN P3B on the basis of load demand forecast and the power development program. Power system analysis, which provides a basis for expansion of the power system is conducted by PLN P3B.

In accordance with the latest power reinforcement plan by PLN, transmission lines and transformers required for the trunk power system in the next decade are shown in the tables below.

1) Expansion Plan for Transmission Lines

To meet the rapidly increasing demand, trunk transmission lines are reinforces significantly. As for 500 kV transmission lines, although the total length of 3,128 km is already in place as of 2006, substantial addition of 2,557 km is planned for the next decade.

Table 2.4-3 Expansion Plan of 500 kV and 150 kV Transmission Line (km)

Transmission Line	2006*)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
500 kV	3,128	129	165	773	462	622	56	20	100	210	20
150 kV	11,055	1,759	2,358	1,767	445	184	534	388	382	46	45

*) Existing as of year 2006 Source : RUPTL 2007-2016

2) Transformer

Also for the trunk transformers, additional 22,164 MVA are planned for 500/150 kV transformers, and additional 28,530 MVA are planned for 150/70 or 20 kV transformers. 70 kV power system is under reduction, and this voltage system should be absorbed to 20 kV system to simplify the system voltage level in future.

Table 2.4-4 Expansion Plan of 500 kV and 150 kV Transformer (MVA)

Transformer	2006*)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
500/150kV	15,500	1,832	2,832	1,500	4,000	1,500	2,000	1,500	1,500	3,000	2,500
150/70kV	3,579	480	220	100	-	180	100	30	-	-	-
150/20kV	24,470	5,220	4,470	2,700	3,090	2,160	2,610	2,010	2,430	1,860	870

*) Existing as of 2006 Source : RUPTL 2007-2016

3) New Trunk Substations

To respond to the increase of demand in the area, installation of new substations are planned to provide basis to satisfy electric demand in the area. New trunk substations, as many as twelve 500 kV substations and eleven for 150 kV substations are planned for the next decade as shown in table below.

Table 2.4-5 Expansion Plan of 500 kV and 150 kV Substation (Number)

Substation	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
500 kV	1	3	-	3	-	1	1	-	2	2
150 kV	21	16	17	11	6	12	11	14	2	1

Source : RUPTL 2007-2016

4) Criteria for Power System Planning

As for criteria for power system planning, reinforcement of power system is considered to maintain stable power supply with existing equipments even when any of them is forced to be out of service. Purpose of power system planning is to mainly consider results of the analysis based on so called N-1 rule, to maintain quality of the power supply within certain levels like 500 kV ±5%. Currently, system reliability for the Transient stability is not evaluated, and no criterion is adapted.

From now on, it is recommend to gradually establish and apply criteria to evaluate Transient stability, to accomplish stable power supply in the near future.

(3) Outline of Major Projects

Following two projects are mentioned and planned in RUPTL (2007-2016). Their outlines are as follows;

1) Java-Sumatera Interconnection Project

According to the investigation, this interconnection is planed to send the surplus power of 3,000 MW from Sumatra to Java. This surplus power is generated by a new coal-fired power plant at mine-mouth (600 MW × 4 units) and coal-fired Musi Rawas P/S (600 MW × 2 units). 400 MW will be consumed by Sumatra, and 200 MW will be losses on the HVDC system.

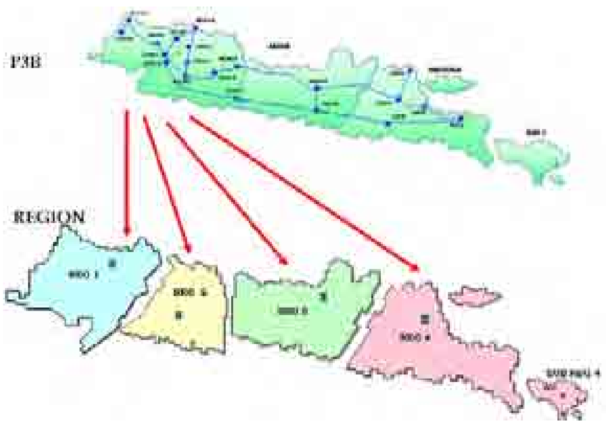
2) Java-Bali Interconnection Project

In order to strengthen the system interconnection, a new 500 kV transmission line will be constructed between Paiton S/S in Java and newly installed Kapal S/S in Bali by 2016.

500 kV transmission line will pass through a national park or protection forests, and the landscape for tourism has to be protected from impacts by 500 kV transmission towers. It is necessary to overcome this problem to realize this project.

2.4.6 Current Condition of System Operation

Regional operation boundary of Jamali system is shown in the right figure. Central dispatching control center (JCC) conducts dispatching, and observes and controls 500 kV system. While, regional control centers observe and control 150 kV and 70 kV system. Regional control centers are separated into Region 1 (RCC1), Region 2 (RCC2), Region 3 (RCC3) and Region 4 (RCC4). Region 4 is subdivided into East Java and Bali.



Regional Control Area in Jamali System

In PLN, the grid code which describes rules on system operation was revised in 2007, and several documents such as annual operation plan for the next year and monthly and annual operation record are issued. It can be said that structure, facilities and rules for operation are well conditioned. However, problems in power quality such as in voltage and frequency exist, probably because of fundamental lack of facilities. Problems on operation can be classified into voltage, frequency, outage and loss.

(1) Voltage

The table below shows the record of voltage drop below the standard value in recent years. The number in the table represents cumulative number of substations with voltage drop in each year. Although violation of voltage standard was recorded many times, the problem seems to be mitigated briefly due to some factors including the completion of southern 500 kV transmission line in 2006.

Table 2.4-6 Total Number of Substation with Voltage Drop

	2002	2003	2004	2005	2006	2007	2008*
500 kV (S/S)	103	158	149	145	75	60	50
150 kV (S/S)	566	551	407	479	288	153	435
70 kV (S/S)	319	248	198	207	169	252	153

* Up to September, 2008 Source : PLN

In order to maintain proper voltage, reactive power shall be supplied to the grid adequately. In Indonesia, lack of reactive power supply equipment including capacitors and the fact that reactive output from generator is not fully utilized are considered to be fundamental reason for voltage problem.

(2) Frequency

In PLN, rules for maintaining frequency quality such as governor free and LFC capacity are relatively conditioned. However, frequency deviation occurred many times in recent years as shown in Table 2.4-7.

Table 2.4-7 Number of Deviation of Standard Frequency

	2002	2003	2004	2005	2006	2007	2008*
Number of deviation	108	361	338	239	741	510	956

* As of September 2008 Source : PLN

Probable reasons of frequency fluctuation under normal and emergency conditions are listed below.

< Under normal condition >

- Lack of governor free capacity
- Lack of LFC capacity
- Insufficient capacity of generators for middle and peak load
- Difficulty of operation order to IPP generators
- Generators with gas pipeline which is difficult to change output
- Low ramp rate

< Under emergency condition >

- Inadequate calculation of System Frequency Characteristics

(3) Outages

The causes of outage in PLN in recent years are listed in the table below. Of the causes, relay malfunction is considered to be a problem of facility. Combined with defect of facilities, problems of facilities account for most of the cases of outages. Lightning is a major reason for outages in Japan, while facilities are the problem in PLN. In addition, other than general outages, many outages have occurred due to load control, which means that fundamental supply shortage is a problem.

On the other hand, information flow of reporting from regional control center to head quarter through central dispatching control center is established when outage occurs. It is described in the grid code that countermeasures for preventing recurrence shall be studied after outages. The process for reporting and setting up countermeasures after occurrence of outages is in place.

As reasons for frequent outages, following items can be listed;

- Aged deterioration
- Poor performance of equipment
- Lack of support from manufacturers
- Power supply shortage
- Method of calculation of required amount for load shedding
- Violation of N-1 criteria

Table 2.4-8 Causes of Outages

		2002	2003	2004	2005	2006	2007	2008*2
Outage	Nature	68	48	51	54	42	28	25
	Defect of Facilities	130	136	114	113	108	95	102
	Animals	16	19	7	9	9	9	5
	HF	3	4	11	3	10	3	2
	Kite	21	18	13	7	10	9	4
	Overloading	9	13	6	16	3	0	0
	Trees	3	2	3	1	1	3	0
	Relay malfunction	1	16	11	9	8	9	0
	Others	50	29	31	24	11	3	1
Total		301	285	247	236	202	159	139
Control	Load Curtailment	18	9	9	26	29	9	92
	Manual Load Shedding	19	10	10	34	19	61	146
	OLS*1	-	13	6	16	3	9	32
	Automatic load shedding	42	6	15	25	21	15	6
Total		79	38	40	101	72	94	276

*1 OLS; Load shedding system against over load *2: As of September, 2008 Source : PLN

(4) Transmission loss

Currently, transmission loss remains around 2%, and no big issue is here. However, the problem of low voltage, which makes losses worsen, is hoped to be mitigated. On the other hand, when the standard voltage is raised, which is one of possible countermeasures against voltage drop problem, further reduction of loss is expected.

Table 2.4-9 Transmission Loss

	2002	2003	2004	2005	2006	2007
Transmission Loss Ration	2.55	2.42	2.31	2.22	2.11	2.17

Source : PLN

2.4.7 Electricity and Primary Energy Prices

(1) Electricity Prices

New Electricity Law (Law No.20/2002) has been judged unconstitutional and currently effective Old Electricity Law of 1985 stipulates that the electricity tariff shall be determined and enforced by the Central Government. Electricity tariff applicable today is what is called "TDL 2004 (Tarif Dasar Listrik: basic electricity tariff)" which has been enforced by presidential decree in 2003. As there has been no revision to electricity tariff system since 2003, the gap between PLN's revenue and operation expenses has been widening, and the subsidy amount increasing, mainly as a result of oil price hike in recent years.

The current tariff system reveals the pricing policy that is to restraining consumption and redistributing income among members of society, by charging lower rates to small contract customers and higher rates to larger contract customers. A factor for peak hour is set at its maximum, 2, at the moment, in an attempt to divert the use of electricity to off peak hours. Average unit prices by customer categories in 2006, and revenue and government subsidy of PLN for the latest six years are shown in the tables below.

Table 2.4-10 Average Unit Prices by Customer Categories in 2006

(Rp./kWh)

	Residence	Industry	Commercial	Social	Government	Street Light	Overall
Unit price	571.12	624.23	764.25	585.30	755.53	644.87	628.14

Remark: unit price above includes connection fee. Source: PLN Statistiks 2006

Table 2.4-11 PLN's Revenue

(Unit : million Rp.)

	2001	2002	2003	2004	2005	2006	2007
Electricity sales	28,275,983	39,018,462	49,809,637	58,232,002	63,246,221	70,735,151	76,286,195
Connection fee	265,858	302,308	342,257	387,083	439,917	479,991	535,269
Other income	82,907	123,510	182,251	184,057	346,226	602,246	616,472
Subsidy		4,739,074	4,096,633	3,469,920	12,510,960	32,909,148	36,604,751

Source: PLN Statistiks 2006, Laporan Tahunan 2007

Subsidy for 2008 is expected to be more than Rp. 65 trillion. If recent hike of oil prices continues, it can reach Rp. 89 trillion (assuming crude oil price US$ 120 per barrel, and coal Rp. 800 per kg). In order to ease an increasing burden of subsidy, new tariff arrangements to charge a without-subsidy tariff to customers with 6,600 VA contract in residence (R), commercial (B), government (P) categories for their use of power above 80% of category-average.

(2) Fuel Prices

Recent fuel prices released by PLN for 2000 to 2006 are shown in Table 2.4-12. Fuel prices for geothermal power generation represent the steam cost paid to Pertamina.

For fuel oil prices in 2008, Fig.2.4-6 shows the total spot price of FOB for crude oil from May 6, 2005 to April 4, 2008. After April 4, 2008, the spot price of crude oil recorded more than 120 US$ per barrel.

Table 2.4-12 PLN Fuel Prices (Cost) from 2000 to 2006

Year	Ex. Rate	HSD	MFO	Coal	Natural Gas	Geothermal
		$/bbl	$/bbl	$/ton	$/MSC	$/kWh
2000	8,529 Rp/$	11.06	7.12	18.02	2.55	0.0260
2001	10,266 Rp/$	13.61	10.14	19.44	2.54	0.0289
2002	9,261 Rp/$	24.15	19.35	23.73	2.54	0.0335
2003	8,571 Rp/$	32.30	29.59	26.93	2.51	0.0369
2004	8,985 Rp/$	32.37	30.04	25.68	2.37	0.0331
2005	9,751 Rp/$	45.97	39.43	25.80	2.60	0.0473
2006	9,141 Rp/$	97.92	61.48	36.74	2.65	0.0553

Note: MSC means 1,000 Standard Cubic Feet Source: PLN Statistics 2006

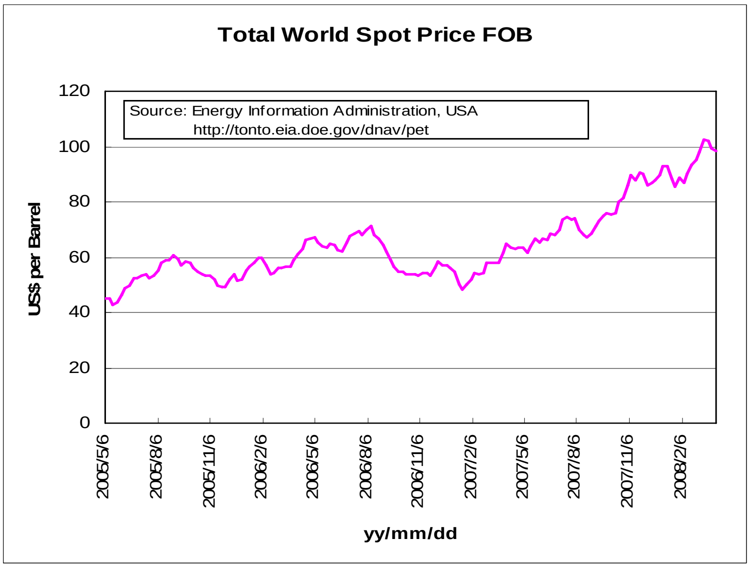


Fig.2.4-6 Crude Oil Total World Spot Price of FOB

As for the current coal prices, 3,400 MW Suralaya Coal-Fired Power Plant purchases fuel coal on CIF basis under conditions as shown in Table 2.4-13.

Table 2.4-13 Coal Prices at PLTU Suralaya Coal-Fired Power Plant

Coal Type	Heat Content	Coal Price (1)	Coal Price (2)	Coming from
Medium Rank Coal	5,100 kcal/kg	540,000 Rp/ton	58.7 US$/ton	Sumatra
Low Rank Coal	4,500 kcal/kg	420,000 Rp/ton	45.7 US$/ton	Kalimantan

Note: 1 US$ = 9,200 Rp. Caloric value is as received base.

Source: Hearing investigation on PLTU Suralaya Thermal Plant on June 3, 2008

As for the current LNG price, no domestic market price is available, since all of LNG production is at present to countries, such as Japan, Korea and Taiwan. For reference, LNG FOB prices to Japan in 2008 are between 9 US$/MMBTU[3] to 12 US$/MMBTU, and their contracts include a clause to reflect escalations of the crude oil price.

2.4.8 IPP and Coal-Fired Power Plant Development in Fast Track Program

(1) IPP (Independent Power Producer)

PLN started purchasing power from IPP in 1990s. Since then, the power purchased by PLN has been growing rapidly.

PLN makes power generation plan in RUPTL where some of generation is set to come from IPPs based on which PLN prepares for announcement of IPP project, call for candidates, selection, PPA, etc, while Minister of Energy and Mineral Resources grants license and approves power purchasing prices in PPA. Selection of developers for an IPP project is done

[3] Source: MIGAS, MEMR on June 5, 2008

in open bidding process in order to assure transparency and efficiency, however, when open bidding is not realistic or efficient, direct appointment is applicable. Geothermal development is an exception to this rule: it is a government that carries out reconnaissance, offers the candidate areas to prospective bidders, open bidding, select the developer. Finally the successful bidder is given a license to develop the resource at his own risks[4].

Power purchase payment based on PPA is done in foreign currency, and the foreign exchange risk is allocated to PLN. The change in fuel prices is also passed on to PLN. The table below summarizes currently effective PPA prices.

Those PPA signed in 1990s had become obsolete due to Asian economic crisis in 1997. Most of such PPA were renegotiated and revised by 2003.

Table 2.4-14 Unit Prices of Power in PPA

Company	Power Plant	Fuel	Capacity (MW)	Component Unit Rate (sen US$/kWh)						Ex.R (Rp)	Op year
				A	B	C	D	E	TOTAL		
PT. Paiton Energy Company	PLTU Paiton I	coal	2 × 615	3.5300	0.2936	0.9754	0.1310		4.9300	10,000	40
PT.Jawa Power	PLTU Paiton II	coal	2 × 610	3.2929	0.2848	1.0153	0.0869		4.6799	9,716	30
PT. Dayabumi Salak Pratama	PLTP Gunung Salak	geo	3 × 55						4.4500	8,500	30
Special Purpose Company	PLTU Tanjung Jati B	coal	2 × 660	3.4600	0.3000	1.0750	0.1000		4.9350		20
Amoseas Indonesia	PLTP Darajat	geo	1 × 50						4.2000	8,000	47
Himpurna Calipornia Energy	PLTP Dieng	geo	3 × 60						4.4500	8,500	30
Patuha Power Limited	PLTP Patuha	geo	3 × 60						4.4500	8,500	30
PT. Cikarang Listrindo	PLTGU Cikarang	gasCC	1 × 150	2.1296	0.3000	1.9404	0.1000		4.4700	9,000	20
PT. Pertamina (Persero)	PLTP Wayang Windu	Geo	1 × 110						4.4376	8,500	30
PT. Latoka Trimas Bina Energy	PLTP Kamojang	Geo	2 × 30						4.4250	8,500	30
Bali Energy Ltd.	PLTP Bedugul	Geo	1 × 10	70-71.25% of elec. Tariff						8,900	30
PT. Sumber Segara Primadaya	PLTU Cilacap	Coal	2 × 300	3.0650	0.3120	1.0920	0.1010		4.5700	8,500	30
PT. Power Jawa Barat	PLTU Serang	Coal	1 × 450	3.4890	0.3000	1.1670	0.1000		5.0560	9,000	30
PT. Bosowa Energi	PLTU Jeneponto	Coal	2 × 100	2.7800	0.3000	1.5300	0.1000		4.7100	9,500	30
PT. Intidaya Prima Kencana	PLTGU Anyer	N Gas	1 × 380	2.0600	0.3000	2,08*	0.1000		4.5400	9,500	20

Source : MEMR

(2) Coal Fire Power Plant Development Projects (Fast Track Program)

In 2006, in order to relieve a shortage of electricity supply and excessive dependency on oil fuel altogether, a new program called Fast Track Program, or alternatively called Crash Program or 10,000 MW coal-fired power plant project, was announced. This program includes 10 coal fired power plant projects, 6,900 MW in total capacity, in Jamali region.

There are institutional arrangements made for the program, that are;

- Selection of EPC contractor
  When PLN carries out a project with untied finance, EPC contractor selection should be done in open bidding
  When PLN carries out a project with tied finance, EPC contractor can be nominated in

[4] Geothermal Law 27/2003

direct appointment.

- Environment
  To expedite the process of building a power plant, authorities and organizations relevant shall proceed and conclude all necessary authorizations for EIA (Environmental Impact Assessment: AMDAL) and land acquisition and compensation for the power plant and transmission line route in 120 days from the receipt of application.

For those projects developed with EPC contract, 85% of initial cost of the project is basically financed through export credit facilities, while the rest, 15%, has to be secured by PLN. In order to ease the PLN's task of securing finance from private banks at better conditions, a government guarantee was decided to be given, by Presidential Decree No.86/2006, to PLN's debts as an exception to government rules. The guarantee reportedly helped PLN secure loan at lower interest rate.

2.4.9 Environmental and Social Considerations

In Indonesia, the Directorate of Protected Areas, the Ministry of Forestry is responsible for designations and managements of protected areas and the protection of endangered/precious/ are species. Six types of protected area; Strict Nature Reserves, Wildlife Sanctuaries, National Parks, Nature Recreation Parks, Hunting Game Reserves and Grand Forest Parks are designated under the Forestry Act (Law No.41/1999). In principle, construction of power stations or installation of transmission lines are not permitted in these protected areas. Locations of designated protected areas in Java as of December 2006 are shown in Fig.2.4-7 below.

Fig.2.4-7 Protected Areas in Java

As for coal-fired power stations under the Fast Track Program, a location map for eight power stations; Suralaya Baru Power Station, Paiton Baru Power Station, Jabar Utara Power Station, Rembang Power Station, Tanjung Awar-Awar Power Station, Tanjung Jati Baru Power Station, Jatin Selatan Power Station and Labuhan Power Station, indicates that they are not located within or in the vicinity of any protected area. The Fast Track Program officers and environmental officer of PT Perusahaan Umum Listrik Negara (PLN) have confirmed that remaining Teluk Naga Power Station and Jabar Selatan Power Station are also not located within or in the vicinity of any protected area.

Location maps of the new power stations to be introduced under RUPTL (National Power Development Plan in Indonesia) suggest that Cirebon Coal-Fired Power Station, Bali Utara Coal- Fired Power Station, Patuha Geothermal Power Station, Dieng Geothermal Power Station and Windu Geothermal Power Station are not located within protected areas. As for reservoir-type hydroelectric power stations, Rajamandala Hydroelectric Power Station and Jatigede Hydroelectric Power Station are already confirmed to operate, but these are not sited within a protected area. Cimandiri Hydroelectric Power Station, Muang Hydroelectric Power Station, Cibuni-3 Hydroelectric Power Station and Cipasang Hydroelectric Power Station are also included in all of the power development scenarios as promising reservoir-type hydroelectric power stations, although these are not included in RUPTL. For those other than Cipasang Hydroelectric Power Station, their location map indicates that they are not located within a protected area. As for pumped-storage power generation, a location map of Upper Cisokan Hydroelectric Power Station, Matennggeng Hydroelectric Power Station and Grindulu Hydroelectric Power Station suggests that they are not located in a protected area.

When involuntary resettlement is required to secure a land to construct some public facility, such as a power station and transmission line, consent from local residents shall be obtained in accordance with the Land Appropriation Law (Presidential Decree No.36/2005) administered by the National Land Agency, and compensations shall be conducted under this Law. There is no regulation in Indonesia to require specific actions to obtain consent from those to be resettled.

3. POWER DEMAND FORECAST

3.1. Review of Existing Demand Forecast

3.1.1 Demand Forecast by MEMR

MEMR forecasts power demand for next 20 years by each sector, which is composed of Residential, Commercial, Industrial and Public, using software named "Simple-E". In Simple-E, regression formula derived with explanatory variables can be set, and energy sales by each sector is calculated through regression analysis with explanatory variable such as GDP per capita. According to published RUKN 2006-2026, the annual energy growth rate in Jamali is expected to be around 6-7%.

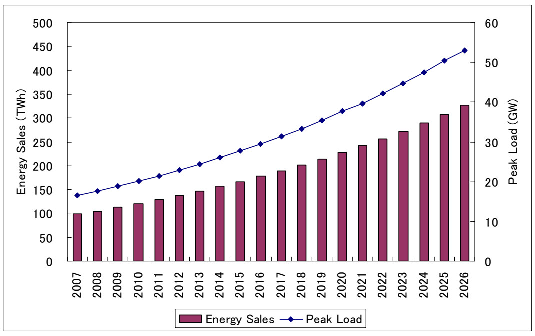


Fig.3.1-1 Demand Forecast in RUKN 2006-2026

3.1.2 Demand Forecast by PLN

In PLN, power demand is forecasted using software "DKL" for the next ten years by each sector (Residential, Commercial, Industrial and Public). The forecast is conducted for each region (Jakarta, West Java, Central Java, East Java and Bali) as well as whole Jamali. DKL is Excel based software developed by PLN, and enables forecast using demand elasticity which indicates the ratio of demand growth to GDP growth. According to RUPTL 2007-2016, annual growth rate of power demand in Jamali will be around 6-7 % until 2016.

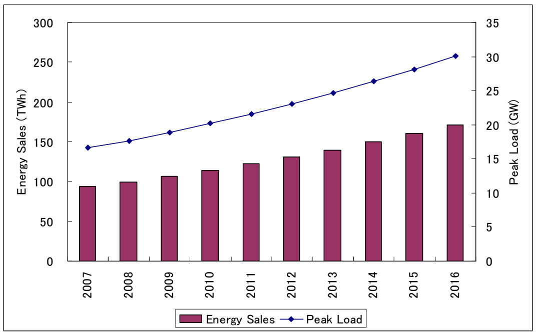


Fig.3.1-2 Demand Forecast in RUPTL 2007-2016

3.1.3 Demand Forecast in Previous JICA Study

In the previous JICA study "Study on the Optimum Electric Power Development in Java-Bali", power demand was forecasted using a model in which explanatory variables such as economic condition (RGDP) were used. According to the study, power demand in Jamali is forecasted to grow by around 7% annually.

