No.

The Republic of Indonesia

Ministry of Energy and Mineral Resources
and PT. PLN(PERSERO)

The Study on Optimal Electric Power Development in Sulawesi in the Republic of Indonesia

Final Report
(Main Report)

August 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

CHUBU ELECTRIC POWER CO., INC.
NIPPON KOEI CO., LTD.

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Preface

In response to the request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct the Study on the Optimal Electric Power Development in Sulawesi, and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team, headed by Mr. Yoshitaka SAITO of Chubu Electric Power Co., Inc. and consists of Chubu Electric Power Co., Inc. and Nippon Koei Co., Ltd. from July 2007 to June 2008.

The Study Team held discussions with the officials concerned of the Government of the Republic of Indonesia and the provincial governments in Sulawesi, and conducted field surveys at the study area. Upon returning to Japan, the Study Team headed by Mr. Hirokazu NAKANISHI conducted further studies and prepared this final report.

I hope that 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 officials concerned of the Government of Republic of the Indonesia, PT. PLN (Persero) and the provincial governments in Sulawesi for their close cooperation throughout the Study.

August 2008

Seiichi NAGATSUKA
Vice President
Japan International Cooperation Agency

August 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 Sulawesi". This study was implemented by Chubu Electric Power Co., Inc. and Nippon Koei Co., Ltd. from July 2007 to August 2008 based on the contract with your Agency.

This report presents the comprehensive proposal, such as the optimal power development plan considering the characteristics of potential primary energy in Sulawesi, and the transmission development plan including an interconnection of small isolated systems to secure a stable power supply. In addition, macroeconomic & financial and environmental measures, and also investment promotion schemes for the power sector are proposed in order to realize the plans.

We trust that the realization 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 Sulawesi as well, and recommend that the Government of Republic of the 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 also wish to express our deep gratitude to Ministry of Energy and Mineral Resources (MEMR), PT. PLN (Persero), the provincial governments in Sulawesi and other authorities concerned for the close cooperation and assistance extended to us throughout the Study.

Very truly yours,

Hirokazu NAKANISHI
Team Leader
The Study on the Optimal Electric Power
Development in Sulawesi

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Acronym

(* Indonesian Language)

ADB		Asian Development Bank
AMDAL	*	Analisis Mengenai Dampak Lingkungan
AP2B	*	Area Penyaluran & Pengatur Beban
ASEAN		Association of Southeast Asian Nations
BAPEDAL	*	Badan Pembangunan Dampak Lingkungan
BAPEDALDA	*	Badan Pembangunan Dampak Lingkungan Daerah
BAPPEDA	*	Badan Prencannan Pembangunan Daerah
BAPPENAS	*	Badan Prencanaan Pembangunan Nasional
BKPM	*	Badan Koordinasi Penanaman Modal (Investment Coordinating Board)
BKPMD	*	Badan Koordinasi Penanaman Modal Daerah (Regional Investment Coordinating Board)
BOO		Build Own Operate
BOT		Build Operate Transfer
BP		British Petroleum (UK)
BPP	*	Biaya Pokok Penjualan
BPS	*	Badan Pusat Statistik
BTO		Build Transfer Operate
BTU		British Thermal Unit
CC		Combined Cycle (Generation)
CDM		Clean Development Mechanism
CER		Certified Emission Reduction
COD		Commercial Operation Date
CP		Captive Power (Generation)
CPI		Consumer Price Index
CR		Critically Endangered
CY		Calendar Year
DGEEU		Directorate General of Electricity and Energy Utilization
DINASPE	*	Dinas Pertambangan dan Energi
DJLPE	*	Direktorat Jenderal Listrik dan Pemanfaatan Energi (Directorate General of Electricity and Energy Utilization)
DOE		Department of Energy (USA)
DOE		Department of Energy (Philippines)
EEP		Electricity Enterprise Permit
EGAT		Electricity Generating Authority of Thailand
EIA		Environmental Impact Assessment
EMSA		Electricity Market Supervisory Agency
EN		Endangered
EPIRA		Electric Power Industry Restructuring Act
EPPO		Energy Policy and Planning Office (Thailand)
ERC		Energy Regulatory Commission (Philippines)

ESDM	*	Departemen Energi dan Sumber Daya Mineral (Ministy of Energy and Mineral Resources)
ETAM		Electricity Tariff Adjustment Mechanism
EVN		Electricity of Viet Nam
F/S		Feasibility Study
FSA		Fuel Supply Agreement
FY		Fiscal Year
GDP		Gross Domestic Product
GRDP		Gross Regional Domestic Product
GT		Gas Turbine (Generation)
HSD		High Speed Diesel Oil
IEA		International Energy Agency
IMF		International Monetary Fund
IPP		Independent Power Producer
IRR		Internal Rate of Return
IUCN		International Union for Conservation of Nature
JBIC		Japan Bank for International Cooperation
JETRO		Japan External Trade Organization
JICA		Japan International Cooperation Agency
JV		Joint Venture
Keppres		Keputusan Presiden
KP	*	Kuasa Pertambangan
KUD	*	Koperasi Unit Desa
LIPI	*	Lembaga Ilmu Pengetahuan Indonesia(Indonesian Institute of Sciences)
LNG		Liquified Natural Gas
LOLP		Loss of Load Probability
LWBP	*	Luar Waktu Beban Puncak (Off-Peak Load Tariff)
M/P		Master Plan
MEA		Metropolitan Electricity Authority (Thailand)
MEMR		Ministry of Energy and Mineral Resources
MFO		Marine Fuel Oil
MIGAS		Directorate General of Oil and Gas
MP		Master Plan
NPC		National Power Corporation (Philippines)
NTB	*	Nusa Tenggara Barat
NTT	*	Nusa Tenggara Timur
O&M		Operation & Maintenance
OBA		Output Based Aid
ODA		Official Development Assistance
P3B	*	Penyaluan dan Pusat Pengatur Beban
PEA		Provincial Electricity Authority (Thailand)
Pertamina	*	Perusahaan Tambang Minyak Negara
Perum	*	Perusahaan Umum (Public Corporation)

PIUKU	*	Pemegang Izin Usaha Ketenagalistrikan untuk Umum (Power Generation for Public Use Holder)
PJB		PLN Java Bali Power Company
PKUK	*	Pemegang Kuasa Usaha Ketenagalistrikan (Electricity Business Authorization holder)
PLN	*	Perusahaan umum Listrik Negara
PLTA	*	Pembangkit Listrik Tenaga Air
PLTD	*	Pembangkit Listrik Tenaga Diesel
PLTFC	*	Pembangkit Listrik Tenaga Fuel Cell
PLTG	*	Pembangkit Listrik Tenaga Gas
PLTGB	*	Pembangkit Listrik Tenaga Gasifikasi Batubara
PLTGU	*	Pembangkit Listrik Tenaga Gas & Uap
PLTP	*	Pembangkit Listrik Tenaga Panas Bumi
PLTU	*	Pembangkit Listrik Tenaga Uap
PMA	*	Penanaman Modal Asing (Foreign Investment Company)
PNOC		Philippine National Oil Company
PPA		Power Purchase Agreement
PPP		Public Private Partnership
PSALM		Power Sector Assets and Liabilities Management Corporation (Philippines)
PSS/E		Power System Simulator for Engineering
PT	*	Perseroan Terbatas
PTBA	*	PT Tambang Batubara Bukit Asam
PTT		Petroleum Authority of Thailand
pu		Power Unit
PV		Present Value
ROA		Return on Assets
Rp		Rupiah
RUKD	*	Rencana Umum Ketenagalistrikian Daerah
RUKN	*	Rencana Umum Ketenagalistrikian Nasional
RUPTL	*	Rencana Usaha Penyediaan Tenaga Listrik
S/W		Scope of Work
SEA		Strategic Environmental Assessment
SHS		Solar Home System
SPC		Special Purpose Company
ST		Steam Turbine (Generation)
Sulbar	*	Sulawesi Barat
Sulsel	*	Sulawesi Selatan
Sulselrabar	*	Sulawesi Selatan, Tenggara dan Barat
Sulten	*	Sulawesi Tengah
Sultra	*	Sulawesi Tenggara
Sulut	*	Sulawesi Utara
Suluttenggo	*	Sulawesi Utara, Tengah dan Gorontalo
TCF, Tcf		Trillion Cubic Feet

TM	*	Tegangan Menengah
TR	*	Tegangan Rendah
TRANSCO		National Transmission Company (Philippines)
TT	*	Tegangan Tinggi
TTM		Telegraphic Transfer Middle (Rate)
UNDP		United Nations Development Program
VAT		Value Added Tax
VINACOAL		Vietnam National Coal Corporation
VU		Vulnerable
WASP IV		Wien Automatic System Planning - version IV
WB		World Bank
WBP	*	Waktu Beban Puncak (Peak Load Tariff)
WESM		Wholesales Electricity Spot Market
WTI		West Texas Intermediate
WTO		World Trade Organization

Chapter 1 Introduction

1.1 Preface

The JICA Study Team conducted the "Study on Optimal Electric Power Development in Sulawesi" (hereinafter referred to as "the Study") for 13 month from July 2007 to August 2008, examining the entire Sulawesi power system. It was carried out in accordance with the April 2007 Scope of Work (hereinafter referred to as "S/W") for the Study agreed upon between the Ministry of Energy and Mineral Resources of the Republic of Indonesia (hereinafter referred to as "MEMR"), the State Electricity Company (PT. PLN (PERSERO), hereinafter referred to as "PLN") and Japan International Cooperation Agency (hereinafter referred to as "JICA").

A number of agencies and experts were involved in the Study and close contact between Japan and the Republic of Indonesia was established during the Study. The JICA Study Team thus proceeded with the Study, paying close attention to promoting friendship between the two countries. In addition, Indonesian central government and Sulawesi regional organization were closely cooperated and supported the Study.

1.2 Background

Electric power demand has grown steadily in Indonesia ever since the country's recovery from the economic crisis in 1997, but due to insufficient power infrastructure, it has become obvious that power supply capacity cannot keep up with the recovered demand. As PLN is currently facing deteriorating financial circumstances, it is prioritizing power development and construction of transmission networks for Java and Bali, due to their urgent needs and importance. For this reason, PLN's power development projects in the outer islands are currently lagging behind, despite significant growth in demand for power. In some regions, economic activities and people's daily lives are affected by power outages due to planned load shedding.

In Sulawesi, located in relatively undeveloped, eastern region of the Indonesia, there has been little progress in power development due to PLN's financial difficulties. Despite the existence of abundant potential of hydropower, load shedding is imposed on a daily basis due to an insufficient supply of power. Even existing hydropower plants are troubled with sedimentation in the reservoirs. In addition, since PLN's transmission network covers only limited area, electrification ratio in the island remains at only about 50%. Promotion of rural electrification, though an important policy issue, hasn't made progress due to PLN's financial difficulties. Since the national financial resources for power development are insufficient, the utilization of private sector resources is under consideration. On the other hand, there is a need to formulate an optimal power development plan for the island of Sulawesi that comprehensively reviews such matters as effective use of primary energy and private investment necessary for promoting development systematically.

Given this background, the Government of Indonesia has requested the Government of Japan to conduct a development study for formulating an optimal power development plan in

Sulawesi by examining the issues on power development such as development of the abundant hydropower resource, promotion of electrification and introduction of private investment.

1.3 Objectives

(1) Formulation of power development plan and transmission plan with maximum utilization of local primary energy resources

(2) Technical transfers for the planning to the Ministry of Energy and Mineral Resources (MEMR) and the state-owned power company (PLN)

1.4 Flow of overall study

The study is comprised of the following three stages.

First stage: Preparatory work

The JICA Study Team elucidated the goals and frameworks of this study and carried out the following items as a basic study for formulating a development plan.

- Checking and conferring with counterparts concerning the framework of this study and the nature of the ways in which it is implemented
- Gathering and analyzing information about policies, the legal system, organizations, the amount of primary energy, power plans
- Review of existing demand forecast, grid extension plans (rural electrification), power development plans, and transmission development plans.

Second stage: Study of the optimal scenarios

The JICA Study Team surveyed the following items and formulated and studied development plans for each scenario.

- Power demand forecast (including survey on the connection of isolated power supply systems through grid extension and off-grid electrification)
- Formulation of development scenarios (Plans for power development and transmission development)
- Study on environmental and social considerations for power development plans and transmission development plans and individual development plans (strategic evaluation of environmental effects)
- Study on power development plans and transmission development plans based on each scenario

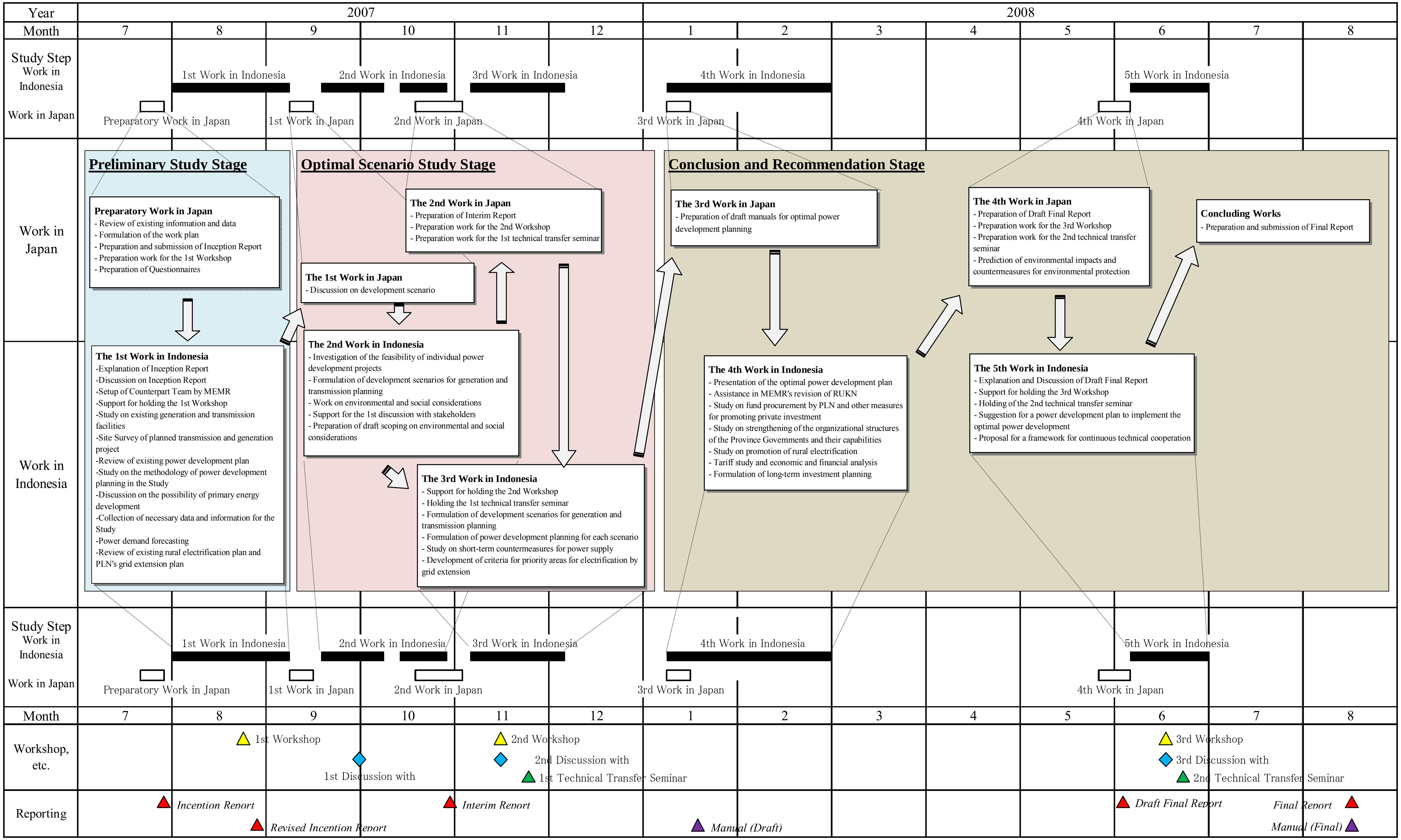
Third stage: Proposal of optimal power development plan

The JICA Study Team suggested an optimal power development plan based on the investigations and results of evaluations from the previous stage. The Study Team also studied and suggested means to improve the feasibility of the development plan, including procurement of funds, encouragement of investment, organizational structures, and enhancement of capacity.

- Suggestions for an optimal power development plan
- Study of PLN's measures for funds procurement and promotion of private investment
- Study of ways for provincial governments and PLN's organizational system to enhance their capacity
- Study of measures to promote regional electrification

The flow chart for all the study work is on the following page.

Overall Workflow of the Study



1.5 Counterpart Team and Study Team

As of June, 2008

(1) Counterpart Team

Member	Designation
Dr. Emy Perdanahari	Director of Electricity Power Program, DGEEU, MEMR
Mr. Benhur PL Tobing	Deputy Director of Electricity Power Program, DGEEU, MEMR
Mr. Zaenul Arief	Section Chief of Electric Power Generation Program, DGEEU, MEMR
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(2) JICA Study Team

Name	Area
SAITO Yoshitaka	Team Leader / Power Development Plan
ISHIGURO Masayasu	Energy Policy/ Supply and Demand
YAMAGATA Hiroo	Demand Forecast
KUTSUKAKE Takao	Power System Plan
WAKABAYASHI Tadaji	Evaluation of Individual Power Development Plan
OZAWA Hiroshi	Power Development Analysis
SUZUKI Atsushi	System Analysis
MIWA Yasushi	System Analysis
YAMASHITA Takeshi	Rural Electrification
NAKANISHI Hirokazu	Economic and Financial Analysis / Investment Promotion
URAGO Akiko	Environment and Social Analysis

Chapter 2 Energy Policy and Primary Energy Resources

2.1 Energy Policy

2.1.1 National Government

(1) Abolition of the 2002 Electricity Law and promulgation of a provisional ordinance

In the second half of the 1990s, Indonesia joined other countries in beginning to promote plans for active introduction of independent power producers (IPPs) based on private-sector investment. Along with this movement, a program for so-called structural reform went ahead in the power sector.

The Perusahaan Listrik Negara (PLN), the national power company, has been given the status of PKUK, (i.e., an exclusive holder of the power business concession), such that it has had the responsibility for supply of power in place of the government. The aims of this structural reform lay in the unbundling of the PLN and creation of a competitive market. The program gathered momentum particularly after the Asian currency and financial crisis of 1997. With the support of international institutions, the new Electricity Law (Law No. 20 of 2002) was passed in 2002, and the legal foundation for the reform was put into place.

Under the 2002 Electricity Law, the aims of the structural reform were defined as follows.

- Designation of areas for instatement of market competition by 2007, and liberalization of the generation and retail markets in these areas
- Determination of tariffs through competition in areas designated for instatement of market competition
- Dismantling of the vertically-integrated and monopolistic PLN organization
- Institution of the committee for supervision of the power market as an independent regulator
- Appointment of a power system operator and a power market operator
- The instatement of market competition, which is the centerpiece of the new Electricity Law, however, evoked strong opposition from opposition party politicians, labor unions, and PLN retirees. These parties instigated a lawsuit on the grounds that the new law was unconstitutional. In December 2004, the constitutional court ruled that the law was invalid on the grounds of unconstitutionality. As a result, the preceding Electricity Law (Law No. 15 of 1985) was reeffected as the basic law for the power sector.

In response to this situation, to avoid legal disruption regarding the handling of the PLN and other power producers, the government promulgated the Government Regulation No.20 of 2005 and made the following points clear.

- The government is responsible for the power supply, and the PKUK will perform its operations.
- The PKUK may purchase power from cooperatives, public enterprises, private enterprises, citizen groups, and individuals.

- Power purchasing shall be based on bidding.

(2) Deliberation over the second new Electricity Law

Because the ruling rejected the 2000 Electricity Law on the grounds that it was unconstitutional, a second new power bill is now undergoing deliberation in the national assembly. Although there were once thought to be good prospects for its passage around the summer of 2006, the bill is still being considered in the national assembly. While it is reportedly expected to pass in 2008, the outlook is not yet firm.

Table 2.1.1 Rulings of the Constitutional Court, and comparison of the 2002, 1985, and second new Electricity Laws

	Court rulings	Law No. 20 of 2002	Law No. 15 of 1985	The Second New Electricity Law
Control by the national government	• The concept of control by the national government goes beyond regulatory authority. • Control includes the idea of what is termed private ownership in civil law.	• No explicit statement regarding control by the national government. • The government has the authority for regulation, licensing/approval, setting of tariffs, and supervision (concept of regulation). • The state enterprise is to be given the first business opportunity for power supply (concept of private ownership).	• Power supply is to be controlled by the national government and performed by a state enterprise. • The government has the authority for regulation, licensing/approval, setting of tariffs, and supervision (concept of regulation). • The government shall have jurisdiction over power supply, which shall be performed by a state enterprise as the party owning the power business concession (concept of private ownership).	• The term “national control” indicates regulation and ownership by the government. • The government has the authority for regulation, licensing/approval, setting of tariffs, supervision (concept of regulation), and performance of power supply through a state enterprise (concept of private ownership), which is to be given the first business opportunity for power supply.
Privatization of the state enterprise	• The government cannot be prohibited from holding stock in enterprises involved in production that both is important to the nation and dominates the lives of much of the population. • The setup is not unconstitutional if the government has the deciding interest in such enterprises, even if it does not hold 100 percent of their stock (provision not rejecting privatization).	• There are no stipulations regarding the privatization of state enterprises. • Stipulations regarding privatization are contained in the State Enterprises and the National Property laws. (Law No. 19 of 2003 regarding state enterprises) • The purpose of privatization is to heighten the business results of state-owned joint-stock enterprise (i.e., PERSERO) and increase the national stock ownership. • National corporations cannot be privatized in fields which only state enterprises are permitted to control. (Law No. 17 of 2003 regarding national property) • Upon approval by the national assembly, the government may sell or privatize state enterprises.	• There are no stipulations regarding the privatization of state enterprises.	• There are no stipulations regarding the privatization of state enterprises.
Competition	• The constitution does not prevent competition between enterprises in fields of production that both is important to the nation and dominates the lives of much of the population as long as the government does not lose its control through regulation,	• Competition is to be introduced into areas equipped with the right technical and economic conditions.		

	Court rulings	Law No. 20 of 2002	Law No. 15 of 1985	The Second New Electricity Law
	management, and supervision. ・ The constitution is not opposed to the market economy. The market economy does not exclude national intervention in the event of occurrence of distortion and inequity.			
Business unbundling	・ The unbundling of power operations through division into different enterprises destroys the state enterprise and makes it impossible to assure supply of power to all citizens. For this reason, it is unconstitutional. Note: The government is of the opinion that unbundling is permissible as long as it does not destroy the state enterprise.	・ Unbundling in competitive areas (i.e., those designated for competition) is compulsive. ・ Unbundling in non-competitive areas (i.e., those not designated for competition) is conditional.	・ Unbundling is conditional (power supply enterprises may engage in generation, transmission, and distribution).	・ Unbundling is conditional.
Role of state enterprises	・ The national government must continue to control the power sector. ・ Only a state enterprise is permitted to engage in power business. Private enterprises may participate in such business only if invited to do so by the state enterprise, in forms such as partnership and capital outlays.	・ In non-competitive areas, the state enterprise is to be given the first opportunity for power supply business. ・ In competitive districts, the state enterprise is to be given the first opportunity for transmission and distribution business. ・ In competitive areas, the state enterprise is to be given the first opportunity for transmission and distribution business.	・ Power supply is to be controlled by the national government and performed by a state enterprise.	・ A state enterprise must exist in the power sector. The state enterprise must be given the first opportunity for power supply. ・ If the state enterprise does not take the first opportunity given to it, the opportunity may be given to a public enterprise, private enterprise, or cooperative, through partnership with the state enterprise.
Role of the private sector	・ Private enterprises may participate in power business only if invited to do so by the state enterprise, in forms such as partnership and capital outlays. ・ Production fields where private enterprises are doing business may be transferred to the national government if said production both is important to the nation and dominates the lives of much of the population.	・ If the state enterprise does not take the first opportunity in the power sector given to it, the opportunity may be given to a public enterprise, private enterprise, or cooperative, through partnership with the state enterprise.	・ The role of the private sector is to reinforce the national capability for power supply. ・ Cooperatives and other enterprises are to be given the maximum opportunity for business as long as this heightens the national power supply capacity and does not detract from the national interest. ・ Private enterprises and cooperatives may engage in business in the power sector either in partnership with a state enterprise or independently.	・ If the state enterprise does not take the first opportunity given to it, the opportunity may be given to a public enterprise, private enterprise, or cooperative, through partnership with the state enterprise.

Source: prepared on the basis of data from the Ministry of Energy and Mineral Resources

(3) 10,000 MW acceleration program (crash program)

To resolve the current shortage of power and promote substitution for oil, the government has determined a program for construction of additional power stations with a combined capacity of 10,000 MW by 2010.

On 5 July 2006, the government issued the Government Regulation No. 71 for accelerated development of coal-fired power stations to be placed into operation by 2009. To this end, it ordered the PLN to designate specific sites and then implement projects.

This accelerated program is to be implemented exclusively by the PLN; construction of coal-fired power stations by IPPs is outside its framework, and targeted capacities have not been indicated for the latter[1].

Table 2.1.2 List of PLN power station projects on Java and Bali

No	Station site	Number of units	Capacity class (MW)
1	PLTU 1 in Banten	1	600 - 700
2	PLTU 2 in Banten	2	300 - 400
3	PLTU 3 in Banten	3	300 - 400
4	PLTU 1 in West Java	3	300 - 400
5	PLTU 2 in West Java	3	300 - 400
6	PLTU 1 in Central Java	2	300 - 400
7	PLTU 2 in Central Java	1	600 - 700
8	PLTU 1 in East Java	2	300 - 400
9	PLTU 2 in East Java	1	600 - 700
10	PLTU 3 in East Java	2	300 - 400

Source: Government Regulation No. 17, 2006

[1] The lack of indication of targets for construction of coal-fired power stations by IPPs was explained as due to the uncertainty surrounding private investment.

Table 2.1.3 List of PLN power station projects outside Java and Bali

No	Station site	Number of units	Capacity class (MW)
1	PLTU in Nangroe Aceh Darussalam	2	100 - 150
2	PLTU 1 in North Sumatra	2	100 - 150
3	PLTU 2 in North Sumatra	2	100 - 150
4	PLTU in West Sumatra	2	100 - 150
5	PLTU 1 in Bangka Belitung	2	10
6	PLTU 2 in Bangka Belitung	2	10
7	PLTU 3 in Bangka Belitung	2	25
8	PLTU 4 in Bangka Belitung	2	15
9	PLTU 1 in Riau	2	7
10	PLTU 2 in Riau	2	5
11	PLTU in Riau Islands	2	7
12	PLTU in Lampung	2	100 - 150
13	PLTU 1 in West Kalimantan	2	25
14	PLTU 2 in West Kalimantan	2	50
15	PLTU in South Kalimantan	2	65
16	PLTU 1 in Central Kalimantan	2	65
17	PLTU 2 in Central Kalimantan	2	7
18	PLTU 1 in North Sulawesi	2	25
19	PLTU 2 in North Sulawesi	2	25
20	PLTU in Gorontalo	2	25
21	PLTU in South Sulawesi	2	50
22	PLTU in Southeast Sulawesi	2	10
23	PLTU 1 in West Nusa Tenggara	2	7
24	PLTU 2 in West Nusa Tenggara	2	25
25	PLTU 1 in East Nusa Tenggara	2	7
26	PLTU 2 in East Nusa Tenggara	2	15
27	PLTU in Maluku	2	7
28	PLTU in North Maluku	2	7
29	PLTU 1 in Papua	2	7
30	PLTU 2 in Papua	2	10

Source: Government Regulation No. 71, 2006

2.1.2 Local level

(1) Abolition of provincial power development plans (RUKD)

As a result of the ruling by the constitutional court in December 2004, the 2002 Electricity Law was abolished, and this halted the preparation of power development plans (RUKD) by provincial governments that had been required by the law. For this reason, no provincial governments have prepared plans for power development since 2005.

(4) Provincial development plans and energy/power policy

Under the policy of local devolution being deployemd by the national government, provincial governments formulate and announce medium- and long-term plans for social and economic development. Nevertheless, while they may present an overall planning framework, these plans do not necessarily extend to detailed measures in each field.

In the field of energy or electric power in particular, the provincial plans merely set forth a basic orientation. The plans in the provinces of North Sulawesi and South Sulawesi, for example, do not present individual policies for energy and power. In the province of West Sulawesi, which was established only recently, provincial development plans per se have not yet been unveiled.

In actuality, the provincial governments would find it difficult to execute large-scale plans owing to their shortage of both financial and human resources. They leave the grid-system development planning to the PLN, and have no choice but to accept its promotion with the national budget.

Meanwhile, to supplement the role of the PLN and the national government, there is a movement afoot among provincial governments for use of local energy to promote electrification in as yet unelectrified areas not connected to the grid. When matters reach the stage of appropriating budget to execute projects, however, the provincial governments have no choice but to seek national assistance, i.e., depend on the national government.

(1) West Sulawesi Province

Although it has not yet announced official policy for power development, the provincial government is inclined to the development and use of renewable and environment-friendly energy on the DINAS level. While it will continue to rely on additional coal-fired capacity now being constructed, there are hopes for development of geothermal and hydropower stations over the longer term.

(2) Gorontalo Province

The policies noted below are presented in management of the provincial mining and energy sector. Although they merely indicate orientation, not specific policies, they emphasize the development of new and renewable energy.

(A) Policy targets and directions

i) The targets of development in the mining and energy sector are as follows.

- Recruitment of workers and development of human resources in the mining and energy sector
- Establishment of environmental concepts and technology, and assurance of worker health and safety, in the sector
- Actualization of the optimal role in the sector for mining, new energy, and renewable energy in order to increase local income

ii) Policy orientation

- Diversification of mining and energy resources
- Optimization of the energy supply by energy conservation and higher utilization efficiency

- Effective utilization of renewable energy

(B) Development program

- Development of mineral and groundwater resources
- Development of mining business
- Development of new and renewable energy
- Development of alternative energy

(3) Central Sulawesi

The provincial development plan does not go beyond presentation of the basic idea, as follows.

- Energy development is to be pursued in parallel with development of the social infrastructure, institutional arrangements, human resources, technology, public involvement, and expanded awareness of environmental problems related to energy utilization.
- Energy consumption in Central Sulawesi is rapidly growing in step with economic reform. Residential customers continue to occupy the majority of the power consumption. Increased consumption by industry requires proper conditioning of power facilities and infrastructure.
- The province is to develop steam-powered and hydropower generation over the medium term for response to these power issues.

(4) Southeast Sulawesi

As compared to other provinces, Southeast Sulawesi Province has more specific plans for energy development. It attaches importance to the diversification of energy development and use of renewable energy to assure a supply capacity needed to meet the power demand increase. Parallel promotion of energy conservation is a pillar of its policy.

1) Perception of the current status

i) Issues

- Development of the energy sector entails a huge cost, and the governmental capacity is extremely limited.
- Private-sector interest in the energy sector is still low. This is because of the high investment costs and long time required for investment retrieval.
- Energy resource deposits are generally in remote areas, and the cost of developing them is very high.
- Knowledge of technical matters required for energy development is still on a low level, and there has been little transfer of new technology in particular.

ii) Agenda to be addressed

- There is still a shortage of generation capacity.
- The demand for power is going to increase along with economic development and population growth.

- An increase in the power supply is indispensable for the provinicial economy and population.
- Assurance of fuel transport by boat requires an expansion of the fuel unloading facilities.
- The province has a large potential of renewable energy resources, but their development has been limited.

2) Development objectives and targets

i) Objectives

- To achieve a proper supply of energy for residential/commercial use, industry, and transportation.
- To reinforce energy development by utilizing the existing potential energy resources, and to assure the power supply by a proper expansion of capacity accompanied by an enhancement of service quality.

ii) Targets

- To assure the supply capacity in correspondence with the increasing energy demand, accompanied by the proper quality and services, and thereby to achieve economic development and raise the standard of living.
- To pursue the possibilities of energy supply in rural areas and islands by utilization of solar power, mini-hydropower, and wind power energy.
- To promote energy conservation and diversification, with a particular focus on installation of cooking stoves in rural areas to reduce use of firewood.
- To promote energy conservation, particularly in the residential sector, through various media; introduction of effective technology is required for promotion of energy conservation.

iii) Policy strategy

- The province shall work to diversify power sources by utilization of renewable energy in forms such as hydropower, wind power, solar power, geothermal energy, and biomass, in a manner adapted to the area. This requires improvement of facilities and infrastructure for hydropower, mini-hydropower, and photovoltaic power generation as well as the development of the human resources to support them.
- The province shall strive to increase official involvement for diversification of power and heighten awareness of environment-friendly energy conservation.
- The province shall provide for optimization of the energy and power supply.

iv) Development programs

- Energy program
- Program for development of human resources in the areas of research, development, design, and engineering of the power sector.
- Rural electrification program.

- Program for reinforcement of official involvement in diversification of power source development, and program for heightening awareness of energy conservation

(5) South Sulawesi

The plan does not contain policies for energy or electric power. The sole related field covered is development of natural resources, but the plan does not go beyond a statement of emphasis on concern for the environment and local welfare in such development.

2.2 Primary Energy

In recent years, crude oil prices have reached record-high levels. There are concerns about further energy price increase, and the tightening energy demand-supply balance has also become a serious issue. Although the aim of this chapter is to discuss the availability of primary energy in Sulawesi, in light of the prevailing climate in the energy market, this section briefly comments on the outlook for future energy prices, and especially crude oil prices.

Crude oil prices, which have a strong influence on other energy prices, have continued to increase since 2003 (Figure 2.2.1). In January 2008, the representative index crude oil in the futures market, i.e., West Texas Intermediate (WTI), went over the line of $100 per barrel (bbl).

There are several factors behind this crude oil price increase over the past five years. First, the demand for oil in developing courtiers including China and India is burgeoning. Needless to say, the current oil price rises are not caused by any actual supply shortage, but there are deep apprehensions about a narrowing of supply-demand gap in the future, and this is having a strong effect on oil market behavior. In addition to these apprehensions about supply tightness, oil prices in the futures market were also driven upward by expectations about a tightening of the supply-demand balance over the short term due to the relative shortage of refinery capacity in the United States.

Moreover, even in this climate of soaring prices, the demand has remained firm and not declined. In fact, crude oil production increased from 65.92 million barrels per day (bbl/d) in 1999 to 73.27 million bbl/d in 2007, and the oil demand continued to stay in high level.

Other factors amplifying worries about the tightening oil supply: unstable political conditions in Middle East countries such as Iraq and Iran; deteriorating securities in Nigeria, an African oil-producing country; and the behavior of Russia and Venezuela, in which nationalistic sentiment is on the rise and the governments are making moves to nationalize the oil industry.

However, there is a big difference between the current oil price surge and that of the oil crises during the 1970s: the former is being driven largely by the inflow of speculative funds into the crude oil trade market. Many observers have pointed out that the effect of this inflow is definitely the main cause of the current price increase.

The easing of monetary policy in the United States beginning in 2001 caused a surplus of money internationally. This surplus money poured into the oil market in anticipation of a much higher return. This is particularly true of hedge-fund money, which has strong appetite for more profitable investment. As a result, crude oil dealing in the futures market became a kind of financial derivatives. Crude oil prices were further pushed up as a consequence of the arbitrage of the crude oil trading in high prices caused by the 2005 hurricane disaster in the United States and the money inflow from the mortgage market to the crude oil futures market triggered by the sub-prime loan securities problem.

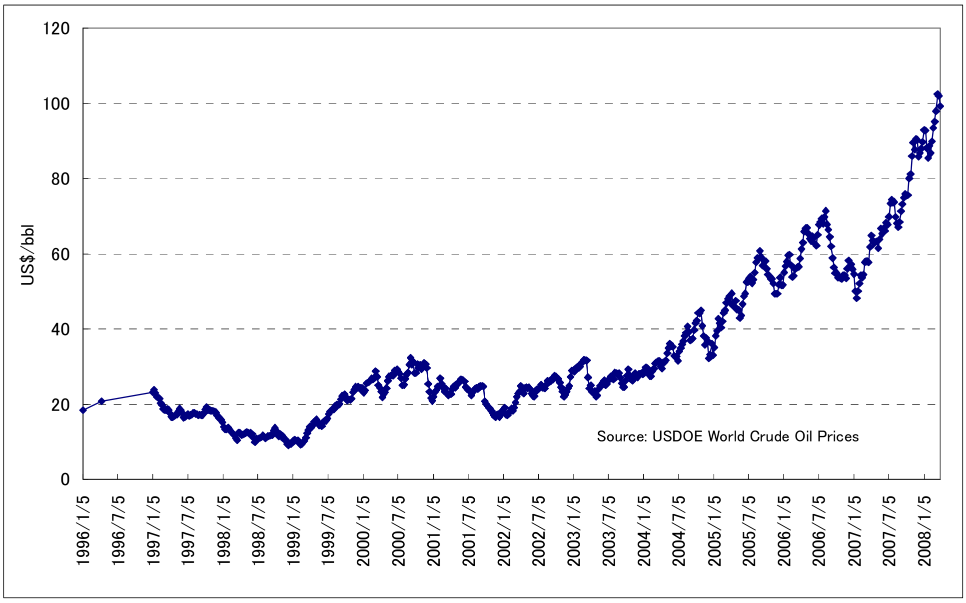


Figure 2.2.1 Transition of Crude Oil Spot Prices (FOB)

What kind of trend will crude oil prices follow from their current high level? On this question, only a few observers predict that prices will continue to increase. This is because, if prices continue to increase, they will hamper global economic growth and thereby act to brake the oil demand. In addition, a continued increase would accelerate campaigns for energy conservation and the switch to oil-alternative energy resources. The consensus is that crude oil prices are currently on a peak level.