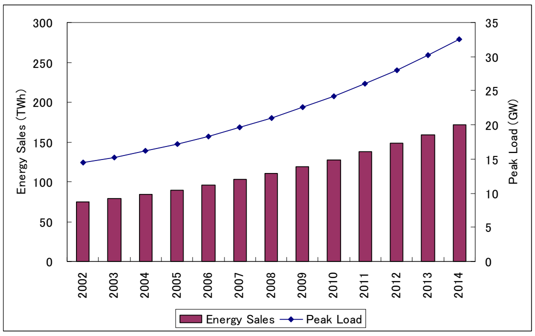


Fig.3.1-3 Demand Forecast by JICA in 2002

3.2. Economic Development and Growth of Jamali Region

Economic development plan currently effective, National Medium Term Development Plan (Presidential Decree No.7/2005), envisages that the country's economy should grow at 6 to 7% per annum in order to lower the present over 10% unemployment to 5% level, with the growth of labor market taken into consideration. Actual growth rate of the economy for the last few years almost reaches this level. In Jamali region, the focus of development efforts seem to have shifted from increasing industrial output to enhancing efficiency by means of improvement of transport infrastructures, etc.

Meanwhile, on the demand side, the level of capital formation has not recovered to that of 1990s. Capital investment has shown a slight recovery in and around 2004, however, it may take long time to take effect, and if it does, it will be in the regions outside Jamali where natural resources endowments are located such as Sumatra and Kalimantan, and would not directly push up economic output of industries in Jamali region. Moreover, the economy has been steadily expanding for the last few years may well be negatively affected by recent oil price increase. Electricity tariff will surely be revised upward in or after 2009.

That the outside regions will expand and contribute to the national development in terms of foreign exchange earnings and primary energy provision on the basis of rich natural resource endowment, while Jamali region will improve its efficiency and move to the next stage of development, seems to be a plausible and desirable grand picture of development of the country for the coming decades.

A fundamental understanding of economic conditions of Jamali region for the purpose of electricity demand forecast is summarized as follows.

- Economy of Jamali region has been growing at 5.5 to 6.5% with some regional variations for the last 5 - 6 years. There seem to be few internal factors that upturn this trend.
- It should be noted that there are some external factors present at the moment that may affect and disturb so-far stable development of the economy, such as energy price increase and resulting inflations.

3.3 Review of DSM and Possibility of Energy Conservation

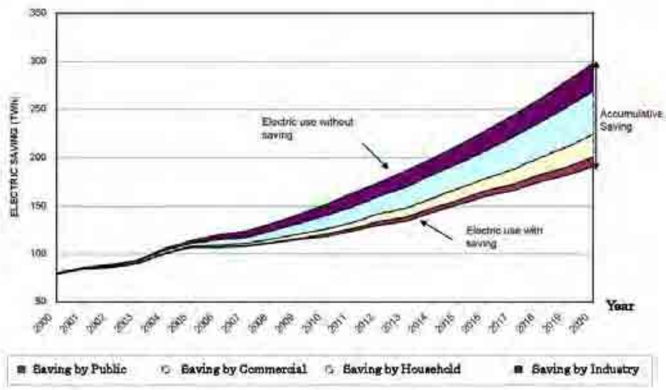
As a specific approach for the energy conservation accomplishment, followings are executed with JICA support.

- Consolidation of legal system
- Energy efficiency labeling
- Enhancement of test equipment
- Manufacturer support

PLN focuses on the following as the strategic approach to DSM.

- Primary/Secondary industry: Introduction of Energy Conservation Technology and Management
- Household and Commercial: Introduction of Energy Conservation Facilities
- Power generation: Introduction of Energy Conservation Technology and Management
- Electricity Tariff Adjustment Strategy (TDL; TARIF DASAR LISTRIK)

The applications of energy conservation technique will be launched one by one, from the one with more effectiveness, and approximately 30% reduction of electricity demand is expected in Indonesia as a whole, if successfully introduced.



Source : Electricity Saving Blueprint 2008

Fig.3.3-1 Electric Power Saving Roadmap

EE&C (Energy Efficiency and Conservation) on the power generation side is also important as well as the approach in power consumption. Among them, Repowering (PLTG to PLTGU) which can produce additional 50% of energy without increasing the fuel consumption is one of the excellent EE&C technology.

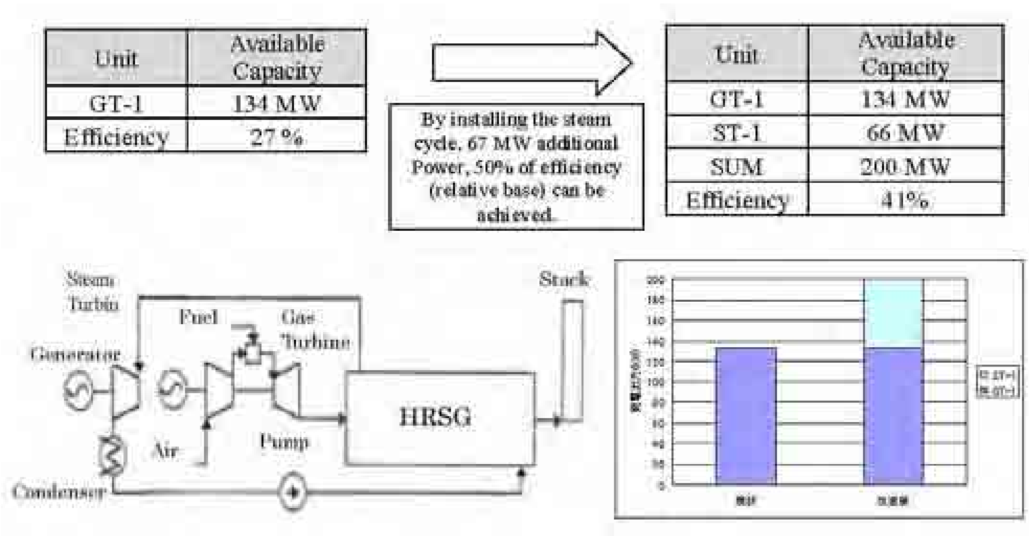


Fig.3.3-2 Effect of Re-powering (Efficiency and Power Generation)

3.4. Update of Power Demand Forecast

Power demand forecast model is established and power demand from 2009 to 2028 is forecasted in the following procedure;

i) Extract variables and parameters which affect demand forecast

ii) Build a demand forecast model and assume a transition of variables and parameters

iii) Calculate energy consumption by sector and total energy consumption

iv) Calculate entire generated energy considering own use and loss

v) Calculate entire peak demand considering load factor

For the transition of load factor, the transition of daily load curve in the future is forecasted, and the peak shift from night to daytime is reflected. According to the study described below, it is considered that there is relationship between economic condition and peak time, and peak time moves from night to daytime in accordance with economy growth. Considering such characteristic, the transition of daily load curve in the future is forecasted.

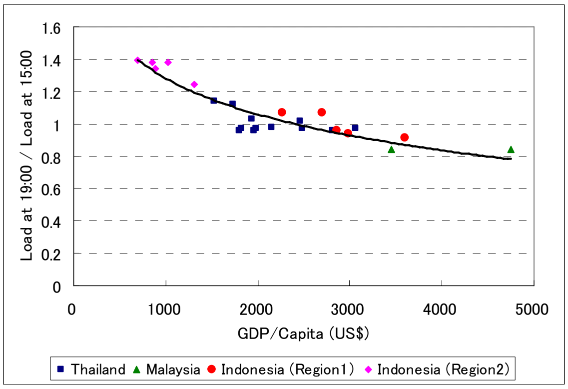


Fig.3.4-1 GDP per Capita and Peak Time

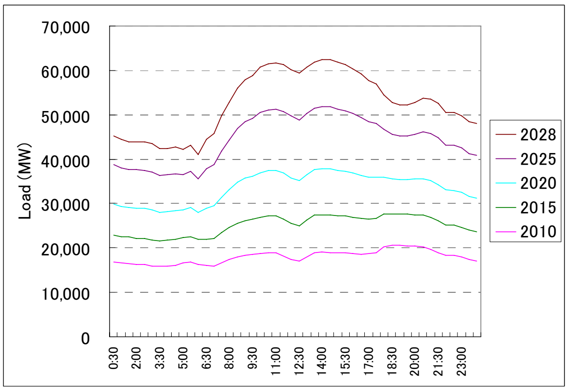


Fig.3.4-2 Daily Load Curve in Jamali

As a result of demand forecast, as shown in Fig.3.4-3, in the base case, energy sales is expected to grow at around 6.5% annually, and reaches 354,835 GWh in 2028. The amount of peak load will be 62,474 MW in 2028.

Suppose that the demand in recent years has been suppressed due to supply shortage, potential demand is possibly larger than the demand in the base case. In high case where this aspect is taken into consideration, energy sale is assumed to grow at around 9% annually for the next ten years.

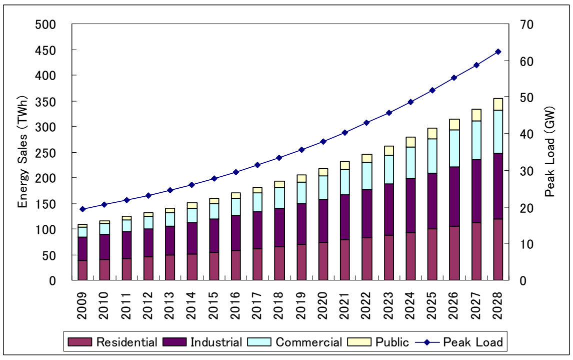
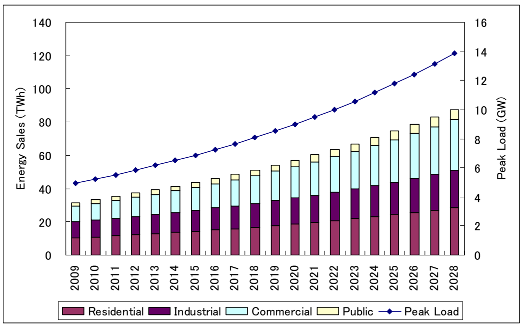
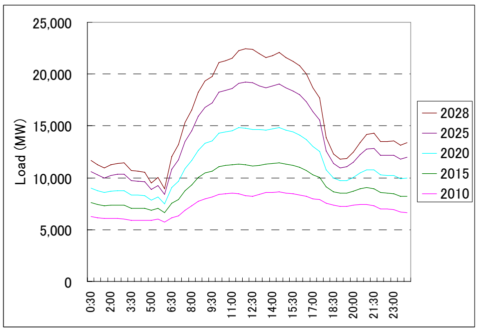


Fig.3.4-3 Energy Sales and Peak Load (Jamali)

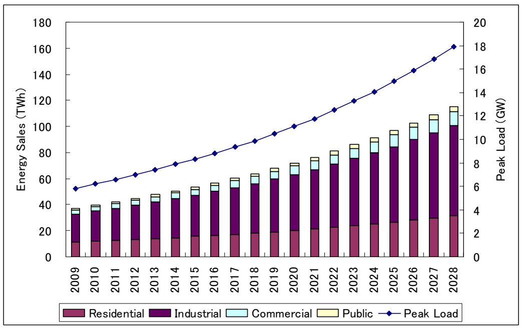
Regional power demand is also forecasted reflecting characteristics in each region as shown in Fig 3.4-4. In Jakarta which is the politic and economic center of Indonesia, residential demand based on millions of people and commercial demand based on commercial activities lead the regional demand. In West Java, which is geographically located near Jakarta, industrial demand including factories leads demand. Central Java does not have metropolis and is not developed much compared to the other regions, and residential demand takes large part of power demand. East Java, which has the second largest city in Java Island, is relatively urbanized and industrialized, and steady growth is expected in all sectors. In Bali, tourism is the major industry, and the proportion of commercial demand is large.



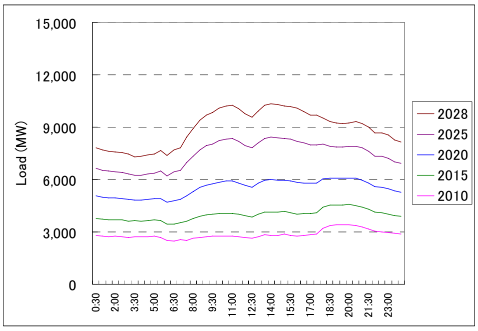
Energy sales and peak demand (Jakarta)



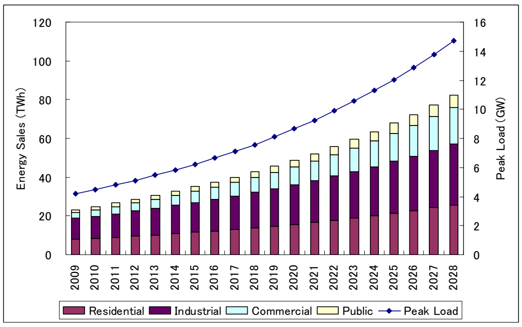
Daily Load Curve (Region1)



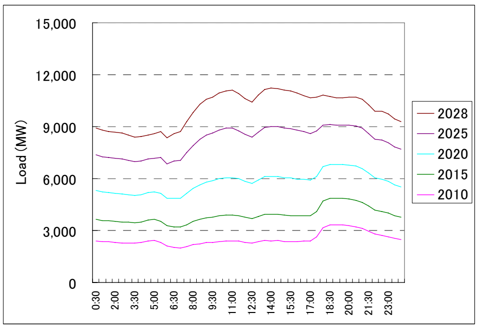
Energy sales and peak demand (West Java)



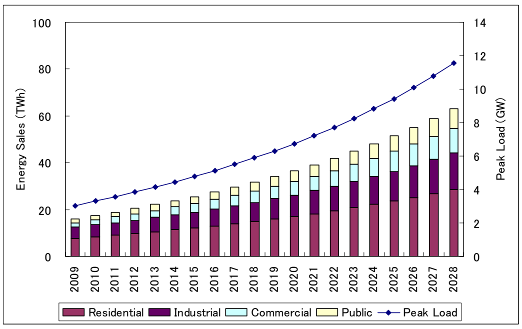
Daily Load Curve (Region2)



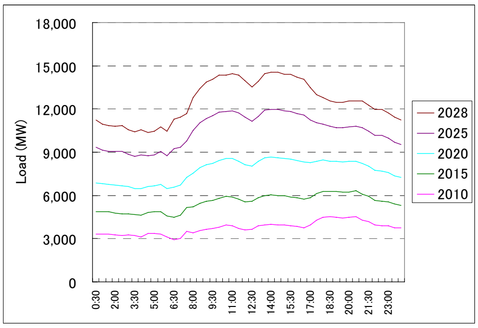
Energy sales and peak demand (Central Java)



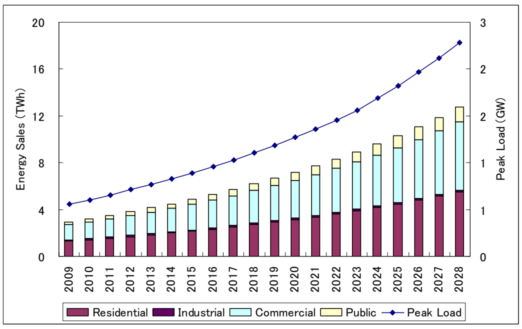
Daily Load Curve (Region3)



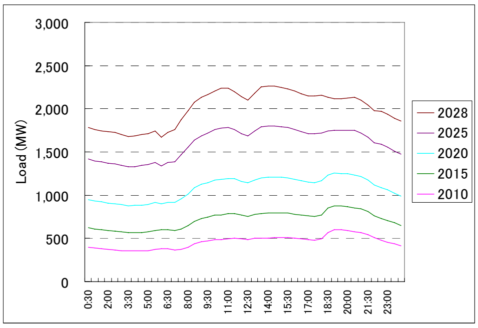
Energy sales and peak demand (East Java)



Daily Load Curve (East Java)



Energy sales and peak demand (Bali)



Daily Load Curve (Bali)

Fig.3.4-4 Result of Regional Demand Forecast

4. STUDY FOR THE OPTIMAL POWER DEVELOPMENT SCENARIO

4.1. Supply and Demand of Primary Energy

Though it has been thought that abundant energy resources such as oil, the natural gas, and coal are reserved in Indonesia, they are also limited. As for oil, the production tends to decrease every year and the amount of import exceeded the amount of export in 2004. In around 2013, the amount of import is expected to exceed the production.

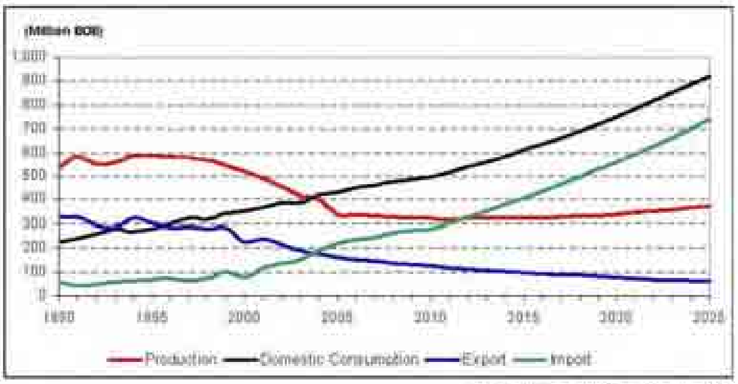
On the other hand, gas production has shown marginal changes since the 1990's and the supply to power plants where a large amount of gas is consumed is delayed in many occasions.
This delay forced many PLTG/PLTGU that were constructed in order to meet the rapid growth of power demand since 2000 to use HSD instead.

Based on the national policy, valuable and marketable high-quality coal is turned to export for the foreign currency earning, and low rank coal which has low calorific value and contains high moisture, is directed to domestic market. Recently, the government is promoting the use of LRC (Low Rank Coal) at power stations where a large amount of primary energy is consumed.

Meanwhile, as primary energy for power generation, geothermal that the country has the world's largest potential, run-of-river hydro, and other renewable energy such as wind and solar power, have also become the candidates of important power resources.

(1) Crude Oil

Domestic production of oil is in a trend to decrease gradually, and gas shows marginal changes in 2004 while it had been in increasing trend after 1990's.
Recently, the possibility of large-scale hydrocarbon source (in the magnitude of 100 billion-bbl) in Aceh Province southwest Simeulue-Island was reported. There can be significant impact on the energy policy if the reserve is confirmed.



Source : Energy Outlook & Statistics 2006

Fig.4.1-1 Crude Oil Balance

(2) Resources/Reserves of Natural Gas

Proven reserve of the natural gas in Indonesia shows gradual increase as shown in Fig.4.1-2. Proven reserve in 2006 is 94 TSCF, and the production may continue for another 31 years at current production rate, 3 TSCF/year. Because the discovery of new gas field can be expected as the result of the recent exploration, it seems that proven reserves may increase.

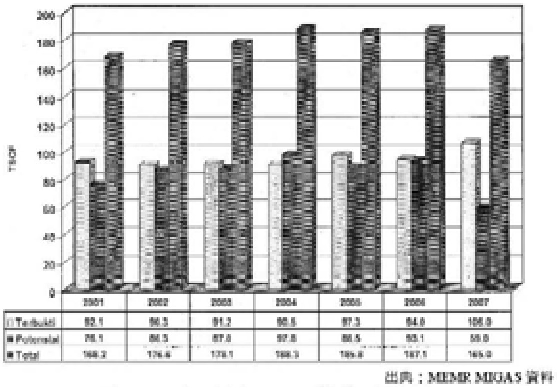


Fig.4.1-2 Gas Resources in Indonesia

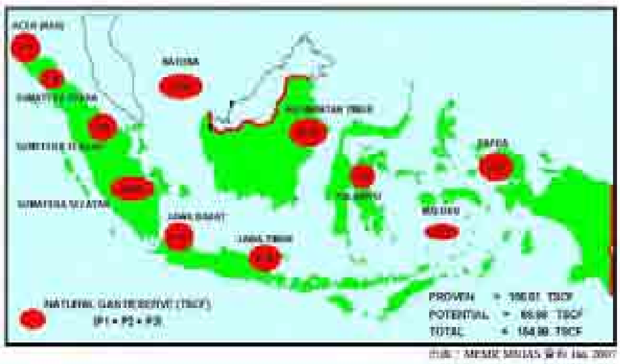


Fig.4.1-3 Area Map of Gas

Gas supply to power stations of PLN is behind the schedule, and that the supply has materialized are the supply of 150 MMSCFD to the Muara Tawar Power Station through Sumatra-Java sub-sea pipeline (SSWJ-1) and the supply of gas from Kangean gas field to Gresik Power Station which is currently under price negotiation. There are no further plans of gas supply to power stations excluding existing and new power stations that have already started construction.

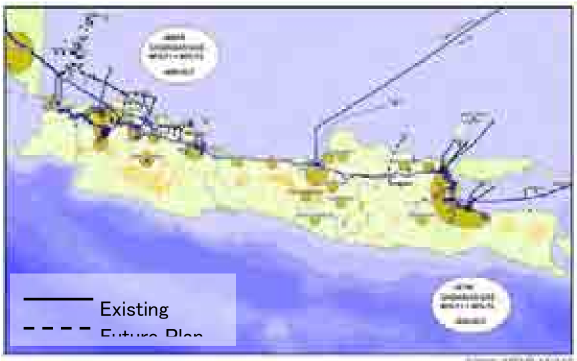


Fig.4.1-4 Gas Pipeline in Java

Fig.4.1-5 LNG Import Terminal in Java

As for the supply flexibility of gas, there are a lot of restrictions of the natural gas which is supplied by the pipeline.

Two ideas are considered as countermeasures that enable variable gas supply.

i) Application of LNG (Liquefied Natural Gas)

ii) Application of CNG (Compressed Natural Gas) System

If CNG system is applied to pipeline at the consumer-side end, peak load operation of the power plant may become possible.

This system consists of branch of pipeline before power station, gas compressor and CNG storage tank

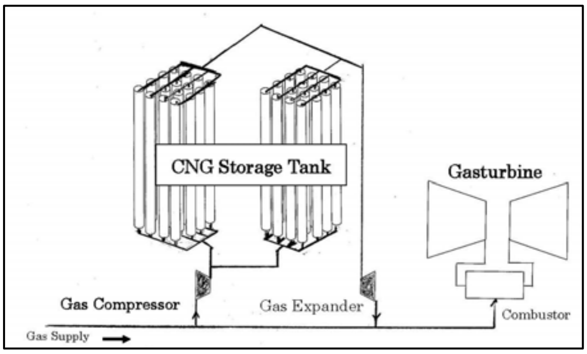


Fig.4.1-6 CNG Application to Pipeline Gas

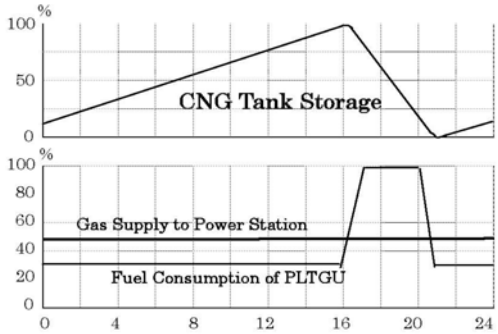


Fig.4.1-7 Operational Flexibility by CNG

(3) Coal

Coal resources in Indonesia are about sixty-one billion tons, and mostly distributed in Sumatra (47%) and Kalimantan (52%). The production in 2006 was one 190 million tons, and the reserve/production ratio is 36 years based on the proven reserve of 6.8 billion tons. When the calculation is made based on 12.4 billion tons that includes the measured reserve, it becomes 101 years.

Among the production of 190 million tons per year, 70% is exported to Japan, Taiwan, Malaysia, Korea, etc. and the remaining 30% is used within the country. 57% of domestic use is consumed for electric power generation.

About 80% of the proven reserves are the middle and low rank coal. The low rank coal has not been appreciated on a commercial base until now.

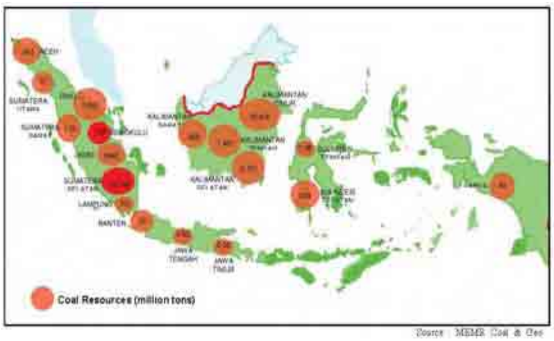


Fig. 4.1-8 Coal Resources in Indonesia

Table 4.1-1 Coal Resources/Reserves for Rank of Coal

Coal Rank	HHV (kcal/kg)	Resources		Reserves	
	Air Dried Base	Billion Ton	%	Billion Ton	%
Low	**< 5100**	**14.95**	24.4	2.98	44.1
Medium	5100-6100	37.65	61.5	2.44	36.1
High	6100-7100	7.97	13.0	1.22	18.0
Very High	>7100	0.67	1.1	0.12	1.8
Total		61.24	100.0	6.76	100.0

♦ Low Rank Coal (LRC)

Major mines of LRC are located in Sumatra and Kalimantan.

A special consideration is required in the design/operation of the boiler in which LRC with the characteristics of high water content and natural-ignition is burned. CO_2 emission is larger than in a bituminous coal fired boiler because the boiler efficiency becomes lower with LRC due to the higher water content. Meanwhile, LRC produced in Indonesia also has preferable properties, such as lower contents of ash and sulfur, which result in lower production of fly ash and SOx.

The coal that will be used in the new power plants currently under construction under the “Fast Track Program (total generation capacity 10,000 MW)” is LRC that is categorized as lignite, and is different from the coal used in existing power plants, which is categorized as sub-bituminous. LRC is not distributed in the market. PLN is negotiating with coal suppliers to purchase LRC of 31,900,000 tons/year. As of the end of April 2008, 28 million tons/year which is approximately 90% of total demands has been secured with the contacts with eight suppliers. The contracts are on the long term of 20 years and CIF basis.

Under the present situation where the infrastructure of coal transportation is not quite developed, the transportation of LRC, which is not widely distribute in market, is difficult to be expanded, to prepare for the completion of power plants under “Fast Track Program”. Now we expect that the production of coal for domestic use increases by 50% in a short period, the overall infrastructure development and upgrading is required urgently, and must be coordinated with the development plans of coal fields.

(4) Geothermal

It is reported that Indonesia possesses the geothermal resources that could produce more than 27,000 MW of power, and accounts for 40% of the geothermal potential of the world. To use these resources effectively, the Indonesian government made the development road map and scheduled to develop 9,500 MW by 2025. As of 2007, total 1,020 MW are operating.

Table 4.1-2 Geothermal Resources in Indonesia

Region	Installed Capacity	Existing Plan	Possible New/ Additional Plan	Total Resource Potential
Sumatra	2	913	3,605	**4,520**
Java-Bali	835	785	2,015	**3,635**
Nusa Tenggara	0	9	138	**146**
Sulawesi	20	140	575	**735**
Maluku	0	0	40	**40**
Total (MW)	**857**	**1,847**	**6,373**	**9,076**

Source : JICA, MP Study for Geothermal Power Development 2007

The potential of large-scale development is concentrated in Sumatra and Java.

Table 4.1-3 Master Plan of Geothermal Development in Java Bali Regions

Source : JICA; M/P Study for Geothermal Power Development 2007

(5) Renewable Energy

Besides oil, gas and coal, the primary energy that is available in Indonesia is Hydro, Mini-hydro, Micro-Hydro, Solar, Bio-diesel, Bio-ethanol, Wind and the Waste. Hydro, Mini-hydro, Micro-hydro, Solar and Wind energy can be utilized for power generation. As shown in Table 4.1-4, the scales of exploited capacity of these resources are small except Hydro.

Table 4.1-4 Non-Fossil Energy in Indonesia

Non-Fossil Energy	Potential	Capacity
Hydro	75,670 MW	4,200 MW
Mini/Micro-hydro	459 MW	84 MW
Solar	4.8 kWh/m^2/day (1203 TW)	8 MW
Wind	3 - 6m/s (9,290 MW)	0.5 MW

Source : Blue print

The developments have been limited as they are located far away from demand centers, constrained by large investment cost and environmental protection, etc.

(i) Hydropower

Table 4.1-5 shows the potential in Java-Bali region. However, the candidates PLN adopted in their development program, RUPTL, are only Rajamandala (run-of-river type), Jatigede (reserved type) and Upper Cisokan (pumped storage type). Other potential sites in Java-Bali region are accompanied by such problems as resettlement and existence of conservation areas, etc.

Table 4.1-5 Hydropower Potential in Java-Bali Region

Location	Project Name	Type	Installed capacity (MW)	Recommended Year of installation
Central Jawa	Maung	RES	360	2004
West Jawa	Cibuni-3	RES	172	2013
	Cipasang	RES	400	2006
	Cimandiri-3	RES	238	2006
	Upper Cisokan-PS	PST	1000	2006
	Cibuni-4	RES	71	2015
	Cijutang-PS-2	PST	1000	2008
Jawa-Bali	Sesayap-1	RES	949	2017
	Boh-2	RES	1120	2018
West Jawa	Cibuni-PS-1	PST	1000	2012
Central Jawa	Klegung-PS	PST	1000	2016
East Jawa	Grindulu-PS-3	PST	1000	2018
West Jawa	Rajamandala	ROR	55	—
	Jatigede	RES	175	—
	Citiman	RES	-	—
	Cikaso-3	RES	29.5	—
Central Jawa	Gintung	RES	19.2	—
	Rawato-1	ROR	0.64	—
East Jawa	Grindulu-2	RES	16.3	—
Note ; RES (Reserved), ROR(Run of River), PST(Pumped Storage)				

Source: Hydro Inventory Study 1999 by PLN

(ii) Wind Power and Solar Energy

The potential in western Indonesia is shown in Tables 4.1-6, 7. Development is a part of the energy policy for the utilization of renewable energy, although there are difficulties in terms of the economy and the operation as the power generation is conditional on weather.

Table 4.1-6 Potential of Wind Power

No	Village/Sub District/Regency	Province	Year of Measurement	Average Velocity at Elevation of 24 m
1	Sabang	Aceh	1994	2.73
2	Meulaboh	Aceh	1994	3.33
3	Polonia Medan	North Sumatera	1994	3.68
4	Sei Dadap Kisaran	North Sumatera	1994	3.06
5	Binaka	North Sumatera	1994	3.06
6	Sicincin	West Sumatera	1994	3.86
7	KP. Laing	West Sumatera	1992	3.72
8	Depati Darbo	Jambi	1994	4.01
9	Simpang Tiga Pakanbaru	Riau	1994	3.97
10	Kijang	Riau	1994	4.22
11	Japura Rengat	Riau	1994	2.83
12	Ranai	Riau	1994	2.45
13	Pangkal Pinang	South Sumatera	1992	3.68
14	Buluh Tumbang Tanjung Pandan	South Sumatera	1995	5.56
15	Serang Banten	West Java	1992	3.01
16	Curug Tangerang	West Java	1994	2.70
17	Tanjung Priok	Jakarta	1993	4.45
18	Cengkareng	Jakarta	1994	3.55
19	Semarang Maritim	Central Java	1992	2.94
20	Kledung	Central Java	1994	4.08
21	Adi Sumarmo Surakarta	Central Java	1995	2.39
22	Iswahyudi Madiun	East Java	1994	5.57
23	Suranaya AURI	East Java	1994	4.65
24	Surabaya Perak	East Java	1994	2.61
25	Kalianget	East Java	1994	5.40
26	Sangkapura Bawean	East Java	1994	2.96
27	Surabaya Maritim	East Java	1994	3.37
28	Ploso	East Java	1991	2.39
29	Kp. Tiekung	East Java	1994	2.55
30	Denpasar	Bali	1992	2.39

- Small Scale : 2 – 3 (m/sec)
- Medium Scale : 3 – 4 (m/sec)
- Large Scale : > 4 (m/sec)

Source :
Rencana Induk Pengembangan Energi Baru dan Terbarukan 1997, Directorate General of Electricity and Energy Development, Ministry of Energy and Mineral Resources

Note ; More than 6m/s is necessary for large scale wind power from the economy

Table 4.1-7 Potential of Solar Energy

No	Regency	Province	Year of Measurement	Average Radiation (kWh/m^2)	Measured by
1	Banda Aceh	Aceh	1980	4.10	LSDE
2	Palembang	South Sumatera	1979-1981	4.95	BMG
3	Menggala	Lampung	1972-1979	5.23	DGEED/BMG
4	Rawasragi	Lampung	1966-1979	4.13	DGEED/BMG
5	Jakarta	Jakarta	1965-1981	4.19	DGEED/BMG
6	Bandung	West Java	1980	4.15	LSDE
7	Lembang	West Java	1980	5.15	LSDE
8	Citius, Tangerang	West Java	1980	4.32	LSDE
9	Darmaga, Bogor	West Java	1980	2.56	LSDE
10	Serpong, Tangerang	West Java	1991-1995	4.45	LSDE
11	Semarang	Central Java	1979-1981	5.49	BMG
12	Surabaya	East Java	1980	4.30	LSDE
13	Kentang, Yogyakarta	Yogyakarta	1980	4.50	LSDE
14	Denpasar	Bali	1977-1979	5.26	DGEED/BMG
15	Pontianak	West Kalimantan	1991-1993	4.55	LSDE
16	Banjarbaru	South Kalimantan	1979-1981	4.80	BMG
17	Banjarmasin	South Kalimantan	1991-1995	4.57	LSDE
18	Samarinda	East Kalimantan	1991-1995	4.17	LSDE
19	Menado	North Sumatera	1991-1995	4.91	LSDE
20	Palu	South East Sulawesi	1991-1994	5.51	LSDE
21	Kupang	West Nusa Tenggara	1975-1978	5.12	DGEED/BMG
22	Waingapu, Sumba Timur	East Nusa Tenggara	1991-1995	5.75	LSDE
23	Maumere	East Nusa Tenggara	1992-1994	5.72	LSDE

Source :
Rencana Induk Pengembangan Energi Baru dan Terbarukan 1997, Directorate General of Electricity and Energy Development, Ministry of Energy and Mineral Resources

4.2. Basic Condition for Power Source Development Plan

(1) Common Assumption

Common assumptions used in the power source development plan are shown in Table 4.2-1.

Table 4.2-1 Common Assumption

Items	Conditions	Remarks
Study Period	20 years	20 years from 2009 to 2028
Demand Forecast	Base Case	6.5 % of average power growth rate
Load Duration Curve	Typical Duration Curve as shown in Fig.4.2-1	Developed by annual operation data for the year 2006 provided by P3B (Constant for 20 years[5])
Minimum Reserve Margin	30 %	Minimum Reserve Margin = Supply Capacity / Peak Load ≥ 30 %
Loss of Load Probability	≤ 0.274 %	Less or equal to one (1) day / year
Hydro Condition	1 condition	
Periods per year	2 periods	Wet season (6 months) and Dry season (6 months)
Peak Load ratio		Rainy season : Dry Season = 1: 0.971 Based on 2006 operation data
Cost of the energy not served	None	Due to the uncertainty of kWh cost of the energy not served because of none actual payment up to now

.

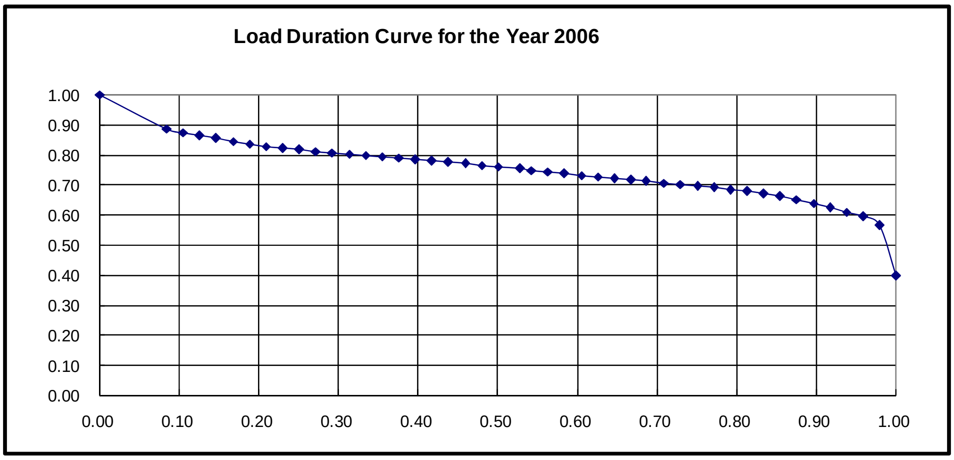


Fig.4.2-1 Load Duration Curve for Power Source Development Plan

<u>Reserve Margin</u>

The average reserve margin of ten (10) power utility companies in Japan from 1995 to 2005 has been fluctuating between 9.3 % (minimum in 2001) and 16.6 %[6] (maximum in 1999). The target reserve margin of thirty (30) % for Jamali is high in comparison with that in Japan. This is because the target reserve margin of 30 % in Jamali includes the following uncertainties.

[5] Using the typical load duration curve leads to 1.7 % more generated energy than that of demand forecast for 2028, which is the largest difference for the planning period, and for most of years the difference is within 1.0 % margin. Therefore, typical duration curve well represents the generated energy obtained in the demand forecast for Jamali region.

[6] Source: “Electric Power Industry in Japan 2007”, Japan Electric Power Information Center

- Once malfunction and/or breakage of generation equipment occurs, the duration for restoration cannot be estimated and/or sometimes requires long time[7], because main parts and/or spare parts for power generation equipment have to be procured from abroad.
- Negotiations on conditions between PLN/MEMR and international financial institutions sometimes cause the delay[8] of project implementation.
- Since peak load always occurs in summer season (July or August) in Japan, periodical maintenance for generation facilities is planned to be conducted in other seasons. On the other hand, timing (month/dates) of peak load in Indonesia cannot be forecasted in advance like Japan. Therefore, there is a possibility that some power stations are under periodical maintenance when peak load occurs, which requires more reserve margin.
- Generation by hydropower fluctuates[9] remarkably between dry season and wet season.
- Derating of existing generation facilities[10], especially thermal power plants

Based on the above observation, the target reserve margin of 30% is kept for the whole planning period at the moment, although PLN have intension to reduce the reserve margin from 2020 onwards keeping LOLP being less than 0.274 %.

(2) Candidates for Future Power Source Development Plan

1) Candidates of thermal power plants

Table 4.2-2 shows the candidate thermal plants for the power source development plan. Java-Sumatra Interconnection and LNG-fired thermal are seemingly promising candidates to be put into the system in 2014 and 2015 respectively.

Table 4.2-2 Candidates of Thermal Power Plants

Power Resource	Abbreviation	Unit Capacity
PLTU-Coal	C6H	600 MW / unit
PLTU-Coal	C10H	1,000 MW/unit
LNG-fired PLTG/TGU	LNG	750 MW / unit
PLTP	GE55	55 MW / unit
PLTN	N10H	1,000 MW / unit
PLTG	G150	150 MW / unit
Java-Sumatra Interconnection	JS-IC	600 MW / unit, Max 5 units

[7] Suralaya unit No.5 stopped operation for 241 days in 2007 and still stopped when JICA team visited Suralaya thermal power station on June 3, 2008.
[8] Commencements of Engineering Service for T.Priok, M.Tawar and M.Karang projects were delayed for more than one year due to delay of issuance of gas supply agreement which consist a part of conditionality.
[9] Monthly average generation energies from 2003 to 2006 in wet season and in dry season are 166.5 GWh and 66.8 GWh respectively for Saguling Hydropower Station (Source: data provided by Indonesia Power)
[10] As shown in Table 2.4-1, differences between installed capacity and rated capacity in 2007 are estimated about 2,000 MW.

2) Candidates of Hydropower Plants and Pumped Storage Power Plants

Under the current soaring oil-based fuel prices, a hydropower plant, especially a reservoir type, seems to be competent even though it requires rather large initial investment cost in comparison with thermal power plants. At the moment, only two (2) projects, Rajamandala (IPP, 47 MW) and Jatigede (PU, 110 MW) are ongoing.

According to "Hydro Inventory and Pre-feasibility Studies", conducted by Nippon Koei CO., LTD. in June 1999, the following four (4) hydropower projects in Jamali are recommended to proceed to D/D stage or implementation stage. The recommended (4) hydropower projects are used as candidates of hydropower plant.

Table 4.2-3 Candidates of Hydropower Plant

Name	Location	Type	Total Cost (M.US$)	Installed Capacity (MW)	Unit Cost ($/kW)	Annual Energy (GWh)
Cibuni-3	W.J	RES	363.3	172.0	2112.2	568.0
Cipasang	W.J	RES	482.4	400.0	1205.0	751.1
Cimandiri-3	W.J	RES	350.6	238.0	1473.1	600.0
Maung	C.J	RES	511.6	360.0	1421.1	534.9

Source : "Hydro Inventory and Pre-feasibility Studies", June 1999, Table 15.1.1(1) & (2)

Concerning the pumped storage hydro power plants, three (3) projects are recommended to proceed to Pre-F/S stage or F/S stage in the abovementioned 1999 report. Among the three (3) projects, only Upper Cisokan project are being advanced to implementation. The remaining two (2) projects are used as candidates of pumped storage power plant. Considering the Fast Track Program (6,900 MW Coal-fired thermal plants in Jamali) expected to provide pumping energy with low cost, pumped storage projects will have advantage in the future.

Table 4.2-4 Candidates of Pumped-Storage Power Plant

Name	Location	Type	Total Cost (M.US$)	Installed Capacity (MW)	Unit Cost ($/kW)	Annual Energy (GWh)
Matenggeng	W.J	PST	585	1,000	585	905.2
Gurindulu	E.J	PST	624	1,000	624	905.2

Source : "Hydro Inventory and Pre-feasibility Studies", June 1999, Table 15.1.1(3) & (4)

According to Table 4.1-5 "Hydro Potential in Java-Bali Region", the remaining hydro potential in Jamali except the ongoing projects and the above candidates seems to be around 2,200 MW.

(3) Fuel Prices

In the course of the JICA Study, crude oil price recorded the high of 147 USD per barrel in early July 2008 and the Jakarta Post reported "Bukit Asam sold coal to the Tanjung Jati B power plant in Java at 80$ a ton, its record price for the domestic market (JKT Post, 2008.08.12)".Not only oil-based fuel prices but also coal and gas prices have been increased in the recent years. Under the current marked fluctuation of fuel prices, it is very difficult to set the fuel prices to be used in the power source development plan. However, the fuel prices may never go down to 2006 price level due to further increase of fuel demand by economic growth in BRICs[11] in the future. Considering the above circumstances, the fuel prices to be used in the power source development plan are set as shown in Table 4.2-5 provisionally.

Table 4.2-5 Fuel Prices for Power Source Development Plan

Kind of Fuel	Price			Heat Content	
	USD		Cents/mKcal		
Coal	80.0	per Ton	1,509	5,300	Kcal/kg
LNG	10.0	per MMBTU	3,968	252,000	Kcal/mmbtu
Gas	5.0	per MMBTU	1,984	252,000	Kcal/mmbtu
HSD	133.0	per Barrel	9,222	9,070	Kcal/l
MFO	81.0	per Barrel	5,437	9,370	Kcal/l
Geothermal	0.0553	per kWh	6,430		
Nuclear			250		

4.3. Evaluation of System Planning Method

The purpose of the study is to develop the integrated optimal power system development plan to secure the stable and sustainable electric power supply in the power sector. For this purpose, necessary evaluation of system planning method and basic condition of optimal system expansion plan in Indonesia were carried out.

4.3.1 System Planning Method in Indonesia

(1) System Planning Method

1) Target of power supply quality

The target of power supply quality in the development of system planning is as below, which is considered proper value judging from the requirement of the power consumers.

(a) Operating voltage
Permissive fluctuation range of operating system voltage should be designed within ±5% of the standard voltage (e.g. 500 kV system voltage → 475 kV ~ 525 kV)

(b) Frequency
Permissive fluctuation range of frequency should be designed at 50±0.2Hz.

2) Criteria of System Planning

Generally the system planning shall be developed to ease overload condition in the whole of the system and maintain adequate system voltage under the normal and abnormal conditions.

[11] Brazil, Russia, India and China

Criteria of system planning are as shown below and they are considered proper in quality in consideration of the present requirement in Indonesia. However it is recommended to develop new criteria to cope with the severe accidents and system stability because the power supply requirement may become severer in the future.

4.3.2 Basic Condition for Developing Optimal System Expansion Plan

Optimal system development plan shall be developed to meet the optimal power development plan for the purpose of securing a stable and flexible power supply in the variable condition of the power sector. Although a system planning shall be basically developed based on the above mentioned criteria, a stability analysis was also carried out to prevent severe accidents. The following conditions were added in this study.

(1) Duration of Study

The objective time span of this study is from 2009 up to 2028.
The specified years for the system diagram and system analysis were selected to be years of 2010, 2015, 2020, 2025 and 2028.

(2) Criteria of system planning

Additional criteria for this study are as follows:

1) In case of more severe criteria (N-2 criteria)

To study the case of more severe accident; fault on a certain T/L of 500 kV trunk loop system which may result in a large-scale block-out, N-2 criteria was adopted.

2) Transient Stability Criteria

No stability criterion is adopted with regard to the transient stability in Indonesia, however, a system stability was evaluated to prevent large-scale black-out under the severe accident condition (route accident) partially.

4.4. Strategic Environmental Assessment

4.4.1 Legal Status of Strategic Environmental Assessment

Indonesia has no legislation to require Strategic Environmental Assessment (SEA) at the moment. The Ministry of Environment in Indonesia is now planning to amend the Environmental Management Law to incorporate a provision to require SEA. A Presidential Decree will be issued under the amended Law to require ministries and local governments to conduct SEA when they establish a policy, plan or program. Actual contents of SEA, or those to be assessed and how to assess them will be specified by a Minister of Environment Decree.

4.4.2 Special Features of the Strategic Environmental Assessment for Study on the Optimal Power Development Scenario in Java-Madura-Bali Area

In power development scenarios, contribution by each type of power generation is proposed, but as for power stations to start operation after 2017, a candidate site for each power station is mostly not identified. On the other hand, construction sites for most of the power stations to start operation until 2016 are identified in the scenarios, but alternative scenarios are identical up to 2016, and there is no difference between the scenarios in power stations to introduce. In the present Strategic Environmental Assessment, sites for most of the individual power stations are yet to be proposed in the scenarios after 2017 when each scenario introduce different power stations, and it is difficult to compare and assess the scenarios quantitatively for their potential impacts on natural and social environment. Power development scenarios are produced after qualitative considerations of their potential impacts on natural and social environment.

4.4.3 Avoidance of Siting in Habitats of Endangered/Precious/Rare Species and Protected Areas

There is no distinct mangrove forest in Jamali area. Coral reefs are observed at many waters in Indonesia. Along the south coast of Java, however, there develop only fringing reefs at limited waters. The largest coral reefs are found at waters off Grajagan Coast and also along from Watu Ulo to Blambangan Peninsula in East Java Province. In contrast, fringing reefs develop only in Banten Bay and Jepara Bay along the north coast of Java.

In Indonesia, protected areas are designated under Forestry Act (Law No.41/1999), and the Act requires a permit from the Minister of Forestry to conduct a development project within a protected area. However, construction of a power station within a protected area has not been permitted except for geothermal power stations. There is no regulation to provide for specific review procedures to follow when an application is submitted for a development project within a protected area. There also is no legal time limit on the review period. Even applications for a permit to construct a geothermal power station within a protected area take a very long period to go through the review procedures, and they have not necessarily been granted a permit.

4.4.4 Potential Environmental Concerns of Various Power Generation Options and Possible Measures against Them

Environmental performances of the major power generation options are summarized in the table below. Potential environmental impacts completely subject to the location of power stations are not included in this table.

Table 4.4-1 Environmental Performances of Major Types of Power Generation

	Coal-Fired	Oil-Fired	Gas-Fired	Geothermal	Hydro	Nuclear
Air Pollution	SO_2, NOx, SPM	SO_2, NOx, SPM	NOx	H_2S	–	–
Water Pollution	Fro Coal Storage/ Ash Disposal	–	–	As, Hg	Water quality degradation in reservoir	–
Greenhouse Gas Emission	CO_2	CO_2	CO_2	–	CH_4 from reservoir	–
Thermal Effluent	Substantial Amount	Substantial Amount	Substantial Amount	Limited Amount	–	Substantial Amount
Involuntary Resettlement	Possible	Possible	Possible	–	May be large-scale	May be large-scale
River Water Use	–	–	–	–	Impacts likely	–
Radiation Risk	–	–	–	–	–	Potential

As an example of potential concerns associated with various types of power generation and possible measures against them, those for Suralaya Baru Power Station, one of the coal-fired power stations under the Fast Track Program, are described below. Suralaya Baru Power Station is actually an extension of the existing Suralaya Power Station.

Environmental Impact Statement of Suralaya Baru Power Station reports monitoring results on survival of corals around existing Suralaya Power Station. Decreasing survival rates of corals and high seawater temperatures have been recorded, and it is suggested that further increase of seawater temperatures in the surrounding water due to additional discharges of thermal effluents from the new power station could aggravate survival of corals. Operation of Suralaya Baru Power Station is not desirable for protection of corals. There are coral reefs in waters off Jamali area, and in siting of thermal power stations in future, potential impacts of the increase of water temperatures by their thermal effluents on survival of corals need to be considered before it is decided whether their construction and operation are acceptable or not.

Monitoring results of emissions of suspended particulate matters from existing Suralaya Power Station indicate that the emission standard was exceeded in Units #1 and #2U at the second quarter of 2005, and in Unit #3 at the third quarter of 2005. Emission standards need to be satisfied. According to the monitoring report of this power station, maintenance work of its electrostatic precipitator was conducted to fix a glitch with it upon exceedance of the emission standard for suspended particulate matters.

As for emissions of SO_2, NOx and suspended particulate matters (SPM) from a coal-fired thermal power station, their diffusions to the surrounding areas shall be predicted by simulations on the basis of their concentrations in the flue gas, emission rates of the flue gas, and meteorological and topographical data, to confirm that air quality in the surrounding areas will still comply with applicable air quality standards even after a coal-fired thermal power station comes into operation. If any of them is predicted to exceed the applicable standard, installation of a desulfurization (deSOx) /denitrification (deNOx) facility or electrostatic precipitator (ESP) shall be considered.

4.4.5 Constraints on Power Development Scenarios by Environmental and Social Considerations

In our identification of power development scenarios, we have considered potential impacts of individual types of power generation on natural and social environment, and we have created scenarios so that particular environmental loads will not be produced excessively. For example, while thermal and nuclear power generation may have impacts on marine organisms and local fishery through thermal effluents, hydroelectric power generation may require large-scale resettlement of local residents. In the present study, we have created scenarios without too much reliance on a particular type of power generation, in order to exclude repeated occurrences of a particular environmental impact and to achieve "diversification of risk".