The International Energy Agency (IEA), the United States Department of Energy (USDOE), and oil majors have published several reports on the subject of the future oil price trend. The latest one is the Annual Energy Outlook 2008 (revised early release) published by the USDOE in March 2008.

In the outlook, the USDOE forecasts that crude oil prices will hit the ceiling in 2008 and continue to decline (in actual term) beginning in 2010 but enter a trend of gradual increase again from the mid-2010s into the 2020s. It also predicts that, in real 2006 values, prices in the United Sates will be in the range of substantially above 50 to under 80 dollars per barrel for crude oil, slightly over 5 to slightly over 6 dollars per mmBtu for natural gas, and in the range of over 30 to under 40 dollars per ton of standard coal equivalent[2] for steam coal.

[2] High heat value: 7,000kcal/kg

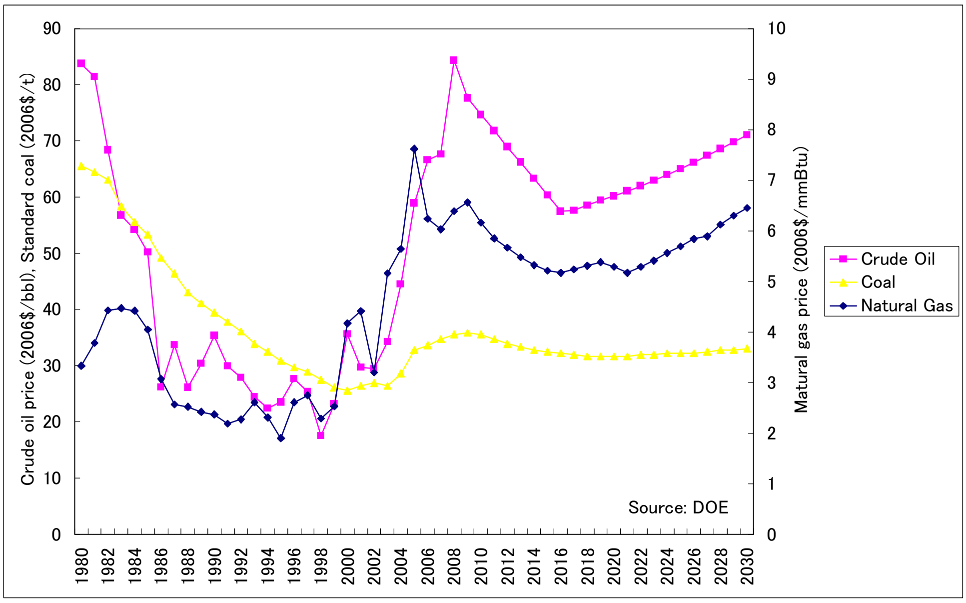


Figure 2.2.2 Energy Price Forecast by the United States Department of Energy (2008 Revised Early Release)

2.2.1 Natural Gas

Central Sulawesi reportedly has 3.92 trillion cubic feet (Tcf) natural gas reserves. This volume is too small to produce liquefied natural gas (LNG), but it is large enough for use as pipeline gas. South Sulawesi has a small gas reserve of 0.79 Tcf (Table 2.2.1).

Although natural gas development in the island is not yet progressing, an independent power producer[3] (IPP) currently owns and operates a 135 MW combined-cycle gas-fired power station in South Sulawesi. It is also constructing an additional 60MW unit, which is expected to start operating in September 2008. In addition, it has proposed construction of a 60 MW open-cycle unit (scheduled to start operation in February 2009) in the second stage and a 60 MW heat-recovery steam-turbine unit (scheduled to start operation in September 2009) in the third stage[4].

In Central Sulawesi, there are several natural gas development plans, but none of them has actually been initiated yet. MEDECOENERGI, which owns a gas field in Senoco, has launched a marketing effort, and the prospective candidate products are chemicals and/or liquefied natural gas.

[3] PT Energi Sengkan

[4] It is announced that natural gas cost applied to the second and third stages of the Sengkan project was $2.30/mmBtu on the year 2007 basis plus 2% p.a. escalation. This price is quite low as compared to the gas price purchased by PLN (i.e., around $5.5/mmBtu, now), because it uses its own gas field.

Table 2.2.1 Natural Gas Reserve, as of January 1, 2006

(Unit: Tcf)

Nangroe Aceh Darusalam	4.57
North Sumatera	1.38
Central Sumatera	7.83
South Sumatera	24.30
Natuna	53.56
West Java	6.04
East Java	6.20
East Kalimantan	45.40
South Kalimantan	2.37
Central Sulawesi	**3.92**
South Sulawesi	**0.79**
Maluku	0.006
Papua	24.47
Proven	93.95
Potential	93.14
Total	187.09

Source: Directorate General of Oil and Gas, MEMR

2.2.2 Coal

Indonesia is a coal-rich country. In 2006, it extracted 150 million tons of coal and exported 106.38 million tons of this total. The majority of its coal deposits are on the Island of Sumatra and in the province of Kalimantan.

In Sulawesi, there are only small coal deposits amounting to about 60,000 tons on the reserve basis in the Maros Pangkajene, Enrekang, and Mamuju areas in Central Sulawesi and South Sulawesi provinces.

Table 2.2.2 Coal Resources and Reserves in Sulawesi

(Unit: million tons)

	Quality	Heat Value (kcal/kg)	Resources					Reserves
			Hypothetical	Inferred	Indicated	Measured	Total	
Central Sulawesi	Low	<5,100	0.00	1.98	0.00	0.00	1.98	-
	Medium	5,100-6,100	-	-	-	-	-	-
	High	6,100-7,100	-	-	-	-	-	-
	Very High	>7,100	-	-	-	-	-	-
	Total		0.00	1.98	0.00	0.00	1.98	
South Sulawesi	Low	<5,100	-	-	-	-	-	-
	Medium	5,100-6,100	0.00	96.13	0.00	21.20	117.33	0.06
	High	6,100-7,100	0.00	13.90	0.78	0.00	14.68	-
	Very High	>7,100	-	-	-	-	-	-
	Total		0.00	110.03	0.78	21.20	132.01	0.06
Total			0.00	112.01	0.78	21.20	133.99	0.06

Source: Indonesian Energy Outlook & Statistics 2006

Original data: Directorate General Mineral, Coal and Geothermal Resources 2005

Table 2.2.3 Regional Coal Resources and Reserves in Indonesia

(Unit: million tons)

No.	Province	Resources					Reserves
		Hypothetical	Indicated	Inferred	Measured		
1	BANTEN	0.00	13.31	0.00	0.00	13.31	0.00
2	CENTRAL JAVA	0.00	0.82	0.00	0.00	0.82	0.00
3	EAST JAVA	0.00	0.08	0.00	0.00	0.08	0.00
4	NAGGROE ACEH DARUSSALAM	0.00	346.35	13.40	90.40	90.40	0.00
5	NORTH SUMATERA	0.00	7.00	0.00	19.97	26.97	0.00
6	RIAU	0.00	1,720.60	0.00	336.62	696.22	15.15
7	WEST SUMATERA	19.19	481.19	42.72	181.24	724.34	36.07
8	BENGKULU	15.15	113.09	7.95	62.18	132.77	21.12
9	JAMBI	0.00	1,462.03	36.32	94.22	1,542.38	18.00
10	SOUTH SUMATERA	1,827.55	8,694.75	11,574.90	143.20	22,240.40	2,653.98
11	LAMPUNG	0.00	106.95	0.00	0.00	106.95	0.00
12	WEST KALIMANTAN	42.12	482.60	1.32	1.48	527.52	0.00
13	MIDDLE KALIMANTAN	0.00	1,232.84	5.08	194.02	1,431.94	48.59
14	SOUTH KALIMANTAN	0.00	5,474.06	222.04	3,171.20	8,867.30	1,803.33
15	EAST KALIMANTAN	1,775.62	13,515.99	335.01	6,453.33	22,079.95	2,410.33
16	**SOUTH SULAWESI**	**0.00**	**110.03**	**0.78**	**21.20**	**132.01**	**0.06**
17	**CENTRAL SULAWESI**	**0.00**	**1.98**	**0.00**	**0.00**	**1.98**	**0.00**
18	PAPUA	0.00	61.86	0.00	0.00	0.00	0.00

Source: MEMR

Original data: Geology and Mineral Reserve Statistic 2005

2.2.3 Peat

In South Sulawesi. there are 1.23 million tons of peat resources on the dray basis. Peat has an average calorific value of 4,943 kcal/kg-dray-weight, which is lower than that of coal.

Table 2.2.4 Peat Resources in Sulawesi

Province	Location	Quality		Average Thickness	Area	Dry Weight	Average Caloric Value		Average Caloric Value	
		Ash (%)	S (%)	(m)	(ha)	(million tons)	(MJ/kg-dry weight)	(kcal/kg-dry weight)	(10^9 MJ)	(10^9kcal)
South Sulawesi	Malangke	3.10	0.31	0.50	1,250	1.25	20.71	4,943	25.89	6,179

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

2.2.4 Geothermal

While Sulawesi has widespread geothermal energy resources, the majority are found in the provinces of North and South Sulawesi. North Sulawesi, which in the most geothermal-rich province, reportedly has 540 MWe on the possible reserve basis, 110 MWe on the probable reserve basis, and 65 MWe on the proven reserve basis.

Data for the other provinces are available only on the possible reserve basis. These possible reserves are estimated at 51 MWe in Central Sulawesi, 49 MWe in South Sulawesi, and

15 MWe in Gorontalo. These figures are much lower than those for North Sulawesi.

Table 2.2.5 Potential and Installed Geothermal Capacity in Sulawesi, as of December 2004

	Area	Regency/City	Resources (MWe)		Reserve (MWe)			Installed (MWe)
			Speculative	Hypothetic	Possible	Probable	Proven	
North Sulawesi	Air Madidi	Minahasa	25	-	-	-	-	-
	Lahendong	Minahasa	-	125		110	65	20
	Tompaso	Minahasa	-	-	130	-	-	-
	Gunung Amtaang	Bolaang Mongondow	-	-	225	-	-	-
	Kotamobagu	Bolaang Mongondow	-	-	185	-	-	-
	Total		25	125	540	110	65	20
Gorontalo	Gorontalo	Gorontalo	-	-	15	-	-	-
	Pentadio	Boalemo	25	-	-	-	-	-
	Total		25	-	15			
Central Sulawesi	Maranda	Poso	25	-	-	-	-	-
	Sapo	Donggala	25	-	-	-	-	-
	Langkapa	Poso	25	-	-	-	-	-
	Napu	Poso	25	-	-	-	-	-
	Torire	Poso	25	-	-	-	-	-
	Toare	Donggala	25	-	-	-	-	-
	Patalogumba	Donggala	25	-	-	-	-	-
	Marana	Donggala	-	-	40	-	-	-
	Bora	Donggala	-	-	8	-	-	-
	Pulu	Donggala	-	-	58	-	-	-
	Sedoa	Donggala	25	-	-	-	-	-
	Wliasa	Poso	25	-	-	-	-	-
	Watuneso	Poso	25	-	-	-	-	-
	Papanpulu	Poso	25	-	-	-	-	-
	Total		275	-	106	-	-	-
South Sulawesi	Limbong	Luwi	25	-	-	-	-	-
	Pararra	North Luwi	-	-	30	-	-	-
	Mambosa	Mamuju	25	-	-	-	-	-
	Somba	Majene	25	-	-	-	-	-
	Mamasa	Polewali Mamasa		-	2	-	-	-
	Bituang	Tana Toraja		-	17	-	-	-
	Sangala	Tana Toraja	25	-	-	-	-	-
	Sengkang	Sindenreng Rappang	25	-	-	-	-	-
	Sulili	Pinrang	25	-	-	-	-	-
	Malawa	Pangkajene	25	-	-	-	-	-
	Baru	Baru	25	-	-	-	-	-
	Watampone	Bone	25	-	-	-	-	-
	Todong	Bone	25	-	-	-	-	-
	Sinjai	Sinjai	25	-	-	-	-	-
	Masepe	Sindenreng Rappang	25	-	-	-	-	-

	Area	Regency/City	Resources (MWe)		Reserve (MWe)			Installed (MWe)
			Speculative	Hypothetic	Possible	Probable	Proven	
	Danau Tempe	Wajo	25	-	-	-	-	-
	Total		325	-	49	-	-	-
Southeast Sulawesi	Mangolo	Kolala	-	-	14	-	-	-
	Parora	Kendari	25	-	-	-	-	-
	Puriala	Kendari	25	-	-	-	-	-
	Amoloha	Kendari	25	-	-	-	-	-
	Loanti	Kendari	25	-	-	-	-	-
	Laenia	Kendari	-	-	36	-	-	-
	Torah	Buton	25	-	-	-	-	-
	Kalende	Buton	25	-	-	-	-	-
	Kanale	Buton	25	-	-	-	-	-
	Wonco	Buton	25	-	-	-	-	-
	Gonda Baru	Bau-Bau	-	-	1	-	-	-
	Kabungka	Buton	25	-	-	-	-	-
	Sampolawa	Buton	25	-	-	-	-	-
	Total		250	-	51	-	-	-
Sulawesi Total			900	125	761	110	65	20

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate Mineral Resources Inventory, Directorate General of Geology and Mineral Resources, MEMR

2.2.5 Ordinary hydropower

Together with geothermal power, hydropower is one of the abundant primary energy resources in Sulawesi. PLN has already proven the existence of a total of 10,749 MW in potential hydropower resources, and this figure represents 14% of the hydro potential in all of Indonesia.

This total consists of 4,000 MW in North and Central Sulawesi and 6,749 MW in West, South, and Southeast Sulawesi (Table 2.2.6).

Table 2.2.6 Potential of Ordinary Hydropower Energy in Indonesia

Island	Site	Power (MW)		Energy (GWh)
Sumatra	474	15,585	20.6%	84,110
Java	149	4,531	6.0%	18,042
Kalimantan	177	21,581	28.5%	107,202
Sulawesi	116	10,749	14.2%	52,952
North & Central	-	4,000	-	-
West, South & South East	-	6,749	-	-
Maluku	53	430	0.6%	3,043
Irian Jaya	210	22,371	29.6%	133,759
Bari, NTB, NTT	136	374	0.5%	2,536
Total	1,315	75,624	100.0%	401,644

Source: PLN

2.2.6 Mini-hydro power

Potential of mini-hydro-power energy larger than 15 kW is measured at 31,440 kW by PLN.

Of which, the largest resources of 12,790 kW exist in North Sulawesi, and the next large 11,765 kW, South Sulawesi. Resources of 6,885 kW, which is a little larger than one half of those figures, exist in Central Sulawesi.

Meanwhile, a total of 30,474 kW potential energy throughout the island is reported by non-PLN institutions.

Table 2.2.7 Potential of Mini-Hydro Energy in Sulawesi (>20kVA (15KW))

(Measured by PLN)

Province	Site	Number of Units	Potential (kW)	Measuring Institution
North Sulawesi	Tamako/U-Peliang	1	1,090	PLN Region VII
	Poigar	2	2,500	PLN Region VII
	Lobong	2	1,500	PLN Region VII
	Kolondom	2	2,000	PLN Region VII
	Kembera	1	430	PLN Region VII
	Toni	1	300	PLN Region VII
	Tawaeri	1	1,270	PLN Region VII
	Tarise	1	1,200	PLN Region VII
	Mongango	1	900	PLN Region VII
	Wining	2	1,600	PLN Region VIII
	Total		12,790	
Central Sulawesi	Bambalo/Poso	1	2,610	PLN Region VII
	Kalumpang	1	700	PLN Region VII
	Hanga-hnaga 2	2	1,670	PLN Region VII
	Rongi	1	845	PLN Region VII
	Mikuasi	2	1,060	PLN Region VII
	Total		6,885	
South Sulawesi	Enrekangu/Lewaja	1	440	PLN Region VIII
	Mamasa/Bala	1	340	PLN Region VIII
	Palangka	1	1,500	PLN Region VIII
	Bonelemo	1	1,340	PLN Region VIII
	Cennae	1	590	PLN Region VIII
	Usu Malili	2	3,750	PLN Region VIII
	Batu Sitanduk	1	1,750	PLN Region VIII
	Kadundung	2	1,443	PLN Region VIII
	Rante Balla	1	612	PLN Region VIII
	Total		11,765	

(Measured by non-PLN)

Province	River	Site	Sub-district	Regency	Potential (kW)
North Sulawesi	Munthe	Tincep 1	Sonder	Minahasa	605.00
	Munthe	Tincep 2	Sonder	Minahasa	1,100.00
	Munthe	Tincep 3	Sonder	Minahasa	2,200.00
	Susua	Rate Limbong 2	Lasusua	Kolaka	712.80
	Lakambula	Olondoro	Teomokale	Boton	441.60
	Total				5,059.40
Central Sulawesi	Tindaki	Tindaki	Parigi	Donggala	515.20
	Dolago	Dolago	Parigi	Donggala	768.00
	-	Banggai	Walatang	Donggala	816.00
	-	Salumpaka	Banawa	Donggala	231.60
	Tamunggu	Nupabomba	Tawaeli	Donggala	319.20
	Pondo	Boboya	Palu Timur	Donggala	299.40
	Pameki	Mantilayo	Sigi Biromaku	Donggala	1,500.00
	Ampana	Sansarino	Ampana Kota	Poso	554.40
	Kanori	Malewa	Tojo	Poso	404.90
	Tomasa	Pandiri	Lage	Poso	2,756.00
	Wimbi	Sawidago 2	Pamona Utara	Poso	436.80
	Mongono	Solan	Klintom	Banggai	1,523.50
	Tanggar	Tombolo	Malino	Tajung Moncong	1,230.00
	Mamuju	Mamuju	Mamuju	Mamuju	648.00
	Tangkok	Manipi	Sinjai Barat	Sinjai	5,616.00
	Urupai	Labole	Lamuru	Bone	1,090.00
	Mayamba	Paumah	Sendana	Mejene	106.60
	Maiting	Kabiraan	Malunda	Mejene	157.00
	Lengkeme	Langkeme	Mario Riwawu	Soppeng	145.60
	Biyalo	Biyalo	Bulukumba	Donggala	360.00
	Sallu	Kendenan	Makale	Tator	194.90
	Kokkang	Tombang	Salluputti	Tator	432.00
	Dolok	Suddu	Alla	Enrekang	224.60
	Mata Allo	Bilajen	Alla	Enrekang	2,820.80
	Matama	Talogo	Tutallu	Polmas	562.80
	Mumbi	Kalimamang	Tutallu	Polmas	547.00
	Total				24,260.30
Southeast Sulawesi	Susua	Rate Limbong 2	Lasusua	Kalaka	712.80
	Lakambula	Olondoro	Teomokale	Buton	441.60
	Total				1,154.40
Grand Total					**30,474.10**

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

2.2.7 Wind and Solar

In the provinces of Southeast and North Sulawesi, measurement indicates an average wind velocity of about 3 m/second at an elevation of 24 m.

In the Palu area of Southeast Sulawesi, measurements found that solar radiation averaged 5.51 kWh/m^2.

Table 2.2.8 Potential of Wind Energy

Province	Village/Sub-District/Regency	Year of Measurement	Average Velocity at Elevation of 24 m (m/sec)
Southeast Sulawesi	Bubung Luwuku	1994	3.01
North Sulawesi	SamratulangiMenado	1994	3.21
	Meteo Bitung	1994	2.8

・ Small scale: 2 -3 (m/sec)
・ Medium scale: 3 -4 (m/sec)
・ Large: > 4 (m/sec)

Source: PLN Energy Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

Table 2.2.9 Potential of Solar Energy

Province	Regency	Year of Measurement	Average radiation (kWh/m^2)	Measured by
Southeast Sulawesi	Palu	1991 - 94	5.51	LSDE

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

2.2.8 Biomass and Biogas

The category of biomass has a lot of variation. In the case of agricultural waste, South Sulawesi has the highest energy potentials at 2.5 MW, followed by Central Sulawesi at 1.1 MW. In contrast, the corresponding potentials in North and Southeast Sulawesi are far below 1 MW.

Biogas produced from livestock manure has a larger energy potential than agricultural waste. South Sulawesi reportedly has the highest such potential at 41.5 MW. The potential is the lowest in Southeast Sulawesi, where it nevertheless comes to 10 MW.

Table 2.2.10 Potential of Biomass (Agricultural Waste) Energy

Province	kWh								kW
	Rice	Corn	Cassava	Wood	Baggase	Coconut	Parm	Total	
North Sulawesi	1,250,948	1,117,723	138,926	3,173,349	16,505	755,977	0	6,453,431	736.69
Central Sulawesi	1,979,301	282,321	352,967	7,040,892	0	408,941	8,814	10,073,238	1,149.91
South Sulawesi	11,037,629	5,659,932	1,236,409	3,555,232	71,889	349,818	44,929	21,955,841	2,506.37
Southeast Sulawesi	1,036,020	644,745	358,275	5,506,430	0	97,876	0	7,643,349	872.53

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

Table 2.2.11 Potential of Biogas (Animal Manure) Energy

Province	kWh				kW
	Cow	Buffalo	Pig	Total	
North Sulawesi	83,926,641	2,414,049	54,189,247	140,529,937	16,042.23
Central Sulawesi	121,577,567	21,287,126	23,807,187	166,671,880	19,026.47
South Sulawesi	201,287,881	119,742,352	42,624,867	363,655,100	41,513.14
Southeast Sulawesi	80,296,106	6,233,922	1,388,381	87,918,409	10,036.35

Source: Indonesia Energy Outlook & Statistics 2006

Original data: Directorate General of Electricity and Energy Development, MEMR

Chapter 3 Demand Forecast

This section forecasts the future demand based on the past sales and the economic indicators

3.1 Methodology

The methodology utilized by the study team is straightforward. It follows the following steps

1) The total demand is forecasted using a standard econometric model, using elasticity of demand against the Gross Regional Domestic Product (GRDP).
2) The demand is converted to generation based on the assumed percentage of the station use and the transmission loss.
3) The total demand is separated to each system based on the current percentage of each system.
4) For each system, the peak load is calculated based on the current load factor. The peak load is aggregated into the total peak load forecast.

3.1.1 Elasticity Assumptions

The total demand forecast was made based on the operating division of PLN. Since all grid operations are undertaken by PLN, this was reasonable. Within North Sulawesi and South Sulawesi, the demand pattern is slightly different. In South Sulawesi, 88% of the total demand is dominated by demand around Makassar (Sulsel system). The second largest system, Kendari system, occupies only 6%. While the systems have their distinct characteristics, they do not affect the overall pattern of the power demand. Therefore, it was reasonable to treat the whole demand as a single block.

North Sulawesi, on the other hand, consists of three distinct regions; North, Central, and Gorontalo. While North, with Manado as its center, has the largest share, it does not necessarily dominate the whole PLN operational area. The distribution between North, Central and Gorontalo is about 60%, 28% and 12%. With somewhat different characteristics of these states, the forecast is made separately for the three regions.

Elasticity is simply the ratio between the growth rate of the GRDP and the power demand. Based on the historic figures, the elasticity for each region was set as follows;

	Sulawesi South	**North**	**Central**	**Gorontalo**
Elasticity against GRDP	1.32	1.25	1.3	1.3

3.1.2 GDP Growth Assumptions

As for the assumption for the GRDP growth, the team has based the forecast on historic figures. It has been established that the growth of Sulawesi as a whole has been higher than the national growth, with an elasticity of about 1.12. This is reasonable, since with a smaller scale of economy compared to the national economy, Sulawesi should show a higher growth. Since the Central Bank has forecasted a future growth of 6% for Indonesia as a whole, this implies that the future growth of Sulawesi is about 6.7%. As the economy grows, however, the growth rate usually tapers down. Therefore, it is assumed that after 2015, the growth will slow down to 6%.

For the northern regions, the team has accepted the GDP growth assumptions made by PLN. It assumes a growth of about 7.4%, gradually declining to about 7.25%. While this seems aggressive, with a smaller sized economy, it is not an unreasonable assumption.

3.1.3 Effects of the pent-up potential demand

Currently, the peak demand is somewhat cut-off by load shedding. Also, due to limitation in supply, there has been a constant waiting list for new customers. If these were properly connected, the demand would increase.

As for load shedding, the actual data has been provided by PLN. In Northern Sulawesi, Minahasa-Kotamobagu System has seen load curtailment since 2008/08 to the present day. Prior to 2006/08, the supply exceeded demand, so load shedding was only done in times of incidental break downs of the facilities. In terms of energy this was negligible. As a result, the un-served energy in 2006 was about 12.8GWh/year. The critical period was 2006/09-11, with an average of 3.41GWh/month. Usually, power was cut during 18:00-24:00. Therefore, the un-served capacity amounts to 18.3MW. The maximum power in 2006 was observed on 12/26. The un-served demand (MW) was about 4.9MW, so the load factor was not heavily affected

Similarly in Southern Sulawesi, the Sulsel system has seen load curtailment, especially since 2005. In 2005, 43GWh was not served to the end users, which amounts to 1-2% of the annual generation. The situation improved slightly in 2006, and the un-served energy at the generation end was 18.9GWh。

Had these demands be met, the total demand would have gone up by about 2%. It is well within the current operational capacity. Therefore, this was included in the demand forecast. Namely, the demand for 2007 was increased by the load-shedded amount.

As for the waiting list, the total amount was significant. In Northern Sulawesi, the capacity on the waiting list was 5.7% of the current generation capacity. In Southern Sulawesi, this was 15.7%. If these demand had the same load factor as the overall area, then the demand would have gone up by this ratio.

However, it is unclear how much of this applied capacity would be actually used. The application would most likely be made at their peak capacity plus some margin, and the load curve for industrial application would be significantly different from those of the overall demand which has a large residential component. Also, to assume that the future system would immediately accommodate this demand would be rather unrealistic. It would also affect the GRDP, which has historically been achieved under the suppressed demand condition. Therefore, although efforts will be made to accommodate the demand from the waiting list, the base case assumed that the tight supply condition will continue somewhat into the future. However, in order to understand the effect of the pent-up demand, a case is assumed where all the demand from the waiting list was somehow completely met, with the same load factor. This will be the high case scenario for the demand.

3.1.4 Other Assumptions

For station use and distribution losses, the current figure is about 15%. The study team has assumed that this will go down to about 10% in the future. While there is no absolute way to forecast this figure, the team feels that this is a realistic figure that is achievable.

As for the distribution of the total to the respective systems, and the load factor of each system, the study team has simply accepted the assumptions of PLN. PLN basically assumes that the current ratio of each system will more or less prevail in the future. It also assumes no significant change in the load factor. The study team finds this to be a reasonable and acceptable assumption.

In any situation, there is a price effect on demand. The change in the power tariff would naturally affect the demand. A higher tariff should lead to a lower demand. This, in theory, should also be observed in Sulawesi.

It has been pointed out, however, that the current power charge is much lower than its actual cost. Since the power tariff is kept artificially low, PLN claims that it has not been a determinant of demand, and the price effects on demand has been negligible.

3.2 Results

Using the above methodology and assumptions, the demand forecast up to 2027. The results show that in 2020, total demand for South Sulawesi will be 7,762GWh, an average growth of 8.5%. For North Sulawesi, the total demand in 2020 will be 3,917GWh, an average growth of 8.97%. The high case would be 15% and 5.7% higher respectively.

This figure is comparable to the historical average growth after the Asian currency crisis in 1997. Prior to the crisis, the economic boom brought a surge in demand, making the annual demand growth in Southern Sulawesi to 20%, but this was not sustainable. We feel that the current figure is a reasonable one that reflects the sustainable realities of the Sulawesi economy.

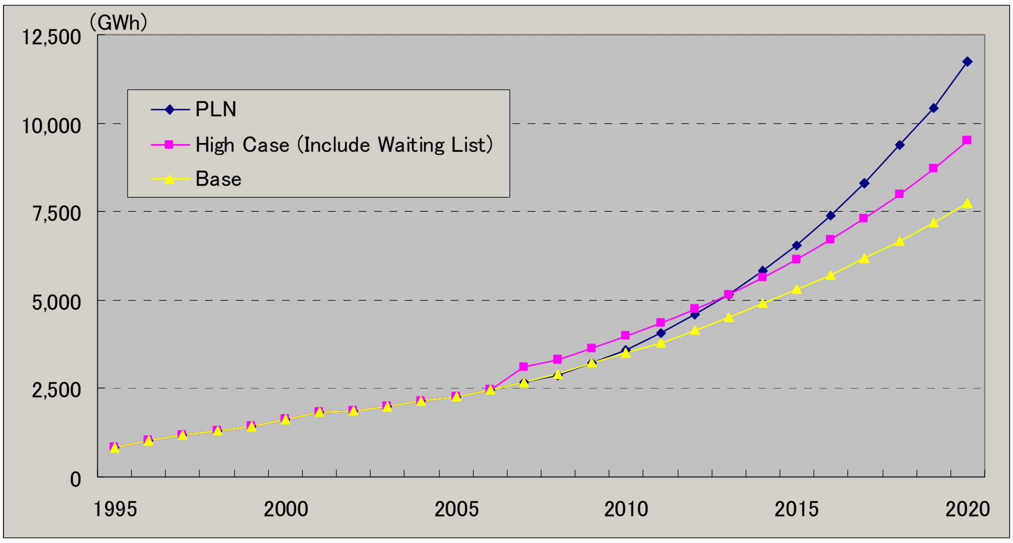


Figure 3.2.1 Demand Forecast for South Sulawesi

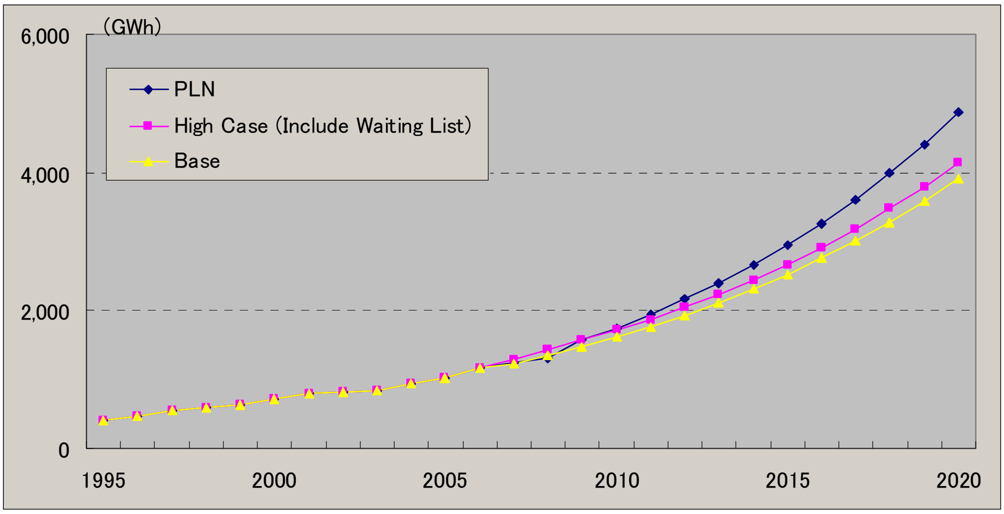


Figure 3.2.2 Demand Forecast results for North Sulawesi

Figure 3.2.1 and Figure 3.2.2 show the results against the forecast of PLN under the current RUPTL. In both regions, the results of the study team are lower than those of PLN. For North Sulawesi, the team's results are about 3/4 of PLN's forecast. In the case of South Sulawesi, it is about 2/3.

The reasons for this difference lie partly in the methodology, but mostly in the assumptions. As for the methodology, PLN forecasts various uses (residential, commercial, industrial, public) separately. The study team has made the forecast in an aggregate form for all uses. While PLN's method is more sophisticated, it will necessarily require the relatively small demand to be further subdivided into use category that may make them susceptible to random noises and fluctuations that does not reflect overall trend. The aggregate forecast used by the study team is rough, but more robust in this sense. Therefore, both approaches have their strengths and weaknesses. PLN also needs to have a consistent methodology with other regions.

The main difference, however, lies in the assumptions, especially the elasticity of demand. PLN chose a more aggressive figure than the study team. The difference was compounded over time, which led to the significant difference.

While the study team believes that the results to be sound, we must also point out that the PLN results are not necessarily out of line. Within the past 20 years, Indonesia has experienced extremely high growth (prior to the Asian Currency Crisis), and extremely low growth (after the Crisis). Therefore, depending on the period that the assumptions are based on, it is possible to make a very optimistic growth scenario, and a very conservative one. The team chose to be rather conservative, basing the assumptions on the periods mostly after 2000 where situation has stabilized. A return to the high growth era, however, may not be out of the question (although it is doubtful whether it can be sustained over an extended period.)

This figure is comparable to the historical average growth after the Asian currency crisis in 1997. Prior to the crisis, the economic boom brought a surge in demand, making the annual demand growth in Southern Sulawesi to 20%, but this was not sustainable. We feel that the current figure is a reasonable one that reflects the sustainable realities of the Sulawesi economy.

3.3 DKL and Simple-E

Initially, there have been significant comments on the use of demand forecast tools, namely DKL and Simple-E. The study team did not rely on either them in making the current forecast, but have looked at these tools.

DKL and Simple-E are demand forecast packages used by the Indonesian authorities. Both are add-on packages for the Microsoft Excel spreadsheet software. Both are based on econometric regression models. In this sense, they are both quite similar. Since the underlying engines that actually does the calculation are the same (namely Excel), there can be no difference in their accuracy or basic calculations.

It should also be pointed out that DKL is an extremely flexible package that allows the user to make many sorts of regression, and to incorporate various additional concerns like captive demand. It is, in fact, possible to create something exactly the same as Simple-E. In this sense, it is rather futile to argue about which program to use.