4.5. Power Development Scenario

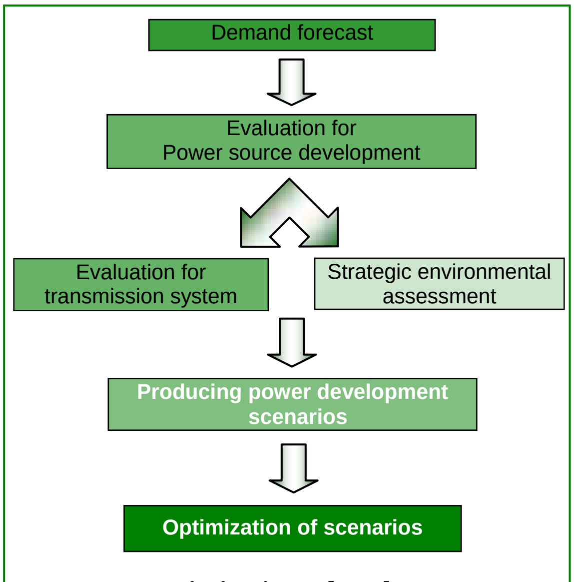
4.5.1 Concept of Power Development Scenario

(1) Framework of Planning

The flowchart of alternative power development scenario and its optimization is shown in the figure in the right hand side.

The optimal power development scenario is examined to make overall power supply economical, stable and reliable, and environmentally friendly. Decrease of oil usage in power production is the first priority in power development scenarios.

On the other hand, it is difficult to secure sufficient power sources substituting for oil-burning plants. Gas supply is very slow to materialize and hydropower development has not even started yet. Therefore, large-scale coal-fired power plant development and pumped storage hydro development are being advanced. Negative social and environmental impacts due to exhaust and thermal water discharge may result when several coal thermal power plants are developed on a limited stretch of land. These are perceived as the downside of substituting coal for oil.



Optimization Flowchart

Configuration of power generation and transmission systems that effectively meets the maximum power demand and energy in 2028 is the long-term goal of each scenario. Installed capacity in Jamali system was 22.3 GW (PLN 18.4 GW and IPP 3.9 GW), and the produced energy is 104.8 TWh (PLN 79.9 TWh and IPP 24.9 TWh) in 2006. Produced energy will be 406.6 TWh and the maximum power demand will reach 62.5 GW in 2028. In the electric power development plan, when the reserve margin of 30% is set, installed capacity must be 81.2 GW in 2028 against the maximum power demand.

(2) Development Plan for Power Generation and Transmission

As for current power sources, coal, geothermal and small-hydro are used to meet base load and oil, gas, and reservoir type hydro to middle to peak load. Coal, geothermal, and nuclear will be main candidates for base load generators in the demand increase in the future. Natural gas (including LNG), and reservoir type hydro and pumped storage hydro are main candidate power for peak load. Small hydro, wind, solar, and biomass (bio-fuel), etc. are expected as renewable sources, too. Moreover, there is a plan to transmit power generated on Sumatra and Kalimantan Islands to Java Island via submarine cables.

4.5.2 Alternative Scenarios

Some alternative scenarios are drawn out first and optimization process is undertaken by comparison of scenarios. In Indonesia the target of primary energy mix for the power sector is set up in RUKN or RUPTL. One scenario can be drawn to follow up this target. Other alternative scenarios give priority to one of the following three themes in power development planning:

a. Lower generation cost (priority to coal),
b. Reliable and stable power supply system,
c. Less global environmental impact

The following scenarios were drawn in terms of policy/plan or priorities:

Scenario 0: Policy oriented scenario
Scenario 1 : Coal power acceleration scenario
Scenario 2 : Power source diversification scenario
Scenario 3 : CO_2 emission reduction scenario

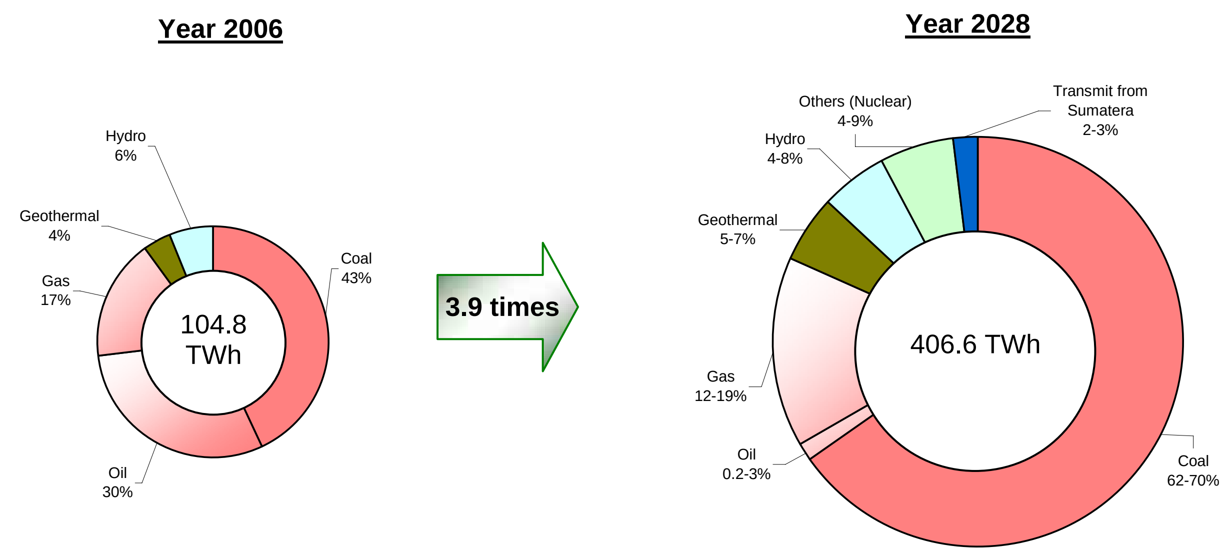


Fig.4.5-1 Change of Primary Energy Consumption by Fuel (Policy oriented scenario)

4.5.3 Comparison of Scenarios

The long term development targets of power sources in four scenarios are summarized in Table 4.5-1 (produced energy 406.6 TWh, maximum power 62.5 GW, and total installed capacity 81.2 GW in 2028). The capacity ratio of each power source in the table is an expected ratio of its capacity to the total installed capacity 81.2 GW, and the energy production ratio is an expected ratio of its generated energy to the total produced energy of 406.6 TWh.

Table 4.5-1 Power Development Scheme in Each Scenario (Target in 2028)

Scenario \ Source		Oil	Coal	Gas	geothermal	hydro	Pumped storage	nuclear	Renewable
Present 2006	Capacity ratio 2006 (%)	29	39	17	3.5	11.5	0	0	0
	Energy ratio 2006 (%)	30.4	43.2	16.8	3.7	5.9	0	0	0
Scenario 0 Policy oriented		Energy ratio 0.2% after PLN target	Energy ratio 62-70% after policy	Energy ratio 12% after policy and on-going projects	Energy ratio 5% after policy and feasible capacity	Energy ratio 4-8% after policy	Appropriate capacity developed for peak load, based on WASP results	Capacity ratio 5-7%, 4-5GW after roadmap	Negligible
Scenario 1 Coal power acceleration		Energy ratio 0.2% after PLN target	Energy ratio 73% due to inexpensive fuel. Intensify development	Capacity ratio 10% due to expensive fuel.	Capacity 1,620 MW, 2% after adding feasible 785 MW	Energy ratio down to 2% due to high initial cost impeding development.	Appropriate capacity developed for peak load, based on WASP results	Capacity up to 5 GW (7%) due to inexpensive generation cost	Negligible due to expensive production cost.
Scenario 2 Power source diversification		Energy ratio kept to 2-3% to sustain diversification	Just as much as to complement the deficit left by other sources	Energy ratio 19%, intensely developed using LNG	Available capacity 3.6 GW, 5%, intensely developed	Energy ratio 4-8%, reservoir type developed	Appropriate capacity developed for peak load, based on WASP results	Capacity 5 GW (7%) to diversify sources	Energy ratio 4%, solar , wind and biomass, to diversify sources
Scenario 3 CO_2 emission reduction		Energy ratio kept to 2-3% to sustain diversification	Just as much as to complement the deficit left by other sources	Energy ratio 19%, intensely developed using LNG	Available capacity 3.6 GW, 5%, intensely developed	Energy ratio 4-8%, run-of-river type developed	Appropriate capacity developed for peak load, based on WASP results	Capacity 5 GW (7%) to reduce CO_2 emission	Energy ratio 5% by solar and wind , and 2% by biomass

Note: Total capacity 22,126 MW and 104.8 TWh (PLN 79.9 TWh, IPP 24.9 TWh) in Jamali system in 2006.

The installed capacity by fuel for thermal power including IPP depends on RUPTL 2007-16. The total capacity of thermal power 18,825 MW (85 %) is divided into steam 10,370 MW (46.9 %), combined cycle 6,143 MW (27.8 %), gas turbine 2,236 MW (10.1 %) and diesel 76 MW (0.3%).

Power supply from Sumatra (Capacity 3 GW, ratio 3.7%) is common to all scenarios but not presented in the Table.

Energy production (consumption) ratio by fuel as of 2028 was roughly estimated on the basis of the above-mentioned targeting. Fig.4.5-2 shows the result.

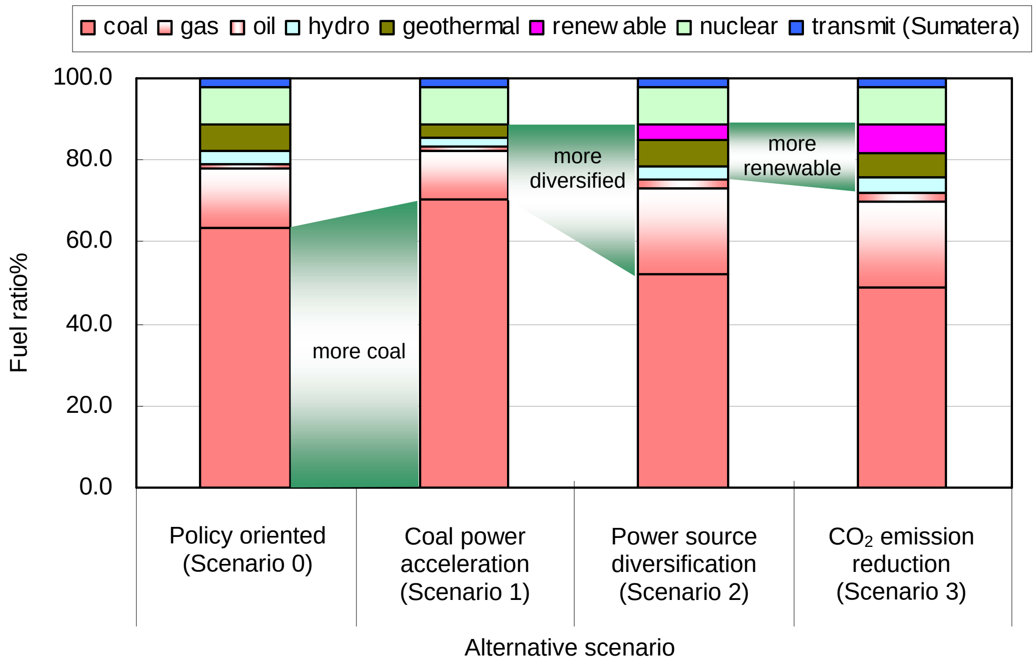


Fig.4.5-2 Energy Production Ratio by Fuel for Scenarios (Total 406.6 TWh, 2028)

4.6. Estimation of Financial Requirements

4.6.1 Power Source Development Plan

(1) Power Source Development Plan

1) Methodology for Translation of Each Scenario by WASP IV

Four alternative scenarios proposed in Section 4.5 are translated into the power source development plans by WASP IV. Since WASP IV is a generation expansion planning tool based on the total cost minimization algorithm and if coal fuel price of 80 $/ton is used, the energy mix in four (4) scenarios cannot be reproduced due to the imbalance of fuel prices. Therefore, coal fuel price is set as a parameter to reproduce the target energy mix of four (4) scenarios. And after reproduction of the targets of four (4) scenarios, operation cost is adjusted by using coal fuel price of 80 $/ton as shown in Fig.4.6 -1.

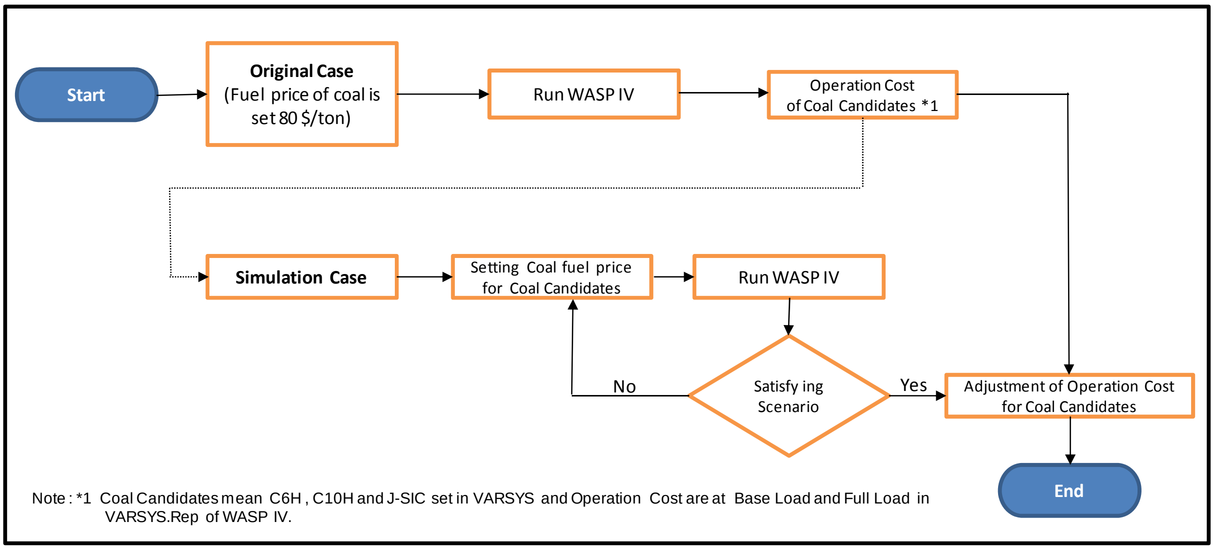


Fig. 4.6-1 Methodology for Reproduction of Each Scenario by WASP IV

2) Development Stage

Power source development plan for the 20 years from 2009 to 2028 is divided into three (3) stages, (a) On-going and committed projects development stage, (b) Prospective projects development stage, and (c) Potential projects development stage as shown in Fig.4.6-2, which shows for Scenario 0.

(a) On-going and committed project development stage (2009 ~ 2015)
On-going and committed projects in RUPTL are to be developed in this stage.

(b) Prospective projects development stage (2016 ~ 2020)
Prospective projects mean the projects whose sites are identified specifically in the relevant studies. Pre-FS, FS and/or D/D including EIA are to be carried out for the future implementation.

(c) Potential projects development stage (2021 ~ 2028)
Potential projects mean the projects whose sites have not yet been identified. Inventory list will be prepared and realization methods will be studied and prepared especially for renewable energy development.

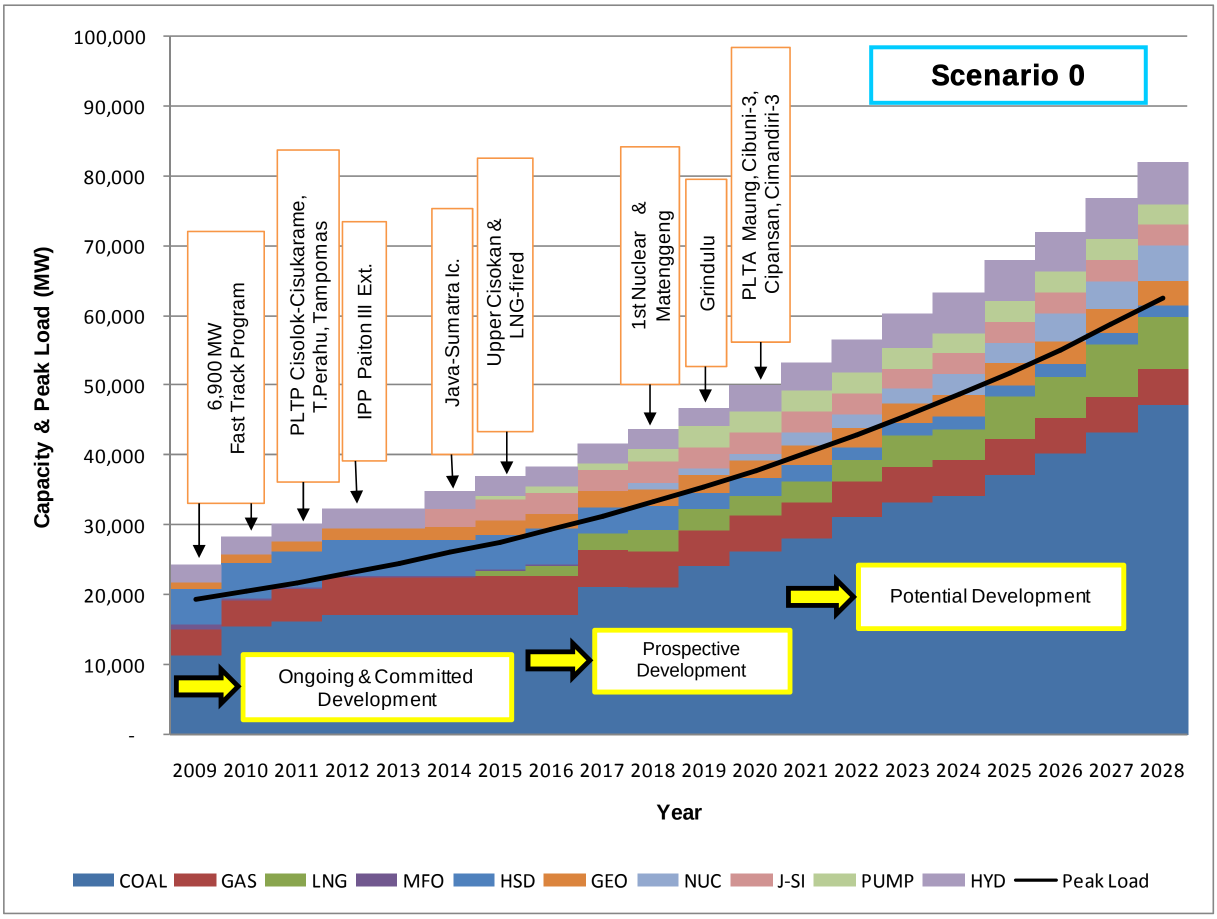


Fig.4.6-2 Development Stage (Scenario 0)

(2) Results of Power Source Development Plan

Main results of simulation by WASP IV are presented from Figure 4.6 -3 to Figure 4.6 -6.

1) Comparison of Target in Scenario and Result of WASP Simulation

The comparison between energy mix targets in four scenarios set in Section 4.5 and the results of WASP simulation are shown in Table 4.6-1.

Table 4.6-1 Comparison with Target Scenario and Results of WASP Simulation

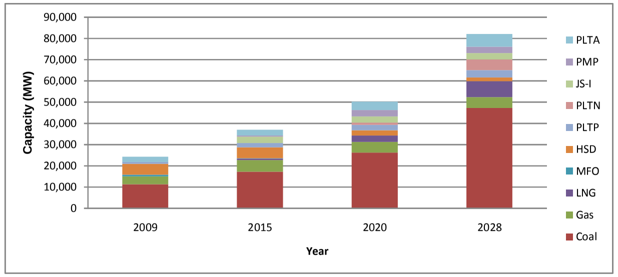
Scenario		Oil	Coal	Gas	Geothermal	Hydro	Pumped Storage	Nuclear	Other Renewable
Base Scenario	Target in 2028	Energy rate 0.2 %	Energy rate 56 ~ 66 %	Energy rate 12 %	Energy rate 5 %	Energy rate 4 ~ 8 %	Up to WASP IV economic development	Capacity rate 5 ~ 7 %, 4 ~ 5 GW	Negligible
	Results in 2028	Energy rate 1.1 %	Energy rate 65.7 %	Energy rate 14.5 %	Energy rate 9 %	Energy rate 3.3 %	Negligible	Capacity rate 6.1 %, 5 GW	None
Scenario 1	Target in 2028	Energy rate 0.2 %	Energy rate 70 %	Capacity rate 10 %	Capacity 1,620 MW	Energy rate 2 %	Up to WASP IV economic development	Capacity rate 7 %, 5 GW	Negligible
	Results in 2028	Energy rate 1.1 %	Energy rate 72.3 %	Capacity rate 10.8 %	Capacity 1,696 MW	Energy rate 2.2 %	Negligible	Capacity rate 6.1 %, 5 GW	None
Scenario 2	Target in 2028	Energy rate 2 ~ 3 %	Cover power shortage	Energy rate 19 %	Available capacity 3.6 GW, 5 %	Energy rate 4 ~ 8 %	Up to WASP IV economic development	Capacity rate 7 %, 5 GW	Energy rate 4 % by solar, wind and biomass
	Results in 2028	Energy rate 2.2 %	Energy rate 54.1 %	Energy rate 21.0 %	Available capacity 3.5 GW, 4.2 %	Energy rate 3.3 %	Negligible	Capacity rate 6.1 %, 5 GW	Energy rate 4 %
Scenario 3	Target in 2028	Energy rate 2 ~ 3 %	Cover power shortage, at least 18 % capacity after FTP	Energy rate 19 %	Available capacity 3.6 GW, 5 %	Energy rate 4 ~ 8 %	Up to WASP IV economic development	Capacity rate 7 %, 5 GW	Energy rate 5% by solar, wind and 2 % by biomass
	Results in 2028	Energy rate 2.2 %	Energy rate 51.0 %	Energy rate 20.8 %	Available capacity 3.5 GW, 4.2 %	Energy rate 3.5 %	Negligible	Capacity rate 6.1 %, 5 GW	Energy rate 7 %

As shown in the table above, most of targets except hydropower have been met by WASP IV simulation. Hydropower targets could not be met due to limited hydro potential in Jamali.