Table 3.3.1 Location of Systems and Jurisdiction

System	Province	PLN District	System
Sistem Gorontalo	Gorontalo	North	North
Sistem Marisa	Gorontalo	North	North
Sistem Buroko	Gorontalo	North	North
Isolated Propinsi Gorontalo	Gorontalo	North	--

System	Province	PLN District	System
Sistem Palu	Central	North	South
Sistem Poso	Central	North	South
Sistem Toli-toli	Central	North	--
Sistem Moutong-Kotaraya-Palasa	Central	North	--
Sistem Leok	Central	North	--
Sistem Kolonedale	Central	North	--
Sistem Bangkir	Central	North	--
Sistem Luwuk	Central	North	--
Sistem Ampana	Central	North	--
Sistem Banggai	Central	North	--
Isolated Tersebar	Central	North	--

System	Province	PLN District	System
Sistem Minahasa + Kotamobagu	North	North	North
Sistem Tahuna	North	North	--
Sistem Ondong / Siau	North	North	--
Sistem Talaud	North	North	--
Sistem Molibagu	North	North	--
Sistem Tagulandang	North	North	--
Sistem Bintauna	North	North	--
Isolated Propinsi SULUT	North	North	--

System	Province	PLN District	System
Sulsel	South	South	South
Selayar	South	South	--
Kendari	South - East	South	South
Kolaka	South - East	South	South
Raha	South - East	South	--
Bau Bau	South - East	South	--
Wangi Wangi	South - East	South	--
Tersebar	South	South	--

Table 3.3.2 Demand Forecast results (Total)

South	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sales (GWh)	2,685.1	2,908.9	3,216.1	3,500.5	3,810.1	4,147.1	4,513.8	4,913.0	5,302.1	5,722.1	6,175.3	6,664.3	7,192.2	7,761.8	8,376.5	9,039.9	9,755.9	10,528.6	11,362.4	12,262.3	13,233.5
Loss & Self Use (%)	14.6%	14.3%	13.9%	13.6%	13.2%	12.9%	12.5%	12.2%	11.8%	11.5%	11.1%	10.7%	10.4%	10.0%	10%	10%	10%	10%	10%	10%	10%
Generation (GWh)	3,145.7	3,393.8	3,736.8	4,050.6	4,390.9	4,759.8	5,159.8	5,593.5	6,012.3	6,462.5	6,946.6	7,467.0	8,026.6	8,624.2	9,307.2	10,044.4	10,839.9	11,698.4	12,624.9	13,624.8	14,703.9
Load Factor (%)	63.5%	63.6%	63.8%	63.9%	64.1%	64.2%	64.4%	64.5%	64.6%	64.8%	64.9%	65.1%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%
Peak Load (MW)	565.8	609.0	669.0	723.5	782.4	846.2	915.3	990.0	1,061.7	1,138.7	1,221.3	1,310.0	1,405.1	1,509.6	1,629.2	1,758.2	1,897.5	2,047.8	2,210.0	2,385.0	2,573.9

North	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sales (GWh)	1,219.1	1,353.2	1,482.9	1,620.5	1,770.8	1,934.8	2,113.7	2,309.1	2,522.1	2,754.8	3,008.5	3,285.3	3,587.1	3,916.5	4,275.9	4,668.2	5,071.7	5,510.2	5,986.9	6,505.0	7,068.1
Loss & Self Use	14.9%	13.9%	13.6%	13.2%	12.9%	12.6%	12.2%	11.9%	11.5%	11.2%	10.9%	10.5%	10.2%	9.8%	10%	10%	10%	10%	10%	10%	10%
Generation (GWh)	1,432.6	1,572.0	1,715.9	1,867.7	2,033.0	2,212.7	2,408.0	2,620.5	2,851.2	3,102.4	3,375.3	3,671.9	3,994.0	4,342.7	4,739.8	5,173.2	5,620.4	6,106.5	6,634.8	7,209.0	7,833.2
Load Factor (%)	56.5%	56.3%	56.3%	56.4%	56.6%	56.9%	57.1%	57.4%	57.7%	57.9%	58.3%	58.5%	58.8%	59.0%	59.4%	59.7%	59.7%	59.8%	59.8%	59.8%	59.8%
Peak Load (MW)	289.3	318.9	347.6	377.8	409.7	444.0	481.0	521.2	564.4	611.2	661.5	716.2	775.5	839.6	911.1	989.0	1,074.1	1,166.7	1,267.2	1,376.5	1,495.2

Table 3.3.3 Demand forecast by system (South Sulawesi)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sulsel																						
- Production (GWh)	2,533.8	2,772.3	2,991.0	3,293.2	3,569.8	3,869.7	4,194.8	4,547.3	4,929.5	5,298.6	5,695.4	6,122.0	6,580.7	7,073.8	7,600.5	8,202.5	8,852.1	9,553.2	10,309.8	11,126.3	12,007.5	12,958.5
- Load Factor (%)	65.0%	64.9%	65.1%	65.2%	65.4%	65.6%	65.7%	65.9%	66.1%	66.3%	66.4%	66.6%	66.8%	66.9%	67.1%	67.1%	67.1%	67.1%	67.1%	67.1%	67.1%	67.1%
- Peak Load (MW)	445.0	487.6	524.7	576.3	623.0	673.6	728.3	787.5	851.5	912.9	978.8	1,049.5	1,125.2	1,206.5	1,293.1	1,395.5	1,506.0	1,625.3	1,754.0	1,892.9	2,042.8	2,204.6
Selayar																						
- Production (GWh)	10.1	10.8	11.6	12.7	13.7	14.7	15.9	17.1	18.4	19.6	20.9	22.3	23.8	25.4	27.1	29.2	31.6	34.1	36.8	39.7	42.8	46.2
- Load Factor (%)	35.0%	35.8%	36.8%	37.9%	38.9%	39.9%	40.9%	41.9%	43.0%	44.0%	45.0%	46.0%	47.1%	48.1%	49.3%	49.3%	49.3%	49.3%	49.3%	49.3%	49.3%	49.3%
- Peak Load (MW)	1.8	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.9	5.1	5.3	5.5	5.8	6.0	6.3	6.8	7.3	7.9	8.5	9.2	9.9	10.7
Kendari																						
- Production (GWh)	170.2	185.1	199.7	219.5	237.5	257.0	278.1	301.0	325.7	349.5	375.0	402.4	431.7	463.3	496.9	536.2	578.7	624.5	674.0	727.3	785.0	847.1
- Load Factor (%)	58.2%	58.0%	58.1%	58.1%	58.2%	58.2%	58.3%	58.3%	58.4%	58.4%	58.5%	58.5%	58.6%	58.6%	58.9%	58.9%	58.9%	58.9%	58.9%	58.9%	58.9%	58.9%
- Peak Load (MW)	29.9	36.4	39.3	43.1	46.6	50.4	54.5	58.9	63.7	68.3	73.2	78.5	84.1	90.2	96.3	103.9	112.2	121.0	130.6	141.0	152.1	164.2
Kolaka																						
- Production (GWh)	33.5	36.6	39.5	43.6	47.3	51.4	55.8	60.6	65.8	70.9	76.3	82.2	88.5	95.2	102.5	110.6	119.4	128.9	139.1	150.1	162.0	174.8
- Load Factor (%)	42.7%	42.9%	43.3%	43.6%	44.0%	44.3%	44.7%	45.0%	45.4%	45.7%	46.1%	46.4%	46.8%	47.1%	47.6%	47.6%	47.6%	47.6%	47.6%	47.6%	47.6%	47.6%
- Peak Load (MW)	9.0	9.7	10.4	11.4	12.3	13.2	14.3	15.4	16.6	17.7	18.9	20.2	21.6	23.1	24.6	26.5	28.6	30.9	33.3	36.0	38.8	41.9
Raha																						
- Production (GWh)	20.5	22.4	24.2	26.7	29.0	31.4	34.1	37.0	40.2	43.3	46.6	50.1	54.0	58.1	62.5	67.5	72.8	78.6	84.8	91.5	98.7	106.6
- Load Factor (%)	50.5%	50.5%	50.7%	50.9%	51.0%	51.2%	51.4%	51.5%	51.7%	51.9%	52.1%	52.2%	52.4%	52.6%	52.9%	52.9%	52.9%	52.9%	52.9%	52.9%	52.9%	52.9%
- Peak Load (MW)	3.6	5.1	5.5	6.0	6.5	7.0	7.6	8.2	8.9	9.5	10.2	11.0	11.8	12.6	13.5	14.6	15.7	17.0	18.3	19.7	21.3	23.0
Bau Bau																						
- Production (GWh)	33.6	38.2	41.3	46.5	51.5	57.0	63.2	69.9	77.3	84.8	92.9	101.8	111.5	122.1	133.6	144.2	155.6	168.0	181.3	195.6	211.1	227.8
- Load Factor (%)	51.4%	51.8%	52.4%	53.0%	53.6%	54.2%	54.9%	55.5%	56.1%	56.7%	57.3%	57.9%	58.5%	59.1%	59.9%	59.9%	59.9%	59.9%	59.9%	59.9%	59.9%	59.9%
- Peak Load (MW)	5.9	8.4	9.0	10.0	11.0	12.0	13.1	14.4	15.7	17.1	18.5	20.1	21.8	23.6	25.5	27.5	29.7	32.0	34.5	37.3	40.2	43.4
Wangi Wangi																						
- Production (GWh)	5.3	5.9	6.3	7.0	7.7	8.4	9.2	10.1	11.0	12.0	13.0	14.1	15.3	16.5	17.9	19.4	20.9	22.5	24.3	26.3	28.3	30.6
- Load Factor (%)	52.7%	52.6%	52.7%	52.8%	52.8%	52.9%	53.0%	53.0%	53.1%	53.2%	53.3%	53.3%	53.4%	53.5%	53.7%	53.7%	53.7%	53.7%	53.7%	53.7%	53.7%	53.7%
- Peak Load (MW)	1.1	1.3	1.4	1.5	1.7	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.5	3.8	4.1	4.4	4.8	5.2	5.6	6.0	6.5
Tersebar																						
- Production (GWh)	69.7	74.3	80.2	87.5	94.1	101.1	108.7	116.8	125.5	133.7	142.4	151.7	161.5	172.1	183.1	197.7	213.3	230.2	248.4	268.1	289.3	312.3
- Load Factor (%)	58.2%	61.5%	60.2%	59.3%	58.3%	57.3%	56.4%	55.4%	54.5%	53.5%	52.6%	51.6%	50.6%	49.7%	44.8%	44.8%	44.8%	44.8%	44.8%	44.8%	44.8%	44.8%
- Peak Load (MW)	12.2	13.8	15.2	16.9	18.4	20.1	22.0	24.0	26.3	28.5	30.9	33.6	36.4	39.5	46.7	50.4	54.4	58.7	63.3	68.3	73.7	79.6
Total South																						
- Production (GWh)	2,881.7	3,145.7	3,393.8	3,736.8	4,050.6	4,390.9	4,759.8	5,159.8	5,593.5	6,012.3	6,462.5	6,946.6	7,467.0	8,026.6	8,624.2	9,307.2	10,044.4	10,839.9	11,698.4	12,624.9	13,624.8	14,703.9
- Load Factor (%)	65.0%	63.5%	63.6%	63.8%	63.9%	64.1%	64.2%	64.4%	64.5%	64.6%	64.8%	64.9%	65.1%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%	65.2%
- Peak Load (MW)	445.0	565.8	609.0	669.0	723.5	782.4	846.2	915.3	990.0	1,061.7	1,138.7	1,221.3	1,310.0	1,405.1	1,509.6	1,629.2	1,758.2	1,897.5	2,047.8	2,210.0	2,385.0	2,573.9

Table 3.3.4 Demand forecast by system (North Sulawesi Province)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Sistem Minahasa - Kotamobagu																				
- Production (GWh)	774.3	849.5	923.4	1,003.7	1,081.9	1,176.8	1,279.9	1,392.1	1,513.8	1,646.1	1,789.9	1,946.0	2,115.5	2,298.7	2,508.6	2,737.6	2,988.4	3,262.3	3,561.2	3,887.4
- Load Factor (%)	60.2	60.2	60.3	60.3	60.7	61.0	61.4	61.7	62.1	62.4	62.9	63.3	63.7	64.1	64.5	64.9	64.9	64.9	64.9	64.9
- Peak Load (MW)	146.9	161.0	174.9	190.1	203.4	220.1	238.1	257.6	278.4	300.9	324.8	351.0	379.2	409.5	444.1	481.7	525.8	574.0	626.6	684.0
Sistem Tahuna																				
- Production (GWh)	21.8	24.2	26.5	29.1	31.9	35.0	38.4	42.2	46.2	50.7	55.6	61.0	66.9	73.3	80.7	88.8	96.9	105.8	115.5	126.1
- Load Factor (%)	40.3	40.4	40.5	40.6	40.9	41.2	41.5	41.8	42.2	42.5	42.9	43.3	43.7	44.1	44.4	44.8	44.8	44.8	44.8	44.8
- Peak Load (MW)	6.2	6.8	7.5	8.2	8.9	9.7	10.6	11.5	12.5	13.6	14.8	16.1	17.5	19.0	20.7	22.6	24.7	26.9	29.4	32.1
Sistem Ondong /Siau																				
- Production (GWh)	7.4	8.2	8.9	9.7	10.6	11.7	12.8	14.0	15.3	16.8	18.4	20.1	22.1	24.1	26.5	29.2	31.9	34.8	38.0	41.4
- Load Factor (%)	41.7	41.8	41.8	41.9	42.1	42.4	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.8	45.1	45.4	45.4	45.4	45.4	45.4
- Peak Load (MW)	2.0	2.2	2.4	2.6	2.9	3.1	3.4	3.7	4.1	4.4	4.8	5.2	5.7	6.2	6.7	7.3	8.0	8.7	9.5	10.4
Sistem Talaud																				
- Production (GWh)	6.7	7.4	8.1	8.9	9.7	10.6	11.7	12.8	14.0	15.3	16.8	18.4	20.1	22.0	24.2	26.6	29.1	31.7	34.6	37.8
- Load Factor (%)	35.7	35.7	35.8	35.8	36.0	36.3	36.5	36.8	37.0	37.3	37.6	37.9	38.2	38.5	38.8	39.1	39.1	39.1	39.1	39.1
- Peak Load (MW)	2.1	2.4	2.6	2.8	3.1	3.3	3.6	4.0	4.3	4.7	5.1	5.5	6.0	6.5	7.1	7.8	8.5	9.3	10.1	11.1
Sistem Molibagu																				
- Production (GWh)	4.6	5.1	5.5	6.0	6.5	7.1	7.7	8.4	9.1	9.9	10.8	11.8	12.8	13.9	15.2	16.6	18.1	19.7	21.6	23.5
- Load Factor (%)	25.9	26.3	26.8	27.3	27.9	28.6	29.3	29.9	30.7	31.4	32.2	33.0	33.8	34.7	35.5	36.4	36.4	36.4	36.4	36.4
- Peak Load (MW)	2.0	2.2	2.3	2.5	2.7	2.8	3.0	3.2	3.4	3.6	3.8	4.1	4.3	4.6	4.9	5.2	5.7	6.2	6.8	7.4
Sistem Tagulandang																				
- Production (GWh)	3.9	4.3	4.8	5.2	5.8	6.3	7.0	7.6	8.4	9.2	10.1	11.1	12.2	13.4	14.8	16.3	17.9	19.7	21.8	24.0
- Load Factor (%)	30.4	30.7	30.9	31.2	31.6	32.1	32.5	33.0	33.5	34.0	34.5	35.1	35.6	36.1	36.7	37.2	37.2	37.2	37.2	37.2
- Peak Load (MW)	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.9	3.1	3.3	3.6	3.9	4.2	4.6	5.0	5.5	6.1	6.7	7.3
Sistem Bintauna																				
- Production (GWh)	0.0	0.0	0.0	0.0	9.2	10.1	11.1	12.3	13.5	14.9	16.4	18.0	19.8	21.8	24.1	26.6	29.4	32.4	35.8	39.5
- Load Factor (%)					45.3	45.6	45.8	46.1	46.4	46.7	47.0	47.3	47.6	48.0	48.3	48.6	48.6	48.6	48.6	48.6
- Peak Load (MW)					2.3	2.5	2.8	3.0	3.3	3.6	4.0	4.3	4.8	5.2	5.7	6.3	6.9	7.6	8.4	9.3
Isolated Propinsi SULUT																				
- Production (GWh)	5.0	6.0	7.3	8.6	10.1	10.7	11.3	12.0	12.7	13.4	14.1	14.8	15.5	16.3	17.1	17.9	19.0	20.2	21.5	22.9
- Load Factor (%)	19.2	20.3	21.3	22.3	23.4	23.6	23.9	24.2	24.5	24.8	25.1	25.5	25.8	26.1	26.5	26.8	26.8	26.8	26.8	26.8
- Peak Load (MW)	3.0	3.4	3.9	4.4	4.9	5.2	5.4	5.7	5.9	6.1	6.4	6.6	6.9	7.1	7.4	7.6	8.1	8.6	9.2	9.7
North Total																				
- Production (GWh)	823.7	904.7	984.5	1,071.2	1,165.7	1,268.4	1,379.9	1,501.3	1,633.0	1,776.4	1,932.1	2,101.2	2,284.9	2,483.6	2,711.2	2,959.6	3,230.7	3,526.8	3,849.9	4,202.6
- Load Factor (%)	57.4	57.5	57.5	57.5	57.8	58.1	58.5	58.8	59.2	59.6	60.1	60.5	60.9	61.3	61.7	62.2	62.2	62.2	62.2	62.2
- Peak Load (MW)	163.7	179.7	195.4	212.5	230.2	249.0	269.4	291.4	314.8	340.1	367.0	396.5	428.2	462.3	501.3	543.5	593.2	647.5	706.7	771.4

Table 3.3.5 Demand forecast by system (Central Sulawesi Province)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sistem Palu																					
- Production (GWh)	226.2	253.0	278.0	303.6	331.4	361.8	394.9	431.0	470.4	513.3	560.1	611.0	666.5	727.0	793.0	865.0	932.9	1,006.1	1,085.1	1,170.3	1,262.2
- Load Factor (%)	60.0	60.2	60.5	60.8	61.1	61.4	61.8	62.1	62.4	62.8	63.1	63.4	63.8	64.1	64.4	64.8	64.8	64.8	64.8	64.8	64.8
- Peak Load (MW)	43.1	48.0	52.5	57.0	61.9	67.2	73.0	79.2	86.0	93.4	101.3	110.0	119.3	129.5	140.5	152.4	164.4	177.3	191.2	206.2	222.4
Sistem Poso																					
- Production (GWh)	23.2	26.0	28.5	31.2	34.0	37.1	40.5	44.2	48.3	52.7	57.5	62.7	68.4	74.6	81.4	88.8	95.8	103.3	111.4	120.1	129.6
- Load Factor (%)	50.2	50.1	50.4	50.6	50.9	51.1	51.4	51.7	51.9	52.2	52.5	52.7	53.0	53.3	53.5	53.8	53.8	53.8	53.8	53.8	53.8
- Peak Load (MW)	5.3	5.9	6.5	7.0	7.6	8.3	9.0	9.8	10.6	11.5	12.5	13.6	14.7	16.0	17.4	18.8	20.3	21.9	23.6	25.5	27.5
Sistem Toli-toli																					
- Production (GWh)	22.2	24.8	27.3	29.8	32.5	35.5	38.8	42.3	46.2	50.4	55.0	60.0	65.4	71.4	77.8	84.9	91.6	98.8	106.5	114.9	123.9
- Load Factor (%)	42.2	42.1	42.4	42.6	42.8	43.1	43.3	43.6	43.8	44.1	44.3	44.6	44.8	45.1	45.4	45.6	45.6	45.6	45.6	45.6	45.6
- Peak Load (MW)	6.0	6.7	7.4	8.0	8.7	9.4	10.2	11.1	12.0	13.0	14.2	15.4	16.7	18.1	19.6	21.2	22.9	24.7	26.7	28.8	31.0
Sistem Moutong - Kotaraya - Palasa																					
- Production (GWh)	15.6	17.5	19.2	21.0	22.9	25.0	27.3	29.8	32.5	35.4	38.7	42.2	46.0	50.2	54.8	59.7	64.4	69.5	74.9	80.8	87.2
- Load Factor (%)	35.3	35.1	35.3	35.5	35.7	35.9	36.2	36.4	36.6	36.8	37.0	37.2	37.5	37.7	37.9	38.1	38.1	38.1	38.1	38.1	38.1
- Peak Load (MW)	5.0	5.7	6.2	6.7	7.3	7.9	8.6	9.3	10.1	11.0	11.9	12.9	14.0	15.2	16.5	17.9	19.3	20.8	22.4	24.2	26.1
Sistem Leok																					
- Production (GWh)	7.9	8.8	9.7	10.6	11.6	12.6	13.8	15.1	16.4	17.9	19.6	21.4	23.3	25.4	27.7	30.2	32.6	35.2	37.9	40.9	44.1
- Load Factor (%)	23.5	28.3	28.4	28.6	28.8	28.9	29.1	29.2	29.4	29.6	29.7	29.9	30.1	30.2	30.4	30.6	30.6	30.6	30.6	30.6	30.6
- Peak Load (MW)	3.8	3.6	3.9	4.2	4.6	5.0	5.4	5.9	6.4	6.9	7.5	8.1	8.8	9.6	10.4	11.3	12.2	13.1	14.2	15.3	16.5
Sistem Kolonedale																					
- Production (GWh)	7.2	8.0	8.8	9.6	10.5	11.4	12.5	13.6	14.9	16.2	17.7	19.3	21.1	23.0	25.1	27.3	29.5	31.8	34.3	37.0	39.9
- Load Factor (%)	45.8	45.6	45.8	46.0	46.3	46.5	46.8	47.0	47.2	47.5	47.7	48.0	48.2	48.5	48.7	49.0	49.0	49.0	49.0	49.0	49.0
- Peak Load (MW)	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.2	4.6	5.0	5.4	5.9	6.4	6.9	7.4	8.0	8.6	9.3
Sistem Bangkir																					
- Production (GWh)	2.0	2.2	2.4	2.6	2.9	3.1	3.4	3.7	4.1	4.4	4.8	5.3	5.8	6.3	6.9	7.5	8.1	8.7	9.4	10.1	10.9
- Load Factor (%)	21.6	21.5	21.6	21.7	21.9	22.0	22.1	22.2	22.3	22.5	22.6	22.7	22.8	23.0	23.1	23.2	23.2	23.2	23.2	23.2	23.2
- Peak Load (MW)	1.0	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.7	2.9	3.1	3.4	3.7	4.0	4.3	4.6	5.0	5.4
Sistem Luwuk																					
- Production (GWh)	40.3	45.0	49.5	54.0	59.0	64.4	70.3	76.7	83.7	91.4	99.7	108.8	118.7	129.4	141.2	154.0	166.1	179.1	193.2	208.4	224.7
- Load Factor (%)	52.8	52.7	53.0	53.2	53.5	53.8	54.1	54.4	54.6	54.9	55.2	55.5	55.8	56.1	56.4	56.6	56.6	56.6	56.6	56.6	56.6
- Peak Load (MW)	8.7	9.8	10.7	11.6	12.6	13.7	14.8	16.1	17.5	19.0	20.6	22.4	24.3	26.4	28.6	31.0	33.5	36.1	38.9	42.0	45.3
Sistem Ampana																					
- Production (GWh)	7.7	8.6	9.5	10.4	11.3	12.3	13.5	14.7	16.0	17.5	19.1	20.8	22.7	24.8	27.0	29.5	31.8	34.3	37.0	39.9	43.1
- Load Factor (%)	47.8	47.5	47.7	48.0	48.3	48.5	48.8	49.0	49.3	49.5	49.8	50.1	50.3	50.6	50.8	51.1	51.1	51.1	51.1	51.1	51.1
- Peak Load (MW)	1.8	2.1	2.3	2.5	2.7	2.9	3.2	3.4	3.7	4.0	4.4	4.8	5.2	5.6	6.1	6.6	7.1	7.7	8.3	8.9	9.6

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sistem Banggai																					
- Production (GWh)	4.8	5.3	5.9	6.4	7.0	7.6	8.3	9.1	9.9	10.8	11.8	12.9	14.1	15.4	16.8	18.3	19.7	21.3	22.9	24.7	26.7
- Load Factor (%)	45.5	45.5	45.7	45.9	46.2	46.4	46.6	46.9	47.1	47.3	47.6	47.8	48.0	48.3	48.5	48.8	48.8	48.8	48.8	48.8	48.8
- Peak Load (MW)	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.8	6.2
Isolated Tersebar																					
- Production (GWh)	19.3	21.6	23.8	26.0	28.3	30.9	33.8	36.9	40.2	43.9	47.9	52.3	57.0	62.2	67.8	74.0	79.8	86.0	92.8	100.1	108.0
- Load Factor (%)	20.0	21.0	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.0	21.0	20.9	20.7	20.6	20.3	20.1	20.1	20.1	20.1	20.1	20.1
- Peak Load (MW)	11.0	11.7	12.9	14.0	15.3	16.7	18.2	19.9	21.8	23.8	26.1	28.6	31.4	34.5	38.1	42.1	45.4	48.9	52.8	56.9	61.4
Central Total																					
- Production (GWh)	376.4	420.9	462.6	505.1	551.5	602.0	657.1	717.2	782.6	854.0	931.9	1,016.7	1,109.1	1,209.7	1,319.5	1,439.2	1,552.2	1,674.1	1,805.5	1,947.3	2,100.2
- Load Factor (%)	48.4	49.0	49.3	49.5	49.8	50.0	50.2	50.5	50.7	50.9	51.1	51.3	51.5	51.7	51.9	52.0	52.0	52.0	52.0	52.0	52.0
- Peak Load (MW)	88.8	98.0	107.2	116.4	126.5	137.5	149.3	162.2	176.2	191.5	208.1	226.1	245.7	267.0	290.3	315.7	340.5	367.2	396.0	427.1	460.7

Table 3.3.6 Demand forecast by system (Gorontalo Province)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Sistem Gorontalo																					
- Production (GWh)	130.85	146.96	161.78	176.83	193.34	211.35	231.03	252.50	275.87	301.48	329.43	359.93	393.17	429.57	469.24	512.58	554.67	600.22	649.52	702.86	760.58
- Load Factor (%)	57.74	57.43	57.69	57.95	58.21	58.48	58.74	59.01	59.28	59.55	59.82	60.09	60.36	60.63	60.91	61.18	61.18	61.18	61.18	61.18	61.18
- Peak Load (MW)	25.87	29.21	32.01	34.83	37.91	41.26	44.90	48.85	53.13	57.80	62.87	68.38	74.36	80.88	87.95	95.63	103.49	111.99	121.18	131.14	141.90
Sistem Marisa																					
- Production (GWh)	20.44	22.97	25.30	27.67	30.27	33.11	36.22	39.61	43.31	47.36	51.78	56.61	61.87	67.62	73.87	80.69	87.31	94.48	102.24	110.64	119.73
- Load Factor (%)	34.71	34.86	35.35	35.85	36.36	36.88	37.40	37.93	38.47	39.02	39.57	40.13	40.70	41.28	41.86	42.46	42.46	42.46	42.46	42.46	42.46
- Peak Load (MW)	6.72	7.52	8.17	8.81	9.50	10.25	11.05	11.92	12.85	13.86	14.94	16.10	17.35	18.70	20.14	21.69	23.48	25.40	27.49	29.75	32.19
Sistem Buroko																					
- Production (GWh)	2.04	2.29	2.52	2.76	3.01	3.29	3.60	3.93	4.30	4.70	5.13	5.61	6.13	6.70	7.31	7.99	8.64	9.35	10.12	10.95	11.85
- Load Factor (%)	11.36	11.41	11.58	11.75	11.92	12.09	12.27	12.44	12.62	12.81	12.99	13.18	13.37	13.57	13.77	13.97	13.97	13.97	13.97	13.97	13.97
- Peak Load (MW)	2.05	2.29	2.49	2.68	2.89	3.11	3.35	3.61	3.89	4.19	4.51	4.86	5.23	5.63	6.06	6.53	7.07	7.65	8.27	8.95	9.69
Isolated Propinsi Gorontalo																					
- Production (GWh)	3.53	3.95	4.33	4.72	5.14	5.60	6.10	6.64	7.26	7.91	8.61	9.37	10.20	11.12	12.15	13.27	14.36	15.54	16.82	18.20	19.70
- Load Factor (%)	19.55	20.25	20.97	21.57	22.09	22.54	22.95	23.32	23.66	23.98	24.28	24.57	24.83	25.08	25.32	25.54	25.54	25.54	25.54	25.54	25.54
- Peak Load (MW)	2.06	2.23	2.36	2.50	2.66	2.84	3.03	3.25	3.50	3.76	4.05	4.36	4.69	5.06	5.48	5.93	6.42	6.95	7.52	8.14	8.80
Gorontalo Total																					
- Production (GWh)	156.86	176.17	193.93	211.98	231.76	253.36	276.94	302.68	330.74	361.45	394.96	431.52	471.37	515.01	562.57	614.52	664.99	719.61	778.70	842.65	911.86
- Load Factor (%)	48.79	48.75	49.17	49.57	49.96	50.34	50.72	51.09	51.46	51.83	52.20	52.57	52.95	53.31	53.68	54.05	54.05	54.05	54.05	54.05	54.05
- Peak Load (MW)	36.70	41.25	45.03	48.82	52.96	57.46	62.33	67.63	73.37	79.61	86.37	93.70	101.63	110.27	119.63	129.79	140.45	151.98	164.47	177.97	192.59

3.4 Substation Demand Data

In this section, the data for each substation are made from the demand forecast previously prepared. The results are shown in Table 3.4.1 Substation Demand Data in South Sulawesi SystemTable 3.4.1 and Table 3.4.2. Details of the data preparation are shown in Appendix.

Table 3.4.1 Substation Demand Data in South Sulawesi System

Area	Substation	Demand (MW) for each year				
		(2007)	2012	2017	2022	2027
Sulsel	Pangkep	13.3	21.7	33.3	50.0	76.1
	Mandai	14.0	21.2	30.3	42.5	60.0
	Maros	5.4	8.2	11.7	16.4	23.2
	Daya	17.8	31.4	51.5	82.8	135.4
	Tello	22.9	37.4	57.3	86.2	131.0
	Tallo Lama	34.2	55.9	85.6	128.7	195.7
	Bontoala	36.0	58.8	90.1	135.5	206.0
	Panakkukang	46.2	75.5	115.6	173.8	264.4
	Borongloe	6.9	10.4	14.9	20.9	29.6
	Sungguminasa	19.0	28.8	41.1	57.6	81.5
	Tallasa	11.0	16.6	23.8	33.4	47.2
	Tanjung Bunga	16.5	27.0	41.3	62.1	94.4
	Pare Pare	10.4	15.7	22.5	31.5	44.6
	Barru	4.7	7.1	10.2	14.3	20.2
	Bakaru	3.3	5.0	7.1	10.0	14.2
	Pinrang	11.5	17.4	24.9	34.9	49.3
	Polmas	9.8	16.0	24.5	36.9	56.1
	Majene	8.5	12.9	18.4	25.8	36.4
	Soppeng	11.7	19.1	29.3	44.0	67.0
	Bone	22.9	37.4	57.3	86.2	131.0
	Sidrap	13.3	20.1	28.7	40.3	57.0
	Sengkang	14.3	15.5	23.8	35.7	54.4
	Siwa	-	7.3	10.4	14.6	20.6
	Bulukumba	14.8	22.4	32.0	44.9	63.5
	Jeneponto	10.7	16.2	23.1	32.4	45.9
	Sinjai	9.8	14.8	21.2	29.7	42.0
	Palopo	9.7	15.8	24.3	36.5	55.5
	Makale	5.5	8.3	11.9	16.7	23.6
	Tonasa	43.8	44.4	44.0	43.0	41.5
	Bosowa	34.4	34.9	34.5	33.8	32.6
	Barawaja	5.1	5.2	5.1	5.0	4.8
South (except Sulsel)	Wotu	3.5	5.2	7.6	10.9	15.9
	Malili	1.5	2.2	3.2	4.7	6.8
West	Mamuju	5.2	7.8	11.2	16.1	23.5
South East	Kendari	36.4	36.3	52.3	74.8	109.5
	Unaha	-	18.2	26.2	37.4	54.7
	Kolaka	9.7	14.3	20.2	28.6	41.9
	Lasasua	2.5	3.7	5.4	7.8	11.4

Table 3.4.2 Substation Demand Data in North Sulawesi System

Area	Substation	Demand (MW) for each year				
		(2007)	2012	2017	2022	2027
Minahasa	Tonsealama	5.3	7.8	11.3	16.4	24.7
	Sawangan	10.0	14.7	21.3	30.9	46.5
	Bitung	18.9	11.9	16.1	16.1	16.1
	Kema	-	11.9	18.5	34.0	63.5
	Likupang	-	4.0	5.8	8.4	8.4
	Ranomut	28.6	21.1	30.5	32.8	32.8
	Paniki	-	21.1	30.5	55.6	100.3
	Teling	29.3	28.8	41.7	60.4	90.9
	Tateli	-	14.4	20.8	30.2	45.4
	Tomohon	8.5	12.5	18.1	26.3	39.6
	Tasik Ria	3.4	6.1	10.5	18.4	34.0
	Kawangkoan	11.8	17.4	25.2	36.5	54.9
	Lopana	8.4	15.0	26.1	45.5	84.1
	Otam	22.7	22.3	32.3	46.8	70.4
	Lolak	-	11.2	16.1	23.4	35.2
North (except Minahasa)	Bintauna	-	2.5	4.0	6.3	10.2
	Molibagu	2.0	2.8	3.8	5.2	8.1
Gorontalo	Gorontalo	25.9	34.4	52.4	79.7	118.3
	Isim	-	6.9	10.5	15.9	23.7
	Marisa	6.7	10.3	14.9	21.7	32.2
	Buroko	2.1	3.1	4.5	6.5	9.7
Central	Talise	36.6	50.4	76.0	114.3	166.8
	Paligi	6.5	10.1	15.2	22.9	33.4
	Donggala	-	6.7	10.1	15.2	22.2
	Poso	5.3	8.3	12.5	18.8	27.5
	Toli-toli	6.0	9.4	14.2	21.2	31.0
	Moutong - Kotaraya -	5.0	7.9	11.9	17.9	26.1
	Leok	3.8	5.0	7.5	11.3	16.5
	Kolonedale	1.8	2.8	4.2	6.4	9.3
	Bangkir	1.0	1.6	2.4	3.7	5.4
	Luwuk	8.7	13.7	20.6	31.0	45.3
	Ampana	1.8	2.9	4.4	6.6	9.6

Appendix 1 Preparation of Substation Demand Data

(1) South Sulawesi System

Preparation method of substation demand data in Sulsel system (in Southern system) is as follows.

i) Substation demand data on 2007 was made by load flow diagram and actual demand.

ii) Set growth ratio for each substations

- Three types of growth ratio was set, first is base ratio which was based on Sulsel growth ratio on Table 3.3.3. Second is 1.2 times and third is 1.4 times of base ratio.
- One of the growth ratio listed above was applied for each substations. The type was decided by prospect of each area based on RUPTL data or information from PLN.

iii) Calculation of each substation demand

- From the actual demand of 2007 and growth ratio as above, calculate each substation demand up to 2027.
- To equalize summation of substation to Sulsel system demand on Table 3.3.3, suppress substation demands by same ratio.

Substation data on other systems listed below were made by demand forecast result on Table 3.3.3.

<table>
<tr><th></th><th>Area</th><th>Substation</th><th>Remarks</th></tr>
<tr><td rowspan="3">Substations in South Sulawesi</td><td>South except Sulsel</td><td>Wotu,
Malili</td><td></td></tr>
<tr><td>South East</td><td>Kendari
Unaha
Kolaka
Lasausa</td><td>Unaha will be divided from Kendari as follows:
Kendari:Unaha=2:1</td></tr>
<tr><td>West</td><td>Mamuju</td><td></td></tr>
</table>

(2) North Sulawesi System

Preparation method of substation demand data in Minahasa-Kotamobagu system (in Northern system) is as follows.

i) Substation demand data on 2007 was made by load flow diagram and actual demand.

ii) Set growth ratio for each substations

- 2 types of growth ratio was set, first is base ratio which was based on Minahasa-Kotamobagu growth ratio on table 3.3.4, and second is 1.5.
- One of the growth ratios (base ratio or 1.5 times) was applied for each substation. The type was decided by prospect of each area based on RUPTL data or information from PLN.

iii) Calculation of each substation demand

- From the actual demand of 2007 and growth ratio as above, calculate each substation demand up to 2027.
- To equalize summation of substation to Minahasa-Kotamobagu system demand on table 3.3.4, suppress substation demands by same ratio.

Substation data on other systems listed below were made by demand forecast result on Table 3.3.4 to Table 3.3.6.

	Area	Substation	Remarks
Substations in North Sulawesi (except Minahasa)	North	Bintauna, Molibagu	
	Gorontalo	Gorontalo Isimu Marisa Buroko	Isimu will be divided from Gorontalo as follows: Gorontalo:Isimu=5:1
	Central	Talise Parigi Donggala Poso Toli-Toli Moutong-Kotaraya-Palisa Leok Kolonedale Bangkir Luwuk Ampana	Parigi and Donggala will be divided from Talise as follows: Talise:Parigi:Gorontalo=15:3:2

For actual PSS/E analysis, some substation demands were divided if these became too large (especially in urban area). Then, some 70/20kV substation demands were transferred to nearby 150/20 substation to avoid reinforcement of 70 kV system.

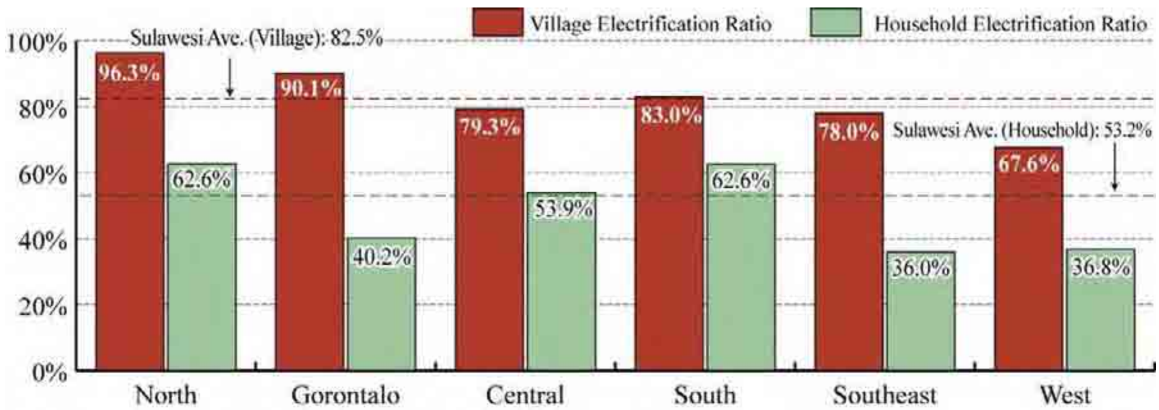
Chapter 4 Rural Electrification

4.1 Current Situation of Rural Electrification in Sulawesi

4.1.1 Electrification Ratio in Sulawesi

Figure 4.1.1 indicates village electrification ratio[5] and household electrification ratio[6] of Sulawesi by provinces. According to PLN Statistics in 2006, out of 6,490 villages in the Island, 5,353 villages were electrified by PLN; village electrification ratio of the island was 82.5%. Village electrification ratios in North Sulawesi and Gorontalo Provinces were high at 96.3% and 90.1% in 2006, respectively. However, that of West Sulawesi was only 67.6%, one-third of villages were remained un-electrified. Village electrification ratio of Sulawesi was slightly higher than the national average of 80.9%, but was still considerably lower than the Java Island of 99.4%.

The household electrification ratio in the Island was only 53.2%. The household electrification ratio was higher in South Sulawesi (62.6%) and North Sulawesi (62.3%), but was considerably lower in Southeast Sulawesi (36.0%) and West Sulawesi (36.8%). Household electrification ratios were far lower than village electrification ratio. Particularly, in the case of Gorontalo, while village electrification ratio was reached 90.1%, household electrification ratio was low at 40.2%.



Source: PLN North and South Sulawesi Branch Statistics 2006

*Note: Due to data constraints, data of Kabupaten Pinrang in South Sulawesi was included not in South Sulawesi but in West Sulawesi

Figure 4.1.1 Province-wise Village and Household Electrification Ratio in 2006

The lower household electrification ratio is mainly resulted from insufficient capability for paying connection fee and electricity tariff. In addition, PLN's rejection for connecting new customer due to lack of generating capacity (especially true for small isolated diesel system), and to distant households from the existing distribution system, is also considered to be

[5] Number of Electrified Villages (Desa) ÷ Number of Villages × 100. Here, electrified villages indicate the villages electrified by PLN, as well as the villages electrified by other parties but O&M activities were transferred to PLN.

[6] Number of Electrified Household in rural area ÷ Number of Villages in rural area × 100. Here, "electrified household" includes only PLN's official customers. Households received electricity from their own generators / PV, from privately mini grids, and from electrified neighbors are not included.

attributed lower household electrification ratio.

4.1.2 Historical Changes in the Rural Electrification Ratios in Sulawesi

PLN's has been playing vital role for increasing accessibility of electricity in rural area of the country, with financial and technical support from foreign donor agencies. Village electrification ratio of Sulawesi rose from 39.0% in 1990 to 82.6% in 2006, which includes the villages electrified by PLN.

Figure 4.1.2 illustrates change in the province-wise village electrification ratios of Sulawesi from 1990 to 2006. As shown in the figure, village electrification ratios have rapidly increased during 1990 and 1997. During the period 2,531 villages were electrified in Sulawesi, which accounted 47.4% of the existing electrified villages. Increase in the number of newly electrified village slowed down significantly after the economic crisis in 1997.

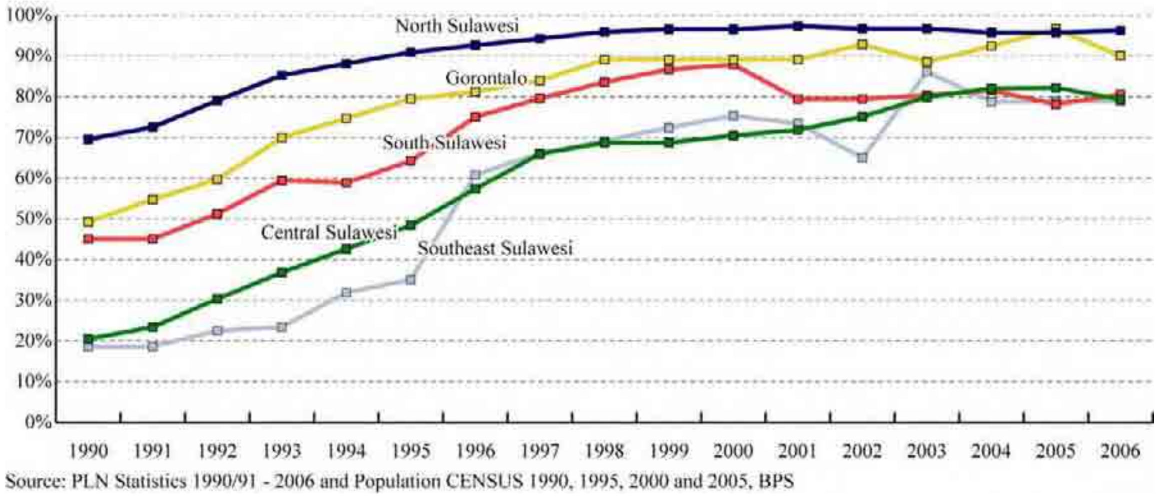


Figure 4.1.2 Change in the province-wise village electrification ratio of Sulawesi 1990 - 2006

As the Figure 4.1.3 shows, the household electrification ratio in Sulawesi has progressively increased. Household electrification ratio of Sulawesi rose from 21.3% in 1990 to 53.2% in 2006 for PLN official connections only.

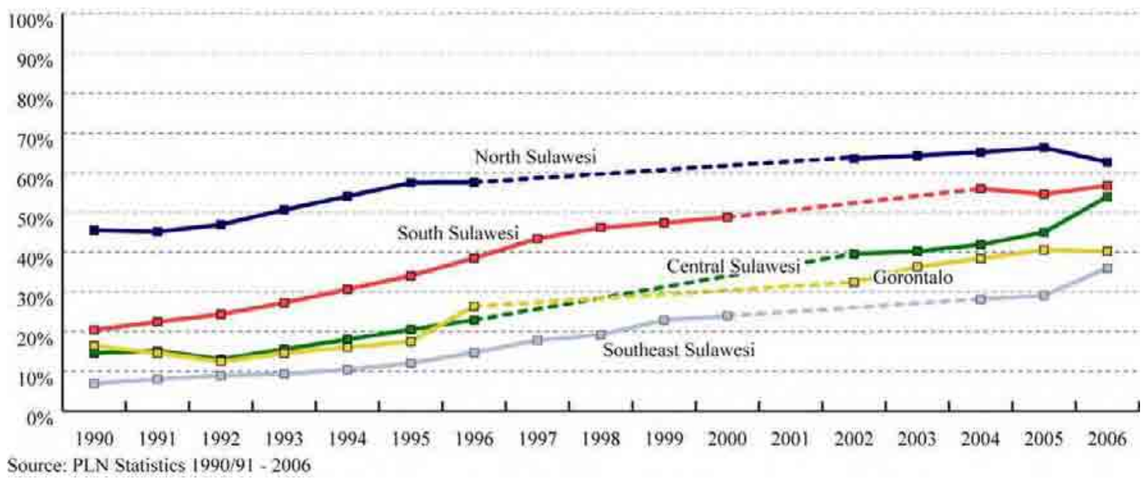


Figure 4.1.3 Change in the province-wise household electrification ratio of Sulawesi 1990 - 2006

As shown in the above figures, household electrification ratio increased more slowly than village electrification ratio. This indicates the Government of Indonesia placed relatively greater importance of extension (connecting more villages) compared to intensification (connecting more customers in electrified villages) in the overall process.

A crude estimate shows that about 65% of households in these electrified villages actually are connected. This kind of coverage shows the degree to which connectivity permeates village environments once PLN electrification arrives. It also shows, however, that there still is significant scope for increasing the customer base in many of these electrified villages.

It is important to keep in mind that PLN's household electrification ratio of 53.2% figure does not represent the full share of electrified households. In reality, Intercensal survey 2005 of BPS indicates that nearly 70% of rural households in the Sulawesi Island use electricity for their primary lighting source.

4.1.3 Household Electrification Ratio and Electricity Penetration Ratio in the Sulawesi Island

(1) Estimation of the Household Electrification Ratio including Non-PLN Supply

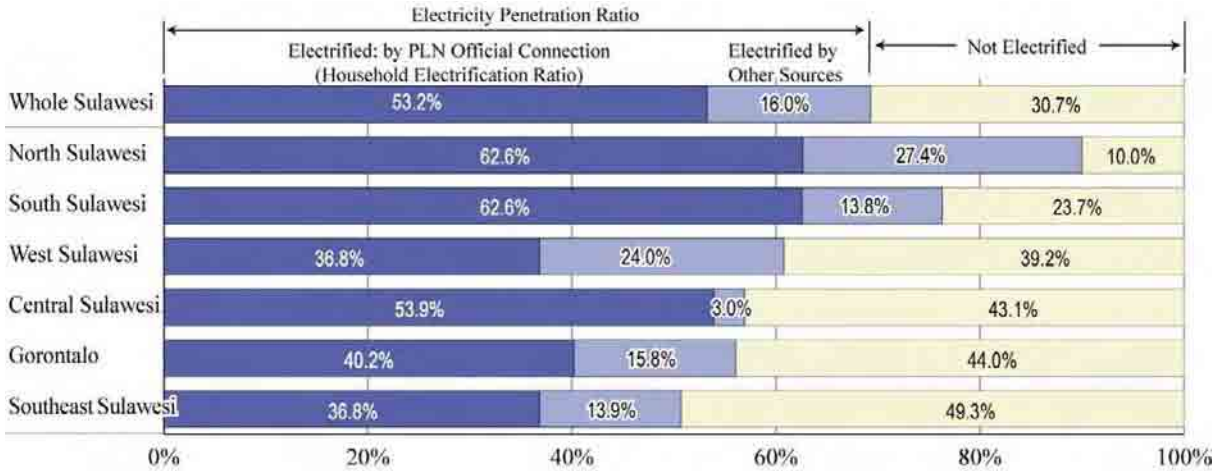
Electrification ratios discussed in the previous section were the electrification supplied by PLN in rural area. The household electrification ratios were measured based on the number of PLN connections, which does not accurately portray the actual number of households due to many instances where more than one household is served by a single connection. Un-ignorable numbers of households are supplied electricity by the local government owned mini grids, privately owned diesel generators, battery charging station, micro-hydro and etc. Also, other institutions or NGOs have contributed to rural electrification, notably by the dissemination of solar home systems (SHS). In addition to the number of electrified villages/households, total number of villages/households used in PLN statistics as denominators for calculating electrification ratio are different from the National Statistics Agency's (BPS)

Census data[7].

To know more precise household electrification ratio in Sulawesi, Census 2005 data was adopted; number of households using electricity as primary source of energy divided by number of household, which may indicate true penetration of electricity (hereafter called as the electricity penetration ratio).

(2) Electrification by PLN and by Non-PLN

According to the Intercensal data 2005, percentage of rural household using electricity as a primary lighting source in rural area of Sulawesi was 69.3%[8] (96.4% in urban area, and 77.0% in whole area). Since PLN statistics indicated that household electrification ratio of rural area of Sulawesi Island was 53.2%, remaining 16.0% of households are supplied electricity from other sources. Electricity penetration ratio in rural area of North Sulawesi, including non-PLN supply, was high at 90.0% (62.6%: PLN official connections, and 27.4%: other sources). On the other hand, the ratio was the lowest in Southeast Sulawesi of 50.8% (36.8%: PLN official connections, and 13.9%: other sources).



Source: Intercensal Survey 2005 and PLN North and South Sulawesi Branch Statistics 2006

Figure 4.1.4 Percentage of Electrified Villages by Sources

(3) Change in the Electricity Penetration Ratio and its District wise Data

Using 1990 Census, the electricity penetration ratios were also calculated for urban/rural and for each district (Kabupaten). The ratio was calculated as 81.9% in urban area, 30.7% in rural

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7 According to the PLN Statistics number of villages and number of households in Sulawesi was 6,490 and 2,197,674, respectively. However, "Village Potential Statistics of Indonesia in 2005" and "Population Intercensal 2005" published by BPS shows 7,286 rural villages and 2,656,098 households in rural area of the Island. Number of villages in Indonesia has been in increasing trend due to establishment of new villages by transmigration and separation from existing villages. Also, change in the BPS's definition of rural and urban makes difficult for PLN to calculating appropriate rural electrification rate.

8 Rural households with no access to electricity are using Wick-kerosene lump (20.0%), pressurized-kerosene lump (8.0%), gas (1.3%), and others (1.3%) as primary lighting source.

area, and 39.9% in the whole Island. In 1990, while the electricity penetration ratio in urban area was already high at 81.9%, the ratio in rural area was only 30.7%. Electrification effort was intensively made in rural areas during the period from 1990 to 2005. Whereas electricity was a rarity in rural areas (30.7%) in 1990, 69.3% of household in rural area had access to electricity in 2005.

Figure 4.1.5 compares the district-wise electricity penetration ratio of Sulawesi Island in 1990 and in 2005. As the figure shows, electrification penetration ratio was generally lower across the whole Island in 1990. During the period from 1990 to 2005, electricity penetration ratios show drastic change especially in North Sulawesi and South Sulawesi Provinces. The electrification efforts in the both provinces were mainly made by PLN through development of the 70 kV and 150 kV grid systems and development of large-scale power stations such as the Bakaru hydropower and the Sengkang gas-combined cycle power station. Electrification in West, Southeast, Central Sulawesi and Gorontalo Provinces were also made by PLN thorough mainly diesel generators, small scale grid systems and isolated mini gird systems. The electricity penetration ratios of these 4 provinces were lower than those of North and South Sulawesi. In addition to these conventional energy sources, the renewable energy, such as solar house systems and micro-hydro, has somehow contributed electrification in Sulawesi, although on a small scale.

The electricity penetration ratios vary significantly from one district to another. According to the Intercensal data in 2005, the highest electricity penetration ratios were observed in Tomohon City (99%), Manado City (98%), Minahassa district (97%), and Bitung City (93%) in North Sulawesi, Palu City (95%) in Central Sulawesi, Makassar City (99%), Pare-pare City (93%), Palopo City (94%), Takalar (90%), Gowa (90%) and Pinrang (91%) districts in South Sulawesi, Kendari City (94%) in Southeast Sulawesi, and Gorontalo City (96%) in Gorontalo. Active economic performances and higher population densities (between the range from 204 /km^2: Minahassa District and 6,796 /km^2: Makassar City) of these cities/districts are made it easy for PLN to implement rural electrification.

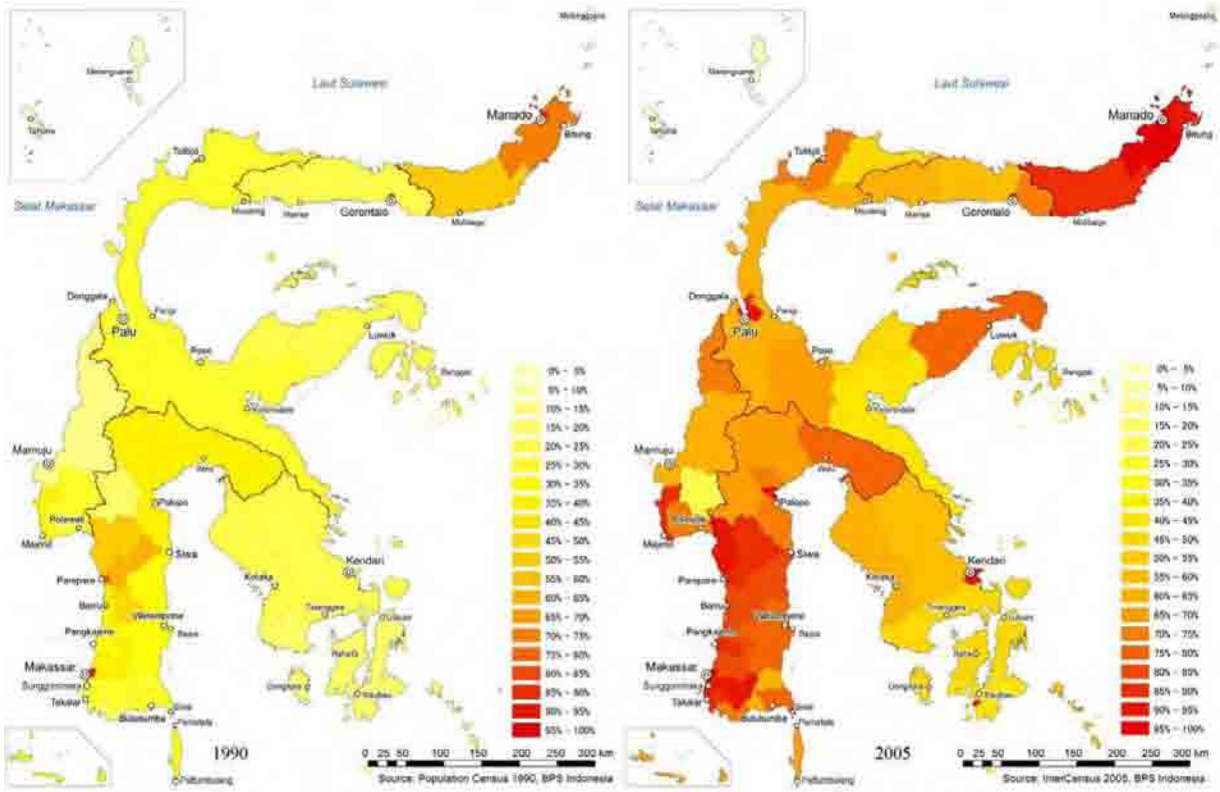

Figure 4.1.5 Percentage of H/Hs using Electricity as Primary Lighting Source 1990 (R) and 2005

Whereas the lowest were in Banggai Islands (45%), Toja Una Una (46%), Buol (47%), and Morowali (43%) in Central Sulawesi, Buton (43%), South Konawe (48%), Bombana (46%), and Muna (46%) in Southeast Sulawesi, and Mamasa (only 23%) in West Sulawesi. Of which, Toja Una Una, Banggai Islands, Bombana, Buton, Muna, and part of South Konawe districts are small islands away from the main island of Sulawesi. Population densities of these districts were lower than the Island average of 60 /km^2 (between 10.7 /km^2 of Morewali and 58.8 /km^2 of Muna) with the exception of Buton district (99.6 /km^2).

4.2 Institutional Setup and Budgeting for Rural Electrification

4.2.1 Change in the Institutional Setup for Rural Electrification before and after the Establishment/ Annulations of the New Electricity Law 2002

Electricity Law 1985 implies that PLN holds the mandate for electricity supply in the country, which can be interpreted that PLN holds two missions, commercial and social including execution of electrification in rural area. This dual-role is inconsistent with the legal mandate of PLN as a state-owned enterprise to generate profit.

In September 2002, the Government of Indonesia enacted the new Electricity Law replacing the former. The new law designed to reform the electricity sector, and contained provisions for introducing market competition, vertically unbundling the electricity industry, increasing the role of local government, and encouraging enhanced private sector participation. Under the new Electricity Law, PLN released from the un-profitable mandate of implementation of rural electrification, and they abolished rural electrification related divisions. Instead, the Central and Regional Government are obligated to take initiative for implementation of rural electrification with technical help from PLN.

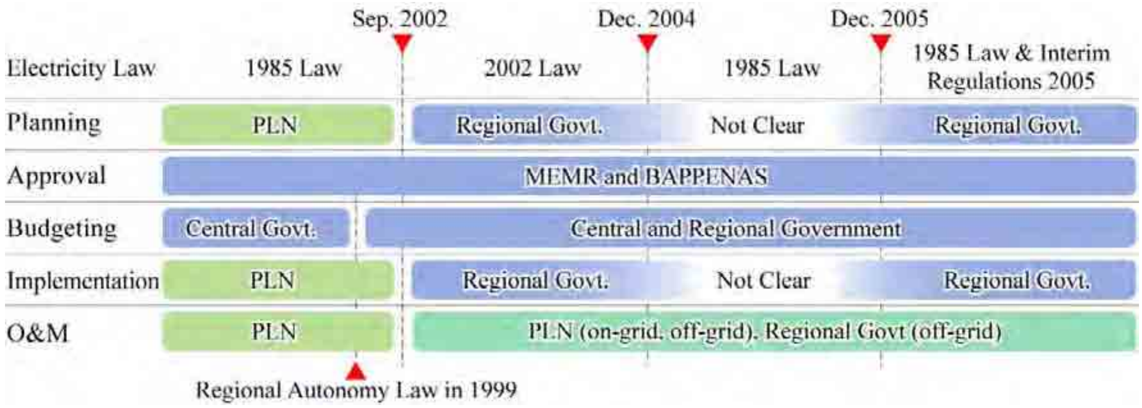

Figure 4.2.1 Changes in the Responsibility for Rural Electrification (Draft)

However, in December 2004, the Constitutional Court in Indonesia annulled the Electricity Law 2002. The annulment of the new Law automatically reverted authority to the previous Electricity Law 1985. The responsibilities of implementing rural electrification had been in state of flux till the issuances of the interim Ministerial Regulations in 2005. After the interim regulations in 2005, central and regional governments have responsible for budgeting and implementing "social electrification"[*9], which includes electrification in rural area. There was, however, no clarity on the implementation of this obligation, the budget allocation and distribution between Central and Regional Government as well as mechanism on reward and punishment.

4.2.2 Role of Each Organization for Rural Electrification

(1) Ministry of Energy and Mineral Resources (MEMR)

The Ministry of Energy and Mineral Resources (MEMR), Directorate General of Electricity and Energy Utilization (DJLPE/ DGEEU) is responsible for making policy for electricity sector including rural electrification, issuing laws and regulations of the sector, and also establishing most of the tariff policy for on and off grid system. MEMR responsibilities also extend to formulating and facilitating subsidies for electrification.

Within DJLPE, there is a sub-directorate for Social Electrification that has given the central government responsibility for rural electrification. Sub-directorate for Social Electrification is responsible for reviewing the proposals from regional governments and making comments if necessary. They are also responsible to decide allocation of budget to each regional

[9] Social Electrification is social-missioned electricity supply, which includes electricity supply for rural area, low-income communities, under developed region, remote areas, and borders areas.

government taking progress of electrification and their proposals in to consideration (the provinces with lower electrification ratios will obtain the larger budget). Then after the approval from BAPPENAS and Ministry of Finance, MEMR will disburse budget to the regional governments. Amount of allocated budgets to regional governments through MEMR were between the range from Rp. 350 to 650 billion/year during the past 5 years (detail will be mentioned in the following section).

(2) Local Government

After the establishment of decentralization of national governance in 1999 and Electricity Law in 2002 as well as the issuances of the interim Ministerial Regulations in 2005, significant role for electrification was placed on the district and the provincial governments. Provincial governments have the mandate to provide input into national electricity planning, issue electricity business licenses, and define tariffs that are outside the PLN's grid system. Under present regulation, they are also obligated to allocate funds from their budgets for supporting the provision of electricity to "social customers[10]".

Provincial governments have responsibility for designing and submitting yearly proposals to MEMR regarding rural electrification. Under the provincial governments, DINAS (regional office of MEMR) exercise these relatively new responsibilities with technical help from regional offices of PLN. DINAS requested PLN for dispatching their staffs for making implementation plan of rural electrification. These groups (P2K) were established in each province. The staffs of P2K usually station in not DINAS but PLN office. For these reasons, however, coordination between regional government and PLN's regional offices are well done to some extent.

(3) PLN

PLN has the most extensive technical expertise in Indonesia when it comes to electrification. And, they still provide new electricity connections in rural area through their daily expansion activities.

In the case of on-grid projects executed by regional government using the budget from MEMR, assets as well as duties of the operation and maintenance (O&M) activities are usually transferred to PLN. The grid extensions to rural villages done by the regional governments levied no development cost for PLN. However, while recurrent supply cost to rural villages are considerably higher than the revenue from the customers in rural areas. Accordingly, although PLN has unfettered from the mandate of rural electrification, rural electrification still levied heavy burden to PLN.

In the case of off grid projects implemented by such as the regional governments using the budgets from MEMR and SMOC, assets and responsibility for O&M activities are usually transferred to regional governments (MEMR projects) as well as the village cooperatives

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[10] Customers living in the rural area, low-income communities, under developed region, remote areas, and borders areas.

(SMOC projects). While, the regional governments have limited experiences and technical capacities, some of the facilities are remain unattended. In addition, the regional governments sometime still force PLN to take responsibility of O&M activities for off-grid projects.

(4) The State Ministry of Cooperatives (SMOC)

The State Ministry of Cooperatives (SMOC) actively participates in the process of financing and facilitating rural electrification as a part of their rural development activities.

According to the Decree of Ministry of Finance 2% to 3% of all profits of the productive state companies should be allocated to developing and improving co-operatives and small and medium enterprises. This budget is allocated from SMOC to the regional governments for the purpose of rural electrification. Amount of the budget in recent years were about Rp. 10 - 15 billion/ year, which is considerably smaller than that of MEMR, but is the second biggest financial source for rural electrification.

SMOC's assistance provided in the field of energy to the rural areas doesn't include extension of distribution system, but composed for 1) Solar Energy Systems, 2) Micro-hydro power Systems, 3) Wind Energy Systems, 4) Biomass Energy Systems, and 5) Diesel generators. After the completion, project facilities are transferred to village corporative (KUD) and/or regional government. Operation and maintenance activities as well as revenue collection is done mainly by KUD.

(5) The National Development Planning Agency (BAPPENAS) and Ministry of Finance (MOF)

The National Development Planning Agency (BAPPENAS) and the Ministry of Finance (MOF) also play important roles in supporting rural electrification. BAPPENAS is responsible for coordinating overall planning in the country, including for the rural electrification plan. Since their endorsement is required for public financing, MEMR annually submit their proposal regarding rural electrification to them.

MOF, meanwhile, is the ultimate authority on public financing, and therefore must authorize any public money offered in the form of development cost, subsidies or loans for rural electrification. After obtaining the endorsement from BAPPENAS, MEMR submits budget request to MOF. Then, MOF allocate the amount of the proposed budget to those respected agencies for carrying out their projects mainly through MEMR. Soft loans from bilateral and multilateral agencies are also allocated from MOF through MEMR.

4.3 Targets of the Electrification and their Financing Needs

4.3.1 Targets of the Electrification Ratio in Sulawesi

The government of Indonesia has recognized the importance of rural electrification in order to improve living standard of people, to enhance regional development, and to reduce poverty. National Electricity General Plan (RUKN) 2006 – 2026 prepared by MEMR aims to expand electrical access to 100% in village level by 2010 and to 90% by 2020 in household level. To achieve this PLN target, South Sulawesi branch are expected to increase household electrification ratio from present level of 54% in 2005 to 85% in 2020, and 97% in 2025. Also, North Sulawesi branch are expected to increase the ratio from 49% in 2005 to 88% in 2020, and 95% in 2025.

On the other hand, PLN aims to achieve more ambitious target of 100% household electrification in the 75 years after independence of the country, namely 2020. To achieve the PLN's targets, about 113,500 connections per year[11] will need to be added for whole Sulawesi Island. Also, the MEMR target required 89,400 of additional connections in rural area per year.

Table 4.3.1 Target Electrification Ratio of MEMR and PLN for Sulawesi and Indonesia

		2005	2010	2015	2020	2025
Wilayah Suluttenggo	MEMR Target	49%	57%	68%	88%	95%
	PLN Target		70%	83%	100%	100%
Wilayah Sulselrabar	MEMR Target	54%	57%	61%	85%	96%
	PLN Target		n.a	74%	100%	100%
Indonesia Total	MEMR Target	51%	69%	76%	90%	93%
	PLN Target		n.a	n.a	100%	100%

Source: RUKN 2006, MEMR and Data collected from PLN South and North Sulawesi Branch

During the Indonesia's Fifth Five-Year Development Program (REPELITA V: 1988/89-1993/94), 44,380 rural households were electrified in Sulawesi per annum on an average. During the REPELITA VI (1994/95- 1999/2000) rural electrification was expanding at an average pace of 67,592 households per year. The pace was suddenly slow down to 34,204 households per year during REPELITA VII (2000-2004).

Taking past PLN's efforts in to consideration, PLN as well as MEMR's targets are considered to be ambitious.

4.3.2 Rural Electrification Budgets for the Sulawesi Island

During the past 7 years, budget allocation for rural electrification form the Central Government has steadily increased in nominal term. While the expenditure remained stagnant in real term during 2001- 2005, percentage of the budgets for rural electrification to the total national budgets were also in increasing trend (see the Figure 4.3.1). The percentages to total national expenditure have almost quadruple, increased from 0.04% in 2000 to 0.155% in 2007.

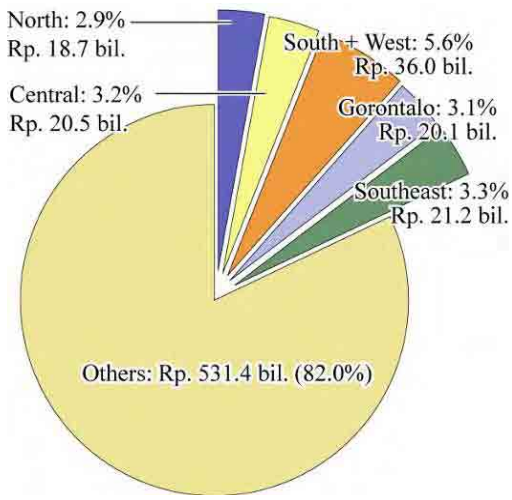
[11] Number of households was estimated to increase with an annual increase rate of 1.9% for South Sulawesi, Southeast Sulawesi and West Sulawesi, and 1.2% for North Sulawesi, Central Sulawesi and Gorontalo. These growth rates are same as the assumption used for PLN's demand forecast.

Note: Fixed prices were calculated using consumer price index, which was quoted from IMF, International Financial Statistics

Source: MEMR, National Statistics Office (BPS)

Figure 4.3.1 Approved Budgets for Rural Electrification and its Occupation to the National Budgets

In 2006, out of total MEMR's budget for rural electrification in Indonesia (Rp. 648.0 billion), Rp. 116.5 billion or 18.0% of total budget was allocated for the Sulawesi Island (see Figure 4.3.2). Using the budget from MEMR, 8,689 set of solar house systems (SHSs) with total capacity of 434.5 kWp and distribution lines with total length of 377.1 km were installed in 2006. In addition, 1 unit of the wind power station having installed capacity of 80 kW was constructed in Malamenggu, Sangihe Island, North Sulawesi (2 units of the wind power stations with total installed capacity of 160 kW are currently under construction in the same Island using the MEMR's budget allocation for 2007).



Source: MEMR

Figure 4.3.2 Budget Allocation for the Provinces in Sulawesi in 2006

On the other hand, SMOC's budget is the second biggest financial source for rural electrification having about Rp. 10- 15 billion per annum.

4.3.3 Financing Needs to Achieve the Target

To achieve the ambitious targets set by MEMR and PLN, electrification not only through grid extension but also development of isolated small system using renewable energy, and individual systems such as solar panel, and Pico-hydro will be required.

The World Bank estimated cost of electrification in Indonesia through extension of gird system or through a mini grid system as US$ 500 ~ 1,250 per households*[12]. When two third of non-electrified households will be connected electricity thorough main grid system or the mini isolated grid systems, about US$ 52.2~ 66.2 million of budget will be needed every year. In addition, about US$ 19.4~ 24.6 million per year[13] of budget will be required for electrification of remaining households by SHS. Total cost required to achieve the target needs about US$ 71.5~ 90.8 million per year. On the other hand, electrification budget from MEMR for Sulawesi in 2006 and 2007 was only about US$ 12 million and US$ 17 million, respectively. Taking the current budget allocation for Sulawesi in to consideration, achievements of the targets are considered to be quite difficult.

4.4 Issues and Problems Regarding Rural Electrification in Sulawesi

4.4.1 Increase in the Cost of Supply (particularly true for diesel powered mini/ micro grid)

Recent hike in the international crude oil price levied heavy burden on the Government of Indonesia. In 2004, subsidy for oil amounted to a Rp. 69 trillion, which was equivalent to the total national development expenditure of Rp. 71 trillion and accounted for 18.8% of the total national expenditure). To accommodate with the hike in the oil price, Indonesian government decided to cut subsidy for oil to a great extent, and raised fuel prices in March 2005 by a weighted average of 29%, followed by a more drastic increase in October 2005 by an additional 114%.

In the case of PLN South Sulawesi Branch, the average purchase price of fuel oil from PT Pertamina (state-owned oil company) has rapidly increased from Rp. 1,560 per liter in 2004 to Rp. 3,480 per liter in 2005 for MFO (Marine Fuel Oil) and from Rp. 1,650 per liter to Rp. 4,950 per liter for HSD (High Speed Diesel Oil), see the Figure 4.4.1.

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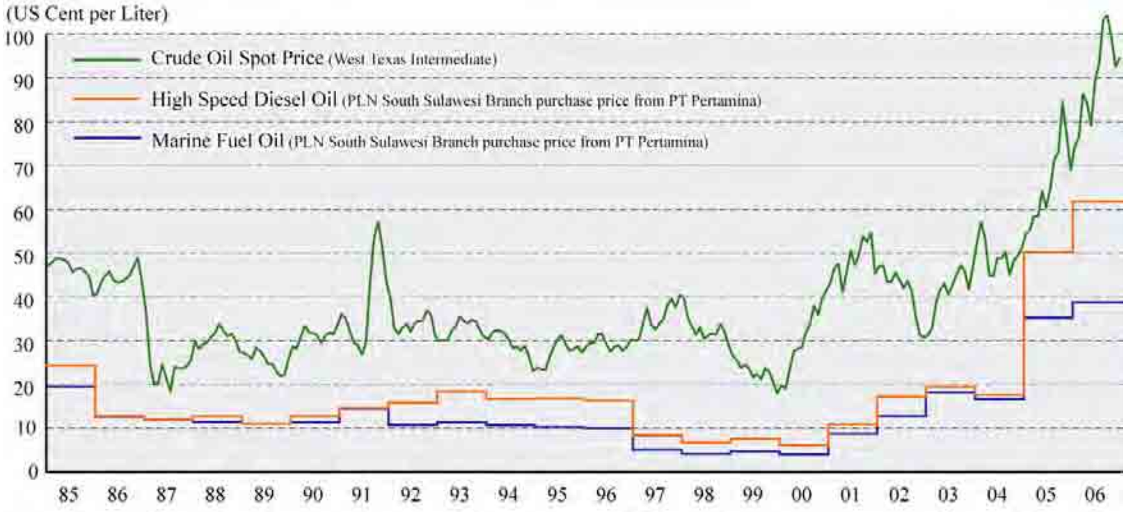
[12] Electricity for All – Options for Increasing Access in Indonesia, December 2005, The World Bank Energy and Mining Unit, Infrastructure department, East Asia and Pacific Region

[13] SHS with 61.2 Watt-peak costs about US$ 650 (Source: PLN Suluttenggo).



Source: International Energy Administration, United States, and PLN South Sulawesi Branch Statistics 1990 - 2006

Figure 4.4.1 Changes in the International Crude Oil Price and PLN's Purchase Prices of Fuel Oils

In Sulawesi Island, PLN generates 36.9% of its power through diesel-fired plants, oil-fired gas turbine plant and oil-fired steam turbine. The medium-scale regional grid systems and the isolated small systems are greatly rely on the diesel generators for its power sources, and accordingly face sharply higher costs in the wake of the October 2005 fuel price hikes. Such hike in the fuel oil price made it difficult for the government to execute rural electrification through isolated system using small diesel generator, also to expand capacity of diesel generators to coop with increasing demand. Given circumstances, introduction of new and renewable technology in the field of rural electrification is getting more important.

4.4.2 Insufficient Electricity Tariff to Cover the Cost of Supply

In 2006 the total number of customers in the Sulawesi Island was 2.15 million, of which 93.3% or 2.01 million belong to residential category. The number of customers in rural areas of the Island was about 1.17 million or 54.4% of total customers. Most of these rural customers belong to residential category of the R1 tariff (categories with connected capacity of 0.25- 2.2 kVA and cheapest electricity tariff). On the other hand, fuel costs for the oil-fired power stations (main source of power generation for the regional grid system, and the isolated mini grid systems in Sulawesi) were about Rp. 1,000 ~ 2,000 per kWh (US¢10.9 ~ 21.8), PLN South Sulawesi Branch in 2006. Taking O&M cost, labor cost, and transmission and distribution losses in to consideration, the unit supply cost is actually more expensive than the said cost. Therefore, it is obvious that the electricity tariff is not sufficient to cover the cost of supply, and thus resulting operating losses from electricity supply in rural area.

Under the Electricity Law 1985, the Government of Indonesia adopted the concept of universal tariff across the region, despite the disparity of costs in various regions. On the other hand, Electricity Law 2002 encouraged the application of regional tariffs to take into account the disparity of cost of supply across the region as well as fair and reasonable competition. However, as a result of annulment of the 2002 Law, universal tariff system remains unchanged, which is not reflect high cost of supply in the outer island.

In order to cover increased generating costs, Indonesian government decided to increase tariffs up to 50% in January 2006. However, in March 2006, the government announced that they would not increase electricity tariffs, because their plans to raise electricity tariffs had encountered strong resistance from Parliament and the business community since its announcement shortly after the October 2005 fuel subsidy cuts. Despite the continuous rise in the international oil price, electricity tariff remain unchanged till now.

4.4.3 Insufficient Availability of Sustainable Financing

Most of the budget for rural electrification is allocated from central government through MEMR. While the budget is in increasing trend, it is enough to cover only less than 20% of required budget for achieving the targets of electrification ratio established by MEMR and PLN.

Indonesian government expected to enhance private sector's participation for financing the rural electrification. However, annulment of the 2002 Electricity Law exposed the power sector to a significant amount of uncertainty, which created a negative impact on rural electrification programs, particularly those with private sector participation. In addition, the Rural Electrification Fund, which aims to secure the budget for rural electrification, was not included in the 2002 Electricity Law and is remain unattended since then. Also, role sharing between the central government and regional government for financing rural electrification remains undefined. To accelerate the pace of rural electrification, such issues regarding financing for rural electrification need to be solved in properly.

4.4.4 Lack of Sustainable Setup for Operation and Maintenance in Off-grid Electrification

In the case of rural electrification through grid extension, O&M activities are done mainly by PLN regardless of financial source of the project. Thus, sustainability for O&M activities of these grid extension projects is considered to be more or less satisfactory.

On the other hand, in case of the off-grid electrification project done by regional government using the fund from MEMR, O&M activities will be done mainly by the regional government. Since, the regional governments have limited experiences and technical capacities for this relatively new task for them, some of the facilities, such as mini hydropower stations, are said to remain unattended. However, it is also difficult for PLN to be responsible for operating and maintaining small scale facilities located in remote area.

Taking the recent hike in the fuel oil price in Indonesia, as mentioned, it is difficult to rely on diesel generators, which is relatively easy for operation and maintenance. Given these conditions, while rural electrification should be executed fully introducing new and renewable energy such as micro hydro and wind power, NGOs and private companies still have limited experiences and technical expertise for those kind of facilities.

In order to set up sustainable structure for rural electrification in off-grid area using new and renewable energy, participation of NGO, private companies, and village organization for operation and maintenance activities, as well as provision of training for them will be indispensable.

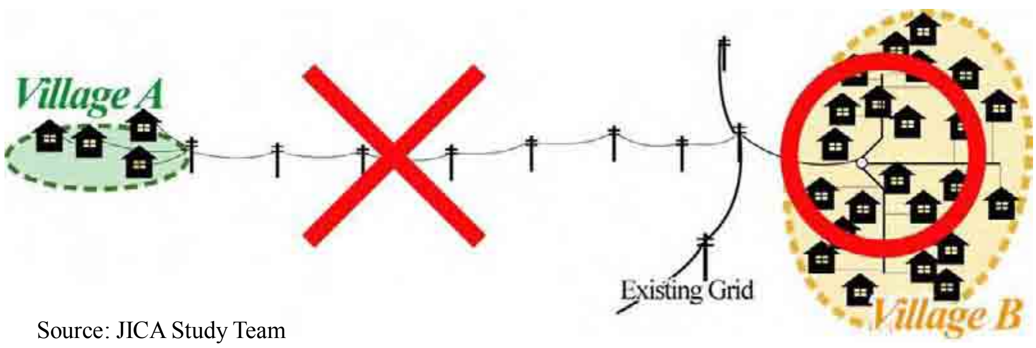
4.5 Setting the Criteria for Judging the Optimal Alternative for Rural Electrification

4.5.1 Methodology

Since large number of the unconnected households living in rural Sulawesi is sparsely populated, the cost of connecting customers is likely to be higher than before. Further more electricity tariff for these customers are far below the supply cost, and thus causing financial loss. Also, while diesel generators and associated mini grid systems has been widely used as the easy solution for rural electrification in Sulawesi, recent hike in the international fuel prices made it becoming increasingly unfeasible. In addition, current budget allocation for executing rural electrification is far below to achieve the target level of electrification.

Taking such severe circumstances into consideration, in order to maximize benefits and to minimize financial loss of rural electrification, selection of the optimum technical alternative of electrification (such as grid extension, installation of solar home system, and formulation of isolated mini-grid system powered by diesel generator, small/mini hydro, and other new and renewable sources) is becoming increasingly important.

For example, it is easy to understand the rationale for the judgment of grid extension to the extreme cases such as, A) a village of a few houses with tens of km distance away from an existing grid, and B) a village of hundred houses only few hundred meters away from an existing grid (see the Figure 4.5.1). The problem of grid extent determination exists in the middle ground of these extreme cases. The drawing line would be difficult at any point in the middle area without clearly predetermined criteria.