1 Base Scenario (Policy Oriented)

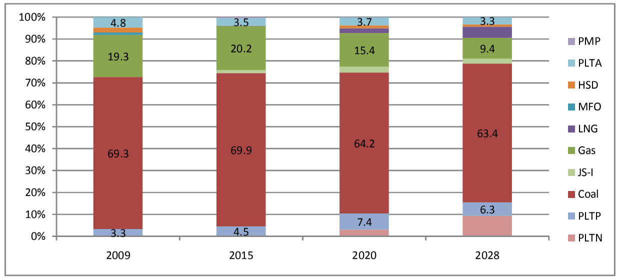
(1) Power Components (MW)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	11,371	3,713	0	718	5,128	886	0	0	0	2,574	24,390
2015	17,261	5,438	750	192	5,078	2,026	0	3,000	500	2,731	36,976
2020	26,261	5,072	3,000	0	2,384	2,576	1,000	3,000	3,000	3,901	50,194
2028	47,261	5,072	7,500	0	1,779	3,456	5,000	3,000	3,000	6,001	82,069



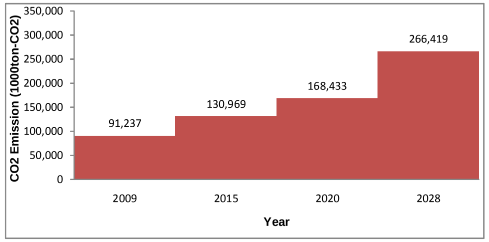
(4) Generation Energy (%)

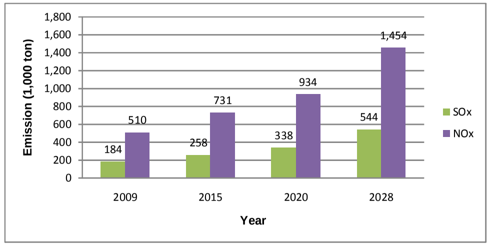
Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	69.3	19.3	0.0	1.1	2.3	3.3	0.0	0.0	0.0	4.8	100
2015	69.9	20.2	0.0	0.0	0.1	4.5	0.0	1.4	0.4	3.5	100
2020	64.2	15.4	2.2	0.0	1.3	7.4	3.0	2.7	0.1	3.7	100
2028	63.4	9.4	5.1	0.0	1.1	6.3	9.2	2.3	0.0	3.3	100



(8) Annual Emission (1000 t)

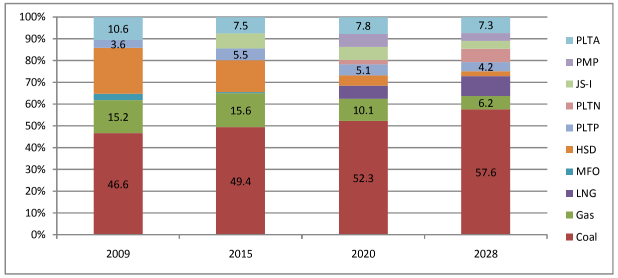
Year	CO2	SOx	NOx
2009	91,237	184	510
2015	130,969	258	731
2020	168,433	338	934
2028	266,419	544	1,454





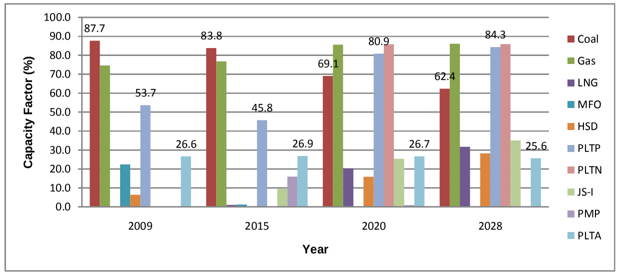
(2) Power Components (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	46.6	15.2	0.0	2.9	21.0	3.6	0.0	0.0	0.0	10.6	100
2015	49.4	15.6	0.0	0.6	14.5	5.5	0.0	6.9	0.0	7.5	100
2020	52.3	10.1	6.0	0.0	4.7	5.1	2.0	6.0	6.0	7.8	100
2028	57.6	6.2	9.1	0.0	2.2	4.2	6.1	3.7	3.7	7.3	100



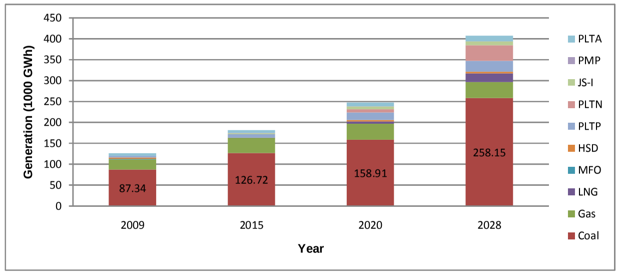
(5) Capacity Factor (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA
2009	87.7	74.7	0.0	22.4	6.4	53.7	0.0	0.0	0.0	26.6
2015	83.8	76.8	1.1	1.2	0.3	45.8	0.0	9.6	16.0	26.9
2020	69.1	85.6	20.3	0.0	15.9	80.9	85.8	25.4	0.9	26.7
2028	62.4	86.1	31.6	0.0	28.2	84.3	85.9	35.1	0.1	25.6



(3) Generation Energy (1000 GWh)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	87.34	24.29	0.00	1.41	2.86	4.17	0.00	0.00	0.00	6.00	126.07
2015	126.72	36.58	0.07	0.02	0.13	8.12	0.00	2.51	0.70	6.43	181.28
2020	158.91	38.04	5.34	0.00	3.32	18.25	7.52	6.68	0.24	9.13	247.43
2028	258.15	38.25	20.79	0.00	4.40	25.52	37.62	9.23	0.02	13.47	407.45

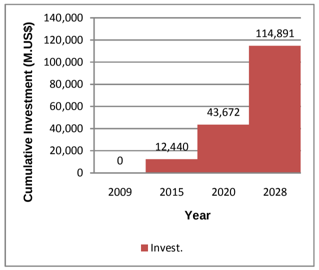


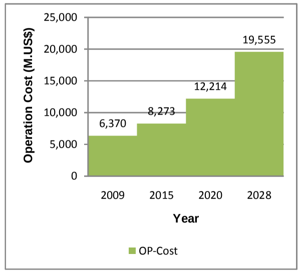
(6) Cumulative Investment Cost & Annual Operation Cost (M.US$)

Year	Invest.	OP-Cost
2009	0	6,370
2015	12,440	8,273
2020	43,672	12,214
2028	114,891	19,555

(7) Operation Cost (USc/kWh)

Year	OP-Cost	Gene.	OP-Cost
	M.US$	1000 GWh	c/kWh
2009	6,370	126.1	5.05
2015	8,273	181.3	4.56
2020	12,214	247.4	4.94
2028	19,555	407.5	4.80





(9) Annual Fuel Consumption

Year	Coal	Gas +LNG	MFO+HSD
	M.ton	M.mmbtu	M. KL
2009	44.1	221.1	1.20
2015	66.4	331.6	0.00
2020	83.2	381.4	1.10
2028	129.2	496.0	1.70

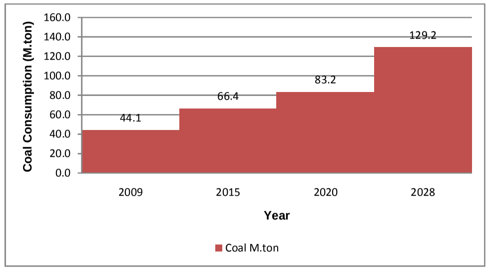
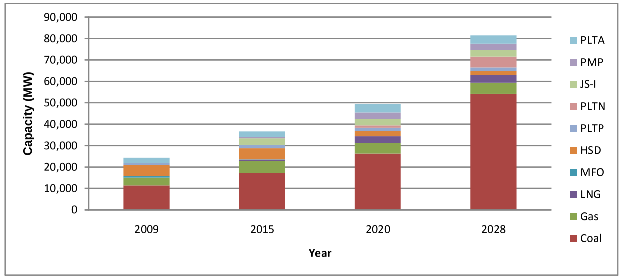


Fig. 4.6-3 Results of Simulation for Scenario 0

2 Scenario 1 (Coal Power Acceleration)

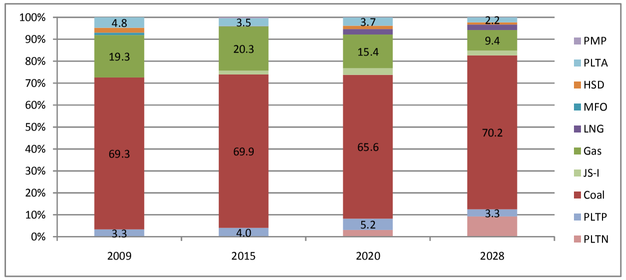
(1) Power Components (MW)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	11,371	3,713	0	718	5,128	886	0	0	0	2,574	24,390
2015	17,261	5,438	750	192	5,078	1,696	0	3,000	500	2,731	36,646
2020	26,261	5,072	3,000	0	2,384	1,696	1,000	3,000	3,000	3,901	49,314
2028	54,261	5,072	3,750	0	1,779	1,696	5,000	3,000	3,000	3,901	81,459



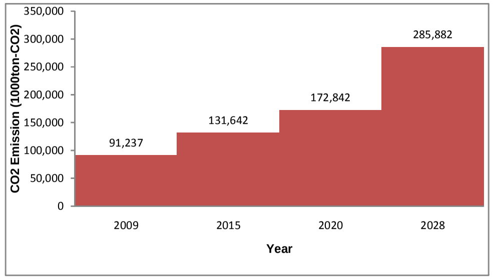
(4) Generation Energy (%)

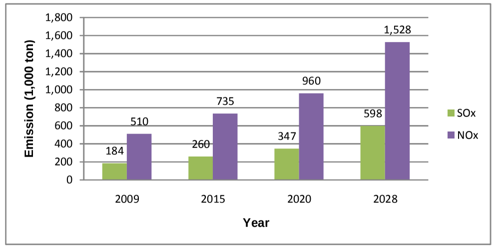
Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	69.3	19.3	0.0	1.1	2.3	3.3	0.0	0.0	0.0	4.8	100.0
2015	69.9	20.3	0.1	0.0	0.1	4.0	0.0	1.6	0.4	3.5	100.0
2020	65.6	15.4	2.4	0.0	1.6	5.2	3.0	3.0	0.1	3.7	100.0
2028	70.2	9.4	2.5	0.0	1.1	3.3	9.2	2.1	0.0	2.2	100.0



(8) Annual Emission (1000 t)

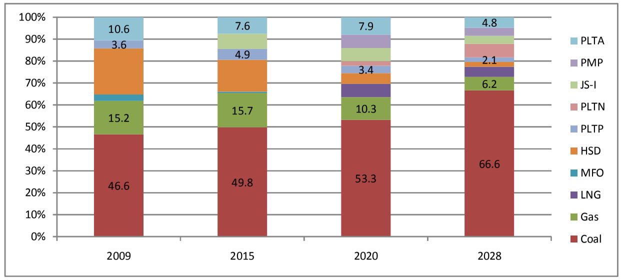
Year	CO2	SOx	NOx
2009	91,237	184	510
2015	131,642	260	735
2020	172,842	347	960
2028	285,882	598	1,528





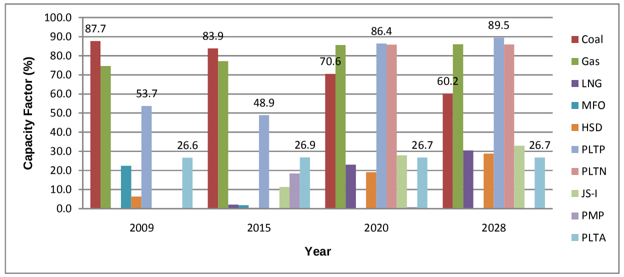
(2) Power Components (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	46.6	15.2	0.0	2.9	21.0	3.6	0.0	0.0	0.0	10.6	100.0
2015	49.8	15.7	0.0	0.6	14.6	4.9	0.0	6.9	0.0	7.6	100.0
2020	53.3	10.3	6.1	0.0	4.8	3.4	2.0	6.1	6.1	7.9	100.0
2028	66.6	6.2	4.6	0.0	2.2	2.1	6.1	3.7	3.7	4.8	100.0



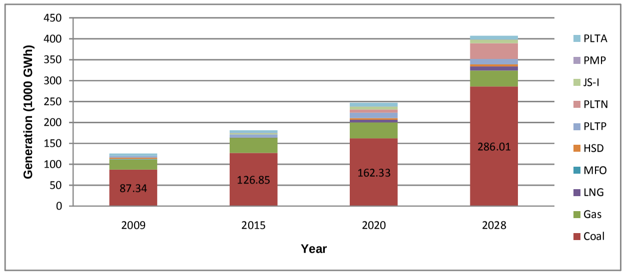
(5) Capacity Factor (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA
2009	87.7	74.7	0.0	22.4	6.4	53.7	0.0	0.0	0.0	26.6
2015	83.9	77.2	2.1	1.8	0.4	48.9	0.0	11.3	18.5	26.9
2020	70.6	85.7	23.0	0.0	19.1	86.4	85.8	27.9	0.9	26.7
2028	60.2	86.0	30.4	0.0	28.8	89.5	85.9	32.9	0.0	26.7



(3) Generation Energy (1000 GWh)

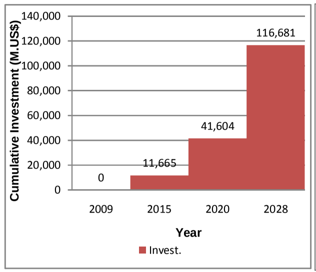
Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	SUM
2009	87.34	24.29	0.00	1.41	2.86	4.17	0.00	0.00	0.00	6.00	126.07
2015	126.85	36.77	0.14	0.03	0.17	7.27	0.00	2.97	0.81	6.43	181.44
2020	162.33	38.07	6.05	0.00	3.99	12.84	7.52	7.33	0.24	9.13	247.50
2028	286.01	38.23	10.00	0.00	4.49	13.30	37.62	8.64	0.01	9.13	407.43

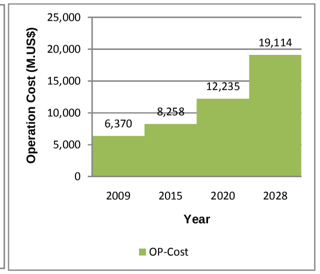


(6) Cumulative Investment Cost & Annual Operation Cost (M.US (7) Operation Cost (USc/kWh)

Year	Invest.	OP-Cost
2009	0	6,370
2015	11,665	8,258
2020	41,604	12,235
2028	116,681	19,114

Year	OP-Cost	Gene.	OP-Cost
	M.US$	1000 GWh	c/kWh
2009	6,370	126.1	5.05
2015	8,258	181.4	4.55
2020	12,235	247.5	4.94
2028	19,114	407.4	4.69





(9) Annual Fuel Consumption

Year	Coal	Gas +LNG	MFO+HSD
	M.ton	M.mmbtu	M. KL
2009	44.1	221.1	1.20
2015	66.8	334.3	0.00
2020	85.0	386.9	1.40
2028	141.5	417.4	1.70

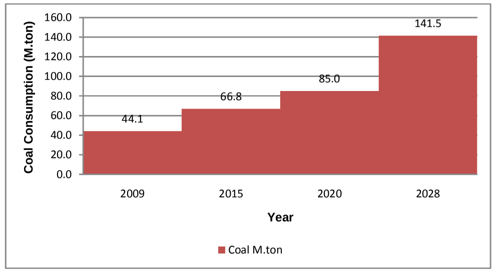
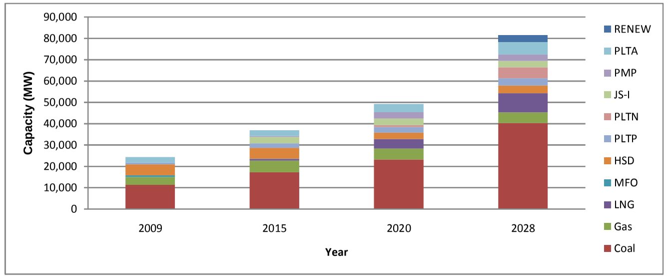


Fig. 4.6-4 Results of Simulation for Scenario 1

3 Scenario 2 (Power Source Diversification)

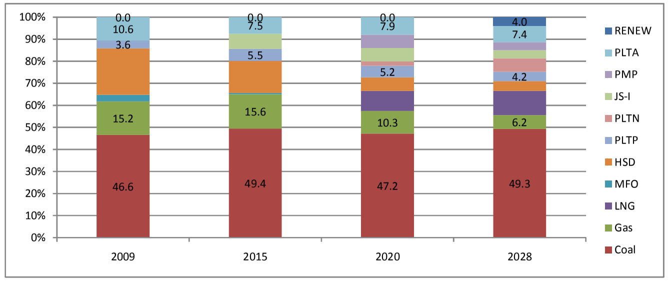
(1) Power Components (MW)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	11,371	3,713	0	718	5,128	886	0	0	0	2,574	0	24,390
2015	17,261	5,438	750	192	5,078	2,026	0	3,000	500	2,731	0	36,976
2020	23,261	5,072	4,500	0	2,984	2,576	1,000	3,000	3,000	3,901	0	49,294
2028	40,261	5,072	9,000	0	3,579	3,456	5,000	3,000	3,000	6,001	3,250	81,619



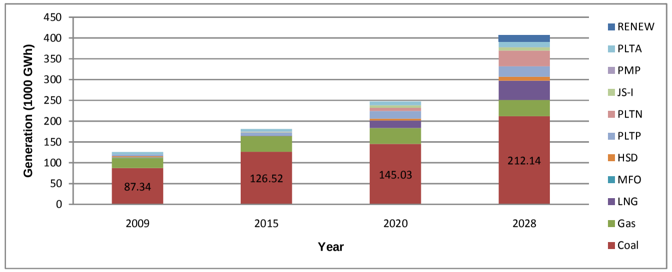
(2) Power Components (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	46.6	15.2	0.0	2.9	21.0	3.6	0.0	0.0	0.0	10.6	0.0	100.0
2015	49.4	15.6	0.0	0.6	14.5	5.5	0.0	6.9	0.0	7.5	0.0	100.0
2020	47.2	10.3	9.1	0.0	6.1	5.2	2.0	6.1	6.1	7.9	0.0	100.0
2028	49.3	6.2	11.0	0.0	4.4	4.2	6.1	3.7	3.7	7.4	4.0	100.0



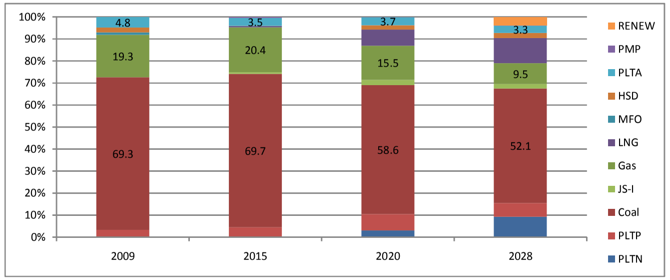
(3) Generation Energy (1000 GWh)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	87.34	24.29	0.00	1.41	2.86	4.17	0.00	0.00	0.00	6.00	0.00	126.07
2015	126.52	37.00	1.02	0.02	0.13	8.12	0.00	1.41	0.90	6.43	0.00	181.55
2020	145.03	38.45	18.11	0.00	4.70	18.32	7.52	5.93	0.24	9.13	0.00	247.43
2028	212.14	38.79	46.79	0.00	8.96	25.41	37.62	7.95	0.02	13.47	16.27	407.42



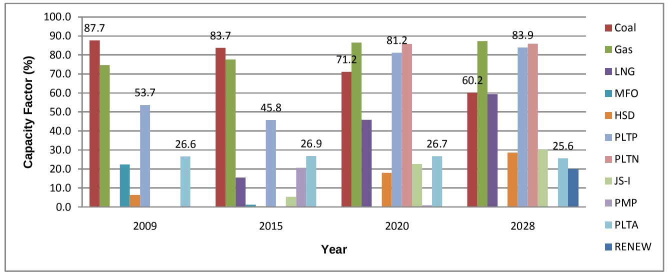
(4) Generation Energy (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	69.3	19.3	0.0	1.1	2.3	3.3	0.0	0.0	0.0	4.8	0.0	100.0
2015	69.7	20.4	0.6	0.0	0.1	4.5	0.0	0.8	0.5	3.5	0.0	100.0
2020	58.6	15.5	7.3	0.0	1.9	7.4	3.0	2.4	0.1	3.7	0.0	100.0
2028	52.1	9.5	11.5	0.0	2.2	6.2	9.2	2.0	0.0	3.3	4.0	100.0



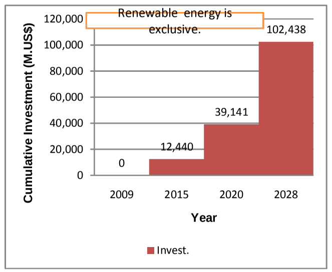
(5) Capacity Factor (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW
2009	87.7	74.7	0.0	22.4	6.4	53.7	0.0	0.0	0.0	26.6	0.0
2015	83.7	77.7	15.5	1.2	0.3	45.8	0.0	5.4	20.6	26.9	0.0
2020	71.2	86.5	45.9	0.0	18.0	81.2	85.8	22.6	0.9	26.7	0.0
2028	60.2	87.3	59.4	0.0	28.6	83.9	85.9	30.3	0.1	25.6	20.0



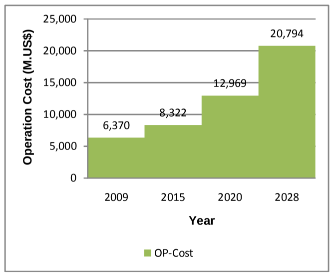
(6) Cumulative Investment Cost & Annual Operation Cost (M.US$)

Year	Invest.	OP-Cost
2009	0	6,370
2015	12,440	8,322
2020	39,141	12,969
2028	102,438	20,794



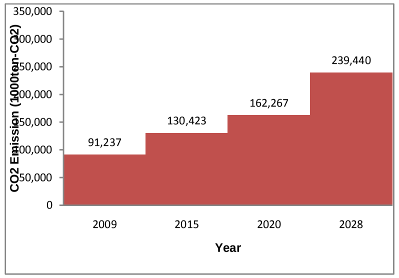
(7) Operation Cost (USc/kWh)

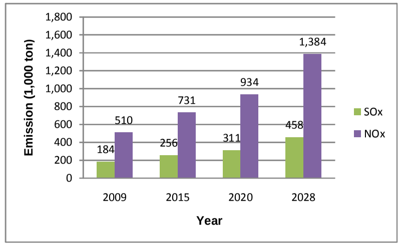
Year	OP-Cost	Gene.	OP-Cost
	M.US$	1000 GWh	c/kWh
2009	6,370	126.1	5.05
2015	8,322	181.6	4.58
2020	12,969	247.4	5.24
2028	20,794	407.4	5.10



(8) Annual Emission (1000 t)

Year	CO2	SOx	NOx
2009	91,237	184	510
2015	130,423	256	731
2020	162,267	311	934
2028	239,440	458	1,384





(9) Annual Fuel Consumption

Year	Coal	Gas +LNG	MFO+HSD
	M.ton	M.mmbtu	M. KL
2009	44.1	221.1	1.20
2015	65.7	343.5	0.00
2020	76.5	479.8	1.60
2028	107.9	692.1	3.10

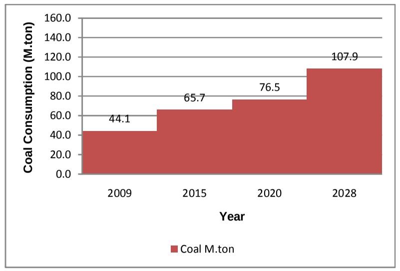
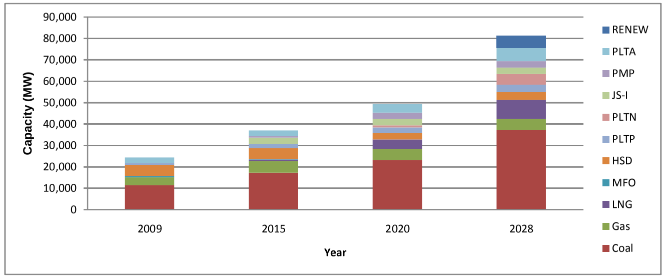


Fig. 4.6-5 Results of Simulation for Scenario 2

4 Scenario 3 (CO2 Emission Reduction)

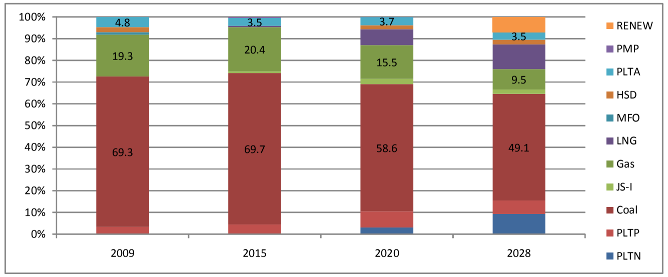
(1) Power Components (MW)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	11,371	3,713	0	718	5,128	886	0	0	0	2,574	0	24,390
2015	17,261	5,438	750	192	5,078	2,026	0	3,000	500	2,731	0	36,976
2020	23,261	5,072	4,500	0	2,984	2,576	1,000	3,000	3,000	3,901	0	49,294
2028	37,261	5,072	9,000	0	3,579	3,456	5,000	3,000	3,000	6,301	5,686	81,355



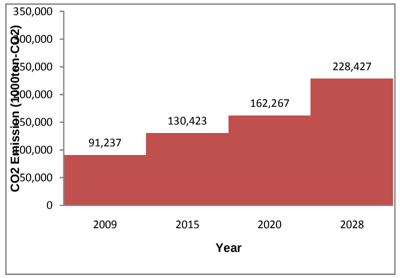
(4) Generation Energy (%)

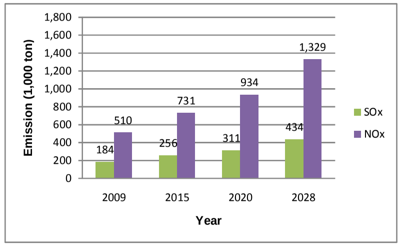
Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	69.3	19.3	0.0	1.1	2.3	3.3	0.0	0.0	0.0	4.8	0.0	100.0
2015	69.7	20.4	0.6	0.0	0.1	4.5	0.0	0.8	0.5	3.5	0.0	100.0
2020	58.6	15.5	7.3	0.0	1.9	7.4	3.0	2.4	0.1	3.7	0.0	100.0
2028	49.1	9.5	11.3	0.0	2.2	6.2	9.2	1.9	0.0	3.5	7.0	100.0



(8) Annual Emission (1000 t)

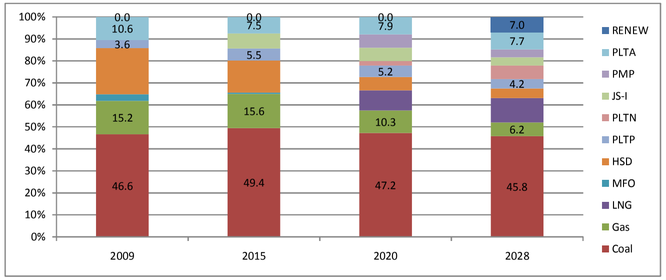
Year	CO2	SOx	NOx
2009	91,237	184	510
2015	130,423	256	731
2020	162,267	311	934
2028	228,427	434	1,329





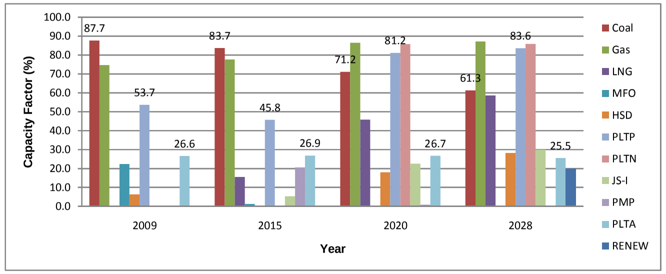
(2) Power Components (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	46.6	15.2	0.0	2.9	21.0	3.6	0.0	0.0	0.0	10.6	0.0	100.0
2015	49.4	15.6	0.0	0.6	14.5	5.5	0.0	6.9	0.0	7.5	0.0	100.0
2020	47.2	10.3	9.1	0.0	6.1	5.2	2.0	6.1	6.1	7.9	0.0	100.0
2028	45.8	6.2	11.1	0.0	4.4	4.2	6.1	3.7	3.7	7.7	7.0	100.0



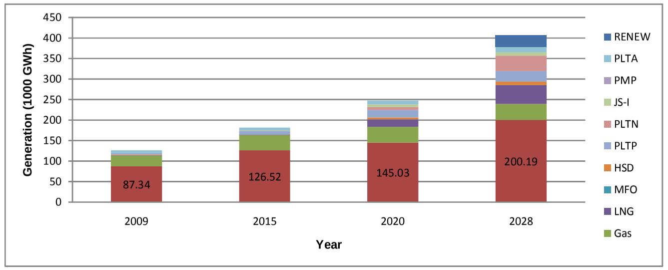
(5) Capacity Factor (%)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW
2009	87.7	74.7	0.0	22.4	6.4	53.7	0.0	0.0	0.0	26.6	0.0
2015	83.7	77.7	15.5	1.2	0.3	45.8	0.0	5.4	20.6	26.9	0.0
2020	71.2	86.5	45.9	0.0	18.0	81.2	85.8	22.6	0.9	26.7	0.0
2028	61.3	87.3	58.6	0.0	28.2	83.6	85.9	30.0	0.1	25.5	20.0



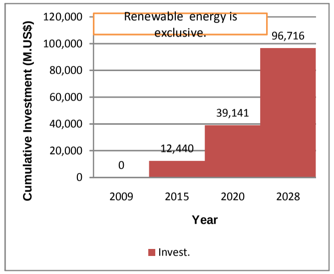
(3) Generation Energy (1000 GWh)

Year	Coal	Gas	LNG	MFO	HSD	PLTP	PLTN	JS-I	PMP	PLTA	RENEW	SUM
2009	87.34	24.29	0.00	1.41	2.86	4.17	0.00	0.00	0.00	6.00	0.00	126.07
2015	126.52	37.00	1.02	0.02	0.13	8.12	0.00	1.41	0.90	6.43	0.00	181.55
2020	145.03	38.45	18.11	0.00	4.70	18.32	7.52	5.93	0.24	9.13	0.00	247.43
2028	200.19	38.77	46.19	0.00	8.84	25.31	37.62	7.89	0.02	14.09	28.46	407.38



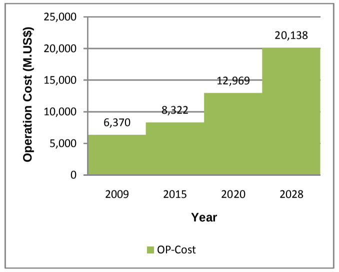
(6) Cumulative Investment Cost & Annual Operation Cost (M.US$)

Year	Invest.	OP-Cost
2009	0	6,370
2015	12,440	8,322
2020	39,141	12,969
2028	96,716	20,138



(7) Operation Cost (USc/kWh)

Year	OP-Cost	Gene.	OP-Cost
	M.US$	1000 GWh	c/kWh
2009	6,370	126.1	5.05
2015	8,322	181.6	4.58
2020	12,969	247.4	5.24
2028	20,138	407.4	4.94



(9) Annual Fuel Consumption

Year	Coal	Gas +LNG	MFO+HSD
	M.ton	M.mmbtu	M. KL
2009	44.1	221.1	1.20
2015	65.7	343.5	0.00
2020	76.5	479.8	1.60
2028	102.4	687.7	3.10

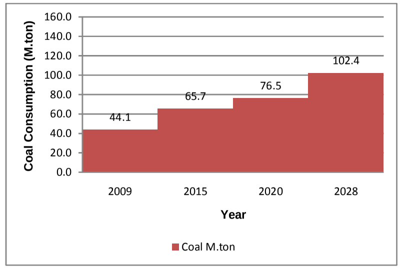


Fig. 4.6-6 Results of Simulation for Scenario 3

2) Study on results

(a) Coal consumption

Table 4.6-2 shows the estimate of coal consumption in 2028.