Source: JICA Study Team

Figure 4.5.1 Feasibility of the Grid Extension

Under this Study, selection criteria of the optimum technical alternative for rural electrification were developed based on both financial and economic point of view. Three technical options, namely grid extension, SHS (solar home system), and mini-grid system powered by diesel generator, were selected as the alternative methodologies of electrification. In the case of small/micro hydro and other new and renewable energy source, while they are one of the promising alternatives for rural electrification, their cost and technical feasibility are widely varied upon site condition. On this account, it is almost impossible to generalize their cost, and thus excluded from the examined alternatives.

Formulas with objective function of "net present value" (present value of benefit – present value of cost) and variable functions of "distance from the existing grid" and "number of households to be electrified" were prepared for each alternative. When certain values are substituted for the variables, an alternative having the largest net present value was selected as the optimum.

The criteria developed under this Study were consists of "financial criteria" and "economic criteria". The former aims to select an alternative, is which can minimize financial loss*[14] of project executing agency during the economic life of the electrification project. On the other hand, the latter aims to select an alternative, which will maximize net economic benefit of beneficiaries from national economic perspective. Brief overview of both criteria is as shown in the following table.

Table 4.5.1 Brief Overview of Financial and Economic Criteria

	Cost	Benefit	Purpose of Use
Financial Criteria	Financial Cost of Electrification	Revenue from Sales of Electricity	To minimize financial loss of the executing agency resulting from electrification
Economic Criteria	Economic Cost of Electrification	Incremental Consumer Surplus	To maximize net economic benefit of electrification from the national economic perspective

Source: JICA Study Team

4.5.2 General Assumption

All costs and benefits are expressed in Indonesian Rupiah at 2006 constant prices. The U.S. dollar based prices are converted to Indonesian Rupiah using exchange rate of Rp. 9,141 per US dollar[15]. Cost and benefit data at nominal prices are converted 2006 prices using the consumer price index (CPI) revealed by the Indonesia's Central Bureau of Statistics (BPS). Construction periods of all alternatives are assumed as one year. Based on the discussion with PLN staffs, economic lives of alternatives are assumed as 30 years for SHS and distribution systems, 15 years for diesel generators, and 3 years for battery using for SHS. The discount rate of 12% has been applied, which is commonly used in Indonesia.

[14] In rural area, electricity tariff are obviously not sufficient to cover supply cost. Thus, financial criteria aim to pursue not maximization of profit but minimization of financial loss.

[15] Source: Central Bank of Indonesia, 2006 period average

4.5.3 Electrification Cost of Each Alternative

(1) Financial Costs of Electrification

Financial costs of each alternative include both capital expenditure (construction costs) and recurrent expenditure (such as operation and maintenance cost, fuel cost, and battery replacement cost) throughout the project periods. Most of assumptions shown below are determined based on the data collected from PLN South and North Sulawesi Branch Offices.

Costs of Grid Extension

Construction cost of the "gird extension" includes medium voltage (20 kV) and low voltage (220 V) distribution line with their associated facilities. Yearly operation and maintenance cost of distribution line was assumed 1% of their construction cost. Incremental energy supply costs of the SULSEL system, Minahasa- Kotamobagu system, and other medium-scale systems[16] were estimated based on generation and transmission cost of each system after due consideration of transmission loss. As a result, incremental supply cost of the main grid systems were estimated to be Rp. 826/kWh (US¢ 9.04/kWh) for SULSEL System, Rp. 1,252/kWh (US¢ 13.69/kWh) for Minahasa- Kotamobagu System, and Rp. 2,597/kWh (US¢ 28.42/kWh) for other medium- scale systems.

Present value of the electrification cost by grid extension throughout the economic life of the project (30 years) can be formulated as following function having two independent valuables: namely distance from existing grid (x) and number of household to be electrified (h).

$$C_g = f(x,h) = MV*x + LV*\beta*h + \sum_{t=1}^{30}\left\{\frac{12\alpha*h \div (1-DL_x)\times E + (MV*x + LV*\beta*h)*\gamma}{(1+\varphi)^{t-1}}\right\}$$

Here:

- Cg = present value of grid extension cost during economic life
- x = distance from the existing main grid system (variable)
- h = number of households to be electrified (variable)
- t = years after completion of the electrification
- φ = discount rate (12%)
- E = generation and transmission cost of main grid system (please refer to the Table 4.5.2)
- DL_x = distribution loss of medium voltage line of "x km"
- α = monthly electricity consumption per household (30.2 kWh)
- β = low voltage distribution line per household (10 m)
- γ = operation and maintenance cost (1% of construction cost)
- MV = construction cost of medium voltage line and its associated facilities (US$ 8,862 per km)
- LV =construction cost of low voltage line and its associated facilities (US$ 5,989 per km)

Note: Cost of low and medium voltage distribution line were determined based on hearing from PLN Staff. Other data was assumed by the study team.

[16] Other medium-scale systems includes Tahuna, Ondong, Molibagu, Talaud, Tagulandang, Gorontalo, Marisa, Buroko, Palu, Poso, Toli-Toli, Parigi, Moutong- Palasa- Kotaraya, Leok, Kolonedale, Bangkir, Luwuk, Ampana, Banggai, Selayar, Kendari, Raha, Bau-bau, and Wangi-wangi.

Table 4.5.2 Unit Generation and Transmission Cost of Grid Systems

	Generation Cost*1 (Rp. mil)	Transmission Cost*2 (Rp. mil)	Energy Production (GWh)	Cost of Gen. and Trans. (Rp./kWh)	Transmission Loss (%)	Adjusted Cost of Gen. and Trans. (Rp./kWh)
Minahasa-Kotamobagu System	748,213	22,407	631.32	1,220.64	2.47%	1251.55
Sulsel System	2,130,342	72,200	2,813.12	782.95	5.26%	826.42
Other Small Scale Systems	986,475	3,912	424.05	2,335.56	10.08%	2597.38

Source: Calculated based on financial data of PLN North/South Sulawesi Branch (2006)

Note: *1: Generation Cost includes fuel cost, operation and maintenance cost, and depreciation cost of PLN owned power station as well as power purchase cost from IPP and rental engines.

*2: Transmission cost includes operation and maintenance cost and depreciation cost of facilities. That of Minahasa- Kotamobagu System was referred to financial data of AP2B North Sulawesi, SULSEL system was referred to AP2B South Sulawesi, and other medium-scale systems was referred to same cost items other than the mentioned two AP2B.

Costs of Solar Home System (SHS)

Initial cost of SHS was assumed Rp. 5,000,000 (US$ 547.0), which includes solar panel and battery. Rp. 200,000 of replacement cost of battery was accounted every three years during project period (30 years). Since such battery replacement cost borne by not project operator but customers, this cost item included in economic cost but not in financial cost.

Present value of the electrification cost by SHS throughout the economic life of the project can be formulated as the following function having independent valuable of "number of household to be electrified (h)".

$$C_s = f(h) = \alpha * h + \sum_{t=1}^{30} \left\{ \frac{\beta * h}{(1+\varphi)^{t-1}}) \right\}$$

Here:

Cs = present value of SHS cost during economic life

h = number of households to be electrified (variable)

t = years after completion of the electrification

φ = discount rate (12%)

α =cost of 60Wp SHS and Battery (US$ 547.0)

β = cost of battery to be replaced (US$ 21.9, required once a three years)

Note: Data of SHS cost and batter replacement cost were determined based on the hearing from PLN Staff. Other data was assumed by the study team.

Cost of Diesel Mini-Grid

As same as the data used for RUPTL, cost of diesel generator was assumed as US$ 500 per kW. Installed capacity of diesel generator was estimated based on assumed average energy demand (16.0 kWh/month/household), number of households electrified, average load factor of 45%, reserve margin of 20%. Specific fuel consumption of diesel generator was assumed 0.38 liter/kWh for the generator with capacity below 50 kW, and 0.28 liter/kWh for the generator with capacity above 500 kW based on the actual data of PLN owned small diesel generators.

Also, plant load factor of the generator having capacity between 50 kW and 500 kW was assumed using linear interpolation ranged between 0.28 and 0.38 liter/kWh. Annual operation and maintenance cost of diesel generator and distribution facilities were assumed as 3% and 1% of their construction cost, respectively.

Present value of the electrification cost by "diesel mini-grid" throughout the project's economic life (15 years) can be formulated as following function having independent valuable of "number of household to be electrified (h)".

$$C_d = f(x,h) = \frac{DG * 12\alpha * h}{(1-DL)*(1-RM)*8760*LF} + LV * \beta * h$$

$$+\sum_{t=1}^{15}\left\{\frac{12\alpha * h \times FP * FC}{(1-DL)*(1+\varphi)^{t-1}} + \frac{DG*12\alpha*h*\varepsilon}{(1-DL)*(1-RM)*8760*LF*(1+\varphi)^{t-1}} + \frac{LV*\beta*h*\gamma}{(1+\varphi)^{t-1}}\right\}$$

Here:

Cd= present value of diesel mini grid cost during economic life
h = number of households to be electrified (variable)
t = years after completion of the electrification
φ = discount rate (12%)
FC = specific fuel consumption (0.28 - 0.38 liter/kWh)
LF =average load factor of the mini-grid (45%)
RM = reserve margin (20%)
FP = fuel price (Rp. 6,250 / liter)
DL = distribution loss within mini-grid (3%)
α = monthly electricity consumption per household (16.0 kWh)
β= low voltage distribution line per household (10 m)
γ= O&M cost of distribution system (1% of construction cost)
ε = O&M cost of generator (3% of construction cost))
DG = cost of diesel generator (US$ 500 / kW)
LV = construction cost of low voltage line and its associated facilities (US$ 5,989 per km)

Note: Data of specific fuel consumption, fuel price, cost of diesel generator and low voltage distribution line were determined based on PLN statistic data in 2006 as well as hearing from PLN Staff. Other data was assumed by the study team.

(5) Economic Cost of Electrification

Cost items of each alternative were same as that of financial cost, except for batter replacement cost for SHS. Battery replacement cost was accounted only for economic The local currency portion of the project cost (assumed as 60% of total project cost) was converted to economic cost using the standard conversion factor of 0.9, which is commonly used in Indonesia.

4.5.4 Electrification Benefits of Each Alternative

(1) Financial Benefit of Electrification

Financial benefits of grid extension and diesel mini grid were calculated based on revenue from sales of electricity, which can be worked out as the product of average electricity tariff and total electricity consumption. Average electricity tariff was assumed as same as the average electricity tariff of R1 category in Sulawesi in 2006 (Rp. 533.7 /kWh or US¢ 5.84 /kWh). Since there are no data about electricity consumption of rural consumers, the Study team assumed typical pattern of electric appliance based on the past socio-economic survey of rural electrification projects in Indonesia[17] (see the following tables);

Monthly Energy Consumption Patter of a Typical Consumer (Grid Extension)

	Rated Power Consumption		Typical Rural Household: 85%				Well-off Rural Household: 15.0%			
			No.	Hours of Use/ Day	Monthly Consumption		No.	Hours of Use/ Day	Monthly Consumption	
Fluorescent light	40	W					2	5.00	12.00	kWh
Fluorescent light	20	W	2	5.00	6.00	kWh	1	5.00	3.00	kWh
Color TV Set	90	W	1	3.00	8.10	kWh	1	4.00	10.80	kWh
Rice Cooker	400	W					1	0.50	6.00	kWh
Refrigerator*	60	W					1	24.00	43.20	kWh
Iron	500	W					1	0.50	7.50	kWh
Radio-Cassette	30	W	1	3.00	2.70	kWh	1	2.00	18.00	kWh
Electric Fan	40	W	1	3.00	3.60	kWh	1	4.00	4.80	kWh
Total					20.40	kWh			89.10	kWh

Note: * Capacity of Refrigerator indicates average figure
Source: JICA Study Team

Monthly Energy Consumption Patter of a Typical Consumer (Diesel Isolated Grid)

	Rated Power Consumption		Typical Rural Household: 85%				Well-off Rural Household: 15.0%			
			No.	Hours of Use/ Day	Monthly Consumption		No.	Hours of Use/ Day	Monthly Consumption	
Fluorescent light	40	W					2	3.00	7,200	Wh
Fluorescent light	20	W	2	3.00	3,600	Wh	1	3.00	1,800	Wh
Color TV Set	90	W	1	2.00	5,400	Wh	1	3.00	8,100	Wh
Rice Cooker	400	W					1	0.50	6,000	Wh
Iron	500	W					1	0.50	7,500	Wh
Radio-Cassette	50	W	1	2.00	1,800	Wh	1	2.00	3,000	Wh
Electric Fan	40	W	1	1.50	1,800	Wh	1	2.50	3,000	Wh
					12,600	Wh			36,600	Wh

Source: JICA Study Team

Monthly Energy Consumption Patter of a Typical Consumer (SHS)

	Rated Power Consumption		No.	Hours of Use/ Day	Monthly Consumption	
Fluorescent light	15	W	2	4.00	3,600	Wh
Total					3,600	Wh

Source: JICA Study Team

As a result, monthly electricity consumptions of grid-connected consumers, diesel mini grid consumers, and SHS consumers were calculated as 30.2 kWh, 16.0 kWh and 3.6 kWh. Given assumptions, monthly financial benefits of electrification by grid extension, and diesel mini grid were worked out Rp. 16,099 /household (US$ 1.76), and Rp. 8,550 /household (US$ 0.94), respectively.

[17] Socio-economic survey executed under the post evaluation project of "Indonesia Rural Electrification Project I and II", JBIC, 2002, and 2004

On the other hand, since currently PLN not levied any tariff for consumers using SHS, there are no financial benefit resulted from electrification by SHS.

(6) Economic Benefit of Alternatives

According to the BPS's intercensal survey data in 2005, most of unelectrified households used kerosene lamps for lighting. In rural area of Sulawesi Island, out of unelectrified households, 65.2% of households are using wick kerosene lamp, pressurized kerosene lump 26.1%, and others 8.7%. Pressurized lamps were used by relatively wealthy households because the lamps consume more fuel, though they give off brighter light than wick lamps.

Table 4.5.3 compares 20W fluorescent light and pressurized/ wick kerosene lamps in brightness and cost. A 20W fluorescent light is generally brighter than kerosene lamp and costs only 1/32 to 1/8 per hour.

Table 4.5.3 Comparison of Electric Light and Kerosene Lamps

	20W Fluorescent Light	Pressurized Kerosene Lamp	Wick Kerosene
Shape			
Brightness	900 lumens[*a]	220 – 1,300 lumens[*a]	10 – 100 lumens[*a]
Efficiency	20 W/hour	0.11 – 0.17 liter / hour[*a]	0.04 – 0.06 liter / hour[*a]
Price	Rp. 533.7 / kWh	Rp. 2,000 / liter[*b]	
Unit Price	Rp. 10.7 / hour	Rp. 220 – 340 / hour	Rp. 80 – 120 / hour

Source: *a= IAEEL (International Association for Energy-Efficient Lighting)
*b= PT. Pertamina, July 2007, price for household and small industry

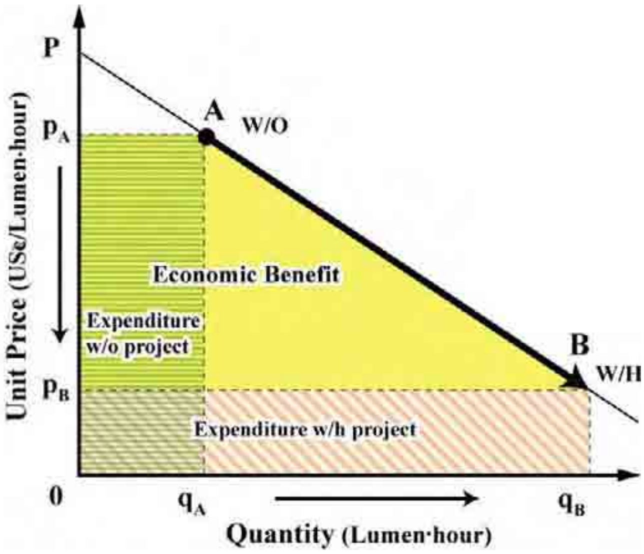
Electricity supply lowers the cost of energy and brighter the source of lighting to the user, resulting in an increase in the consumer surplus[18], which is the difference between what the consumer is willing to pay and what they actually do pay. Such increase in the consumer surplus resulting from the switch from kerosene lamps to fluorescent lights was regarded as economic benefit.

Figure 4.5.2 in the right indicating change in the quantity (lumen·hour) and cost (Rp./lumen·hour) of lighting with and without electrification. Assume that before electricity, energy is supplied from a kerosene lamp at price "p_A" with consumption "q_A" (Figure 4.5.2). Once electricity is available at lower price "p_B", consumption rises to "q_B". Using these two points, the demand curve was interpolated.

[18] Consumer's surplus is defined as the benefit received by consumers by paying the market equilibrium price in spite of their willingness to pay a higher price. It is obtained by integrating the area enclosed by the market equilibrium price curve and demand curve.

Without electrification condition, sum of the maximum willingness to pay for lighting can be illustrates as the area of trapezium O P A q_A. On the other hand, actual payment at price p_A is shown as the area of rectangle O p_A A q_A. Thus, the consumer surplus "without electrification" is calculated as the area of triangle p_A P A. Similarly, the consumer surplus "with electrification" is calculated as the area of triangle p_B P B.

Accordingly, economic benefit (increase in the consumer surplus) can be illustrated as the area of the trapezium p_B p_A A B. Adopting these assumptions, increase in the consumer surplus was calculated for each alternative.



Source: JICA Study Team

Figure 4.5.2 Schematic Figure of the Consumer

4.5.5 Results of the Analyses

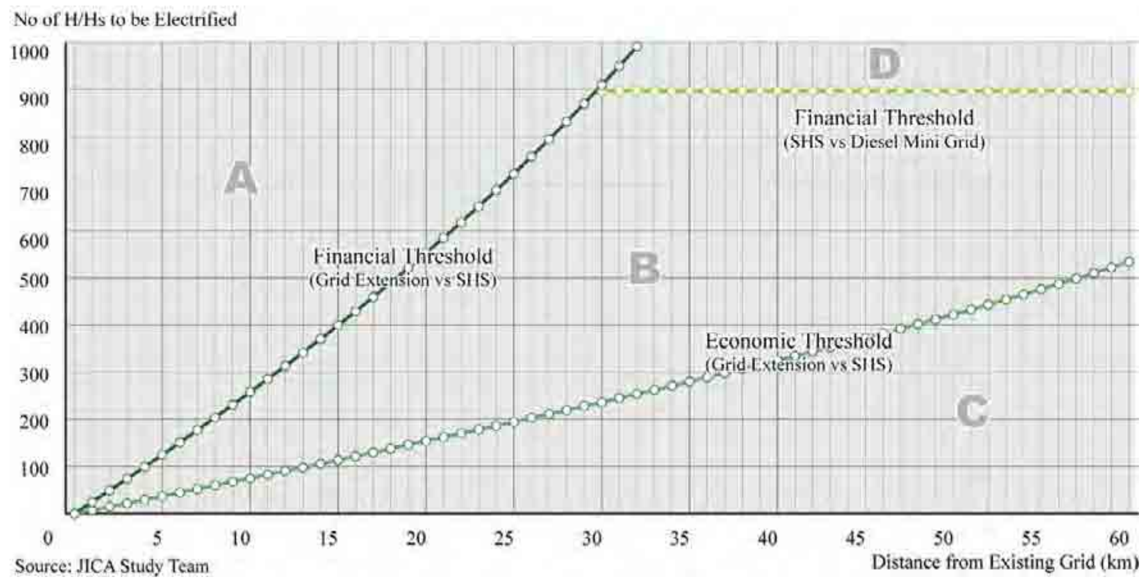
Results of analyses were summarized as graphic representation of the relation between "number of households to be electrified" and "distance from existing grid" (please refer to the Figure 4.5.3 to Figure 4.5.5). The vertical axis indicates number of households to be electrified (attention should be paid this figure is different from number of household in the villages along the medium voltage line). The horizontal axis indicates distance from existing grid (from tapping point of the main grid system to termination of the newly constructed medium voltage line). These graphic charts were separately prepared for the SULSEL system, Minahasa – Kotamobagu System, and other medium-scale systems. Each graph chart includes both the financial criteria and the economic criteria.

In using the criteria, user need to plot a dot, based on "number of households to be electrified" and "distance from existing grid", on the correspond graphic chart. The area including the dot shows the optimum alternative.

<u>The Sulsel System</u>

Figure 4.5.3 shows the criteria for the SULSEL System. The Area "A" indicates the area where grid extension is the optimum in term of both economic and financial aspects. The Area "B" indicates the area where grid extension is the optimum in term of economic aspect, but SHS is the optimum in terms of financial aspect. In other words, in order to minimize financial loss of executing agency, SHS will be the optimum alternative. However, in order to maximize net economic benefit of the beneficiaries, grid extension is selected as the optimum. The Area "C" idicates the area where SHS is the optimum in term of both economic and financial aspects.

The Area “D” indicates the area where diesel mini-grid is the optimum in term of both economic and financial aspects[19].



Area A:	Grid extension is selected as the optimum alternative from both financial and economic aspects
Area B:	While SHS is selected as the optimum from financial aspect, grid-extension is the optimum from economic aspect
Area C:	SHS is selected as the optimum alternative from both financial and economic aspects
Area D:	Diesel mini-grid is selected as the optimum alternative from both financial and economic aspects

Figure 4.5.3 Criteria for Selecting the Optimum Alternative at “SULSEL System”

For example, when planning to electrify 300 households, as shown in the graphic chart, maximum distance of extension is about 12 km in terms of financial aspect, and is about 37 km in economic point of view.

The Minahasa-Kotamobagu System

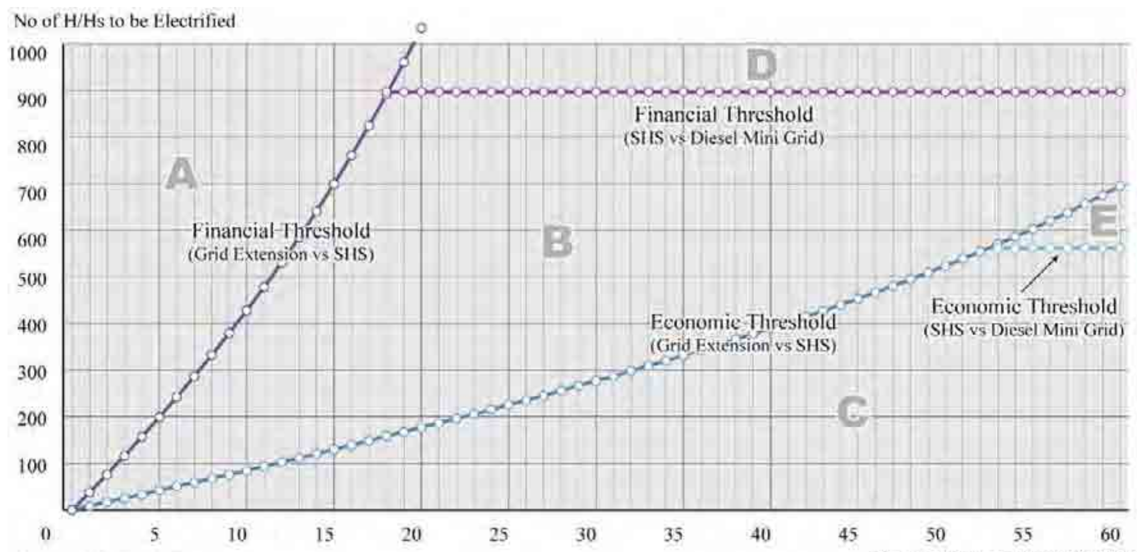
Figure 4.5.4 shows the criteria for the Minahasa- Kotamobagu System. The Area “A” illustrates the area where grid extension is the optimum in term of both economic and financial aspects. The Area “B” indicates the area where grid extension is the optimum in term of economic aspect (maximization of net economic benefit of beneficiaries), but SHS is the optimum in terms of financial aspect (minimization of financial loss of the project executing agency). The Area “C” indicates the area where SHS is the optimum in term of both economic and financial aspects. The Area “D” indicates the area where diesel mini-grid is the optimum in term of both economic and financial aspects.

[19] As to diesel mini-grid, various assumptions were determined with supply of small area in mind (e.g. low voltage line required per customer of 10m, distribution loss ratio of the mini-system of 3%, and no medium voltage line required). However, if the diesel mini-grid needs to supply more than 900 households in rural where population density is scared, more investment will be required for distribution system and distribution loss will be higher than 3%. Taking such conditions into consideration, diesel mini-grid seems to be not selected as the optimum alternative for rural electrification, in reality. Same is true for the criteria for the Minahasa – Kotamobagu System and other medium-scale systems.

The Area "E" indicates the area where SHS is selected as the optimum from a financial point of view, and diesel mini-grid is the optimum from an economic point of view.

For example, when planning to electrify 300 households, as shown in the graph, maximum distance of extension is about 7 km in terms of financial aspect, and is about 32 km in economic aspect.

The unit generation and transmission cost of the Minahasa- Kotamobagu System is higher than that of the SULSEL System, because of the higher dependency of generation on oil-fired power stations. On this account, maximum distance of grid extension from the Minahasa-Kotamobagu System is shorter than the Sulsel System.



Source: JICA Study Team

Area A:	Grid extension is selected as the optimum alternative from both financial and economic aspects
Area B:	While SHS is selected as the optimum from financial aspect, grid-extension is the optimum from economic aspect
Area C:	SHS is selected as the optimum alternative from both financial and economic aspects
Area D:	Diesel mini-grid is selected as the optimum alternative from both financial and economic aspects
Area E:	While SHS is selected as the optimum from financial aspect, diesel mini-grid is the optimum from economic aspect

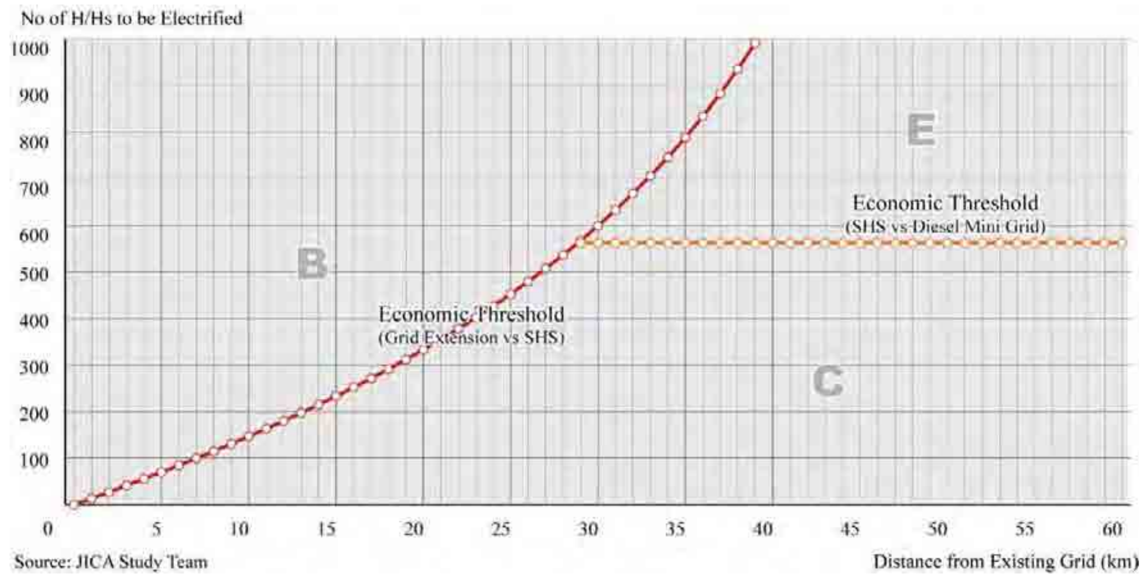
Figure 4.5.4 Criteria for Selecting the Optimum Alternative at "Minahasa - Kotamobagu System"

<u>Other Medium-Scale Systems</u>

Figure 4.5.5 shows the criteria for "Other Medium-Scale Systems". From a financial point of view, grid extension from "other medium-scale systems" wasn't selected as the optimum regardless of "number of households to be electrified" and "distance from existing grid". In order to minimize financial loss of executing agency, only SHS is selected as the optimum. Under the current high fuel oil price, grid extension from other medium-scale systems cannot be the feasible option from a financial point of view.

However, taking economic benefit into consideration, grid extension is still viable. The

Area “B” illustrates the area where grid extension is the optimum in term of economic aspect, but SHS is the optimum in terms of financial aspect. The Area “C” illustrates the area where SHS is the optimum in term of both economic and financial aspects. The Area “E” indicates the area where SHS is selected as the optimum from a financial point of view, and diesel mini-grid is the optimum from an economic point of view.



Area B:	While SHS is selected as the optimum from financial aspect, grid-extension is the optimum from economic aspect
Area C:	SHS is selected as the optimum alternative from both financial and economic aspects
Area E:	While SHS is selected as the optimum from financial aspect, diesel mini-grid is the optimum from economic aspect

Figure 4.5.5 Criteria for Selecting the Optimum Alternative at “Other Medium-Scale Systems”

When planning to electrify 300 households, the maximum distance of grid extension from other medium-scale systems in an economic perspective is only about 18 km, which is far shorter than 37 km of the SULSEL System and 32 km of the Minahasa- Kotamobagu System.

In the case of financial point of view, as mentioned previously, grid extension from “other medium-scale system” was not selected as the optimum regardless of distance.

4.6 Rural Electrification and Productive Use of Electricity

4.6.1 Rural Electrification and Productive Use of Electricity

Sulawesi is rich in agricultural products (especially rice, maize, coconuts, coffee, cacao, cashewnuts, clove and vanila) and marine products (fishes, shrimps, crabs, and seaweed). The primary sector, including agriculture, fishery, plantation, livestock and forestry, shared 33.7% of total GDP in the Island, which is far higher than the national average of 15.0%. Although the manufacturing sector is expected to support agricuture in terms of agro-industrial input, the sector occupied only 10.8% of total GDP, which was far lower than the national average of

28.1%. As these figure indicates, manufacturing industries in Sulawesi have not well developed yet. Thus, rich agricultural and marine products are exported to other part of Indonesia as well as abroad without processing in most cases. While manufacturing sector in Sulawaesi is concentrated only in urban area such as Makassar and Manado, their activities in local cities and rural area are quite limited.

Of small industries in rural area/local city, such as brick burning, ceramic firing, salt drying, fish drying, and charcoal production depend on biomass fuels and natural sunlight as a source of process heat and use electricity service only for lighting of the working space. Also, other small busnesses and/or industries like retail shops, restaurant, depend on electricity services only for lighting, and entertaining customers (playing radio, music systems and television). On the other hand, some small industries like wood processing, furniture making, rice hasking and milling, extraction of vegitable oil using not electric machines but mainly diesel/oil engines driven equipments. While some of the cottage industries benefit from electrification because its enable for them to work at night, there are quite few example in using electricity for productive purpose in rural area of Sulawesi.

As mentioned, electrifiaction are not necessary utilized for productive use and thus play an limited role in stimulating economic development in rural area. This is condiered to be resulted from following constraints; 1) limited capital for starting business, 2) insufficient knowledge and skill regarding productive use of electricity, and 3) lack of access to markets.

While primal objective of rural electrification is providing lighting source and better living standard, the coming electrification project should also aims to empower the community through providing electricity to facilitate income generating activities both home based and community based..

4.6.2 Potential Industries in Rural Sulawesi Using Electricity for Productive Purposes

Because of cheaper labor cost and smaller operation scale, merit of electrification and mechanization of manufacturing process is smaller in rural area. However, electrification of manufacturing process On the other hand, various types of industries are using electricity for productive purposes in urban area of Sulawesi Island. Of which some of them listed below seems viable in rural area.

(1) Agro-industry

Fruits Juice Factory

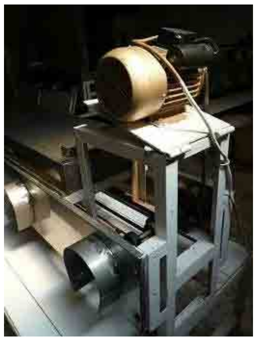
Various fruits are growing in Sulawesi; including passion fruits (*markisah*), mango, banana, water maroon, pineapple, orange, and soursop *(sirsuk)*.

Particularly, passion fruits are one of important fruits in Sulawesi that can be developed to become an export commodity in the form of processed products (particularly essence, and juice). Passion fruit plants have been have been greatly developed in North Sulawesi and South Sulawesi and they can grow in an elevation of 800 to 1,500 m above sea level.

Small enterprise “CV. Sarimas Lestari” with 15 employees located in Makassar is producing passion fruits juice using electricity for extraction of , separation of fruits and seeds, mixing, refrigerating, and packing.

It seems difficult for fruits juice industries in local cities and/or rural area to exporting the products to abroad, because its required high quality products as well as strict quality control. Major market of fruits juice produced in local cities and/or rural area will be domestic market. Also fruits juice factory in urban area will be the target for selling their primary processed products. In each case, introduction of refrigerator and electric equipments will be required for advance in quality and its stabilization.



Shot at Factory of CV. Sarimas Lestari in Makassar

Passion Fruits Juice and Electrified Machines Used in the Factory

Coconuts Processing Industry

Indonesia is the largest producer of coconuts in the world, and copra is one of important export commodities. According to FAO statistics, the total production volume in the country in 2005 accounted for 31.6 % of the total production in the world. Coconut production in Sulawesi shares 17.9 % of the national total. About two-thirds of coconuts in the island are harvested in Central Sulawesi (33.5 %) and North Sulawesi (30.8 %).

The productivity of coconut trees in Sulawesi has been declining. Most of coconuts trees in Sulawesi are planted in not large-scale commercial plantation but people’s narrow farm land. Particularly, in the case of North Sulawesi, most of its coconut trees are aging and thus production volumes have progressively decreased. In addition, their relative tallness adds a constraint in harvesting the crop. The above characteristics lead to the low level income for coconut farmers. One of the ways to increase the income of these coconut farmers’ income is by increasing the added value of this product.

There are various coconuts related in industries in Sulawesi, such as coconut fiber manufacturing, coconut oil factory, coconuts powder milling, dried coconuts processing, coconut charcoal and activated carbon processing, and a coconut wood furniture factory. Processing this kind of coconuts industries is relatively simple and can be carried out by small scale enterprises, and they mainly use bio-mass and/or natural sunlight as well as human power as a source of process, except for coconuts wood furniture factory. In order to improve productivity and quality of products, gradual introduction of electrical machinery will be becoming increasingly important.

Rotary-Dryer for Grated Coconut | Coconut deshelling machine | Coconut milk extracting machine

Source: National Engineering Research and Development Center (NERC), Sri Lanka

Sample of Coconuts Processing Machines

Flouring and Husking

Flour milling and powderize of agricultural products is one of the easy way for adding value of products. Of major crops in Sulawesi, maize (corn flour, cornstarch), chili (chili powder) cassava (cassava powder, tapioca powder), rice (rice milling, rice husking, rice flour), and soybean (soybean flour) are suitable for husking as well as milling.

Such flouring and husking process are made using mainly diesel engine driven machines, particularly in rural area. Taking recent rise in the crude oil price, introduction of electric motor driven machine needs to be considered.

Chili Milling Machine

Cassava Powder made in Makassar

Mixer for Making Soy Source

Oven for dehumidification of Palm Sugar

Shot in Makassar

Other Agro-processing Industries

A small enterprise "UD. Bintang Sejati", located in Makassar, is using mixing machine for making soy source. The machine is used for mixing the source more than 16 hours continuously. Such process cannot be made by human power, and thus more appropriate for using electrified machine. "UD. Makassar Agrotech" using electric oven for making palm sugar. According to the entrepreneur, the enterprise used to using gas oven for removing moist from sugar powder, continuous stirrer and adjustment of fire was required to prevent burn of sugar. After introduction of electric oven, employee no need to care during dehumidification, it has brought about better quality of product as well as lesser cost compare to gas. These processes are relatively simple, and need less capital investment. Since abundant materials are available in rural area,

(7) Fishery and Aquatic Processing Industries

Fishery industry is one of very potential economic sub sectors in Sulawesi. Fisheries play a significant role in increasing export and foreign exchange earnings. It has various qualities not only for providing employment opportunities, local incomes for fishermen. Promising fishery and aquatic processing industries using electricity for productive purposes in rural area is as listed as follows;

<u>Fishing Light System</u>

Possible utilization electricity for fish catch fields is introduction of a fishing light system. Fishing light is a fishing aid which uses lights to attract both fish and members of their food chain to specific areas in order to harvest them. Portable batteries for fishing light are charged at home during night. At the time of site visit at fishing village near from Manado, most of fish boat equipped with fishing light. Introduction of fish light is suitable even in rural villages because of its relatively smaller capital investment and greater benefit. Combination of electrification project in fishing villages and promotion of fish light in the villages seems worth executing.

Shot in Manado

Fishing Boat Equipped with Fish Light

<u>Cold Storage Warehouse, Ice Plant, and Ice Breaking Machine</u>

In Sulawesi, ice making factory and cold storage warehouse for fishery products are available only around the bigger city area such as Makassar, Manado, Bitung, Kendari, Palu, and Gorontalo. Thus, if the market is located within 2 hours drive, ice is generally not used for transporting fishes landed in the early morning. However, rural area away from market and without ice plant and cold storage, caught fishes are consumed locally within one or two days and unsold surplus fishes are processed as salted/dried fish. Selling prices of these dried/ salted fish are considerably cheaper than raw fish. Also, such products become

Shot at Fish Market in Manado

Block Ice (L) and Diesel Engine Driven Ice Crushing Machine (R)

abundant during the peak fishing season and is difficult to sell at the local market[20].

Given circumstances, in the case of coastal villages having bigger fish catch potential and having problem on the access to the market or fish processing factory, electrification and subsequent construction of ice plant or cold storage facilities needs to be considered.

At fish market, diesel engine driven ice crushing machines are generally used for crushing block ice. Crushed ice is used for preserving fresh seafood. Taking current hike in the oil price in to consideration, gradual introduction of the electric motor driven ice crushing machine will became important.

Fish Processing Industries

Numbers of modern fish/marine products processing factories are located in Sulawesi. Most of them are located only in and around Makassar City and Manado - Bitung area. While capital intensive and export oriented factory cannot be expected in rural area, relatively simple fish processing factory (e.g. fish power/ seaweed powder making, fish ball processing, press and packaging of dried fish and seaweed) targeting local market can be expected in rural area of Sulawesi

In the case of coastal areas having bigger fish catch, dissemination of fish processing technology and introduction of electrified fish processing facilities needs to be examined.

Shot at Bone Fisheries High School in South Sulawesi

Fish Processing Machine for Fish Ball (*Ikan Bakso*)

In the case of dried fish industries in Sulawesi, since the peak fishing season is overlaps with rainy season (October to April), quality of sun-dried fish is quite inferior due to lack of adequate isolation[*21]. On the other hand, in urban area, some of the fish drying factories are using electric heater for drying. For example, PT Sakana Indonesia situated in Makassar Industrial Estate (KIMA), producing dried fishes (Katsuo-bushi, Iwashi Boshi) using electric heater and exporting products to Japan.

Seaweed Processing

The sea in Sulawesi with a coast line of about 5,478 km has a great potential to produce seaweed. Some of the seaweed species are known to have a high economic value. Of which, Eucheuma sp. and Gracilaria have high economic value, and are the most cultivated types in

[20] Reference: The study on fisheries infrastructure support and coastal communities development plan in Eastern Indonesia final report, Oct. 2002, JICA/ System Science Consultants Inc.: Overseas Agro-Fisheries Consultants Co., Ltd.

[21] The mechanized dried fish factories are located in Makassar and Manado-Bitung area, some of the companies are exporting their products, such as *Katsuo Bushi* (dried bonito), and *Iwashiboshi* (dried sardine), to Japan. PT. Sakana Indonesia located in Makassar Industrial Estate (KIMA) also exports their products to Japan.

Sulawesi. Apart from being used as raw material for food industries such as jelly food and food additives for burgers and others, seaweed is also useful for other kinds of industries including cosmetics, pharmacy, textile, paper, ceramic, photography and insecticide. Seaweed is also used for firming agent and gelatinizing agent of the various industrial products.

As one of the export commodities, it has become a source of income for Sulawesi; its aqua-culture has already been a source of income for fishermen in Southern part of South Sulawesi. Aqua-culture of seaweed can absorb labor force and it can utilize the potential coast-lines of Sulawesi.

Middle scale enterprises PT Bantimurung Indah located in Maros, South Sulawesi processing powdered/ dried seaweed and exporting to mainly Korea, United States, Chilli, and EU. At the factory, electricity is used for the process of refrigerating, conveying (electric crane), cutting, blending, drying (natural sunlight is sufficient for a part of drying process), and grinding.

Since engineering process of seaweed industry is relatively simple, establishment of seaweed processing factory can be expected in rural area, where raw materials are abundant.

Wood Processing, Furniture Making, and Shipbuilding

Wood processing, furniture making and shipbuilding industry are one of the promising industries using electricity for various processing such as grinding, cutting, polishing, drilling and curving.

There are medium and small scale furniture making-factories both in urban and rural area of Sulawesi. Some of them producing high-class furniture (including Buddhist alter for exporting Japan) using Rattan, Teak and Ebony. In North Sulawesi, several factories are making furniture and knockdown house using coconuts tree. Shipbuilding is an important economic activity for the Bugis ethnic group, who is said to be a tribe with excellent talent in shipbuilding and ocean navigation, particularly living in the coastal regions of southern part of Sulawesi. Establishment of such industries is also expected in rural area.

Shot in Pangkep, South Sulawesi (left), Bulukumba (center), and Exhibition in Makassar, South Sulawesi (right)

Furniture Making Equipment, Shipbuilding Factory, and Marble Products (from left to right)

Other Industries

Marble processing industries (making such as floor tile, craved ornament, and furniture) are also available in South Sulawesi such as Pangkep, Luwu and Makassar. Electrified equipments are used for polishing, craving, drilling and cutting marble. Salt industries are also available in Sulawesi, some of them are using electricity for processing.

4.6.3 Recommendation for Promoting Productive Use of Electricity in Rural Area

Various types of industries are using electricity for productive purposes in urban area of Sulawesi Island. Of which some of them seems also viable in rural area. However, several constraints are imposed on productive use of electricity in rural area. Especially, i) lack of adequate financing for starting business, ii) lack of adequate access to market, iii) lack of sufficient skills and knowledge about productive use of electricity, seems one of the biggest constraints needed to be addressed.

In order to address these issues, in implementing rural electrification project, 1) coordination with existing micro finance scheme, 2) coordination with rural road development project, and 3) provision of training for the candidates of entrepreneur about productive use of electricity, will be recommended. In executing rural electrification project, implementation of pilot project for productive use of electricity taking these solution into consideration will be also recommended.

(1) Coordination with Existing Microfinance Institutions

Inauguration of business/industries needs certain amount of initial investment cost. Particulary, when inauguration of business using electric facilities need more investment. However, traditionally commercial banks have usually not provided financial services to clients living in rural area with little cash income. Such lack of access to adequate financing deemed constraints in starting business in rural area. One possible solurtion on this matter is utilization of microfinance scheme.

Since there are numbers of well organized microfinance institutions in Indonesia. Some of the institutions are not not only providing financing service but also providing technical assistance and trainning for business activities (e.g. Bina Desa, Bank Rakyat Indonesia Unit Desa (BRI-UD), Civil Society Community and Bank Relation Program).

In executing coming rural electrification project, it is recommended to coordinate with the existing microfinancing institutions, particularly institutions actively involving training activities for entrepreneurs. In the case of rural electrification project with financial help from international development assistance agencies, part of project cost should be utilized for assisting inauguration of electricity oriented-bussiness acitvities through two-step loan via the existing microfinancing institutions.

(2) Coordination with Road Development Project

Rural road projects usually significantly contributes rural development. This is because rural road developments improve the accessibility to the markets, and then stimulating inauguration of small scale industries in rural area. In other word, even after the electrification project, without adequate transportation infrastructure, prosperity of small scale industries cannot be expected in rural area. For this reason, promotion of productive use of electricity in rural area is considered to be better to coordinate with rural road development projects.

At present, road improvement works, including rehabilitation and maintenance, are vigorously pursued in Sulawesi with the assistance of international donors such as JICA, the World Bank, Asian Development Bank, and AusAID. JICA has just finished the road development master plan in Sulawesi under the ” the Study on Arterial Road Network Development Plan for Sulawesi Island”. Also, three ongoing projects under other donors are as follows: Eastern Indonesia Region Transport Project (EIRTP) – World Bank, Road Rehabilitation Sector Project (RRSP) – Asian Development Bank, Eastern Indonesia National Road Improvement Project (EINRIP) – AusAID. In addition, World Bank and AusAID are going to launch soon the next phase of their projects (EIRTP 2 and EINRIP 2).

In selecting target area of coming electrification project, coordination of these road development projects will be highly recommended.

(3) Provision of Training for Productive Use of Electricity

Lack of knowledge and technical skill is deemed one of the major constaints for staring busines using electricity in rural area. Provision of basic training (including, bookkeeping, organizational, administrative, capital, and networking) of candidate entrepreneur will be recommended.

If the industry is possibilities for exporting their products, coordination with Regional Export Training and Promotion Center of Sulawesi (RETPC) will be suitable counterpart agency. RETPC Sulawesi was established in 2003 with technical assistance from JICA, to promote the export of small and medium enterprises (SMEs) and to provide export training, trade information and promotion services to SMEs in the respective regions.

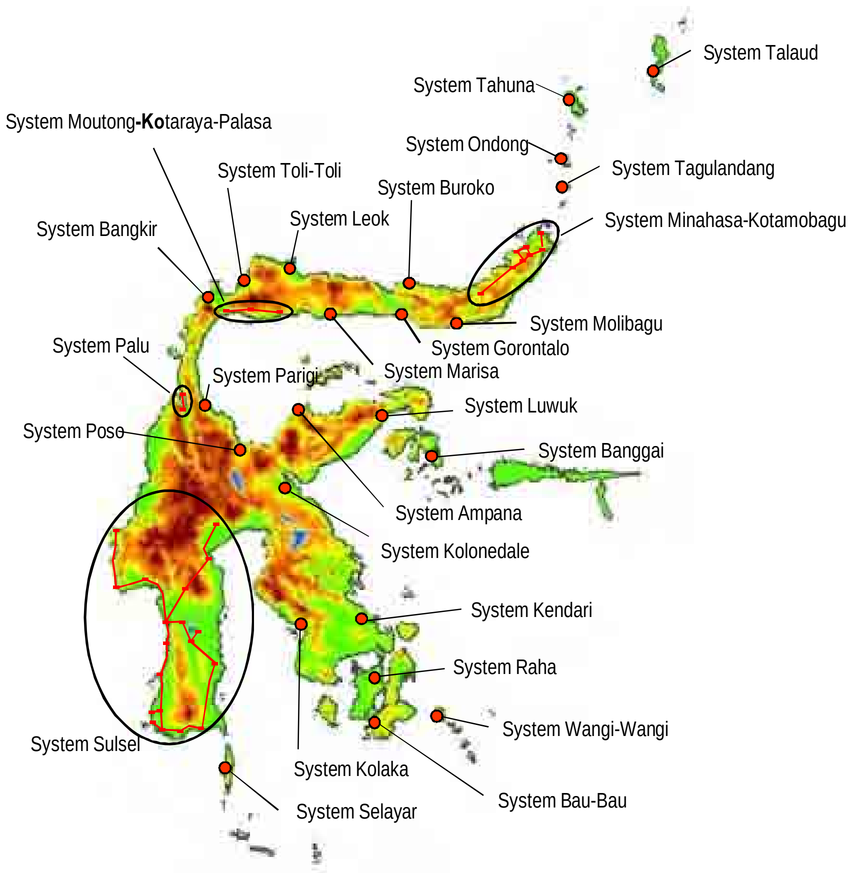
Chapter 5 Generation Development Planning

JICA Study team will propose an optimal generation development plan considering conditions such as future demand, supply capacity, required supply reliability, costs and environmental aspects. This chapter discusses the generation development plan for power systems in Sulawesi up to 2027.

5.1 Procedure for Generation Development Planning

5.1.1 Target System for the Study

This Study aims to formulate an expansion plan for power systems which PLN owns and operates in the main island of Sulawesi. Figure 5.1.1 shows the target power systems in the generation development planning[32].



No.	System	Province
PLN Wilayah Suluttenggo		
1	Minahasa-Kotamobagu	Sulawesi Utara
2	Tahuna	
3	Ondong	
4	Molibagu	
5	Talaud	
6	Tagulandang	
7	Gorontalo	Gorontalo
8	Marisa	
9	Buroko	
10	Palu	Sulawesi Tengah
11	Poso	
12	Toli-Toli	
13	Parigi	
14	Moutong-Kotaraya-Palasa	
15	Leok	
16	Kolonedale	
17	Bangkir	
18	Luwuk	
19	Ampana	
20	Banggai	
PLN Wilayah Sulselrabar		
21	Sulsel	Sulawesi Selatan, Sulawesi Barat
22	Selayar	Sulawesi Selatan
23	Kendari	Sulawesi Tenggara
24	Kolaka	
25	Raha	
26	Bau-Bau	
27	Wangi-Wangi	

Figure 5.1.1 Target Power Systems for the Study

[32] Status as of the end of September 2007

5.1.2 Workflow of Generation Development Planning

Figure 5.1.2 shows a workflow for the formulation of a generation development plan in the Study.

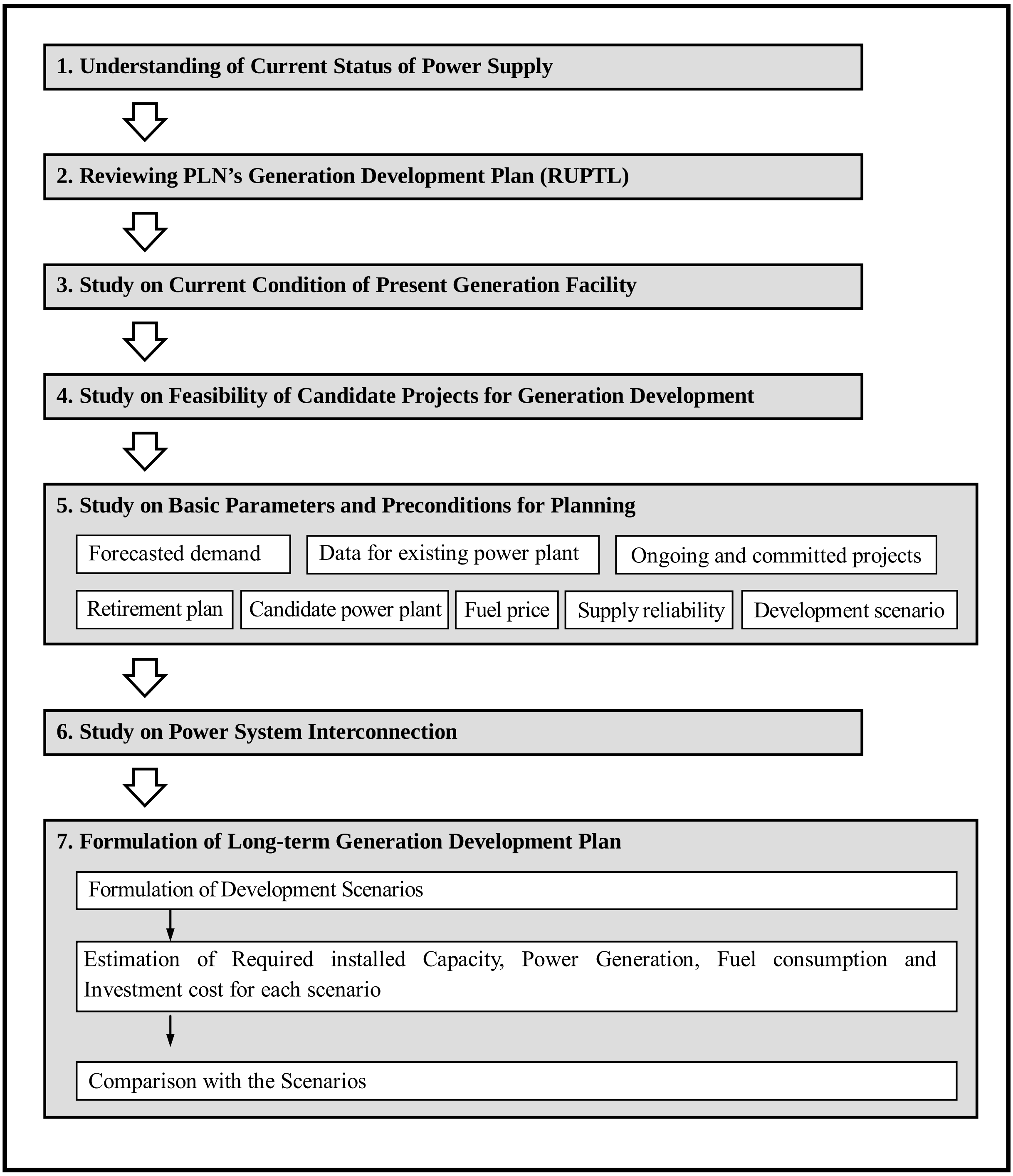


Figure 5.1.2 Workflow of Generation Development Planning

5.2 Power Supply in Sulawesi

5.2.1 PLN Power Supply

PLN supplies power almost all the area in Sulawesi. The energy production in Sulawesi was 4,164 GWh in 2006, which was about two (2) percent of the total PLN production in the whole country of Indonesia. Table 5.2.1 shows the PLN's power supply in Sulawesi from 2002 to 2006.

Table 5.2.1 PLN's Power Supply in Sulawesi

	Year				
	2002	2003	2004	2005	2006
Peak Demand (MW)	681.2	704.1	722.2	741.7	853.9
Energy Production (GWh)	3,356	3,451	3,764	3,929	4,164

(Source: Statistiks PLN Suluttenggo 2002-2006, Statistiks PLN Sulselrabar 2002-2006)

PLN's power supply systems in Sulawesi divided into three (3) types; (1) Interconnected Systems of the System Minahasa-Kotamobagu in northern Sulawesi and the System Sulsel in southern Sulawesi, (2) Small-scale isolated systems (25 systems), and (3) Scattered stand-alone systems with very small capacity.

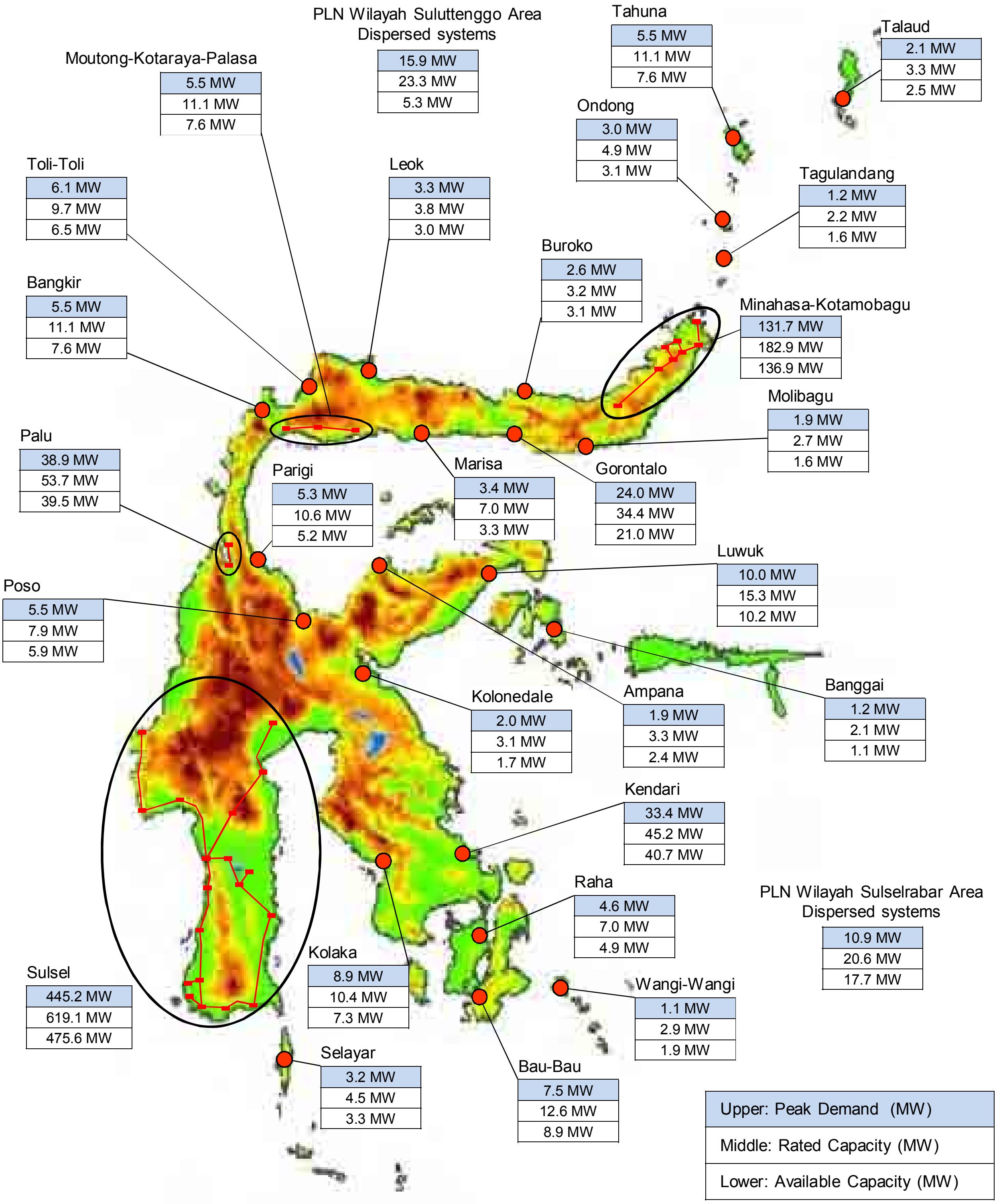
Wilayah Suluttenggo in Manado and Wilayah Sulselrabar in Makassar are PLN regional office which are responsible for power supply in north area and south area, respectively.

Figure 5.2.1 shows outline of PLN's systems in Sulawesi as of the end of 2006.

Table 5.2.2 shows PLN energy production in Sulawesi. The annual energy productions of the System Minahasa-Kotamobagu and System Sulsel are 694 GWh and 2,487 GWh, respectively, which corresponds to 16.7% and 59.7% of PLN energy production in Sulawesi..

Table 5.2.2 PLN Energy Production in 2006

system	Annual Energy Production (GWh)	Component Ratio (%)
Minahasa-Kotamobagu	694	16.7
Sulsel	2,487	59.7
Other systems	983	23.6
Total	4,164	100.0



Source: RUPTL 2008-2017 PLN Wilayah Suluttenggo (Draft)
RUPTL 2008-2017 PLN Wilayah Sulselrabar (Draft)

Figure 5.2.1 Outline of PLN Power Systems in Sulawesi

5.2.2 PLN Power Supply by the Systems

(1) Installed Capacity of the Systems

Table 5.2.3 shows the installed capacity of power plants in PLN systems from 2002 to 2006. The installed capacity was increased to 1,138.6MW in the end of 2006. PLN owns the most of the generation facilities in PLN Wilayah Suluttenggo area, but only 60 % in PLN Wilayah Sulserlabar area while private sector has 30% of the facilities.

Table 5.2.3 Installed Capacity of Power Plants in PLN Systems

(Unit: MW)

Responsible Area	Owner	Year				
		2002	2003	2004	2005	2006
PLN Wilayah Suluttenggo	PLN	314.0	333.1	359.3	363.5	356.5
	Private	-	-	-	-	-
	Rental	24.7	42.8	31.6	27.5	53.0
	Sub-total	338.6	375.9	390.9	391.0	409.5
PLN Wilayah Sulselrabar	PLN	470.4	457.1	485.4	474.6	484.9
	Private	202.2	202.2	205.2	202.2	200.0
	Rental	-	-	-	43.3	44.2
	Sub-total	672.6	659.3	690.6	720.1	729.1
Total		1,011.3	1,035.3	1,081.5	1,111.1	1,138.6

(Source: Statistik PLN Wilayah Suluttenggo, Sulselrabar, 2002-2006)

(2) Power Generation of PLN Systems

Table 5.2.4 shows the annual power generation by the PLN power Systems from 2002 to 2006. The annual power generation is increased to 4,164 GWh in 2006. About 50% of the power generation in Wilayah Sulselrabar area depends on private-owned power plants.

Table 5.2.4 Annual Power Generation of PLN Power Systems

(Unit: GWh)

Responsible Area	Owner	Year				
		2002	2003	2004	2005	2006
PLN Wilayah Suluttenggo	PLN	915.5	815.6	881.0	927.3	986.8
	Private	-	-	-	-	-
	Rental	84.9	224.7	244.0	277.2	295.9
	Sub-total	1,000.3	1,040.2	1,124.9	1,204.4	1,282.7
PLN Wilayah Sulselrabar	PLN	1,264.0	1,231.2	1,312.6	1,326.7	1,246.9
	Private	1,091.3	1,179.8	1,284.7	1,297.5	1,433.0
	Rental	-	-	-	100.6	201.7
	Sub-total	2,355.3	2,411.0	2,597.3	2,724.9	2,881.7
Total		3,355.7	3,451.3	3,722.3	3,929.3	4,164.4

(Source: Statistik PLN Wilayah Suluttenggo, Sulselrabar, 2002-2006)

5.2.3 Supply-Demand Balance in PLN Systems

Table 5.2.5 shows supply-demand balances each system as follows.

(1) Supply-Demand Condition of the System Minahasa-Kotamobagu and System Sulsel

The reserve capacity of the System Minahasa-Kotamobagu was 5.23 MW (2006), which corresponds to only 3.9% of the peak demand. This means that electricity supply tends to short in case an accidental outage of a power plant occurs in the system. Lahendong geothermal power plant unit No.2 (20 MW) commenced its operation in April 2007 and it was expected that the reserve capacity in the system increased drastically. However, the power unit could not operate at rated capacity because the steam supply to the power unit from PT PERTAMINA was strictly limited as of the end of September in 2007 and the situation of supply-demand of the system was not improved.

The reserve capacity of the System Sulsel was 30.4 MW (2006), which corresponds to 6.8% of the peak demand. Consequently, the situation of power supply in the System Sulsel is also severe. A truck-mounted gas turbine unit (20 MW) and a new diesel unit (70 MW) will be introduced in the system in 2008, however, it will not improve the supply situation drastically because of high demand increase. Moreover, Bakaru hydropower plant with a rated capacity of 126 MW, which corresponds to 30% of the peak demand, may probably operate at less than half of the rated capacity in dry season.

(2) Supply-Demand Status of the Small-scaled Isolated Power System

Some systems such as System Gorontalo in northern Sulawesi region and the system Kolaka in southern Sulawesi region, have not enough supply capacity to meet the peak demand. Although the System Gorontalo is the fifth largest demand in Sulawesi, but the system has no reserve in 2006.

Table 5.2.5 Supply-Demand of PLN Systems in Sulawesi (As of 2006)

No.	Responsible Office	System	Supply-Demand (as of 2006)						
			(1) Peak Demand	(2) Available Capacity	(3) Reserve ((2) - (1))		Reserve (> 0)	(4) Max. Unit Capacity	(3) - (4) (> 0)
1		Minahasa-Kotamobagu	131.7 MW	136.9 MW	5.2 MW	(3.9 %)	O.K.	20.0 MW	
2		Tahuna	5.5 MW	7.6 MW	2.1 MW	(38.2 %)	O.K.	1.1 MW	O.K.
3		Ondong	3.0 MW	3.1 MW	0.1 MW	(3.3 %)	O.K.	0.7 MW	
4		Molibagu	1.9 MW	1.6 MW	▲0.3 MW	(▲15.8 %)		0.7 MW	
5		Talaud	2.1 MW	2.5 MW	0.4 MW	(19.0 %)	O.K.	0.5 MW	
6		Tagulandang	1.2 MW	1.6 MW	0.4 MW	(33.3 %)	O.K.	0.5 MW	
7		Gorontalo	24.0 MW	21.0 MW	▲3.0 MW	(▲12.5 %)		2.9 MW	
8		Marisa	3.4 MW	3.3 MW	▲0.1 MW	(▲2.9 %)		0.7 MW	
9	PLN Wilayah Northern Sulawesi - Gorontalo - Central Sulawesi	Buroko	2.6 MW	3.1 MW	0.5 MW	(19.2 %)	O.K.	0.9 MW	
10		Palu	38.9 MW	39.5 MW	0.6 MW	(1.5 %)	O.K.	13.5 MW	
11		Poso	5.5 MW	5.9 MW	0.4 MW	(7.3 %)	O.K.	1.3 MW	
12		Toli-Toli	6.1 MW	6.5 MW	0.4 MW	(6.6 %)	O.K.	1.3 MW	
13		Parigi	5.3 MW	5.2 MW	▲0.1 MW	(▲1.9 %)		1.1 MW	
14		Moutong-Kotaraya-Palasa	5.5 MW	7.6 MW	2.1 MW	(38.2 %)	O.K.	1.0 MW	O.K.
15		Leok	3.3 MW	3.0 MW	▲0.3 MW	(▲9.1 %)		1.0 MW	
16		Kolonedale	2.0 MW	1.7 MW	▲0.3 MW	(▲15.0 %)		0.7 MW	
17		Bangkir	5.5 MW	7.6 MW	2.1 MW	(38.2 %)	O.K.	0.7 MW	O.K.
18		Luwuk	10.0 MW	10.2 MW	0.2 MW	(2.0 %)	O.K.	1.6 MW	
19		Ampana	1.9 MW	2.4 MW	0.5 MW	(26.3 %)	O.K.	0.8 MW	
20		Banggai	1.2 MW	1.1 MW	▲0.1 MW	(▲8.3 %)		0.5 MW	
21		Sulsel	445.2 MW	475.6 MW	30.4 MW	(6.8 %)	O.K.	67.5 MW	
22		Selayar	3.2 MW	3.3 MW	0.1 MW	(3.1 %)	O.K.	0.6 MW	
23	PLN Wilayah Southern Sulawesi - South-eastern Sulawesi - Western Sulawesi	Kendari	33.4 MW	40.7 MW	7.3 MW	(21.9 %)	O.K.	2.4 MW	O.K.
24		Kolaka	8.9 MW	7.3 MW	▲1.6 MW	(▲18.0 %)		2.2 MW	
25		Raha	4.6 MW	4.9 MW	0.3 MW	(6.5 %)	O.K.	2.0 MW	
26		Bau-Bau	7.5 MW	8.9 MW	1.4 MW	(18.7 %)	O.K.	1.7 MW	
27		Wangi-Wangi	1.1 MW	1.9 MW	0.8 MW	(72.7 %)	O.K.	0.5 MW	O.K.

(Source: JICA Study Team, refferece: RUPTL 2008-2017 Draft by PLN Wilayah Suluttenggo and Wilayah Sulselrabar)

5.2.4 Present Generation Facilities

Table 5.2.6 and Figure 5.2.2 show the present generation facilities in the power systems. The outstanding point of Wilayah Suluttenggo area is that diesel generation dominates because there are many small demand independent areas(in Sulaswsi main island) and small islands such as Tahuna where only diesel supply the power.

On the other hand, Wilayah Sulselrabar area has a variety type of generation units and the capacity mixture is well balanced. The system utilizes local primary energy such as natural gas used for Senkang combined cycle power plant and hydropower at Bakaru and Bili-Bili power plants.

Table 5.2.6 Present Generation Facilities (as of the end of 2006)

Responsible Area	Plant Type		No. of Plants	No. of Units	Rated Capacity (MW)	Available Capacity (MW)
Wilayah Suluttenggo	Hydropower (incl. Mini-hydro)	PLTA, PLTM	10	17	64.370	59.248
	Diesel Plant	PLTD	62	314	285.437	175.182
	Geothermal Plant	PLTP	1	1	20.000	20.000
	Sub-total		73	332	369.807	254.430
Wilayah Sulselrabar	Hydropower (incl. Mini-hydro)	PLTA, PLTM	4	9	149.320	148.179
	Diesel Plant	PLTD	22	144	266.311	187.250
	Steam Turbine Plant	PLTU	1	2	25.000	10.500
	Gas Turbine Plant	PLTG	1	5	122.716	110.300
	Combined Cycle Plant	PLTGU	1	3	135.000	108.300
	Sub-total		29	163	698.347	564.529
Total			102	495	1,068.154	818.959

(Source: JICA Study Team, referrence: Statistiks 2006 PLN Wilayah Suluttenggo, Sulselrabar)

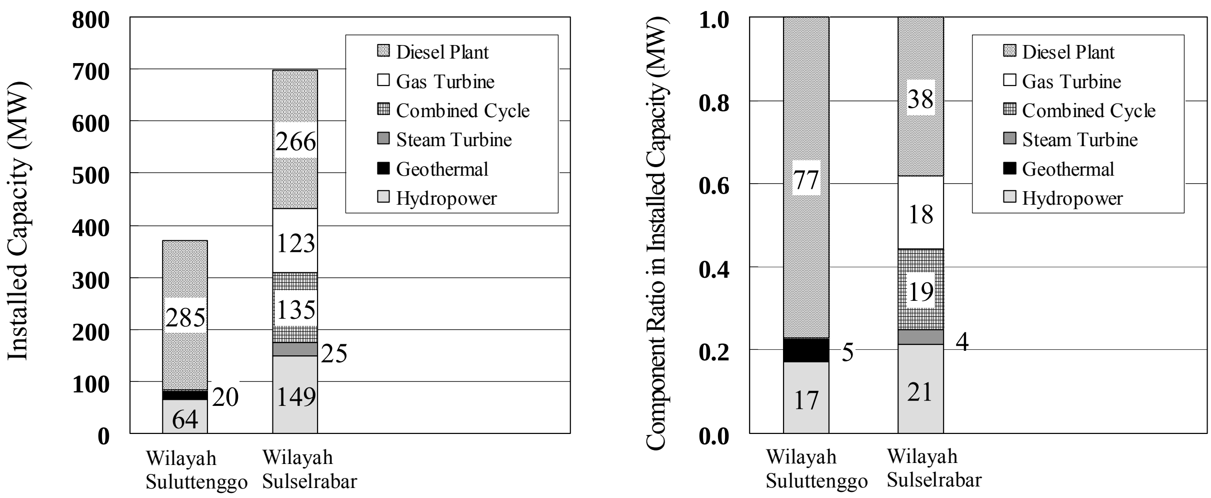


Figure 5.2.2 Installed Capacity and Component Ratio by Plant Type (as of the end of 2006)

Table 5.2.7 shows the breakdown of the present generation facilities in the power systems. The total available capacity is about 846 MW, which is 79% of the rated capacity. The difference between rated and available capacities comes to 224 MW and the reason of this decline of rated capacity (hereinafter referred to as derating capacity) is composed of 1) unworkable due to outage of equipment, 2) derating due to trouble in equipment, and 3) stand-by units.

Table 5.2.7 Breakdown of the Present Generation Facilities (as of the end of 2006)

System	Plant Type		No. of Plants	No. of Units	Rated Capacity (MW)	Available Capacity (MW)
PLN Wilayah Suluttenggo						
Minahasa-Kotamobagu	Hydro (incl. mini-hydro)	PLTA, PLTM	4	9	53.780	50.000
	Diesel Unit	PLTD	8	51	110.140	61.570
	Geothermal	PLTP	1	1	20.000	20.000
	Subtotal		13	61	183.920	131.570
Tahuna	Mini-hydro	PLTM	1	1	1.000	1.000
	Diesel Unit	PLTD	4	25	10.098	6.510
	Subtotal		5	26	11.098	7.510
Ondong	Diesel Unit	PLTD	1	14	4.860	3.145
Molibagu	Diesel Unit	PLTD	1	8	2.730	1.550
Talaud	Diesel Unit	PLTD	3	16	3.250	2.430
Tagulandang	Diesel Unit	PLTD	1	8	2.180	1.570
Gorontalo	Diesel Unit	PLTD	4	21	34.440	20.950
Marisa	Diesel Unit	PLTD	2	10	7.011	3.330
Buroko	Diesel Unit	PLTD	1	6	3.220	2.580
Palu	Diesel Unit	PLTD	22	22	51.700	37.500
Poso	Mini-hydro	PLTM	1	2	2.640	2.400
	Diesel Unit	PLTD	2	8	5.232	3.500
	Subtotal		3	10	7.872	5.900
Toli-Toli	Mini-hydro	PLTM	1	2	1.600	1.600
	Diesel Unit	PLTD	1	15	8.076	4.910
	Subtotal		2	17	9.676	6.510
Parigi	Diesel Unit	PLTD	1	19	10.558	5.200
Moutong-Palasa-Kotaraya	Diesel Unit	PLTD	3	27	8.250	4.735
Leok	Diesel Unit	PLTD	1	13	3.820	3.045
Kolonedale	Diesel Unit	PLTD	2	11	3.100	1.670
Bangkir	Diesel Unit	PLTD	1	7	1.920	1.557
Luwuk	Mini-hydro	PLTM	3	3	5.350	4.248
	Diesel Unit	PLTD	2	15	9.964	5.960
	Subtotal		5	18	15.314	10.208
Ampana	Diesel Unit	PLTD	1	9	3.250	2.350
Banggai	Diesel Unit	PLTD	1	9	2.138	1.120
PLN Wil. Suluttengo Total			73	332	370.307	254.430
PLN Wilayah Sulselrabar						
Sulsel	Hydro (incl. mini-hydro)	PLTA, PLTM	3	7	147.720	146.650
	Diesel Unit	PLTD	13	79	185.021	123.870
	Steam Turbine	PLTU	1	2	25.000	10.500
	GasTurbine	PLTG	1	5	122.716	110.300
	Combined Cycle	PLTGU	1	3	135.000	135.000
	Subtotal		19	96	615.457	526.32
Selayar	Diesel Unit	PLTD	1	6	4.544	3.300
Kendari	Diesel Unit	PLTD	4	19	45.800	39.300
Kolaka	Diesel Unit	PLTD	1	10	10.430	7.160
Raha	Diesel Unit	PLTD	1	11	7.082	4.950
Bau-Bau	Mini-hydro	PLTM	1	2	1.600	1.529
	Diesel Unit	PLTD	1	12	11.048	6.985
	Subtotal		2	14	12.648	8.514
Wangi-Wangi	Diesel Unit	PLTD	1	7	2.948	1.685
PLN Wil. SulselrabarTotal			29	163	698.909	591.229
Grand Total			102	495	1,069.216	845.659

Table 5.2.8 shows the breakdown of the derating capacity by the power system.