Table 4.6-2 Estimate of Coal Consumption in 2028

Scenario	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Coal (Million ton)	129.2	141.5	107.9	102.4

Note: Heat Content is 4,800 kcal/kg approximately and Heat Rate is 2,450 kcal/kWh at full load in average

(b) Oil consumption

Table 4.6-3 shows the estimate of oil consumption in 2028.

Table 4.6-3 Estimate of Oil Consumption in 2028

Scenario	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Oil (Million Kilo Liter)	1.7	1.7	3.1	3.1

(c) Gas and LNG consumption

Table 4.6-4 shows the estimate of gas and LNG consumption in 2028.

Table 4.6-4 Estimate of Gas and LNG Consumption in 2028

Scenario	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Gas & LNG (MM BTU)	496	417	692	688
Gas & LNG (Billion ft^3)	496	417	692	688

Note: 1000 Cubic Feet equal to about 1 mmbtu.

(d) Capacity Factor of Coal-fired Power Plants

Table 4.6-5 shows the estimate of capacity factor of coal-fired thermal plants in 2028.

Table 4.6-5 Capacity Factor of Coal-fired Power Plants in 2028

Scenario	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Capacity Factor (%)	62.4	60.2	60.2	61.3

(e) Capacity Factor of Nuclear Power Plant

Table 4.6-6 shows the estimate of capacity factor of nuclear power plant in 2008.

Table 4.6-6 Capacity Factor of Nuclear Power Plants in 2028

Scenario	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Capacity Factor (%)	85.9	85.9	85.9	85.9

3) Conclusion

(a) All scenarios indicate more than 50 % of generated energy will be provided by coal-fired thermal plants including Java-Sumatra Interconnection up to the year 2028. And coal-fired thermal plants will play an important role in the power source development plan.

(b) Maximum coal consumption in 2028 will be 75 % of domestic coal production of 190 million ton in 2006. Exportable volume will be remarkably decreased unless acceleration of coal production is achieved.

(c) The position of coal-fired thermal plants will be changed from a base load plant to a base & middle load plant.

(d) Despite its large initial investment cost, a nuclear power plant will be at full operation for all scenarios due to its lowest operation cost.

(e) Oil-fired power plants will account for 1 to 2 % of generated energy in 2028 as a peak load plant.

(f) Gas and LNG-fired plants will account for 15 to 21 % of generated energy in 2028 as peak load & middle load plants.

4.6.2 Capital Requirement and Unit Generation Cost

Capital requirement in the form of investment schedule for four scenarios are summarized in the table below. Scenario 1, in which coal thermal is to be developed with emphasis, costs most. The difference with Scenario 0 is, however, as much as 2% in the total until 2028. Total capital requirement is getting smaller towards scenario 2 to 3, when the investment in solar equipment is not included. When included, Scenario 2 and 3 will become much more expensive than Scenario 0 and 1.

As for unit generation cost per kWh, there is only slight differences

Table 4.6-7 Comparison of Investment Schedule of Four Scenarios

(Unit : US$ million)

YEAR	Scenario 0	Scenario 1	Scenario 2	Scenario 2 with Solar	Scenario 3	Scenario 3 with Solar
2009	3,893	3,893	3,893	3,893	3,893	3,893
2010	5,355	5,355	5,355	5,355	5,355	5,355
2011	2,539	2,539	2,539	2,539	2,539	2,539
2012	2,764	2,764	2,764	2,764	2,764	2,764
2013	-	-	-	-	-	-
2014	5,243	4,755	5,243	5,243	5,243	5,243
2015	2,873	2,629	2,873	2,873	2,873	2,873
2016	1,409	3,200	1,409	1,409	1,409	1,409
2017	9,134	6,854	9,134	9,134	9,134	9,134
2018	5,121	6,912	5,121	5,121	5,121	5,121
2019	7,181	6,937	5,146	5,146	5,146	5,146
2020	7,316	5,037	4,744	4,744	4,744	4,744
2021	7,611	9,402	8,241	13,211	8,241	13,211
2022	8,659	8,141	6,124	6,424	6,124	6,424
2023	5,812	4,819	7,103	13,038	5,776	17,296
2024	7,885	9,402	7,435	8,120	7,480	8,515
2025	7,848	8,141	7,241	14,271	8,090	21,820
2026	9,646	11,437	7,222	8,392	7,319	9,249
2027	8,617	9,680	8,178	16,528	7,917	24,182
2028	11,681	11,437	11,902	13,642	10,033	13,078
Total	120,589	123,334	111,668	141,848	109,202	161,997

between scenario 0 and 1. Scenarios 2 and 3 bear higher cost than 0 and 1, primarily because there is more LNG burnt in scenario 2 and 3 after 2015, and energy generated by solar units is purchased at US cent 30 per kWh later in the planning period, 2028.

Table 4.6-8 Comparison of Unit Generation Cost of Four Scenarios

(Unit : Rp. per kWh)

Year	Scenario 0	Scenario 1	Scenario 2	Scenario 3
2009	614	614	614	614
2015	649	643	650	650
2020	725	720	734	734
2028	733	732	852	914

4.6.3 Environmental and Social Considerations

Predicted emissions of CO_2, SOx and NOx from power generation in Jamali area as of 2028 are presented below separately for scenarios 0 to 3.

Scenario 3 will have the least annual emissions for all of CO_2, SOx and NOx, followed by Scenario 2 and Scenario 0. Scenario 1 will emit the largest amounts for all of them. Scenario 3 is most favorable against global warming and air pollution, and Scenario 2 is the second most favorable scenario. Most undesirable is Scenario 1.

Table 4.6-9 Predicted Annual Emissions of CO_2, SOx and NOx in 2028

(Unit : 1,000 ton/year)

	CO_2	SOx	NOx
Scenario 0	266,419	544	1,454
Scenario 1	285,882	598	1,528
Scenario 2	239,440	458	1,384
Scenario 3	228,427	434	1,329

4.6.4 Proposed Scenario

In the previous section the validity of the following scenarios was compared and evaluated in terms of power source development plan including power system, finance and environmental impact.

Scenario 0: Policy oriented scenario
Scenario 1: Coal power acceleration scenario
Scenario 2: Power source diversification scenario
Scenario 3: CO_2 emission reduction scenario

Main conclusion from the comparison of four scenarios is summarized in Table 4.6-10. The values forecasted or targeted as of 2028 are shown in the table.

Table 4.6-10 Main Conclusion in Comparison with Scenarios

Description	Reliability		Cost	Environmental impact
	Power sources	System		
Scenario 0: Policy oriented scenario	Energy production ratio by fossil fuel 81% including coal 66%. No renewable energy	Energy production ratio by middle to peak power sources of oil, gas, reservoir hydro and pumped storage 19%	Generation cost 733 Rp/kWh (100%).	Second largest emission of CO_2, NOx and SOx
Scenario 1: Coal power acceleration scenario	Energy production ratio by fossil fuel 85% including coal 72%. No renewable energy	Energy production ratio by middle to peak power sources 15%	Generation cost 732 Rp/kWh (100%).	Largest emission of CO_2, NOx and SOx
Scenario 2: Power source diversification scenario	Energy production ratio by fossil fuel 77% including coal 54%. Renewable energy 4%, Capacity 3.3 GW.	Energy production ratio by middle to peak power sources 26%	Generation cost 852 Rp/kWh (116%). Production cost by renewable energy is large.	Second least emission of CO_2, NOx and Sox Impact of coal is reduced.
Scenario 3: CO_2 emission reduction scenario	Energy production ratio by fossil fuel 74% including coal 51%. Renewable energy 7%, capacity 5.7 GW.	Energy production ratio by middle to peak power sources 26%	Generation cost 914 Rp/kWh (125%). Production cost by renewable energy is large.	Least emission of CO_2, NOx and Sox Impact of coal is reduced.

The positive and negative outcomes of four scenarios with respect to power source development, finance and environmental impact are varied. But Scenarios 2 and 3 are, as a whole, well balanced in consideration of fuel supply reliability and environmental impact as well as cost.

Based on the discussion with counterparts, the target energy ratio of 7% was evaluated to be too risky to be accomplished. In conclusion, Scenario 2, power source diversification scenario, was selected as the optimal one because the scenario is best balanced in power supply reliability, production cost and environmental impact.

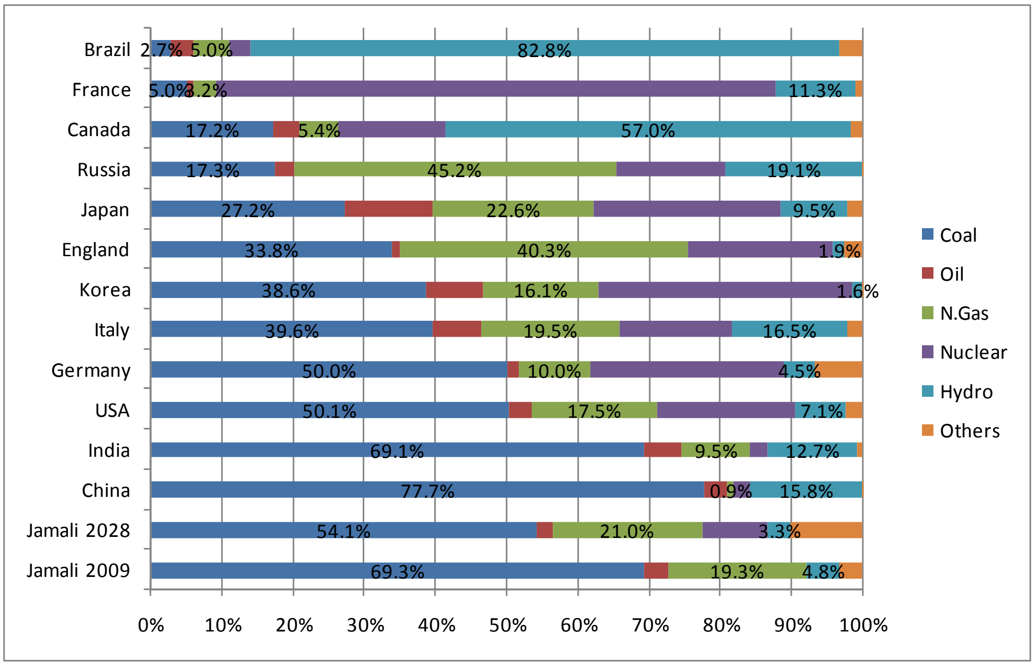
5. OPTIMAL POWER DEVELOPMENT PLAN

5.1. Optimal Power Source Development Plan

5.1.1 Optimal Power Source Development Plan and its Salient Feature

As discussed in Section 4.6.4, Scenario 2, Diversification of Power Sources, is selected as the optimal power source development plan for Jamali.

Figure 5.1-1 shows primary energy component of generated energy in major countries in 2004. Figure 5.1-1 also includes Jamali 2009 and 2028 for reference.



Source : IEA Electricity Information 2006 Edition

Fig.5.1-1 Generation Component for Main Countries (2004)

5.1.2 Towards Implementation of the Optimal Power Source Development

(1) Coal-fired Thermal Plants

1) Preparation of candidate sites

Coal-fired thermal plants will play a dominant role in the future power source development in Jamali even in the power sources diversification scenario. The additional capacity excluding the fast track program 6,900 MW will be 29,000 MW. If the unit capacity of new coal-fired thermal plant is assumed 1,000 MW, twenty-nine (29) project sites are required. Inventory of candidate sites with the possibility of land acquisition should be prepared as soon as possible.

2) Introduction of Supercritical coal-fired thermal plant

Currently, existing coal-fired thermal plants are operated at base load pattern. However, operation pattern of coal-fired thermal plants in the future are expected to cover not only base load but also middle load due to the introduction of a lot of geothermal plants and nuclear power plants, which are to be operated at full base load. The current subcritical coal-fired thermal plant can be operated at middle load pattern. However partial operation of subcritical thermal plants cause less thermal efficiency and offer with stable operation within the range of 50 to 100 % maximum continuous rating (MCR) approximately. On the other hand, supercritical thermal plants offer with stable operation within the range of 35 to 100%[12] MCMR approximately and high thermal efficiency of more than 40% in comparison with 30% ~ 37% of the PJB Paiton and IP Suralaya thermal plants. Higher thermal efficiency means less fuel consumption and less air pollution emission. Based on the above reasons, introduction of supercritical coal-fired thermal plants with proven technology is recommended.

3) Introduction of clean coal technology

(a) FGD and low NOx burners
Except the introduction of supercritical coal-fired thermal plants, introduction of clean coal technology such as FGD (flue gas desulphurization) equipment and low NOx burners should be introduced to avoid the acceleration of air pollution in Jamali.

(b) IGCC (Integrated Gasification Combined Cycle)
IGCC is also one of the latest clean coal technologies. High thermal efficiency of 40 % or more is expected and fuel flexibility is also expected because IGCC fires gas converted from coal.

4) Utilization of Low Rank Coal (LRC)

As mentioned in Section 4.1.3, about 80% of the proven reserves are the middle and low rank coal. Utilization of low rank coal seems to be one of the key issues for not only PLN but also the Indonesian Government.

In order to utilize low rank coal, the following measures are proposed;

(a) Developing coal-fired thermal plants at mine-mouth in Kalimantan and Sumatra, and using low rank coal as fuel because LRC is not suitable for storage/transport for long time due to its more water content and more active oxidizing substances as mentioned in Section 4.1.3.
(b) Using low rank coal by mixture with fuel coal, as being mixed in Suralaya thermal plant and/or using LRC in the form of gasification like IGCC.

[12] Source: "Latest Experience of Coal Fired Supercritical Sliding Pressure Operation Boiler and Application for Overseas Utility", Babcok-Hitachi

(c) Dismantling HSD and MFO-fired thermal plants in outer islands, and constructing LRC-fired coal thermal plants in terms of not only utilization of LRC but also saving of operation cost because fuel price of LRC is far less than HSD and MFO prices at the moment.

(2) Gas-fired Thermal Power Plant

Study on the introduction of CNG (Compressed Natural Gas) System is recommended as proposed in Chapter 4. CNG System is expected to allow gas-fired thermal power plants more flexible operation (such as peak pattern operation) by storing gas at power stations.

(3) Geothermal Plants

1) PLN Participation

According to the optimal power source development, about 2,600 MW of geothermal plants are to be developed from 2010 to 2028 and most of them are presumably to be developed by IPP scheme. To promote the IPP development, MEMR announced the "Ministerial Regulation No.14/2008" as mentioned before.

At the moment, the relevant provincial government[13] executes PQ/Bid evaluation of the prospective developers. PLN is formally involved in the PPA negotiation stage and onwards. There is a concern that the capability of provincial government to execute technical evaluation of bidders may not be sufficient. In terms of proper development of geothermal plants, the central government, with a help from PLN if necessary, should prepare the evaluation criteria to be adopted by local governments.

2) Risk Reduction

A preliminary FS level study for potential sites prior to bidding is desirable to lessen the risk burden of developers.

(4) Java-Sumatra Interconnection

Basic concept of Java-Sumatra Interconnection is to develop IPP coal-fired thermal plants at mine-mouth in South Sumatra and to deliver surplus power of 3,000 MW by HVDC (High Voltage Direct Current) to the Jamali system which is under tight power balance condition.

Java-Sumatra Interconnection seems to have the following advantages;

(a) No transportation of coal. This means stable power supply will be available because coal transportation by ships is sometimes interrupted by weather condition.

[13] A part (2.5%) of electricity sale is paid to the relevant provincial government as mentioned in 2.2.2.

(b) No plant sites in Jamali. This means less deterioration of air pollution in Jamali where population density is very high.

(c) Development of the area surrounding power plants. This will contribute to the revitalization of local communities and economy through the improvement of infrastructures.

This idea may also be applicable to Java-Kalimantan Interconnection planning because South and Central Kalimantan have the largest coal reserve and production in Indonesia and have great potential of coal.

Fig.5.1-2 shows the tentative Java-Sumatra interconnection route.

Fig.5.1-2 Tentative Java-Sumatra Interconnection Route

(5) Renewable Energy (Solar, Wind, etc.)

1) Solar Power (Photovoltaic Power Generation)[14]

Solar power seems to be the most appropriate generation system among renewable energy (solar power, wind power and biomass) considering the preferable weather of Indonesia. In the optimal power source development, about 6,000 MW of solar power systems are to be developed for the next 20 years.

MEMR will need to establish specific measures to promote expanding use of and investment in solar power system because the current energy law stipulates the target

[14] The numbers presented in this item are referred to "Cloudy German unlikely hotspots for solar power", Reuters, July 29, 2007(www.boston.com/news/science/articles/2007/07/30/cloudy_german_unlikely...)

primary energy mix which, however, does not accompany any specific measures for realization.

2) Wind Power

Wind power system is economical only in locations where average wind velocity is 6 m/s or more at 30 m above the ground level. Wind power totaling 0.5 MW[15] in capacity has been installed in Indonesia so far. In the optimal power source development, about 3,200 MW of wind powers are assumed to be developed for the next 20 years. Installation of wind power sometimes accompanies environmental issues as listed below;

(a) Installation in and around national parks and conservation forest areas posing concerns for landscape
(b) Radio disturbance caused by metal rotors
(c) Threats of rotors hitting birds

MEMR is recommended to develop an Environmental Impact Assessment guidelines or criteria in cooperation with MOE.

(6) Utilization of JICA Reports

JICA has a library and most of JICA reports can be accessed or downloaded from the JICA Library Website.
The JICA Library address in English is "http://lvzopac.jica.go.jp/libary/indexeng.html". Utilization of the JICA Library and its archives is strongly recommended especially for PLN and MEMR local offices[16] which may have infrequent access to the relevant JICA reports, not only as references for projects but also for capacity building.

5.1.3 Study on the Leading Power Projects in Indonesia

The validity of the implementation of a nuclear power plant and a pumped storage power plant, which are the leading, first-of-a-kind, power projects in Indonesia, is studied in this section.

(1) Nuclear Power Plant

The first unit of nuclear power plant 1,000 MW is scheduled to be put into the system in 2018 and the total capacity of 5,000 MW by 2028 in the optimal power source development plan. Since the development of nuclear power plants is an unprecedented challenge for Indonesia, the schedule allows for a four year period until 2012 to address key issues, such as safety and environmental assessments, and to develop consensus over the development itself, leaving six years for the

[15] Source; Presentation material "Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement in Indonesia", at Manila 5-8 October 2004 by MEMR
[16] P3B Sumatra responsible for power development planning in Sumatra does not know the existence of "Master Plan Study for Geothermal Power Development in the Republic of Indonesia "

construction of the first unit. Considering the current progress[17] toward the implementation, the scheduling of implementation of nuclear power plants is full of uncertainties.

1) Power source development plan without nuclear power plants

Influence of delay or postponement of the nuclear power program on power source development plan is studied by the following case.

Case without nuclear power plant (W/O Nuclear):
Additional coal-fired thermal plants with unit capacity of 1,000 MW will substitute for nuclear power plants with the same capacity. Reserve margin of 30 % will be kept after 2018.

(a) Net Present Value (NPV) of Objective Function
Table 5.1-1 shows the cumulative cost of power source development plan until 2028 converted to 2009 price with discount rate of 12 %. As shown in the table, NPV of the plan will be increased by 1.3 % for w/o Nuclear.

Table 5.1-1 Cumulative Objective Function for With and Without Nuclear

Case	Investment Cost (Million US$)	Salvage Value (Million US$)	Operation Cost (Million US$)	Objective Function (Million US$)	Ratio
With Nuclear	26,429	-9,505	73,001	89,925	1.000
W/O Nuclear	25,091	-8,834	74,857	91,114	1.013

(b) CO_2, NOx and SOx Emission
Table 5.1-5 shows CO_2, NOx and SOx emission in 2028. As shown in the table, CO_2 emission will be increased by 30.2 Million ton or by 12.6 % for W/O Nuclear case mainly due to increase of generated energy by coal-fired thermal plants. NOx and SOx emission for W/O Nuclear will keep the almost same emission level as those of "With Nuclear".

Table 5.1-2 CO_2, NOx and SOx Emission in 2028

(Million ton)

Case	CO_2	NOx	SOx
With Nuclear	239.4	1.4	0.5
W/O Nuclear	269.6	1.5	0.5

(c) Conclusion
Increase of total cost, fuel consumption and CO2 emission are confirmed by WASP simulation in the case of "Without Nuclear Plants".

(2) Pumped Storage Power Plant

Table 5.1-3 shows the generation energy and capacity factor of pumped storage power plant(s) in the case of original coal price of 80 $/ton. Pumped storage power plants will be operated at

[17] The national team has not yet established and the establishment are delayed for 1 ~ 2 years against the schedule.

full load after 2020 affected by the large scale introduction of coal-fired thermal plants and nuclear power plants which will provide pumping energy for pumped storage at low cost. Therefore, the pumped storage power plants will be very efficient and their development should be promoted.

Table 5.1-3 Generation Energy and Capacity Factor of Pumped Storage Power Plants

Year	2015	2018	2020	2022	2024	2026	2028
Capacity (MW)	500	2,000	3,000	3,000	3,000	3,000	3,000
G.Energy (GWh)	751	2,853	4,200	4,200	4,200	4,200	4,200
C.Factor (%)	17.12	16.27	15.98	15.98	15.98	15.98	15.98

5.2 Optimal Power System Expansion Plan

Final goal of system analysis in this study is to develop the optimal power system expansion plan in consideration of technical reliability and economical aspects base on the power development scheme in Jamali region.

A long term optimal power system expansion plan for the coming twenty-years was developed in accordance with the following procedure shown in Fig. 5.2-1.