Table 5.2.8 Breakdown of Derating Capacity

System		Derating Capacity (MW)			
		Unwrokable Unit due to Outage	Trouble in Equipment	Stand-by Unit	Total
1	Minahasa	27.4	19.7	1.0	48.0
2	Tahuna	1.5	2.1		3.6
3	Ondong	0.8	0.9		1.7
4	Molibagu	0.4	0.8		1.2
5	Talaud		0.8		0.8
6	Tagulandang	0.3	0.3		0.6
7	Gorontalo	6.4	7.1		13.5
8	Marisa	2.2	1.5		3.7
9	Buroko	0.1	0.5		0.6
10	Palu		14.2		14.2
11	Poso	0.9	1.1		2.0
12	Toli-Toli	0.8	2.3		3.2
13	Parigi	2.8	2.6		5.4
14	Moutong-Kotaraya-Palasa	1.7	1.8		3.5
15	Leok	0.2	0.6		0.8
16	Kolonedale	0.8	0.7		1.4
17	Bangkir		0.4		0.4
18	Luwuk	1.5	3.6		5.1
19	Ampana	0.5	0.4		0.9
20	Banggai	0.8	0.3		1.0
21	Selatan	58.1	29.1	2.0	89.1
22	Selayar	0.5	0.7		1.2
23	Kendari		6.5		6.5
24	Kolaka	1.0	2.2		3.3
25	Raha		2.1		2.1
26	Bau-Bau	0.6	3.6		4.1
27	Wangi-Wangi		1.3		1.3
Total		109.4	111.2	3.0	223.6

(Source: JICA Study Team, referrence: Statistiks PLN Wilayah Suluttenggo, Sulselrabar)

The sum of the derating capacity due to trouble in equipment 111MW and it means that many generation units in operation cannot run at its rated capacity. Table 5.2.9 shows the ratio of the derating capacity to the installed capacity by plant type.

Table 5.2.9 Ratio of Derating Capacity by Plant Type

Plant Type		Ratio of Derating Capacity to Installed Capacity (%)
Hydropower	PLTA	2.9
Geothermal	PLTP	0.0
Steam Turbine	PLTU	16.0
Combined Cycle	PLGTU	0.0
Gas Turbine	PLTG	10.1
Diesel Unit	PLTD	19.1
Average		11.6

(Source: JICA Study Team, reference: Statistiks 2006 PLN Suluttenggo, Sulselrabar)

The power plant composed by diesel unit has the highest ratio of derating capacity, which is about 19.1% of installed capacity. It seems that such derating capacity mainly caused from the aging of equipment and expanding its maintenance interval due to chronic shortage of supply capacity in the system.

5.3 Present General Electricity Supply Plan (RUPTL[33])

PLN formulates a General Electricity Supply Plan (RUPTL) every year, in which PLN shows a direction of future expansion of generating facilities in PLN system.

The Study Team reviewed the generation development plans in the latest RUPTL Draft (draft version of RUPTL 2007-2016[34]) formulated by PLN Wilayah Suluttenggo and Sulselrabar in order to find and examine key points on generation development planning in the Study.

5.3.1 Conditions and Parameters applied in RUPTL

(1) Planning Period

The planning period for RUPTL is 10 years and the plan is categorized as a mid- and long-term development plan. Therefore, the RUPTL formulated in 2007 will present a generation development plan until 2017.

PLN regional offices (PLN Wilayah Suluttenggo and PLN Wilayah Sulselrabar) applies simulation software of WASP-IV for formulating generation development plan for the System Minahasa-Kotamobagu and the System Sulsel[35].

Wilayahs apply the results of electricity demand forecasts for the next 20 years, which is 10 years longer than the planning period of RUPTL.

WASP simulation tends to select generation units with small initial investment costs in the years around end of the study period. Therefore, the simulation should be carried out for a longer period than the actual planning period (in case of RUPTL, 10 years) for the purpose of excluding the impacts of this tendency.

From this point of view, the manner in setting of the study period and planning period applied by both PLN regional offices is appropriate.

(2) Electricity Demand

Both PLN regional offices formulate generation development plans based on the future electricity demand separately forecasted in the formulation of RUPTL. Out of the results of electricity demand forecasting, the results of 1) annual peak demand, 2) annual production energy and 3) load factor of the system at generation end is to be used in the formulation of generation development plan.

Both PLN regional offices divide a year into four (4) periods in WASP simulation based on the actual record of monthly peak demand in the previous year and prepare the peak demand, load factor and load shape (in the shape of load duration curve) for each period.

As shown in Figure 5.3.1, the monthly peak demand of the System Minahasa-Kotamobagu

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[33] Rencana Usaha Pnyediaan Tenaga Listrik (Indonesian Language)

[34] Both Wilayahs formulated the generation plans in 2006, but the plans have not been issued as of the end of September in 2007.

[35] PLN Wilayah Suluttenggo uses EXCEL software for making the final version of generation development plan in RUPTL and carries out WASP simulation as reference for planning.

and the System Sulsel do not fluctuate through a year. Therefore, there is no strong need for a planner to divide a year into a plural number of periods in the simulation in terms of the setting of demand data. However, it should be divided into an appropriate number of periods in terms of considering the seasonal fluctuation of the production energy from hydropower plants and, therefore, the manner applied in RUPTL seems to be appropriate.

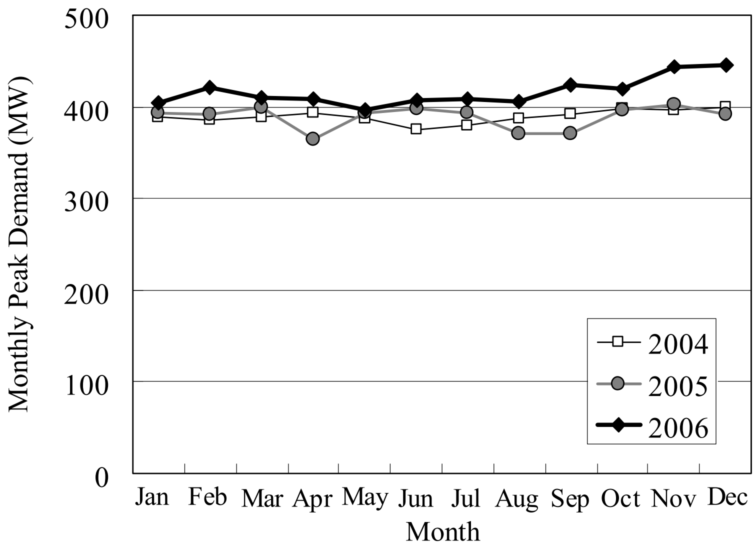


Figure 5.3.1 Monthly Peak Demand in the System Sulsel (2004-2006)

(1) Data Setting for Present Power Plants

Based on the actual performance of the existing power plants in the system, both PLN regional offices prepare data and information on present power plants used for RUPTL.

Although the available capacity of all generation units is considered in the planning as an expected capacity in the future based on the actual performance value as of December in the previous year, for some hydropower plants seasonal fluctuation of the available capacity is not considered in the simulation. For example, although Bakaru hydropower plant in the System Sulsel has relatively large fluctuation in its available capacity through a year due to seasonal rain condition, it is simulated as if operating at a constant capacity through a year and producing constant energy in every month. The impact of these inappropriate setting in the planning is negligible because hydropower plants in the System Sulsel has a share of 20% of total in installed capacity. Consequently, these setting should be changed to appropriate ones. The seasonal fluctuation in available capacity and generation energy through a year is not considered in the planning for the System Minahasa and therefore, it also should be corrected.

The data setting regarding a daily operation pattern for hydropower plants also should be corrected. For example, the operation pattern of Bili-Bili hydropower plants is assumed in the PLN plan as if it operates to meet the peak demand as shown in Figure 5.3.2. However, Bili-Bili hydropower plant operates at constant capacity through a day and therefore, these inappropriate setting should be corrected.

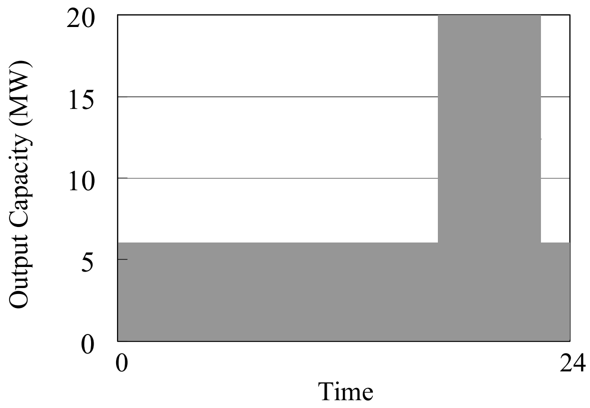


Figure 5.3.2 Image of Daily Operation Pattern Setting of Bili-Bili Hydropower Plant (RUPTL)

(1) Candidate Power Plants for Power Development

Table 5.3.1 shows the major candidate power plants prepared in RUPTL 2007-2016 Draft.

Table 5.3.1 Major Candidate Power Plants for Development (RUPTL 2007-2016 Draft)

System	Plant Type		Fuel	Capacity (MW)	Development Cost (USD/kW)
Minahasa	Steam Turbine	PLTU	Coal	25	1,226
	Steam Turbine	PLTU	Coal	55	1,104
	Poigar Hydropower	PLTA		20	1,533
	Sawangan Hydropower	PLTA		18	1,533
Sulsel	Steam Turbine	PLTU	Coal	65	1,100
	Steam Turbine	PLTU	Coal	100	1,100
	Gas Turbine	PLTG	HSD	50	350
	Combined Cycle	PLTGU	Natural Gas	100	750
	Poko Hydropower	PLTA		166	1,270
	Malea Hydropower	PLTA		182	1,425
	Bonto Batu Hydropower	PLTA		100	1,173

(Source: RUPTL 2007-2016 Draft by PLN Wilayah Suluttenggo, Sulselrabar)

(2) Target Criteria of System Reliability

Table 5.3.2 shows the target criteria of system reliability applied for formulation of generation development plan in RUPTL 2007-2016. The reserve margin will be 30% to the System Sulsel in RUPTL based on the experience in system operation. The System Minahasa-Kotamobagu and the Small-scaled Isolated System have a reserve margin of the biggest two (2) units' capacity in the system.

Table 5.3.2 Target Criteria of System Reliability

Responsible Area	Sstem	Target Criteria of System Reliability
Wilayah Suluttenggo	Minahasa-Kotamobagu System	Reserve margin is 30% or above
	Other Small-scaled Isolated System	Reserve margin is equal to or above the sum of maximum two units
Wilayah Sulselrabar	Sulsel System	Reserve margin is equal to or above the sum of maximum two units
	Other Small-scaled Isolated System	

(Source: RUPTL 2007-2016 Draft by PLN Suluttenggo, Sulselrabar)

5.4 Present Conditions of Power Facilities

5.4.1 General Situation

As shown in Table 5.4.1, unit size of the generating facilities in Sulawesi is rather small. Thus total number of units is relatively large as much as 964. The largest installed capacity per unit is 145 MW in Senkang Gas-fired Steam IPP, and the smallest is 10 kW in Loleha and other stations.

Table 5.4.1 General Situation of Generation Facilities in Sulawesi (as of 2005)

Number of Units	Average Installed Capacity (MW/unit)	Max. Installed Capacity (MW/unit)	Min. Installed Capacity (MW/unit)	Average COD	Oldest COD	Latest COD
764	0.972	145.00	0.01	1989.8	1940	2004

Source: PLN

It should be noted that some extremely old machines are still on active service in the island. Units that are believed much older than the manufacturers' expectation are, for example:

Hydros: Sawito in 1940/43, Tonsea Lama Units No. 1 and No. 2 respectively in 1950[36] and 1970,

Coal-fired: Tello Units No.1 and 2 both in 1971, and

Diesel: Manado GM-made Unit No. 1in 1954.

Table 5.4.2 Power Generation Units Much Older than Expected Lives

Wilayah	Cabang	Name	Units	Maker	DOC	Cap_MW	Type
North	Minahasa	Manado	1	GM / ELLIOT	1954	1.00	Diesel
North	Minahasa	Tonsea Lama	1	ESCHER WYSS / GE	1950	4.44	Hydro
North	Minahasa	Tonsea Lama	1	STORK H. / BBC	1970	4.50	Hydro
South	Pembangkit 2	Sawito	1	BRAAT / SMIT	1940	0.54	Micro H.
South	Pembangkit 2	Sawito	2	S. BERN / SMIT	1943	1.08	Micro H.
South	Pembangkit 1	Tello	1	JUGOTURBINA	1971	25.00	Coal

[36] Unit No. 1 of Tonsealama Hydropower Plant was manufactured in 1917 and commissioned in 1950. It was originally part of a Japanese plant, Yamura, and transferred by the Japanese Army in 1942. It is already 90 years old since its manufacturing. PLN added Unit No. 2 (4.5 MW) in 1970 and Unit No. 3 (5.4 MW) in 1981.

Actual power outputs are often seen enormously less than the original capacities in the island, as seen in Table 5.4.3. This capacity deterioration seems to be closely related to the aging mentioned above.

Table 5.4.3 Installed Capacities and Actual Max Outputs of Sulawesi Plants

System			Installed (MW)	Availability (MW)	Performance
Sistem Minahasa			150	122	81%
		PLTA	54		
		PLTD	76		
		PLTP	20		
Sistem Terisolasi			191	138	72%
	Gorontalo	PLTD	27	18	
	Palu	PLTD	44	31	
	Luwuk	PLTD	12	9	
	Poso	PLTD	8	6	
	Tersebar	PLTD	156	83	
Total Suluttenggo		PLTD	341	260	76%
Sistem Makassar			550	470	85%
	PLN	PLTA	127	127	
		PLTU	25	20	
		PLTG	123	96	
		PLTD	65	30	
	IPP	PLTGU	145	135	
		PLTD	65	62	
Sistem Terisolasi			86	84	98%
	Palopo-Malili	PLTD	25	23	
		PLTA	5	5	
	Kendari	PLTD	36	36	
	Kolaka	PLTD	9	9	
	Bau-bau	PLTD	11	11	
Tersebar		PLTD	32	22	69%
Total	Sulselra		668	576	86%
Overall Sulawesi			1,009	836	83%

Source: PLN

5.4.2 Discussions on Individual Plants

(1) Diesel Power Plants

The diesel power plants within Sulawesi Island are the largest power generation source. It contributes more than 65% in terms of both power (kW) and energy (kWh) in 2006. The diesel power plants, however, are demanded to be rapidly replaced with different power sources except for isolated small islands, because of escalation of the fuel price and consideration on the environmental friendliness. It is observed that the maintenance budgets, which are originally not abundant enough, are decreasing these days, as the expected operational years of the diesel generators are not long. In this circumstance, a number of diesel generators, including the GM-made 1.0 MW installed in 1956 in Manado Station, are reaching their operational lives. Because of the insufficient electricity supply in the island, replacement of the diesel generators needs harmonious combination with the development of new power plants.

Figure 5.4.1 Gorontalo Diesel Power Plant

(2) Hydropower Plants

Some hydro plants are suffering from remarkable aging and demanding total repair or re-development in view of safety and security. The symbolic example is Unit No. 1 of Tonsealama Hydro Plant, Tondano River System in North Sulawesi. It is 90 years old since its manufacturing and its total repair or re-development seems to be required. The Tonsealama's steel penstock is demanding urgent actions, because its thickness has reportedly been reduced down to 1.0 of the safety factor against high water pressure inside.

Another aging example is Hanga-Hanga (1.6 MW), Luwuk, North Sulawesi. Its turbine and generator were manufactured in 1985 and are not extremely old. However, PLN is suffering from extremely low output less than 70% of the designed capacity. This hydro plant utilizes 1.1 m^3/sec of discharge with 171 m of head, and demands relatively high hydropower

(a) Powerhouse

(b) Hydro Turbine

Figure 5.4.2 Tonsealama Hydro

technology. To rectify its power output, PLN North Sulawesi Office is requesting US$ 800 thousand to PLN Headquarters. However, the requested amount seems not enough, if total repair of the turbine and generator or re-development of the plant is required for the rectification.

(3) Geothermal Plants

Sulawesi Island is relatively rich in geothermal potential. According to the Geothermal Master Plan under JICA indicates 735 MW of exploitable geothermal potential in the island. As of October 2007, two units of the geothermal plants turn in operation. They are Lahendong 1 (20 MW) commissioned in 2002 and Lahendong 2 (20 MW) commissioned in 2007. Lahendong 1 has successfully been supplying around 140 GWh of annual energy to the North Sulawesi System since 2003, while Lahendong 2 is still under test operation.

There is a common issue related to the geothermal power development in the country; the steam well and power plant are separately developed by different institutions. Lahendong 2 mentioned above is not an exceptional case. The steam development is not on schedule and Lahendong 2 is not receiving enough steam for generation.

(a) Production Well

(b) Geothermal Plant

Picture 5.4.3 Lahendong 1 Geothermal

5.5 Power Development Candidates and Potentiality

5.5.1 Power Development Candidates

Table 5.5.1 lists project candidates that are expected to be developed up to 2015. The candidates are of the latest Electricity Supply Plan 2006 (RUPTL 2006-2015) plus the development plans prepared by PLN North and South Offices. (The table is not an authorized plan of PLN.)

The candidates are, as tabulated below, 133 units with 22.5 MW of the average unit capacity. 105 units with 1,782 MW of capacity are to be operated by PLN and remaining 28 units with 1,212 MW corresponds to private operators.

Operator	Capacity		Units		Unit Capacity
PLN	1,781.7 MW	60%	105 units	79%	17.0 MW/unit
IPP	1,212.4 MW	40%	28 units	21%	43.3 MW/unit
Total	2,994.1 MW	100%	133 units	100%	22.5 MW/unit

The coal-fired shares roughly half in terms of the energy resource, while the hydro has the largest unit capacity among the candidates, as seen in the following table.

Type	Capacity		Units	Capacity per Unit
PLTD	144.9 MW	5%	38 units	3.8 MW/unit
PLTGB	67.6 MW	2%	8 units	8.5 MW/unit
PLTU	1,364.0 MW	46%	37 units	36.9 MW/unit
PLTG	345.0 MW	12%	9 units	38.3 MW/unit
PLTFC	10.0 MW	0%	1 units	10.0 MW/unit
PLTP	40.0 MW	1%	2 units	20.0 MW/unit
PLTM	57.2 MW	2%	28 units	2.0 MW/unit
PLTA	965.4 MW	32%	10 units	96.5 MW/unit
Total	2,994.1 MW	100%	133 units	22.5 MW/unit

Table 5.5.1 Candidates of Power Development in Sulawesi (up to 2015)

No.	Type	Name	Location	Capacity (MW)	COD	Operator	Status	Financing	Notes
1.	PLTP	Lahendong 2	Sulselrabar	20	2007	PLN	Completed	ADB	
2.	PLTD	Isimu	Sulutenggo	2.5	2007	PLN	On Going	Denmark	
3.	PLTU	Minahasa	Sulutenggo	7.0	2007	PLN	On Going	PLN	
4.	PLTD	Parigi	Sulutenggo	1.0	2007	PLN	Committed	Denmark	
5.	PLTD	Tahuna	Sulutenggo	1.0	2007	PLN	Committed	Denmark	
6.	PLTGB	Tahuna	Sulutenggo	2.4	2007	IPP	Committed	Private	
7.	PLTGB	Toli-toli	Sulutenggo	2.4	2007	IPP	Committed	Private	
8.	PLTD	2 MFO Diesel	Sulutenggo	27.0	2008	PLN	Committed	PLN	
9.	PLTGB	10 Coal Gasification	Sulutenggo	56.8	2008	PLN	Committed	PLN	Chinese technology
10.	PLTM	Mobuya	Sulutenggo	3.0	2008	IPP	On Going	Private	Financial close.
11.	PLTM	Tengka&Ranteballa	Sulselrabar	11.2	2008	PLN	Committed	PLN	
12.	PLTG	Mobile TM 2500	Sulselrabar	20.0	2008	PLN	Committed	PLN	
13.	PLTD	Tello (rental)	Sulselrabar	70.0	2008	PLN	Committed	PLN	
14.	PLTD	Perusda (rental)	Sulselrabar	5.0	2008	PLN	Committed	PLN	
15.	PLTM	Malewa	Sulutenggo	1.6	2008	PLN	Committed	NA	
16.	PLTU	Bau-Bau	Sulselrabar	7.0	2008	PLN	Plan	NA	
17.	PLTU	Takalar	Sulselrabar	15.0	2008	IPP	Plan	Private	Delayed.
18.	PLTP	Lahendong 3	Sulselrabar	20.0	2009	PLN	On Going	JBIC	
19.	PLTD	Raha (rental)	Sulselrabar	3.0	2009	PLN	Committed	PLN	
20.	PLTG	Sengkang	Sulselrabar	65.0	2009	IPP	On Going	Private	
21.	PLTM	Lobong	Sulutenggo	1.6	2009	PLN	On Going	ADB	Delayed due to issues on regional contribution
22.	PLTM	Mangango	Sulutenggo	1.2	2009	PLN	On Going	ADB	
23.	PLTM	Sansarino	Sulutenggo	0.8	2009	PLN	On Going	GOI	
24.	PLTM	Tangka	Sulselrabar	11.0	2009	IPP	Plan	KFF	
25.	PLTD	Wangi-Wangi	Sulselrabar	2.0	2009	PLN	Plan	NA	
26.	PLTU	Amurang-2	Sulutenggo	25.0	2009	IPP	Plan	Private	Delayed due to financing difficulties.
27.	PLTD	Banggai	Sulutenggo	0.5	2009	PLN	Plan	NA	
28.	PLTU	Gorontalo Energi	Sulutenggo	12.0	2009	IPP	Plan	NA	
29.	PLTFC	Likupang Fuel Cell	Sulutenggo	10.0	2009	PLN	Plan	NA	
30.	PLTU	NII	Sulutenggo	20.0	2009	IPP	Plan	NA	
31.	PLTD	Ondong	Sulutenggo	0.5	2009	PLN	Plan	NA	

Table 5.5.1 Candidates of Power Development in Sulawesi (up to 2015)

No.	Type	Name	Location	Capacity (MW)	COD	Operator	Status	Financing	Notes
32.	PLTU	Poso	Suluttenggo	7.0	2009	PLN	Plan	NA	
33.	PLTM	Sawidago	Suluttenggo	1.0	2009	PLN	Committed	PLN	
34.	PLTD	Tersebar	Suluttenggo	1.0	2009	PLN	Plan	NA	
35.	PLTU	Barru	Sulselrabar	100.0	2010	PLN	Plan	NA	
36.	PLTU	Kendari	Sulselrabar	10.0	2010	PLN	Plan	NA	
37.	PLTM	Lapai	Sulselrabar	2.4	2010	PLN	Plan	NA	
38.	PLTA	Poigar-2	Sulselrabar	30.0	2010	PLN	On Going	ADB	Delayed due to environmental issues.
39.	PLTU	Takalar	Sulselrabar	90.0	2010	IPP	Plan	NA	
40.	PLTD	Wangi-Wangi	Sulselrabar	2.0	2010	PLN	Plan	NA	
41.	PLTD	Ampana	Suluttenggo	0.5	2010	PLN	Plan	NA	
42.	PLTU	Amurang-1	Suluttenggo	25.0	2010	IPP	Plan	NA	
43.	PLTU	Amurang-2	Suluttenggo	25.0	2010	IPP	Plan	NA	
44.	PLTD	Banggai	Suluttenggo	0.5	2010	PLN	Plan	NA	
45.	PLTD	Bangkir	Suluttenggo	0.5	2010	PLN	Plan	NA	
46.	PLTU	Bosowa	Suluttenggo	110.0	2010	IPP	Plan	NA	
47.	PLTU	Gorontalo	Suluttenggo	20.0	2010	IPP	Plan	NA	
48.	PLTU	Gorontalo	Suluttenggo	50.0	2010	PLN	Committed	NA	
49.	PLTU	Lolioge	Suluttenggo	20.0	2010	IPP	Plan	NA	
50.	PLTG	Luwuk	Suluttenggo	5.0	2010	PLN	Committed	PLN	
51.	PLTM	Manpueno	Suluttenggo	1.2	2010	IPP	Plan	NA	
52.	PLTU	Marisa	Suluttenggo	3.0	2010	PLN	Plan	NA	
53.	PLTD	Ondong	Suluttenggo	0.5	2010	PLN	Plan	NA	
54.	PLTU	Poso	Suluttenggo	7.0	2010	PLN	Plan	NA	
55.	PLTA	Poso-3	Suluttenggo	398.0	2010	IPP	Plan	NA	Caos in business concession.
56.	PLTU	Sulawesi-1	Suluttenggo	25.0	2010	PLN	Plan	NA	
57.	PLTU	Sulut	Suluttenggo	50.0	2010	PLN	Committed	NA	
58.	PLTU	Sulut 2	Suluttenggo	50.0	2010	IPP	Committed	Private	
59.	PLTD	Tagulandang	Suluttenggo	1.0	2010	PLN	Plan	NA	
60.	PLTD	Toli-toli	Suluttenggo	0.5	2010	PLN	Plan	NA	
61.	PLTM	Wawopada	Suluttenggo	3.6	2010	IPP	Plan	NA	
62.	PLTD	Bau-Bau	Sulselrabar	2.5	2011	PLN	Plan	NA	

Table 5.5.1 Candidates of Power Development in Sulawesi (up to 2015)

No.	Type	Name	Location	Capacity (MW)	COD	Operator	Status	Financing	Notes
63.	PLTD	Raha	Sulselrabar	2.5	2011	PLN	Plan	NA	
64.	PLTM	Rongi	Sulselrabar	0.8	2011	PLN	Plan	NA	
65.	PLTD	Selayar	Sulselrabar	1.4	2011	PLN	Plan	NA	
66.	PLTU	Amurang-1	Suluttenggo	25.0	2011	IPP	Plan	Private	Delayed due to financing difficulties.
67.	PLTD	Banggai	Suluttenggo	0.5	2011	PLN	Plan	NA	
68.	PLTD	Bangkir	Suluttenggo	0.5	2011	PLN	Plan	NA	
69.	PLTU	Bosowa	Suluttenggo	110.0	2011	IPP	Plan	NA	
70.	PLTD	Bungku	Suluttenggo	1.0	2011	PLN	Plan	NA	
71.	PLTM	Dulukapa	Suluttenggo	2.4	2011	PLN	Plan	NA	
72.	PLTD	Kasimbar	Suluttenggo	1.0	2011	PLN	Plan	NA	
73.	PLTG	Luwuk	Suluttenggo	5.0	2011	PLN	Committed	PLN	
74.	PLTM	Milangodaa	Suluttenggo	0.7	2011	PLN	Plan	NA	
75.	PLTD	Moutong	Suluttenggo	1.0	2011	PLN	Plan	NA	
76.	PLTD	Ondong	Suluttenggo	0.5	2011	PLN	Plan	NA	
77.	PLTU	Palu PJPP 2	Suluttenggo	30.0	2011	IPP	Plan	NA	
78.	PLTA	Solewana 2	Suluttenggo	18.2	2011	IPP	Plan	NA	
79.	PLTU	Sulawesi-2	Suluttenggo	25.0	2011	PLN	Plan	NA	
80.	PLTU	Tahuna	Suluttenggo	3.0	2011	PLN	Plan	NA	
81.	PLTD	Talaud	Suluttenggo	0.5	2011	PLN	Plan	NA	
82.	PLTD	Toli-toli	Suluttenggo	1.0	2011	PLN	Plan	NA	
83.	PLTD	Tomata	Suluttenggo	1.0	2011	PLN	Plan	NA	
84.	PLTM	Anoa	Sulselrabar	3.4	2012	PLN	Plan	NA	
85.	PLTU	Jeneponto	Sulselrabar	100.0	2012	PLN	Committed	NA	
86.	PLTA	Konaweha	Sulselrabar	5.0	2012	PLN	Plan	NA	
87.	PLTA	Malea	Sulselrabar	182.0	2012	PLN	PLN	Plan	
88.	PLTD	Ampana	Suluttenggo	0.5	2012	PLN	Plan	NA	
89.	PLTU	Amurang	Suluttenggo	55.0	2012	PLN	IPP	Plan	
90.	PLTG	Bitung	Suluttenggo	35.0	2012	PLN	Plan	NA	
91.	PLTM	Bolontio	Suluttenggo	0.4	2012	PLN	Plan	NA	
92.	PLTM	Doda	Suluttenggo	2.2	2012	PLN	Plan	NA	
93.	PLTM	Duminanga	Suluttenggo	0.5	2012	PLN	Plan	NA	

Table 5.5.1 Candidates of Power Development in Sulawesi (up to 2015)

No.	Type	Name	Location	Capacity (MW)	COD	Operator	Status	Financing	Notes
94.	PLTM	Kamba	Suluttenggo	1.1	2012	PLN	Plan	NA	
95.	PLTD	Kolonedale	Suluttenggo	1.0	2012	PLN	Plan	NA	
96.	PLTM	Limtutu	Suluttenggo	0.6	2012	PLN	Plan	NA	
97.	PLTM	Molibagu	Suluttenggo	0.8	2012	PLN	Plan	NA	
98.	PLTD	Moutong	Suluttenggo	1.0	2012	PLN	Plan	NA	
99.	PLTA	Solewana 3	Suluttenggo	18.2	2012	IPP	Plan	NA	
100.	PLTD	Tersebar	Suluttenggo	1.0	2012	PLN	Plan	NA	
101.	PLTD	Toli-toli	Suluttenggo	1.0	2012	PLN	Plan	NA	
102.	PLTM	Ulung Paliang 2	Suluttenggo	0.3	2012	PLN	Plan	NA	
103.	PLTU	Jeneponto	Sulselrabar	100.0	2013	PLN	Committed	NA	
104.	PLTG	Makassar	Sulselrabar	100.0	2013	PLN	Plan	NA	
105.	PLTG	Tello	Sulselrabar	50.0	2013	PLN	Plan	NA	
106.	PLTU	Amurang	Suluttenggo	55.0	2013	IPP	Plan	NA	
107.	PLTM	Belengan	Suluttenggo	1.2	2013	PLN	Plan	NA	
108.	PLTA	Bone	Suluttenggo	17.0	2013	PLN	Plan	NA	
109.	PLTG	Kwandang	Suluttenggo	15.0	2013	PLN	Plan	NA	
110.	PLTM	Maranti	Suluttenggo	0.3	2013	PLN	Plan	NA	
111.	PLTGB	Ondong	Suluttenggo	1.2	2013	IPP	Plan	NA	
112.	PLTG	Palu-1	Suluttenggo	25.0	2013	PLN	Plan	NA	
113.	PLTM	Sinar Harapan	Suluttenggo	0.4	2013	PLN	Plan	NA	
114.	PLTGB	Talaud	Suluttenggo	1.2	2013	IPP	Plan	NA	
115.	PLTM	Taripa 1	Suluttenggo	0.7	2013	PLN	Plan	NA	
116.	PLTM	Taripa 2	Suluttenggo	0.6	2013	PLN	Plan	NA	
117.	PLTU	Toli-toli	Suluttenggo	6.0	2013	PLN	Plan	NA	
118.	PLTD	Bau-Bau	Sulselrabar	2.5	2014	PLN	Plan	NA	
119.	PLTA	Poko	Sulselrabar	156.0	2014	PLN	Plan	NA	
120.	PLTD	Raha	Sulselrabar	2.5	2014	PLN	Plan	NA	
121.	PLTGB	Ampana	Suluttenggo	1.2	2014	PLN	Plan	NA	
122.	PLTGB	Banggai	Suluttenggo	1.2	2014	PLN	Plan	NA	
123.	PLTM	Lalengan	Suluttenggo	0.5	2014	PLN	Plan	NA	
124.	PLTU	Marisa	Suluttenggo	3.0	2014	PLN	Plan	NA	

Table 5.5.1 Candidates of Power Development in Sulawesi (up to 2015)

No.	Type	Name	Location	Capacity (MW)	COD	Operator	Status	Financing	Notes
125.	PLTU	Moutong	Suluttenggo	6.0	2014	PLN	Plan	NA	
126.	PLTU	Poso	Suluttenggo	7.0	2014	PLN	Plan	NA	
127.	PLTM	Sawidago 3	Suluttenggo	1.7	2014	PLN	Plan	NA	
128.	PLTGB	Tagulandang	Suluttenggo	1.2	2014	PLN	Plan	NA	
129.	PLTU	Tuhana	Suluttenggo	6.0	2014	PLN	Plan	NA	
130.	PLTA	Bakaru 2	Sulselrabar	63.0	2015	PLN	Plan	NA	
131.	PLTA	Poko	Sulselrabar	78.0	2015	PLN	Plan	NA	
132.	PLTU	Tallo Lama	Sulselrabar	100.0	2015	PLN	Plan	NA	
133.	PLTU	Amurang	Suluttenggo	55.0	2015	IPP	Plan	NA	
134.	PLTD	Bangkir	Suluttenggo	1.0	2015	PLN	Plan	NA	
135.	PLTD	Leok	Suluttenggo	1.0	2015	PLN	Plan	NA	
136.	PLTG	Likupang	Suluttenggo	25.0	2015	PLN	Plan	NA	
137.	PLTD	Tersebar	Suluttenggo	1.0	2015	PLN	Plan	NA	

5.5.2 Issues on Power Development

Despite the future power development plan built by PLN every year, unfortunately on-schedule development is achieved not very often. There would be three barriers against the on-schedule development. They are i) budgetary limitation, ii) inappropriateness in planning, and iii) unreasonable IPP promotion.

(1) Budgetary Limitation

The total installed capacity of the future power development is over 2,800 MW for eight years up to 2015. The associated investment required must amount US$ 350 million every year at least. The possible budget for such new power development is any or combination of the following four; i) the PLN's own financing allocated from its corporate budget, ii) the debt financing by PLN, iii) the sub-loan from the Central Government's ODA (the Central Government borrows money from bi- or multilateral funding agencies and PLN re-borrows it), and iv) the private investment through IPP schemes.

As there is no guaranteed PLN's yearly budget allocated for the new power development, i) the PLN' own financing does not seem to be the major source, unless for very small facilities. Because the financial status is evaluated not very sound, ii) PLN's debt financing also seems to be not effective for the large-scale development. Despite the fact that iii) use of the ODA loan must be very effective and economical, it increases the liability of the Central Government and it cannot be exercised all the time. Despite the possibility of the immediate solution if conditions are met, iv) IPPs do not show so far good progress in the country because of difficulties in the governmental guarantees and less electricity tariff compared to developed countries.

As the result, the budgetary source for the power development is always less than the requirement.

(2) Inappropriateness in Planning

One observes that some development is not in progress as good as expected, even though the project preparation has been done. For example, Poigar 2 Hydro (30 MW, with a multilateral soft loan) suffers from a couple of issues. Although PLN chose a design-build contractor in 2006, its construction has been suspended because part of the project site is within the forest reserve defined by the Central Government. Despite rather small capacity, there are arguments on i) the difficulties of the pressured tunnel headrace, ii) the contractor's responsibility in figuring out the topographical and geological conditions, and iii) the difficulty in the high head over 300 m.

(3) Unreasonable IPP Promotion

IPPs, which are developed with private investment, play a very important role, as the public investment cannot be exercised to all of the power development. A number of IPP projects are identified as indispensable options in the PLN's future power development plan. However, it might need further discussions on which projects should be by the public investment and which are by the private investment.

Despite successful experience such as Sengkang (Gas-fired Steam 135 MW), IPPs are hardly achieved up to their commissioning. One example is Amurang Coal-Fired IPP, 110 MW, North Sulawesi. Amurang is one of the so-called 27 Revised IPPs, of which PPAs were revised after the economy crisis. Its original PPA was once signed in 1994 with around 9¢/kWh of the power tariff. The revised PPA sets 4.53¢/kWh of the power tariff. The original developer still keeps his business concession. Because project finance, which is one of the most important components for the successful IPPs, is not achieved yet, the project development can hardly be expected.

Malea Hydro (191 MW) is also in a chaotic situation. Malea Hydro was originally promoted as a public project through the feasibility study in 1980s with USBR finance. After the feasibility study, ADB once decided its financing for construction. However, it was finally cancelled due to the economic crisis. Malea shows relatively high FIRR as high as 13%. Therefore, several private companies including a Japanese trading house conducted self-investigation towards IPP type development immediately after the ADB's cancellation. In 2003, PLN and a Japanese consulting firm executed the feasibility update for IPP re-promotion. A Japanese power company expressed his interest of investment. After all, an Indonesian firm reportedly holds its business concession. However, the legal background of such concession is not clear.

Because progress of the project development is not seen, in 2006 PLN placed the name of Malea into the so-called JBIC long list, which lists candidate projects PLN wants to develop with JBIC soft loan.

5.5.3 Local Energy Candidates

There exist the geothermal power and hydropower that are rich in exploitable potential in Sulawesi. The potential of the geothermal is as large as 735 MW, while the hydro potential is reportedly 12,600 MW within the island. Figure 5.5.1 illustrates those potential locations.