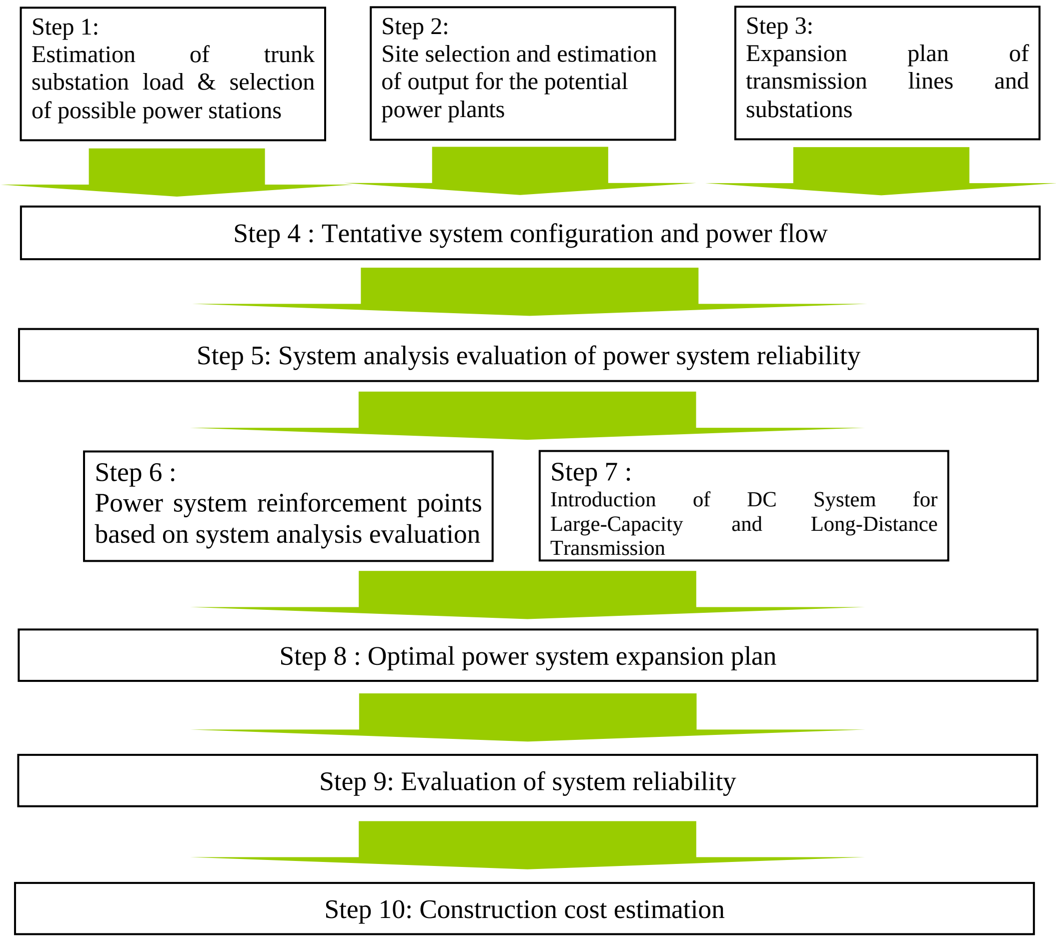


Fig.5.2-1 Workflow to develop the Optimal Power System Expansion Plan

5.2.1 Estimation of Trunk Substation Load and Site Selection of Potential Power Plants

Location and output of the potential power plants to be introduced to Jamali system will heavily affect to the system configuration and trunk line power flow in Jamali system. Therefore the site selection and estimation of power output were carried out based on the optimum power development scenario of this study in consideration of the following issues.

New power plants up to 2016 shall be identified in accordance with the optimal power development scenario of this study based on RUPTL. After 2016, new type of power plants including a nuclear power plant would also be expected as potential power plants. The locations of such power plants have not been officially announced yet, therefore the locations are being tentatively set based on the information obtained from PLN as follows:

- Pumped Storage Power Plants (three (3) sites) : Upper Cisokan, Matenggeng, Grindulu
- Geothermal Power Plant : From the geothermal potential site to the center of West Java (to be connected to the 150 kV system)
- Java-Sumatra Interconnection Transmission Line : Transmission capacity of 3,000 (at receiving end)MW to be connected to Parung S/S
- Nuclear Power Plant (One site) : North of Central Java with installed capacity of 5,000 MW [1,000 MW × 5 units]
- Thermal Power Plants (six (6) sites) : North of West Java…2 sites including Suralaya P/S)
  North & south of Central Java…area 2 sits
  North of East Java … 2 sites
- Conventional Hydro Power Plant To be developed in the whole area of Java Island from the viewpoint of effective use of national resources to be connected to the 150 kV or less system.

5.2.2 Tentative Power System Expansion Plan

For the period after 2016, a tentative power system development plan was produced in accordance with the optimal power development plan and also the draft transmission line and substation expansion plan by PLN.

5.2.3 Power System Analyses

Loads on equipments in the power system and the status of its voltage were analyzed by the power flow analyses for the tentative power system expansion plan of each representative year. Required expansions were recommended in details on the basis of the status of loads on trunk transmission lines and also on transformers. Assessment of the short circuit capacity to maintain voltage indicates that upgrade of the capacity of breakers in 500 kV lines from the present 40 kV to 50 kV, as required, would be effective. Tangent stability analyses suggested several cases where the power system becomes unstable.

5.2.4 Identifications of Sections to be expanded

The power system analyses suggested the sections of 500 kV lines to be expanded in future and when these expansions shall be conducted. On the basis of these suggestions, expansions and installations of transmission lines and substations were proposed in details. Transmission of power from Central Java to the load center in West Java requires special attentions. At least, two routes of AC 500 kV transmission lines have to be constructed for a long distance of about 500 km.

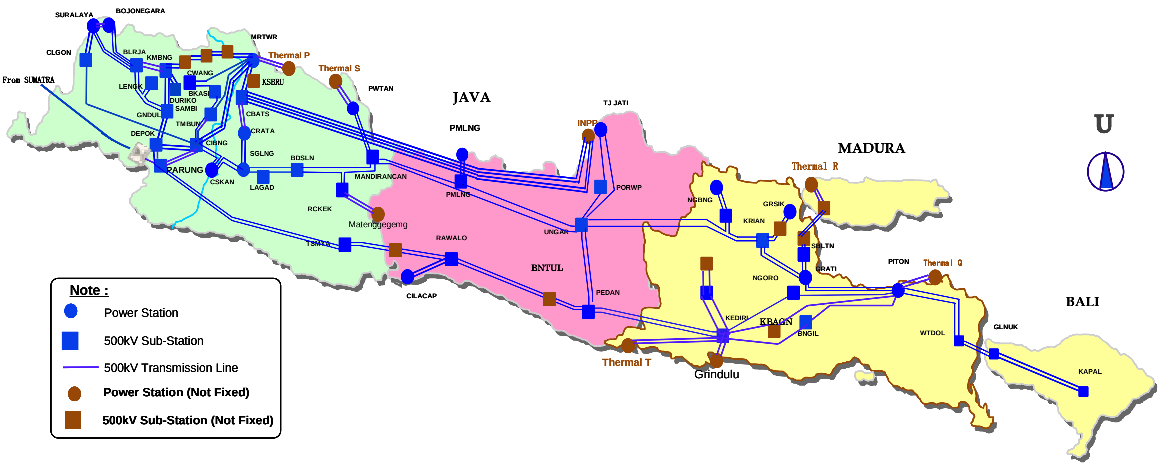


Image of Java-Bali Power System Configuration in the Future (Year 2028)

5.2.5 Introduction of DC System for Large-Capacity and Long-Distance Transmission

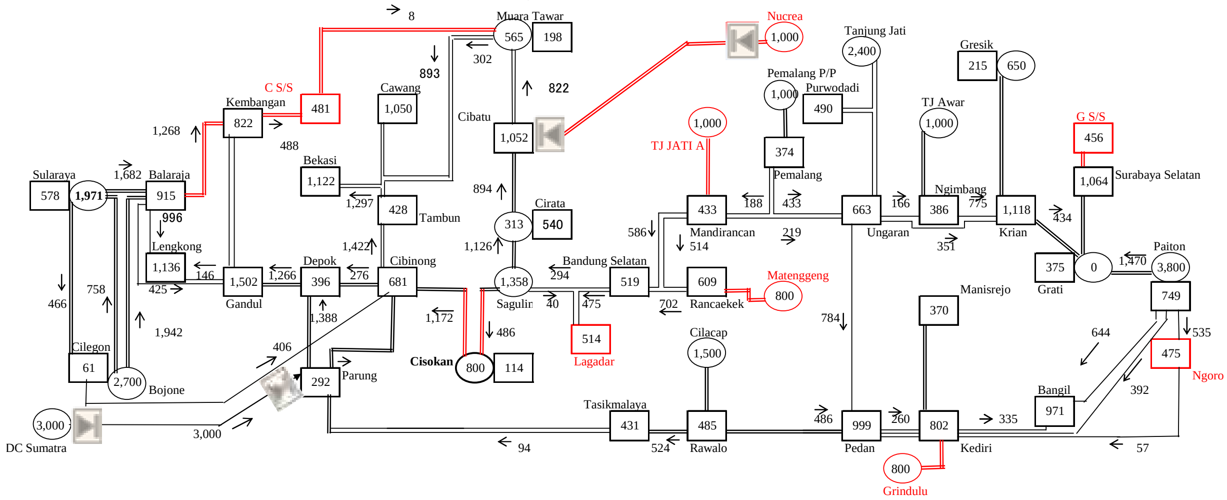
For the trunk line power system configuration in condition of expanding, it is particularly required to keep the flexibility of power system for meeting Change of situation in the future and economically efficiency as well.

AC transmission system was compared with DC transmission system on the basis of information in Japan for transmission of power from Central Java to the load center in West Java. This comparison confirmed that DC transmission system has advantage in terms of construction cost and flexibility for future operation.

5.2.6 Optimal Power System Expansion Plan

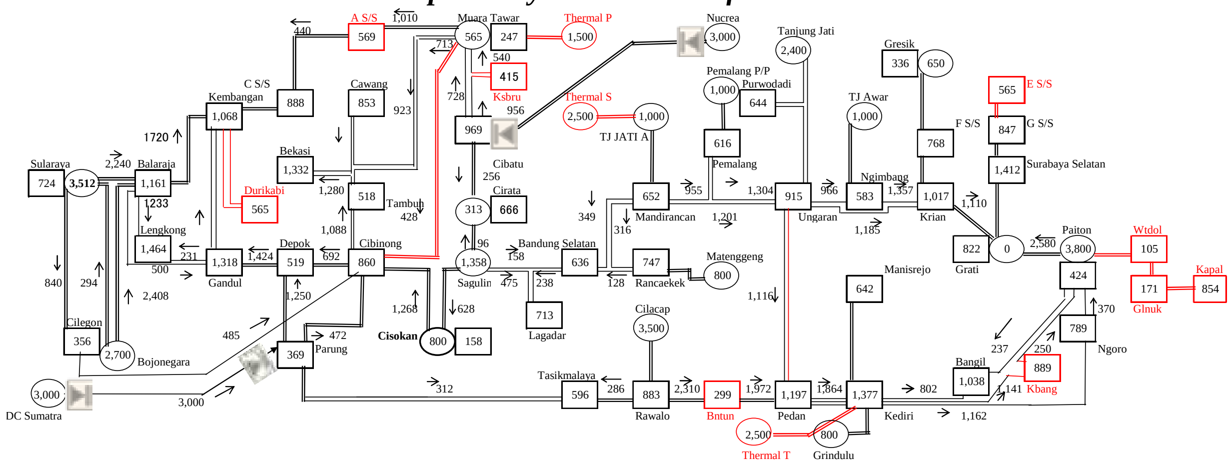
Optimal power system reinforcement plan was developed within cooperating optimal power development plan and the result of power system analysis as follows.

Optimal System Structure for 2020



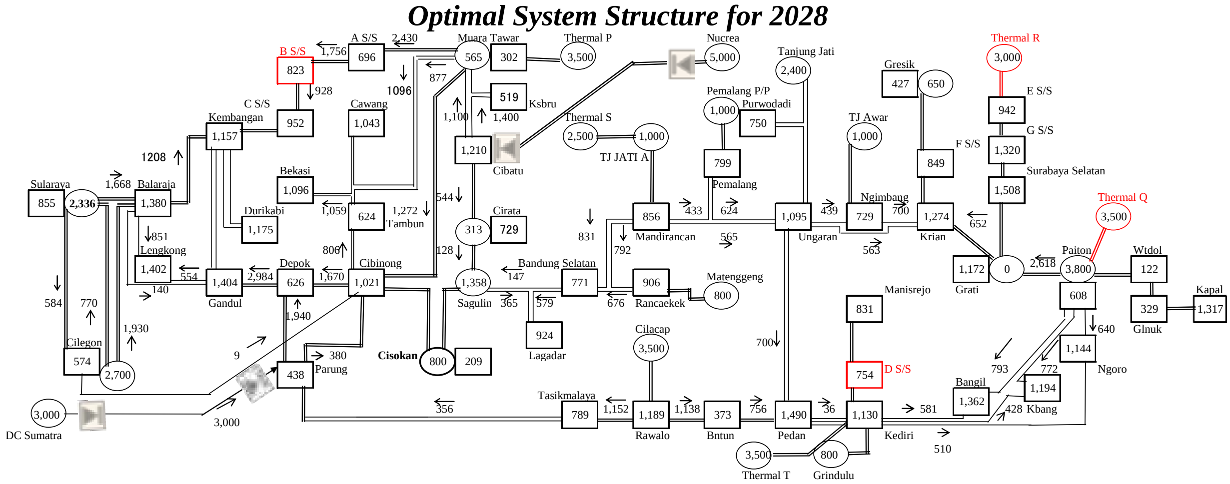
Red is reinforcement point between 2016-2020

Optimal System Structure for 2025



Red is reinforcement point between 2021-2025

Optimal System Structure for 2028



Red is reinforcement point between 2026-2028

500kV Main System Structure Step and Current Assumption Chart based on Optimal System Expansion Plan

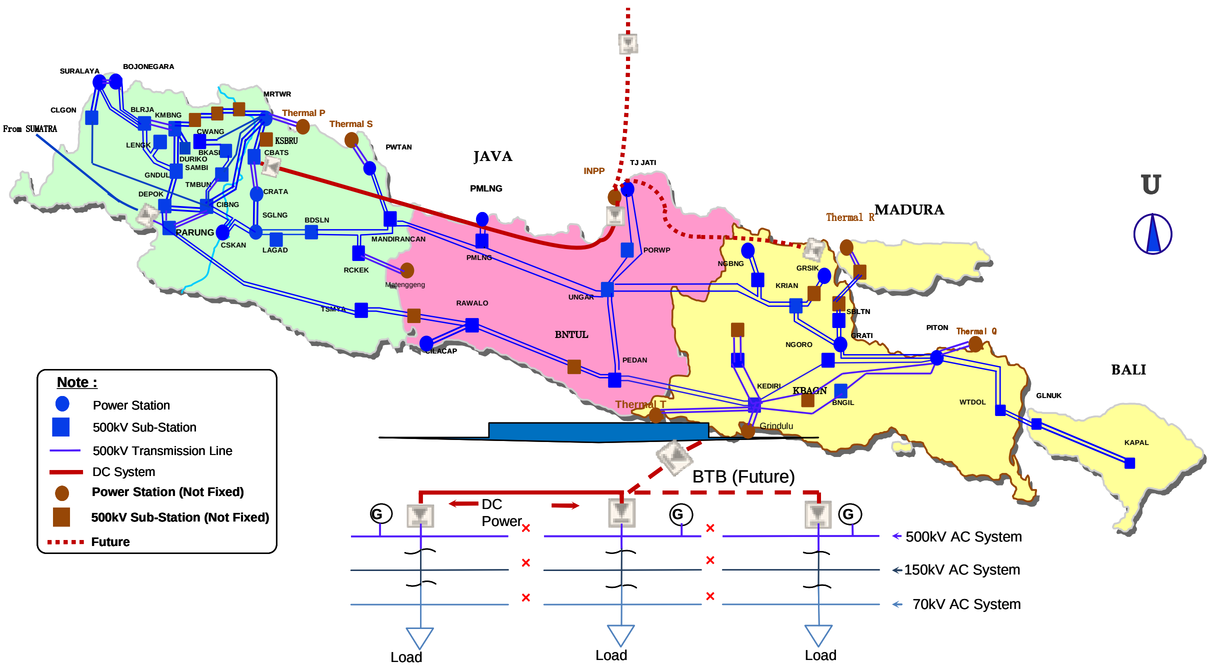


Image of DC system for Java-Madura-Bali Power system by 2028
(Capacity for Power System : Approximate 60 GW)

5.2.7 Construction Cost Estimation

----	2007-2010	2011-2015	2016-2020	2021-2025	2026-2028
Peak Demand(MW)	20535 (2010)	27657 (2015)	37895 (2020)	51840 (2025)	58712 (2028)
500 kV Transmission Line (km)	1529	1008	890	570	110
500 kV Transformer (MVA)	10164	9500	13650	18593	9162
Planned New Substation 500 kV	7	4	4	10	2
In addition, expenses for upgrade and renewal of equipments for the power system no more than 500 kV, AC/DC converters, capacitors and SCADAS.					

Million US$

Estimated Construction Cost	3276	1238	2357	2838	932

5.3. Financing Investment and Promotion of IPP

In the power sector in Indonesia, New Electricity Law (Law 20/2002), which was aiming at the full liberalization of the sector and introduction of market-oriented competition, was judged unconstitutional, on the basis that such a move would lead to an abandonment of assurance to the people of the welfare of the nation. Therefore, for the purpose of the discussion below, current framework of the sector, that is, PLN being the sole purchaser of electricity generated by power generation companies including IPPs and the sole transmission/distribution company of electricity to serve individual consumers, is assumed to remain as it is now.

5.3.1 Capital Requirement of Optimal Power Development Plan

In the optimal power development plan, the investment for power source development totaling US$ 112 billion will be required until 2028. The amount is shown by generation type as in the figure below.

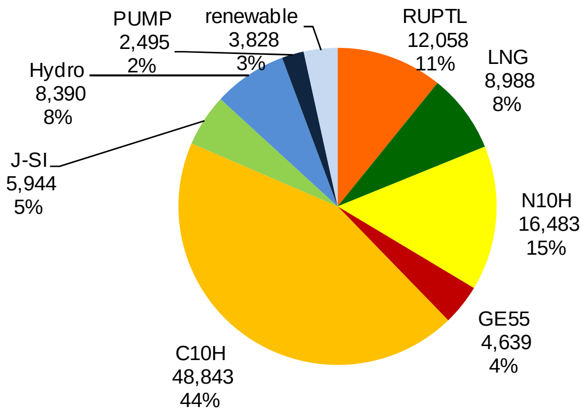


Fig.5.3-1 Component of Investment by 2028

Investments in each year including that for substations, transmission and distribution lines, are shown for foreign and local currencies in the table below. Outline of investment schedule for each generation type is as follows.

LNG thermal : almost constant after 2015, approximately US$ 750 million a year

Nuclear : every three years after 2018, US$ 3,300 million a year

Geothermal : approximately US$ 500 million in 2011 and 2014, almost constant after 2015, approximately US$ 250 million a year

Coal thermal : US$ 2,000 million in 2012, after 2017 with some variation US$ 3,900 million a year

Java-Sumatra Interconnection and mine-mouth coal thermal in southern Sumatra :
total US$ 6,000 million over 2014 and 2015

Hydro : intermittently after 2020, on average US$ 900 million a year

Pumped hydro : in five years between 2015 to 2019, US$ 2,500 million in total

Table 5.3-1 Investment Schedule for Optimal Electric Power Development Program

Descripton		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	total
Power Plant																						
RUPTL	F/C	3,115	4,284	1,445	583	0	0	220	0	0	0	0	0	0	0	0	0	0	0	0	0	9,647
	L/C	779	1,071	361	146	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	2,412
	total	3,893	5,355	1,807	729	0	0	275	0	0	0	0	0	0	0	0	0	0	0	0	0	12,058
LNG	F/C	0	0	0	0	0	0	637	637	637	637	0	1,273	0	1,273	0	1,273	0	1,273	0	0	7,640
	L/C	0	0	0	0	0	0	112	112	112	112	0	225	0	225	0	225	0	225	0	0	1,348
	total	0	0	0	0	0	0	749	749	749	749	0	1,498	0	1,498	0	1,498	0	1,498	0	0	8,988
Nuclear	F/C	0	0	0	0	0	0	0	0	0	2,967	0	0	2,967	0	0	2,967	0	2,967	0	2,967	14,835
	L/C	0	0	0	0	0	0	0	0	0	330	0	0	330	0	0	330	0	330	0	330	1,648
	total	0	0	0	0	0	0	0	0	0	3,297	0	0	3,297	0	0	3,297	0	3,297	0	3,297	16,483
Geo	F/C	0	0	549	0	0	366	183	183	183	183	183	183	183	183	183	183	183	183	183	183	3,480
	L/C	0	0	183	0	0	122	61	61	61	61	61	61	61	61	61	61	61	61	61	61	1,160
	total	0	0	733	0	0	488	244	244	244	244	244	244	244	244	244	244	244	244	244	244	4,639
Coal	F/C	0	0	0	1,730	0	0	0	0	6,919	0	3,460	0	3,460	1,730	5,190	0	5,190	1,730	5,190	6,919	41,517
	L/C	0	0	0	305	0	0	0	0	1,221	0	611	0	611	305	916	0	916	305	916	1,221	7,327
	total	0	0	0	2,035	0	0	0	0	8,141	0	4,070	0	4,070	2,035	6,105	0	6,105	2,035	6,105	8,141	48,843
S-J Interconnectio	F/C	0	0	0	0	0	4,280	1,070	0	0	0	0	0	0	0	0	0	0	0	0	0	5,350
	L/C	0	0	0	0	0	476	119	0	0	0	0	0	0	0	0	0	0	0	0	0	594
	total	0	0	0	0	0	4,755	1,189	0	0	0	0	0	0	0	0	0	0	0	0	0	5,944
Hydro	F/C	0	0	0	0	0	0	0	0	0	0	0	1,651	0	1,270	0	1,270	0	0	423	0	4,614
	L/C	0	0	0	0	0	0	0	0	0	0	0	1,351	0	1,039	0	1,039	0	0	346	0	3,775
	total	0	0	0	0	0	0	0	0	0	0	0	3,002	0	2,309	0	2,309	0	0	770	0	8,390
Pump	F/C	0	0	0	0	0	0	229	229	0	457	457	0	0	0	0	0	0	0	0	0	1,372
	L/C	0	0	0	0	0	0	187	187	0	374	374	0	0	0	0	0	0	0	0	0	1,123
	total	0	0	0	0	0	0	416	416	0	832	832	0	0	0	0	0	0	0	0	0	2,495
Renewable	F/C	0	0	0	0	0	0	0	0	0	0	0	0	473	28	565	65	669	111	794	165	2,871
	L/C	0	0	0	0	0	0	0	0	0	0	0	0	158	9	188	22	223	37	265	55	957
	total	0	0	0	0	0	0	0	0	0	0	0	0	630	38	754	87	892	148	1,059	220	3,828
(Solar)		0	0	0	0	0	0	0	0	0	0	0	0	4,970	300	5,935	685	7,030	1,170	8,350	1,740	30,180
Substation	F/C	413	319	519	256	225	186	171	186	186	186	186	186	349	349	349	349	349	215	215	215	5,409
	L/C	73	56	92	45	40	33	30	33	33	33	33	33	62	62	62	62	62	38	38	38	955
	total	486	375	611	301	265	219	202	219	219	219	219	219	411	411	411	411	411	253	253	253	6,364
Transmission Line	F/C	299	719	851	90	39	81	22	215	215	215	215	215	133	133	133	133	133	49	49	49	3,989
	L/C	53	127	150	16	7	14	4	38	38	38	38	38	24	24	24	24	24	9	9	9	704
	total	351	846	1,001	106	45	96	26	253	253	253	253	253	157	157	157	157	157	58	58	58	4,693
Distribution Line	F/C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	L/C	579	529	553	539	559	595	617	617	617	617	617	617	617	617	617	617	617	617	617	617	11,987
	total	579	529	553	539	559	595	617	617	617	617	617	617	617	617	617	617	617	617	617	617	11,987
Total	F/C	3,826	5,322	3,365	2,659	264	4,913	2,532	1,449	8,140	4,645	4,501	3,508	7,565	4,967	6,420	6,241	6,524	6,529	6,854	10,499	100,723
	L/C	1,483	1,783	1,340	1,051	605	1,240	1,186	1,048	2,082	1,565	1,733	2,324	1,861	2,341	1,867	2,378	1,901	1,621	2,251	2,330	33,989
	total	5,309	7,105	4,705	3,710	869	6,153	3,718	2,497	10,222	6,209	6,234	5,832	9,425	7,308	8,287	8,619	8,425	8,150	9,105	12,829	134,712
(Total with Solar)		5,309	7,105	4,705	3,710	869	6,153	3,718	2,497	10,222	6,209	6,234	5,832	14,395	7,608	14,222	9,304	15,455	9,320	17,455	14,569	164,892

5.3.2 Promotion of IPP

For promotion of IPPs, a key to achieve the optimal power development plan, recommendations are made as follows.

Theme	Issue	Measures to be taken
General		
1) Retail Tariff	Financial conditions of PLN should be strengthened, government's subsidy decreased	PLN's profit margin should be increased by a revision to the calculation method of BPP, for example. Limiting electricity subsidy to customer category R-1, 450VA. Possibility of introducing cost-pass-through system to the electricity tariff should be studied.
2) Process of Private Partner Selection	Process of selecting private partners should be open and fair.	Bidding process should be monitored by independent body. Continuous evaluation and improvement of the process.
3) Project Schedule	Delay in projects discourage private companies, add costs, negatively affect projects	To study cases of delayed projects and to find solutions streamlining the process of financial closing of foreign loans
4) Land Acquisition	Land acquisition is very difficult task for investors	Initiative in land acquisition for power plants and transmission lines should be taken by local government or PLN
5) Long term Perspective and Flexibility in Project Realization	Projects and their implementation details are designed with long term perspective.	Consideration on sustainability in setting bidding and contractual conditions Technical requirements considering system operation - bidding for different power plant operation patterns, - PPA pricing for middle- to peak-operation power plant - setting power plant ramp rate Standardized PPA pricing evaluated and revised, if necessary, for different power plant operations.
6) Use of domestic inputs and increase of local currency portion	Increase of loans and PPA liability expose PLN to foreign exchange risks	A method to evaluate highly the bid with higher local currency portion should be studied.
7) Limitation of Foreign Capital Ownership	limitation of foreign ownership 95% maximum may impede foreign investment.	The efficacy of the regulation should be studied and verified.
For coal thermal		
1) Securing Fuel	Development and exploitation of LRC should be given support. For mine-mouth coal thermal, submarine cables provided	Support to the development of LRC should be provided. Submarine cables should be evaluated from difficulties of power plant site finding in Java, advantage of interconnection of grids, regional development in remote areas, etc.
2) Environmental Protection	Power plants with low environmental protection capabilities would undermine sustainability of development	Higher environmental standard should be demanded in coal thermal projects even if it leads to higher cost.
For geothermal		
1) Institutional Arrangement	There are many institutional uncertainties to investment in geothermal	Regulations/standards for geothermal development should be provided
2) Pre-bid Site Survey	More site survey needed to lower the risks of developers	Setting up a revolving fund to supply necessary resources to local governments
3) Utilizing Developer's Knowledge in Site Selection	Knowledge of private developers should be exploited more.	To offer more candidate sites than to be developed and to have bidders select their preferred sites
4) Development in Protected Forest	Potential sites are often located in and around protected forest	A provision for confirming the possibility of geothermal development; for example an establishment of inter-ministry coordination board.
5) Limitation of Standardized PPA prices	Geothermal development cost varies in one project to another.	The regulation and its effect should be monitored and, if necessary, revised.
6) Accumulation and advancement of Geothermal technology by PLN	Geothermal development will be done mainly by IPP	PLN is to be tasked with the accumulation and advancement of geothermal technology. If necessary, technical and financial support should be provided to PLN for this purpose.
For renewable energy		
1) Promotion of Expensive Renewable Energy	Specific measures to encourage use of and investment for solar power and wind power should be considered and implemented	Special fund to provide subsidy to investors Mandating PLN to purchase energy generated by renewable sources at fixed prices Tax exemption and/or loan with favorable conditions

5.4. Environmental and Social Considerations

Even in Power Source Diversification Scenario, coal-fired power generation is a major power source, and there is a concern over potential impacts on air quality. Siting of coal-fired power stations should be determined after the present levels of air pollution at proposed sites are identified and whether additional air pollution loads are acceptable or not is considered. If a power station is constructed in an area already with heavy air pollution, installation of desulfurization/denitrification facility or efficient electrostatic precipitator should be considered.

Majority of power sources in Power Source Diversification Scenario are those with substantial amounts of thermal effluents, such as thermal and nuclear power generation. There are many waters with coral reefs off Jamali area, and special attentions should be paid to potential impacts of thermal effluents on corals.

Indonesia is not subject to the greenhouse gas emission reduction target under Kyoto Protocol, since it is a non-Annex I country. Thermal power generation to emit substantial amounts of CO_2 provides a major power source in Power Source Diversification Scenario. If legally binding greenhouse gas emission reduction target is established to Indonesia in future, it will be required to improve generation efficiencies of thermal power generation to suppress CO_2 production or to conduct afforestation to sequester CO_2 in the atmosphere.

It used to be said that hydroelectric power generation does not emit CO_2 and that it is friendly to global environment, but now it is known that it will release methane with strong greenhouse effect when water quality in a reservoir goes down. It is required to take efforts to prevent its eutrophication and subsequent degradation of water quality due to uncontrolled discharges of sewage from around a reservoir.

5.5. Measures for the Improvement of System Operation

Against the current situation and causes of problems on system operation, which is mentioned in Section 2.4.6, the suggestions on measures for the improvement of system operation in terms of voltage, frequency and outages are described below.

5.5.1 Voltage

The reasons for system voltage drop in Jamali are that reactive power source to maintain proper voltage is fundamentally lacked and existing reactive source is not fully utilized. Against these reasons, the following countermeasures can be suggested.

< Short Term Measures >

1) Raise of system standard voltage

By raising standard voltage of higher voltage class, such as 500kV, it is possible to make voltage of whole system higher and mitigate voltage drop at lower voltage class. Raise of system standard voltage can be accomplished by raising generator terminal voltage.

2) Introduction of incentives and penalties for reactive power supply

Generally, IPPs are negative to supply reactive power because supply of reactive power doesn’t produce profit for IPP. Against that problem, application of the system where reward is given for reactive power supply to keep system voltage stable can be suggested. In addition, application of penalties for violation of operation order such as to raising terminal voltage can be suggested.

< Long Term Measures >

3) Planning of reactive power equipment

It is necessary to install reactive power equipment such as static capacitors and shunt reactors for fundamental solution of voltage problem. Long term plan is required considering reactive supply and demand balance, and the installation of reactive power equipment in accordance with lack and surplus of reactive supply, such as in the following process:

a) Study of planning phase
b) Reactive demand forecast
c) Checking of supply and demand balance in each block
d) Calculation of the required amount of reactive power equipment
e) Selection of the capacity of single unit
f) Power flow analysis

4) Installation of on-load tap changer to step-up transformer

It is possible to control reactive output of generator by changing tap of step-up transformer at generation plant. When transformation ratio is fixed, with constant voltage control by AVR, it would be difficult to fully utilize reactive power from generators due to restriction of generator terminal voltage in many cases. On the other hand, when transformer is equipped with tap structure, it is possible to enhance ability on reactive power output by changing tap without restriction of terminal voltage.

PLN has already tried to raise voltage by using off-load tap at some generators. However, in case of off-load tap changer, it is difficult to change tap properly against voltage fluctuation, because planned outage is required to change tap. Therefore, in order to change tap properly in accordance with the condition of system voltage and reactive power, and utilize reserve of reactive power from generator, changing tap without outage by on-load tap changer is required.

5) Installation of PSVR (Power System Voltage Regulator)

AVR, which is generally used detects generator terminal voltage and controls reactive supply from generator so as to keep the voltage constant. With this system, even if system voltage drops, reactive power supply doesn't reach limit in many cases.

On the other hand, PSVR controls high side of step-up transformer which is closer to grid and try to keep it constant. Therefore, it is possible to utilize margin of reactive power supply from generator speedily and try to keep system voltage against fast change of load.

5.5.2 Frequency

Countermeasures against frequency fluctuation can be classified into normal and emergency frequency control.

< Measures for Normal Frequency Control >

1) Application of penalty

In case ramp rate is lower than designed value or a generator doesn't follow operation order, which obstructs frequency control, application of penalties for generators can be suggested.

2) Bidding classified by operation type

In general IPP bidding, base type generators have advantage on feasibility, and middle and peak type generators which is capable for frequency control is not likely to be installed. Middle and peak type generators would be competitive by the application of bidding classified by the type considering operation patterns.

3) Application of tariff for middle and peak type generators

In past IPP bidding in Indonesia, tariff was set assuming base type operation. However, it is difficult for middle and peak type generators to secure profit with cheap tariff for base type, because operation hours are short and fuel cost is high.

On the other hand, in other countries, specific tariff for peak and middle type generators considering operation pattern is already applied. Such tariff system would make it easy for middle and peak type generators to secure profit despite of short operation hours.

4) Application of Capacity Fee

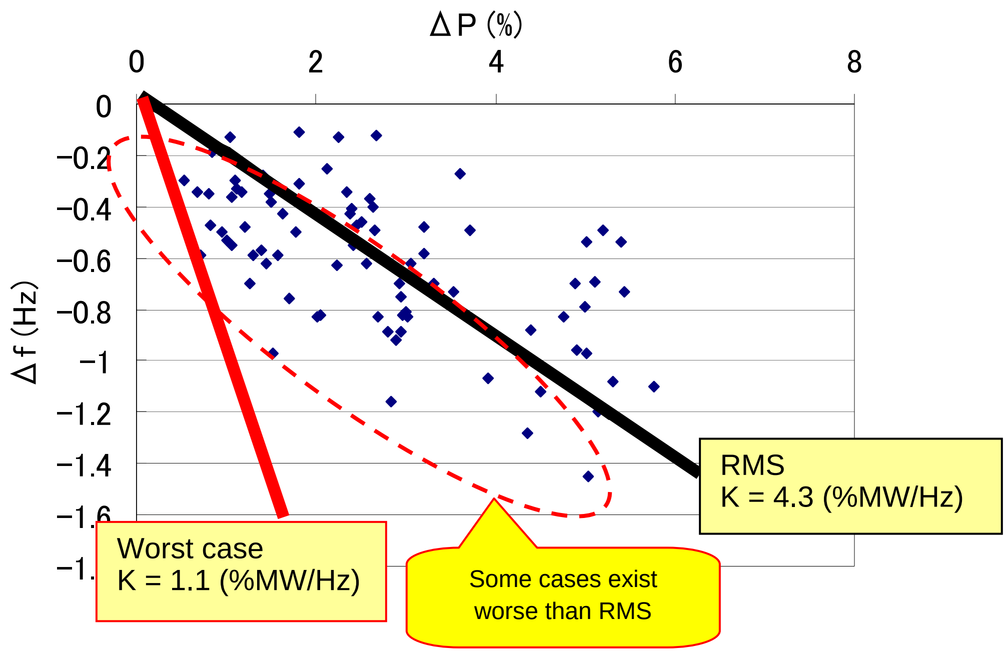
It is important to utilize IPP investment as well as generators of PLN in order to keep enough supply against steady growth of demand in the future. In general, power purchase agreement with IPP is based on energy (kWh). However, especially for middle and peak type generators, such system raise the risk that fixed cost is not recovered, because income of IPP fluctuates in accordance with traded energy. Against such problem, application of capacity fee where minimum payment despite of actual generation is secured is considered to enable IPP to recover fixed cost easily and to prompt investment by IPP for middle and peak type generators.

< Measures for Emergency Frequency Control >

5) Proper calculation of system frequency characteristic

For frequency control under emergency condition, system frequency characteristic which represents change of frequency against large change of output such as trip of generator shall be ascertained. When system frequency characteristic is calculated, not only the tripped capacity of generators (MW/Hz), but also whole system capacity at the time of trip, shall be considered, and tripped capacity shall be represented by the ratio to system capacity (%MW/Hz).

In addition, when system frequency characteristics is calculated based on the past record of trip of generator, as shown in the figure below which represents the result of process of data on the generator trip record in PLN, there is a large difference between the case where data is managed with root mean square (RMS) and the case where data is managed with worst case. When system frequency characteristic is determined, not the value itself calculated through RMS but the value with some margin in consideration with past record and metering error shall be used.



Example of Calculation of System Frequency Characteristic

6) Detailed system frequency characteristic considering K_G and K_L

When system frequency characteristic is calculated precisely, effect of governor free capacity in accordance with tripped capacity shall be considered. In case of large frequency drop such as generator trip, although governor free generators increase output in response to frequency decline, they reach limit and exhaust output margin if frequency drops furthermore. Therefore, system frequency characteristic (K) up to the limit of governor free is represented as $K = K_L + K_G$ (K_L : Load Frequency Characteristic, K_G : Generator Frequency Characteristic). After the limit of governor free, it is represented as $K = K_L$.

In order to study much adequate amount of load shedding, appropriate amount shall be studied with the calculation of system frequency characteristic in consideration with actual governor free capacity.

5.5.3 Outages

As referred in Section 2.4.6, major reason for frequent outage in Jamali is the problem of facilities. For improvement on the problem of outage, following item can be suggested;

(1) Measures for Same Type of Equipment

It is effective to take measures for same type of equipment against failure of equipment. When failure occurs to some equipment, same type of failure is likely to occur on same type of sound equipment in the near future. Therefore, it is important to execute measures not only for the equipment where failure occurs but for all same type of equipment, after analysis of the cause of failure.

(2) Establishment of Quality Management System

As a reason of equipment failure, there might be shortage of performance from the time of installation. It is appropriate to prompt installation of equipment by manufacturers with high quality through the reinforcement of requirements in bidding document, and the consideration of failure rate of each manufacturer in bidding evaluation. Currently, it is deemed to be difficult to exclude manufactures with bad quality immediately, but it is important to recognize manufacturers with bad quality through managing failure records and quality of installed equipment.

In order to keep quality of manufacturers high, installation of quality management system is suggested. In quality management system, for the adoption of equipment, technical division evaluates internal test result and quality assurance program submitted by manufacturer, and witnesses site test at factory of manufacturer if necessary. Based on the result, not the procurement division but the technical division judges new and continuous adoption of the equipment. Therefore, quality of equipment is considered to be kept high.

(3) Cooperation with Manufacturer

Currently, so many manufacturers have supplied equipment to PLN, and PLN could not get enough support from all of them. In order to improve quality of equipment to be installed and get continuous support from manufacturers, it is essential to keep good relationship with manufacturers. Many products are supplied from manufacturers abroad at present, but it is preferable that equipment with high quality will be procured from local manufacturers in Indonesia in the future. For that purpose, it is vital to cooperate with manufacturers with local factories and offices.

In order to enhance cooperation with manufacturers, joint technical development and research among utility and manufacturer are considered to be effective. In Japan, many new technologies have been developed in accordance with needs from utilities through joint development with manufacturers from the past. Continuous joint activities have enhanced cooperation among utilities and manufacturers.

(4) Planned Installation of Facilities based on N-1 Criteria

In PLN, OLS (load shedding system against over load) is used as unavoidable measure against system failure where N-1 criteria is not satisfied, and many outages are caused by the operation of OLS. Fundamentally, generation and transmission facilities shall be planned and installed so as to satisfy N-1 criteria.

(5) Appropriate Calculation of System Frequency Characteristic

With regard to load shedding, not only to secure enough capacity, but also to study the amount of load shedding through proper calculation of system frequency characteristic, as previously mentioned, is required.

(6) Installation of Fault Extension Prevention Relay

It is important to minimize the area of influence by the outage when serious outage occurs in system. In Jamali, although basic protection system such as under frequency load shedding relay is installed, improvement is possible in terms of the prevention of fault extension, and installation of fault extension prevention relay utilized in Japan is recommended.

6. RECOMMENDATIONS

On the basis of the results of this study, the issues to be recognized and actions to be taken are summarized below, in order for the Government of Indonesia and national power utility, PLN, to proceed to the realization of the optimal power development plan. It should be emphasized here that those projects scheduled for next 7 – 8 years in the power development plan and the matters described below related to such projects need immediate actions to be taken by relevant parties.

6.1 Power Source Development

(1) Coal-fired Thermal Power Plant

- New 29 locations are required for the future development of power plants except the ongoing fast track program projects. Inventory study on new candidate sites including possibility of land acquisition shall be commenced as soon as possible.
- Study on an introduction of supercritical plants, which is a proven technology, is recommended because of its capability for flexible operation (base to middle load operation) and higher thermal efficiency resulting in fuel saving and reduction of emission.
- With respect to the utilization of LRC, developing coal-fired thermal plants at mine-mouth in Sumatra, and possibly in Kalimantan in the long term, and using LRC there, would make the best use of LRC for its physical properties
- Advantage of LRC use is its price per calorific value being much lower than HSD/MFO and its availability from domestic mines. Therefore, the benefit of scrapping existing HSD/MFO burning power plants and replacing with LRC burning coal thermal should also be studied.
- More stringent mitigation measures for air pollution will be required as the number of coal-fired thermal power plants will be increasing rapidly.

(2) Java-Sumatra Interconnection

- PLN should exercise an extreme caution in managing the implementation schedule of IPP coal-fired thermal plants in Sumatra to assure that the Java-Sumatra Interconnection will be able to send power to Jamali system in 2014 on schedule.

(3) Geothermal Power Plant

Although the country is endowed with the world-largest geothermal potential, and the government places a priority on geothermal development in his energy policy, necessary regulations/standards in relation with geothermal development have not been put in place, which leaves private entities considering investment in geothermal business with many uncertainties and risks. To encourage and promote private investment in the development, provisions of institutional arrangements and efforts to lower risks are urgently required.

Institutional Arrangement

- As bidding for geothermal development license is administered by local governments, and regulations/standards concerning its procedure have not been provided, there are many uncertainties to investment in geothermal. Standard procedure including bidding process, bidder evaluation criteria, information provided in bidding documents, etc., should be established and put in place as soon as possible.
- With respect to the provision of such arrangement, PLN can contribute by giving technical supports to local governments in project formulation, bid evaluation, etc., which may greatly improve the efficacy of the procedure.
- For a geothermal project located in and around protected forest, it is important to avoid such project being terminated after it is licensed to a private company. Some institutional arrangement is required that enables the confirmation of permission availability at the early stage of project formation, such as setting up an inter-ministry coordination board.
- To develop geothermal resources more efficiently by employing the knowledge of private developers, a bidding process that offers more candidate sites than to be developed and to have bidders select their preferred sites in their bid can be an effective device.

Reduction of Risks

- Among many risks involved in geothermal development, exploration risk allocated to developers is the one most significant. Preliminary FS level exploration study should be carried out prior to license bidding by PLN of local governments, and its information provided to bidders.
- In case that local government lacks the finance necessary for such a pre-bid exploration, setting up a revolving fund to supply necessary resources may be effective.

Others

- PLN has in-depth technical and operational know-how in geothermal business and it should keep its advantage as the sole electric utility in the country. Such technical supports as an introduction of the latest technologies and financial supports should be considered and provided to PLN, when necessary.

(4) Nuclear Power Plant

- As nuclear power development plan may well face a delay, a study on additional coal-fired thermal plants to substitute for nuclear power would be required.

(5) Gas-fired Thermal Power Plant

- For the purpose of improving operational flexibility of gas-fired thermal power plants being provided by gas pipelines, CNG (Compressed Natural Gas) Storage System, which allows the same plant to operate for middle and peak load, is recommended.
- Middle- to small-sized gas fields, which are not suitable for LNG export, may be suitable for supplying fuel to thermal power plants using CNG vessel. Study on such development is recommended. This will also enables conversion of HSD-fired PLTG to CNG-fired PLTGU.

(6) Hydropower

- Re-evaluation of hydropower potential, as a domestic resource of energy, in Jamali is required.
- Pumped storage power plants will be able to fully exploit the advantage of low cost power supply from coal-fired thermal and nuclear power plants for its pumping energy after 2020. As a pumped storage project requires a long lead time, earlier preparation of implementation is recommended.

(7) Solar and Wind Power

- Specific measures to encourage use of and investment for solar power and wind power should be considered and implemented.
- It is recommended to establish Environmental Impact Assessment guidelines and/or criteria for solar and wind power development, in cooperation with Ministry of Environment.

(8) General

- To respond to the climate change, measures to promote energy conservation and use of renewable energy shall be taken.
- To expedite the finding of power plant site, economic measures, such as a support for regional development and/or a subsidy scheme to relevant communities, shall be studied and introduced.
- Initiative in land acquisition for power plants and transmission lines should be taken by local government or PLN, not by private investors.
- Bidding process for power plant/transmission development should be monitored and supervised by an independent body.
- Continuous efforts to evaluate and improve bidding process, particularly concerning the details of tendering information and participation of wide range of bidders should be made.

- Cases of significant delays in project schedule should be studied and their solutions to their causes be found and implemented.

- Technical requirements of bidders for IPP projects should be revised on the basis of the results of the study on improvement of power system operation.

6.2 Environment

(1) Air Pollution

- Siting of a coal-fired power station shall be conducted upon due consideration on whether additional air pollution load is acceptable or not, after the present level of air pollution at the proposed site is clarified.

- Construction of a power station in an area already with noticeable air pollution requires installation of a desulfurization/denitrification facility or electrostatic precipitator.

- Continuous monitoring of emission and ambient air quality shall be conducted.

(2) Thermal Effluents

- Thermal power generation and nuclear power generation produce majority of electricity, and they discharge substantial amounts of thermal effluents. There are many coral reefs off Jamali area, so special attentions shall be paid to potential impacts of thermal effluents on corals.

- In Indonesia, it is required to reduce the temperature of thermal effluents down to less than 2 degree Celsius above the temperature of receiving water, while thermal effluents are required to be less than about 6 degree Celsius in Japan. Indonesian requirement is not practical, and it is desirable to conduct rather an impact assessment through the simulation on diffusions of thermal effluents.

(3) CO_2 Emissions

- If a legally binding emission reduction target is established in future for greenhouse gas emissions from Indonesia, it will be required to reduce CO_2 production through improvements of generation efficiencies in thermal power generation, or to sequester CO_2 in the atmosphere through afforestation.

(4) Water Quality Management in the Reservoir of Hydroelectric Power Stations

- Reservoir-type hydroelectric power generation will emit methane of significant greenhouse effects when water quality in a reservoir goes down. It is required to prevent eutrophication through uncontrolled discharges of domestic sewage into reservoirs for prevention of water quality degradation there.

(5) Industrial Wastes from Nuclear Power Generation

- Appropriate treatment of spent fuel from nuclear power generation is required.

6.3 Promotion of Private Investment

(1) Retail Tariff

- PLN's profit margin should be increased to allow for future investment. Such measures as a revision to the calculation method of BPP shall be considered.
- In relation to the increase of PLN's profit margin, limiting electricity subsidy to customer category R-1, 450 VA is recommended, in order to reduce the government subsidy payment.
- Further, a possibility of introducing cost-pass-through system to the electricity tariff should be studied.

(2) Project Schedule

- The causes of project delay should be studied. Particularly, financial closing process for foreign lending needs to be streamlined.

(3) Standardization of IPP wholesale price

- Regulation on PPA price capping needs to be revised taking into consideration of the difference of plant operation and resulting cost difference.
- As geothermal development cost varies in one project to another, setting PPA price capping on geothermal IPP may preclude investors/developers from participating in bidding. The regulation and its effect should be monitored and, if necessary, revised.

(4) Use of domestic inputs and increase of local currency portion

- A method of valuing higher a bid with larger L/C portion should be considered.

(5) Limitation of Foreign Capital Ownership

- The current regulation on the limitation of foreign capital ownership of power plant, 95% maximum, can be one of factors that impede foreign investment. The efficacy of the regulation in the promotion of domestic industries and private investment in the power sector should be studied and verified.

6.4 Power System Expansion Plan

(1) Land Acquisition

- Right-Of-Way for planned transmission lines and substation facilities should be acquired prior to their construction so that the land acquisition would not cause any delay in their realization.

(2) Countermeasures to Avoid Large Power Failure

- Countermeasures against frequency drop, such as an installation of simple load-breaking system by sending trip signal, should be studied.

- Introduction of system disconnection devices as a countermeasure against the whole system collapse should be studied.

(3) Introduction of Higher Voltage to Transmission and Distribution System

(4) Securing Governor Free (GF) Capacity at Nighttime

- To cope with the increase of base load plants such as coal and nuclear, and to meet the demand for quality electricity in night time, methods to secure the governor free (GF) capacity, such as an introduction of Daily Start Stop thermal power plants (DSS Units) and/or Adjustable Speed pumped storage hydro, should be studied.

(5) Study on Power Supply Method to High Load Density Areas (Jakarta)

- Economic power supply method to high load density areas, such as Jakarta, should be studied comprehensively, which may include raising voltage of middle-voltage system and direct connection of 500 kV system.

(6) Java-Sumatra Interconnection

- Countermeasures against upward frequency deviation, which may occur in the Sumatra system in the case of an interruption of Java-Sumatra Interconnection, should be studied.

(7) Other Considerations

- Phase modifying systems will have to be introduced in large numbers. The balance of the installation of the systems as well as their locations must be examined in the whole-region and sub-region scales.

- At load dispatching facilities for 150 kV systems and the below, manual operation is not effective in coping with voltage collapse. It is recommended to provide automatic voltage controllers (e.g., SVC) at limited locations and the breakers using voltage-down relay.

6.5 Improvement of System Operation

(1) The result of analysis of current conditions on the system operation

- The important issues to be considered on the system operation are related to voltage, frequency and outages. The suggestions on measures for the improvement of the system operation in terms of these issues are described below:

(2) Voltage

- The reasons for system voltage drop in Jamali are that reactive power source to maintain proper voltage is fundamentally lacked and existing reactive source is not fully utilized. Against these reasons, the following countermeasures are suggested.

- As short term measures, in order to make best use of the reactive supply capability of the existing generators, a) Raise of system standard voltage and b) Introduction of incentives and penalties for reactive power supply are suggested.

- As long term measures, planning of reactive supply equipment is required. In addition, in order to follow deviations of voltage, a) Installation of on-load tap changer to step-up transformer and b) Installation of PSVR (Power System Voltage Regulator are to be considered.

(3) Frequency

- Countermeasures against frequency fluctuation can be classified into normal and emergency frequency control.
- As measures for normal frequency control, a) Application of penalty, b) Bidding classified by operation type, c) Application of tariff for middle and peak type generators, and d) Application of Capacity Fee are effective.

- As measures for emergency frequency control, a) Proper calculation of system frequency characteristics and b) Detailed system frequency characteristics considering K_G and K_L are effective.

(4) Outages

- Major reason for frequent outage in Jamali is the problem of facilities.

- For improvement on the problem of outage, a) Measures for same type of equipment, b) Establishment of quality management system, c) Cooperation with manufacturer, d) Planned installation of facilities based on N-1 criteria, e) Appropriate calculation of system frequency characteristic and f) Installation of fault extension prevention relay are effective.