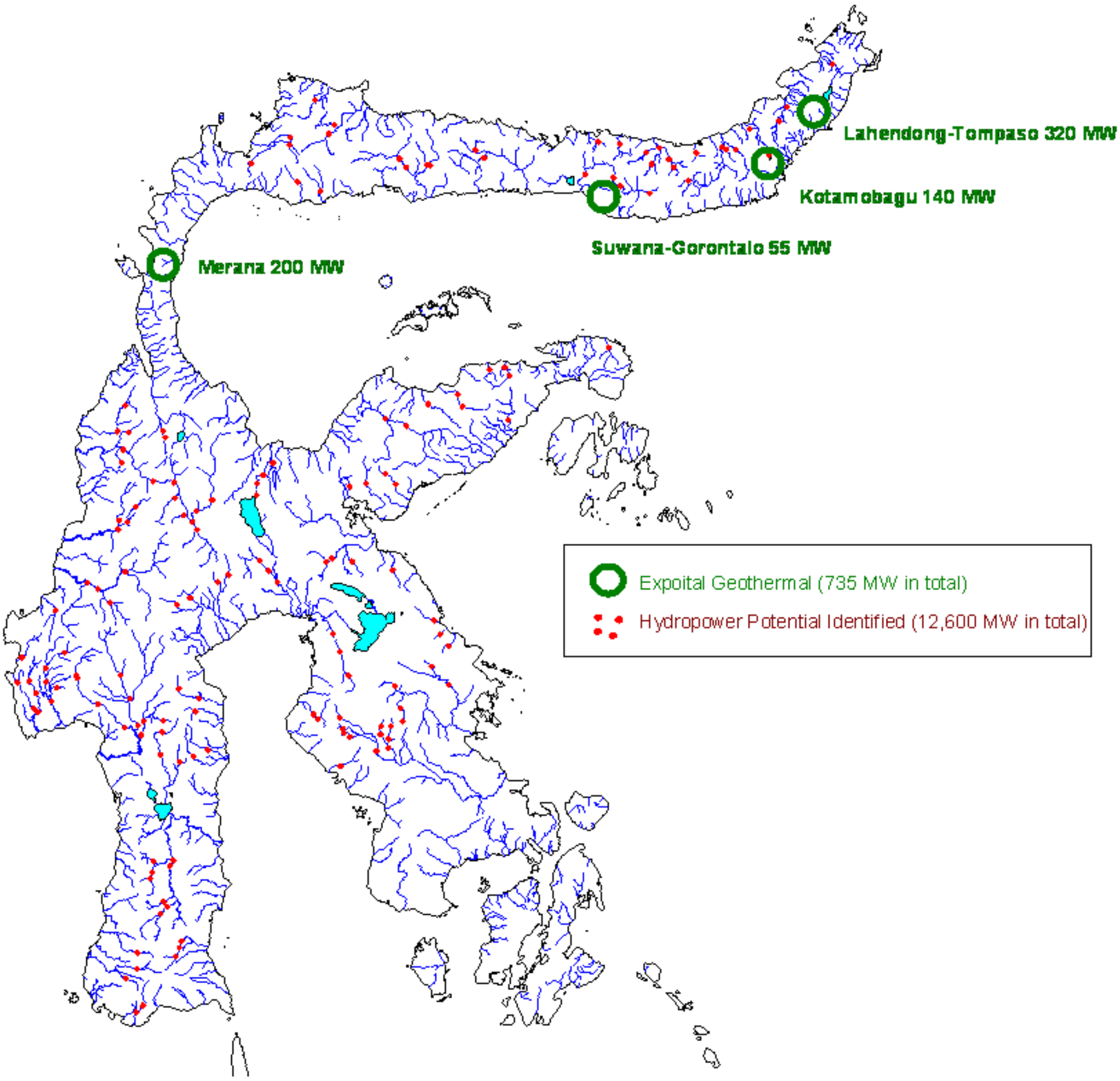


Figure 5.5.1 Hydro and Geothermal Potential

5.6 Examination of Preconditions and Parameters for the Study

5.6.1 Simulation Software

The Study Team applies WASP-IV as software for formulating generation development plan. WASP-IV is a simulation tool, which PLN uses for generation development plan for the System Java-Bali and the System Sumatra.

WASP-IV can seek a configuration with the minimum object function composed of investment cost, fuel cost, operation cost, etc. from the configurations which meets the electricity demand given in consideration of the cost characteristics in operation such as heat rate of thermal power plant and the probabilistic characteristics such as forced outage rate.

To fulfill the function and merit of WASP-IV, it is preferable that the number of generation units is thirty (30) or more in the system. So JICA Study team use the WASP-V for the 1)System Minahasa-Kotamobagu and 2) the System Sulsel.

The Study Team employs Microsoft Excel in order to make capacity balance and energy balance for the Small-scaled Isolated Systems in the same way that PLN applies it. In case that the number of generation unit in an isolated system increases to 30 units by interconnecting to other systems, the Study team applies WASP-IV for the interconnected system.

5.6.2 Forecasted Electricity Demand

(1) Forecasted Demand (Peak Demand and Energy Production)

Figure 5.6.1 shows the peak demand for the System Minahasa-Kotamobagu and the system Sulsel and Table 5.6.1 shows the summary of forecasted demand for the generation planning by the system.

(North Sulawesi system) (South Sulawesi system)

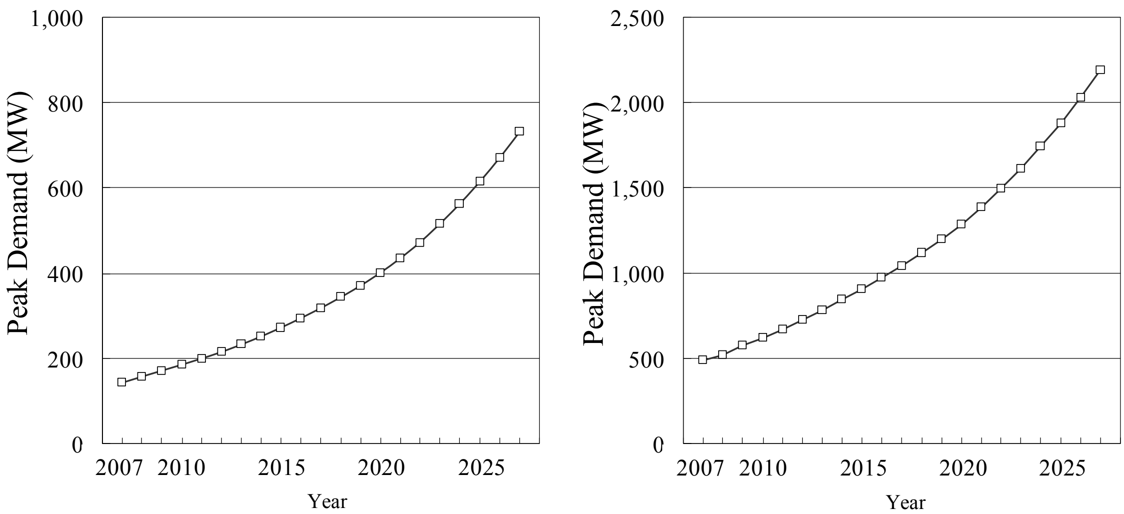


Figure 5.6.1 Peak Demand for the System Minahasa-Kotamobagu and the System Sulsel (2007-2027)

Table 5.6.1 Forecasted Power Demand used for Generation Planning (1/2)

Responsible Area	System	Items		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Wilayah Suluttenggo	Minahasa-Kotamobagu	Peak Demand	(MW)	144.0	157.8	171.4	186.3	199.3	215.7	233.4	252.5	272.9	294.9	318.4	344.0	371.6	401.3	435.3	472.1	515.3	562.6	614.1	670.4	731.8
		Load Factor	(%)	60.2	60.2	60.3	60.3	60.7	61.0	61.4	61.7	62.1	62.4	62.9	63.3	63.7	64.1	64.5	64.9	64.9	64.9	64.9	64.9	64.9
		Energy Production	(GWh)	759	833	905	984	1,060	1,153	1,254	1,364	1,484	1,613	1,754	1,907	2,073	2,253	2,459	2,683	2,929	3,197	3,490	3,810	4,159
	Tahuna	Peak Demand	(MW)	6.1	6.7	7.3	8.0	8.7	9.5	10.4	11.3	12.3	13.3	14.5	15.8	17.1	18.6	20.3	22.2	24.2	26.4	28.8	31.5	34.3
		Load Factor	(%)	40.3	40.4	40.5	40.6	40.9	41.2	41.5	41.8	42.2	42.5	42.9	43.3	43.7	44.1	44.4	44.8	44.8	44.8	44.8	44.8	44.8
		Energy Production	(GWh)	21.4	23.7	26.0	28.5	31.3	34.3	37.7	41.3	45.3	49.7	54.5	59.8	65.5	71.8	79.1	87.0	95.0	103.7	113.2	123.6	134.9
	Ondong	Peak Demand	(MW)	2.0	2.2	2.4	2.6	2.8	3.1	3.4	3.7	4.0	4.3	4.7	5.1	5.6	6.0	6.6	7.2	7.9	8.6	9.4	10.2	11.2
		Load Factor	(%)	41.7	41.8	41.8	41.9	42.1	42.4	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.8	45.1	45.4	45.4	45.4	45.4	45.4	45.4
		Energy Production	(GWh)	2.0	2.2	2.4	2.6	2.8	3.1	3.4	3.7	4.0	4.3	4.7	5.1	5.6	6.0	6.6	7.2	7.9	8.6	9.4	10.2	11.2
	Molibagu	Peak Demand	(MW)	2.0	2.2	2.3	2.5	2.6	2.8	3.0	3.1	3.3	3.5	3.8	4.0	4.2	4.5	4.8	5.1	5.6	6.1	6.6	7.2	7.9
		Load Factor	(%)	25.9	26.3	26.8	27.3	27.9	28.6	29.3	29.9	30.7	31.4	32.2	33.0	33.8	34.7	35.5	36.4	36.4	36.4	36.4	36.4	36.4
		Energy Production	(GWh)	4.5	5.0	5.4	5.9	6.4	7.0	7.6	8.2	9.0	9.7	10.6	11.5	12.5	13.6	14.9	16.2	17.7	19.4	21.1	23.1	25.2
	Talaud	Peak Demand	(MW)	2.1	2.3	2.5	2.8	3.0	3.3	3.6	3.9	4.2	4.6	5.0	5.4	5.9	6.4	7.0	7.6	8.3	9.1	9.9	10.8	11.8
		Load Factor	(%)	35.7	35.7	35.8	35.8	36.0	36.3	36.5	36.8	37.0	37.3	37.6	37.9	38.2	38.5	38.8	39.1	39.1	39.1	39.1	39.1	39.1
		Energy Production	(GWh)	6.5	7.2	7.9	8.7	9.5	10.4	11.4	12.5	13.7	15.0	16.5	18.0	19.7	21.6	23.7	26.1	28.5	31.1	34.0	37.1	40.5
	Tagulandang	Peak Demand	(MW)	1.4	1.6	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.5	3.8	4.1	4.5	4.9	5.4	5.9	6.5	7.2	7.9
		Load Factor	(%)	30.4	30.7	30.9	31.2	31.6	32.1	32.5	33.0	33.5	34.0	34.5	35.1	35.6	36.1	36.7	37.2	37.2	37.2	37.2	37.2	37.2
		Energy Production	(GWh)	3.8	4.3	4.7	5.1	5.6	6.2	6.8	7.5	8.2	9.0	9.9	10.9	12.0	13.1	14.5	16.0	17.6	19.4	21.3	23.5	25.9
	Gorontalo	Peak Demand	(MW)	25.9	29.2	32.0	34.8	37.9	41.3	44.9	48.8	53.1	57.8	62.9	68.4	74.4	80.9	87.9	95.6	103.5	112.0	121.2	131.1	141.9
		Load Factor	(%)	57.7	57.4	57.7	57.9	58.2	58.5	58.7	59.0	59.3	59.5	59.8	60.1	60.4	60.6	60.9	61.2	61.2	61.2	61.2	61.2	61.2
		Energy Production	(GWh)	131	147	162	177	193	211	231	252	276	301	329	360	393	430	469	513	555	600	650	703	761
	Marisa	Peak Demand	(MW)	6.7	7.5	8.2	8.8	9.5	10.3	11.1	11.9	12.9	13.9	14.9	16.1	17.4	18.7	20.1	21.7	23.5	25.4	27.5	29.7	32.2
		Load Factor	(%)	34.7	34.9	35.4	35.9	36.4	36.9	37.4	37.9	38.5	39.0	39.6	40.1	40.7	41.3	41.9	42.5	42.5	42.5	42.5	42.5	42.5
		Energy Production	(GWh)	20.4	23.0	25.3	27.7	30.3	33.1	36.2	39.6	43.3	47.4	51.8	56.6	61.9	67.6	73.9	80.7	87.3	94.5	102.2	110.6	119.7
	Buroko	Peak Demand	(MW)	2.0	2.3	2.5	2.7	2.9	3.1	3.4	3.6	3.9	4.2	4.5	4.9	5.2	5.6	6.1	6.5	7.1	7.6	8.3	9.0	9.7
		Load Factor	(%)	11.4	11.4	11.6	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.0	14.0	14.0	14.0	14.0
		Energy Production	(GWh)	2.0	2.3	2.5	2.8	3.0	3.3	3.6	3.9	4.3	4.7	5.1	5.6	6.1	6.7	7.3	8.0	8.6	9.4	10.1	11.0	11.9
	Palu-Parigi	Peak Demand	(MW)	43.1	48.0	52.5	57.0	61.9	67.2	73.0	79.2	86.0	93.4	101.3	110.0	119.3	129.5	140.5	152.4	164.4	177.3	191.2	206.2	222.4
		Load Factor	(%)	60.0	60.2	60.5	60.8	61.1	61.4	61.8	62.1	62.4	62.8	63.1	63.4	63.8	64.1	64.4	64.8	64.8	64.8	64.8	64.8	64.8
		Energy Production	(GWh)	226	253	278	304	331	362	395	431	470	513	560	611	667	727	793	865	933	1,006	1,085	1,170	1,262
	Poso	Peak Demand	(MW)	5.3	5.9	6.5	7.0	7.6	8.3	9.0	9.8	10.6	11.5	12.5	13.6	14.7	16.0	17.4	18.8	20.3	21.9	23.6	25.5	27.5
		Load Factor	(%)	50.2	50.1	50.4	50.6	50.9	51.1	51.4	51.7	51.9	52.2	52.5	52.7	53.0	53.3	53.5	53.8	53.8	53.8	53.8	53.8	53.8
		Energy Production	(GWh)	23.2	26.0	28.5	31.2	34.0	37.1	40.5	44.2	48.3	52.7	57.5	62.7	68.4	74.6	81.4	88.8	95.8	103.3	111.4	120.1	129.6
	Toli-Toli	Peak Demand	(MW)	6.0	6.7	7.4	8.0	8.7	9.4	10.2	11.1	12.0	13.0	14.2	15.4	16.7	18.1	19.6	21.2	22.9	24.7	26.7	28.8	31.0
		Load Factor	(%)	42.2	42.1	42.4	42.6	42.8	43.1	43.3	43.6	43.8	44.1	44.3	44.6	44.8	45.1	45.4	45.6	45.6	45.6	45.6	45.6	45.6
		Energy Production	(GWh)	22.2	24.8	27.3	29.8	32.5	35.5	38.8	42.3	46.2	50.4	55.0	60.0	65.4	71.4	77.8	84.9	91.6	98.8	106.5	114.9	123.9
	Moutong-Kotaraya-Palasa	Peak Demand	(MW)	5.0	5.7	6.2	6.7	7.3	7.9	8.6	9.3	10.1	11.0	11.9	12.9	14.0	15.2	16.5	17.9	19.3	20.8	22.4	24.2	26.1
		Load Factor	(%)	35.3	35.1	35.3	35.5	35.7	35.9	36.2	36.4	36.6	36.8	37.0	37.2	37.5	37.7	37.9	38.1	38.1	38.1	38.1	38.1	38.1
		Energy Production	(GWh)	15.6	17.5	19.2	21.0	22.9	25.0	27.3	29.8	32.5	35.4	38.7	42.2	46.0	50.2	54.8	59.7	64.4	69.5	74.9	80.8	87.2
	Leok	Peak Demand	(MW)	3.8	3.6	3.9	4.2	4.6	5.0	5.4	5.9	6.4	6.9	7.5	8.1	8.8	9.6	10.4	11.3	12.2	13.1	14.2	15.3	16.5
		Load Factor	(%)	23.5	28.3	28.4	28.6	28.8	28.9	29.1	29.2	29.4	29.6	29.7	29.9	30.1	30.2	30.4	30.6	30.6	30.6	30.6	30.6	30.6
		Energy Production	(GWh)	7.9	8.8	9.7	10.6	11.6	12.6	13.8	15.1	16.4	17.9	19.6	21.4	23.3	25.4	27.7	30.2	32.6	35.2	37.9	40.9	44.1
	Kolonedale	Peak Demand	(MW)	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.2	4.6	5.0	5.4	5.9	6.4	6.9	7.4	8.0	8.6	9.3
		Load Factor	(%)	45.8	45.6	45.8	46.0	46.3	46.5	46.8	47.0	47.2	47.5	47.7	48.0	48.2	48.5	48.7	49.0	49.0	49.0	49.0	49.0	49.0
		Energy Production	(GWh)	7	8	9	10	10	11	12	14	15	16	18	19	21	23	25	27	29	32	34	37	40

Table 5.6.1 Forecasted Power Demand used for Generation Planning (2/2)

Responsible Area	System	Items		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Wilayah Suluttenggo	Bangkir	Peak Demand	(MW)	1.0	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.7	2.9	3.1	3.4	3.7	4.0	4.3	4.6	5.0	5.4
		Load Factor	(%)	21.6	21.5	21.6	21.7	21.9	22.0	22.1	22.2	22.3	22.5	22.6	22.7	22.8	23.0	23.1	23.2	23.2	23.2	23.2	23.2	23.2
		Energy Production	(GWh)	2.0	2.2	2.4	2.6	2.9	3.1	3.4	3.7	4.1	4.4	4.8	5.3	5.8	6.3	6.9	7.5	8.1	8.7	9.4	10.1	10.9
	Luwuk	Peak Demand	(MW)	8.7	9.8	10.7	11.6	12.6	13.7	14.8	16.1	17.5	19.0	20.6	22.4	24.3	26.4	28.6	31.0	33.5	36.1	38.9	42.0	45.3
		Load Factor	(%)	52.8	52.7	53.0	53.2	53.5	53.8	54.1	54.4	54.6	54.9	55.2	55.5	55.8	56.1	56.4	56.6	56.6	56.6	56.6	56.6	56.6
		Energy Production	(GWh)	40.3	45.0	49.5	54.0	59.0	64.4	70.3	76.7	83.7	91.4	99.7	108.8	118.7	129.4	141.2	154.0	166.1	179.1	193.2	208.4	224.7
	Ampana	Peak Demand	(MW)	1.8	2.1	2.3	2.5	2.7	2.9	3.2	3.4	3.7	4.0	4.4	4.8	5.2	5.6	6.1	6.6	7.1	7.7	8.3	8.9	9.6
		Load Factor	(%)	47.8	47.5	47.7	48.0	48.3	48.5	48.8	49.0	49.3	49.5	49.8	50.1	50.3	50.6	50.8	51.1	51.1	51.1	51.1	51.1	51.1
		Energy Production	(GWh)	7.7	8.6	9.5	10.4	11.3	12.3	13.5	14.7	16.0	17.5	19.1	20.8	22.7	24.8	27.0	29.5	31.8	34.3	37.0	39.9	43.1
	Banggai	Peak Demand	(MW)	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.8	6.2
		Load Factor	(%)	45.5	45.5	45.7	45.9	46.2	46.4	46.6	46.9	47.1	47.3	47.6	47.8	48.0	48.3	48.5	48.8	48.8	48.8	48.8	48.8	48.8
		Energy Production	(GWh)	4.8	5.3	5.9	6.4	7.0	7.6	8.3	9.1	9.9	10.8	11.8	12.9	14.1	15.4	16.8	18.3	19.7	21.3	22.9	24.7	26.7
Wilayah Sulselrabar	Sulsel	Peak Demand	(MW)	487.6	521.3	572.5	619.0	669.2	723.6	782.4	846.0	907.0	972.5	1,042.6	1,117.9	1,198.7	1,284.6	1,386.4	1,496.2	1,614.7	1,742.6	1,880.6	2,029.5	2,190.3
		Load Factor	(%)	64.9	65.1	65.2	65.4	65.6	65.7	65.9	66.1	66.3	66.4	66.6	66.8	66.9	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1
		Energy Production	(GWh)	2,772	2,972	3,272	3,547	3,845	4,168	4,518	4,898	5,264	5,658	6,082	6,538	7,028	7,551	8,149	8,795	9,491	10,243	11,054	11,930	12,874
	Selayar	Peak Demand	(MW)	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.9	5.1	5.3	5.5	5.7	6.0	6.2	6.7	7.3	7.8	8.5	9.1	9.8	10.6
		Load Factor	(%)	35.8	36.8	37.9	38.9	39.9	40.9	41.9	43.0	44.0	45.0	46.0	47.1	48.1	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3
		Energy Production	(GWh)	10.8	11.6	12.6	13.6	14.6	15.8	17.0	18.3	19.5	20.8	22.2	23.7	25.3	26.9	29.1	31.4	33.8	36.5	39.4	42.5	45.9
	Kendari	Peak Demand	(MW)	36.4	39.0	42.8	46.3	50.1	54.1	58.5	63.3	67.8	72.7	78.0	83.6	89.6	95.7	103.2	111.4	120.3	129.8	140.1	151.1	163.1
		Load Factor	(%)	58.0	58.1	58.1	58.2	58.2	58.3	58.3	58.4	58.4	58.5	58.5	58.6	58.6	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9
		Energy Production	(GWh)	185	198	218	236	255	276	299	324	347	373	400	429	460	494	533	575	620	670	723	780	842
	Kolaka	Peak Demand	(MW)	9.7	10.4	11.3	12.2	13.2	14.2	15.3	16.5	17.6	18.8	20.1	21.5	22.9	24.4	26.4	28.4	30.7	33.1	35.8	38.6	41.6
		Load Factor	(%)	42.9	43.3	43.6	44.0	44.3	44.7	45.0	45.4	45.7	46.1	46.4	46.8	47.1	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
		Energy Production	(GWh)	36.6	39.3	43.3	47.0	51.1	55.4	60.2	65.4	70.4	75.8	81.6	87.9	94.6	101.9	109.9	118.6	128.0	138.2	149.1	160.9	173.7
	Raha	Peak Demand	(MW)	5.1	5.4	6.0	6.4	7.0	7.5	8.2	8.8	9.5	10.1	10.9	11.7	12.5	13.4	14.5	15.6	16.8	18.2	19.6	21.2	22.8
		Load Factor	(%)	50.5	50.7	50.9	51.0	51.2	51.4	51.5	51.7	51.9	52.1	52.2	52.4	52.6	52.9	52.9	52.9	52.9	52.9	52.9	52.9	52.9
		Energy Production	(GWh)	22.4	24.0	26.5	28.8	31.2	33.9	36.8	39.9	43.0	46.3	49.8	53.6	57.7	62.1	67.0	72.3	78.0	84.2	90.9	98.1	105.9
	Bau-Bau	Peak Demand	(MW)	8.4	8.9	9.9	10.9	11.9	13.1	14.3	15.6	17.0	18.4	20.0	21.6	23.4	25.3	27.3	29.5	31.8	34.3	37.0	40.0	43.1
		Load Factor	(%)	51.8	52.4	53.0	53.6	54.2	54.9	55.5	56.1	56.7	57.3	57.9	58.5	59.1	59.9	59.9	59.9	59.9	59.9	59.9	59.9	59.9
		Energy Production	(GWh)	38.2	41.0	46.2	51.2	56.7	62.7	69.4	76.8	84.2	92.3	101.2	110.8	121.3	132.8	143.3	154.6	166.9	180.1	194.4	209.7	226.4
	Wangi-Wangi	Peak Demand	(MW)	1.3	1.4	1.5	1.7	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.5	3.8	4.1	4.4	4.8	5.1	5.5	6.0	6.5
		Load Factor	(%)	52.6	52.7	52.8	52.8	52.9	53.0	53.0	53.1	53.2	53.3	53.3	53.4	53.5	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
		Energy Production	(GWh)	5.9	6.3	7.0	7.7	8.4	9.2	10.0	11.0	11.9	12.9	14.0	15.2	16.4	17.8	19.2	20.8	22.4	24.2	26.1	28.1	30.4

(1) Load Curve

The Study team created load curve models for each system based on the actual load curve in 2006. As for the System Minahasa-Kotamobagu and the System Sulsel, the Study team prepared load duration curves for each system because WASP simulation requires. Figure 5.6.2 shows the load duration curves used for the formulation of the generation development plan for the System Minahasa-Kotamobagu and the System Sulsel and Figure 5.6.3 shows the load curve models used for the System Gorontalo and the System Kendari.

(Minahasa-Kotamobagu system) (Sulsel system)

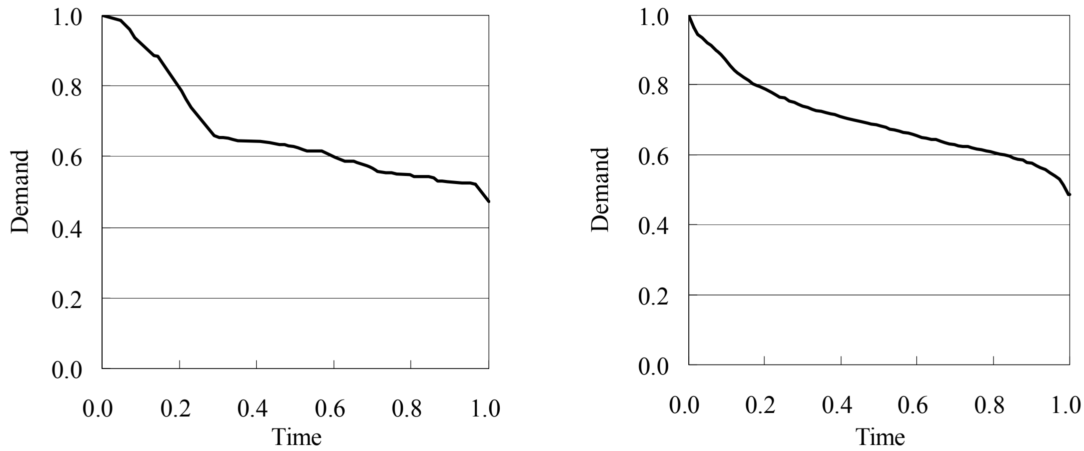


Figure 5.6.2 Load Duration Curves for the System Minahasa-Kotamobagu and the System Sulsel

(Gorontalo system) (Kendari system)

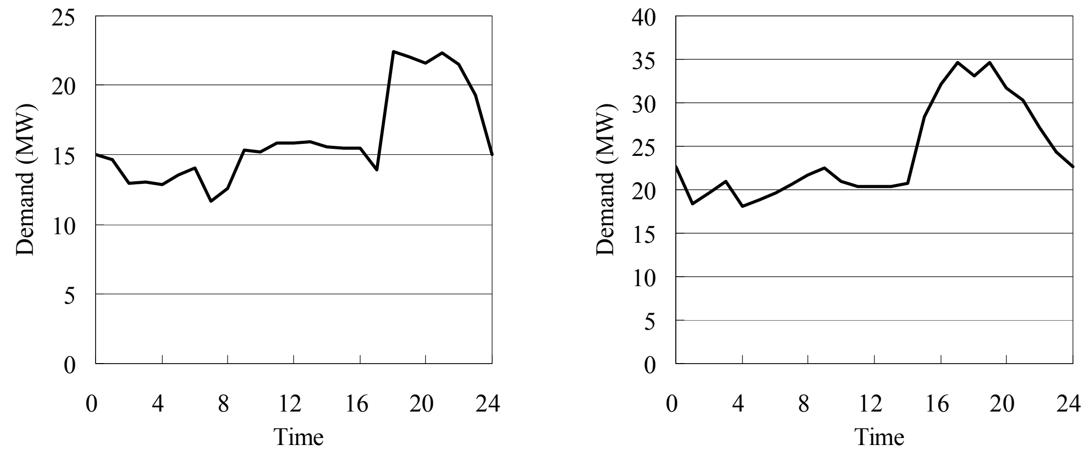


Figure 5.6.3 Load Curve Models for the System Gorontalo and the System Kendari

5.6.3 Fuel Price

Based on the actual purchase price of PLN and the data in RUPTL Draft, the Study team has set the fuel price and the steam price for geothermal power plant as shown in Table 5.6.2.

Table 5.6.2 Fuel Prices and Steam Price for the Geothermal Power Plant used for the Study

Items	Units	Coal	HSD	MFO	Natural Gas	Geothermal (Steam)
Price	USD/ton	40				
	USD/liter		0.60	0.60		
	USD/MMBTU				5.0	
	cent/GCal	800	6,652	7,168	1,984	
	cent/kWh					1.9
Heat Content	kCal/kg	5,000	11,000	9,000		
	BTU/scf				1,000	
Specific Gravity	kg/liter		0.82	0.93		

(Source: JICA Study Team)

5.6.4 Fixed Generation Development Projects

There are several on-going and committed projects for developing power plants in Sulawesi. These projects are considered as fixed developing projects in the simulation and the commissioned capacity and commissioned year are fixed. Also the procedure of optimization excludes these projects. Table 5.6.3 shows the list of the fixed development projects.

Table 5.6.3 Fixed Generation Development Project in the Study

Responsible Area	System	Owner	Plant Name	Plant Type		Fuel Type	Installed Capacity	Year
Wilayah Suluttenggo	Minahasa -Kotamobagu	PLN	Lahendong II	Geothermal	PLTP	Steam	20.0 MW	2007
		IPP	Mobuya	Mini Hydropower	PLTM		3.0 MW	2008
		PLN	Lahendong III	Geothermal	PLTP	Steam	20.0 MW	2009
		PLN	Lobong	Mini Hydropower	PLTM		1.6MW	2009
	Gorontalo	PLN	Mongango I	Mini Hydropower	PLTM		1.2 MW	2009
	Ampana	PLN	Sansarino	Mini Hydropower	PLTM		0.8 MW	2009
Wilayah Sulselrabar	Sulsel	PLN	Tengka&Ranteballa	Mini Hydropower	PLTM		11.2MW	2008
		Rental	Mobile TM 2500	Gas Turbine	PLTG	HSD	20MW	2008
		Rental	Sewa（Tello）	Diesel Unit	PLTD	MFO	70MW (10MW x 7units)	2008
		PLN	Senkang	Gas Turbine	PLTG	GAS	65MW	2009
	Kendari	Rental	Sewa（Perusda）	Diesel Unit	PLTD	MFO	5MW (2.5MW x 2units)	2008
	Raha	Rental	Sewa（Raha）	Diesel Unit	PLTD	MFO	3MW (1MW x 3units)	2008

5.6.5 Fixed Transmission Expansion Project for Interconnection

Only the transmission development in the section between Palu and Parigi is committed as of the end of September 2007. Therefore, the Study team formulates generation development plans under the condition that both isolated power systems will be interconnected in 2008.

5.6.6 Target Criteria of System Reliability

Based on the target criteria of supply reliability by PLN, the Study team set criteria in consideration of the future system scale. Table 5.6.4 shows the target criteria of supply reliability for formulating generation development plan in the Study.

In the case that an isolated system is planned to interconnect to the System Minahasa-Kotamobagu or the System Sulsel, Study team applies the criteria of interconnected system.

Table 5.6.4 Target Criteria of System Reliability for the Study

Responsible Area	System	Target Reliability
Wilayah Suluttenggo	Minahasa-Kotamobagu Interconneced System	Reserve Margin of more than 30%
	Other Small-scaled Isolated System	Reserve Margin of the Maximum two units
Wilayah Sulselrabar	Sulsel Interconnected System	Reserve Margin of more than 30%
	Other Small-scaled Isolated System	Reserve Margin of the Maximum two units

(Source: JICA Study Team)

5.6.7 Unit Capacity of Newly Developed Generation Plant

If the unit capacity of generation units installed in a system is relatively large compared to the demand size of the power system, the decline of the system frequency in case of accidental outage will be relatively large and it will be difficult or impossible to operate the power system stably. Consequently, it is desirable to examine the size of the newly developed generation unit in consideration of the size of the power system and the composition of generation units in the system.

For formulating generation development plan in the Study, this section discusses the unit capacity of the generation units which are newly installed to the system in the future.

Figure 5.6.4 shows the ratio of the maximum unit size to the peak demand as of the end of September 2007.

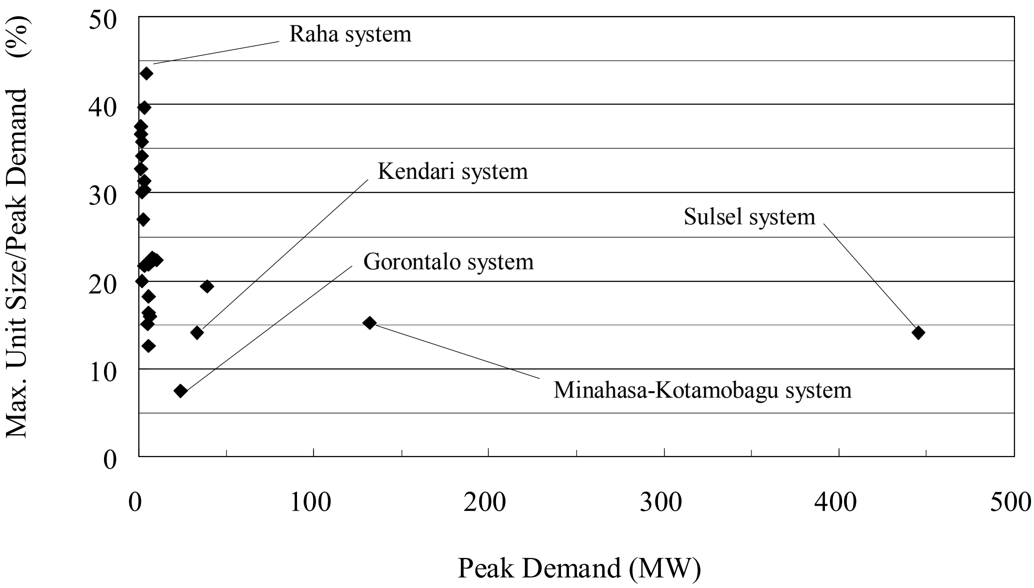


Figure 5.6.4 Ratio of the Max. Unit Size to the Peak Demand (As of the end of September 2007)

The ratio of the maximum unit size of the System Minahasa-Kotamobagu and the System Sulsel, which has a relatively large system capacity, is around 15% of total system capacity. The maximum unit sizes of the isolated systems are scattering but the most of all is larger than that of those two big systems described above.

According to a strategy report for operating the system by PLN Wilayah Suluttenggo[37], PLN sets a lower limitation in the system frequency of 49.25Hz for carrying out load-shedding manually. In the event that the frequency drops below this limitation it could be difficult to operate the power system stably.

According to the Study on The Optimal Electric Power Development and Operation in Indonesia conducted by JICA in 2002, it is reported that the correlation between the rate of capacity drop (= (dropped capacity) / (system capacity)) and the drop of frequency (%) in the Java-Bali system as of 2000 is presented as following equation.

Df = 0.146 x Dp -- (Equation 5.6.1)

where, Df: the rate of capacity drop

Dp: the drop of frequency

As the data and information for carrying out a similar study for the systems is not available, the Study team uses Equation 5.6.1 in the Study.

Examining on the frequency deviation under accidental loss of the generation unit, the Study team obtained a result that if the capacity drop due to accidental outage is lower than about 5.1% of the system capacity at that time, the frequency drop is below 0.75Hz, which is the

[37] Strategi Operasi Sistem Minahasa in 2006 (Indonesia Language)

lower limitation for conducting load-shedding manually.

Compared with this result to the current actual situation of the system shown in Figure 5.6.4, it is shown that in all of the PLN system in Sulawesi the frequency will remarkably decreases to at a severe level and it could be significantly difficult to control supply-demand balance.

Consequently, the Study team formulates generation development plans in the Study in consideration of the limitation of unit size for newly installed generation units in to the system.

The Study team gives a precondition that the capacity of newly developed generation unit in 2027 is around 5% of the peak demand in the system to the formulation of the plans for the System Minahasa-Kotamobagu and the System Sulsel. In case that generation units with the capacity above 5% of the peak demand have been already installed in the system, it is allowed to newly install the generation units with the same capacity or less.

Applying the same precondition as above to the planning for the small-scaled isolated systems composed of many diesel generation units with small capacity, it could be disadvantageous to the formulation of the plan in terms of economic efficiency because the precondition forces the plan to prepare candidate generation units with remarkably small capacity due to its small system capacity and the plan cannot receive an advantage of scale.

Considering the current and future size of the isolated system, the Study team sets precondition that defines that the capacity limitation of newly installed generation unit into the isolated systems is 10% of the peak demand in the Study.

Table 5.6.5 shows the limitation of the capacity of newly installed generation units.

Table 5.6.5 Limitation of the Unit Capacity to be installed into the System

(System North)

	Year																				
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Pead Demand (MW)	147	161	175	190	246	277	309	340	384	415	449	485	525	567	615	667	727	796	867	944	1,028
Upper Limitation of Max. Unit Capacity (MW)	**20**			**25**							**35**									**50**	
Max. Unit Capacity (MW) / Peak Demand (%)	13.6																				**4.9**

(Source: JICA Study Team)

(System South)

	Year																				
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Pead Demand (MW)	488	525	576	623	743	876	876	962	1,117	1,199	1,291	1,386	1,488	1,597	1,724	1,862	2,009	2,168	2,340	2,525	2,725
Upper Limitation of Max. Unit Capacity (MW)	**68**				**80**					**100**						**120**					
Max. Unit Capacity (MW) / Peak Demand (%)	13.8																				**4.4**

(Source: JICA Study Team)

(Other Small-scaled Isolated System)

1) Existing maximum unit capacity, or

2) 10% of the peak demand

5.6.8 Decommissioning Plan

Table 5.6.6 shows diesel power plants that are expected to be decommissioned.

Table 5.6.6 Diesel Power Plants expected to be decommissioned

Wilayah	Office	Name	Units	Manufacturer	COD	Cap (MW)
North	Palu	Parigi	1	SWD	1977	0.54
North	Palu	Moengko	1	SWD	1977	0.34
North	Palu	Moengko	1	SWD	1977	0.34
North	Palu	Bungku	1	CATAPILLAR	1977	0.11
North	Toli-Toli	Leok	1	DEUTZ	1976	0.22
North	Toli-Toli	Leok	1	KOMATSU	1976	0.25
North	Toli-Toli	Kota Raya	1	GM	1976	0.10
North	Toli-Toli	Paleleh	1	MERCEDES	1974	0.10
North	Toli-Toli	Nopi	1	SWD	1977	0.34
North	Luwuk	Luwuk	2	SWD	1977	0.67
North	Tahuna	Tahuna	1	SWD	1977	0.34
North	Tahuna	Tahuna	2	DEUTZ MWM	1977	1.00
North	Tahuna	Tagulandang	1	DEUTZ	1975	0.22
North	Tahuna	Ondong	1	CATERPILLAR	1977	0.11
North	Tahuna	Ondong	1	DEUTZ	1975	0.22
North	Kota Mobagu	Kotamobagu	1	SWD	1973	1.00
North	Kota Mobagu	Kotamobagu	1	SWD	1976	1.00
North	Gorontalo	Marisa	1	SWD	1977	0.54
North	Menado	Papusungan	1	CATERPILLAR	1977	0.11
North	Minahasa	Bitung	2	SWD	1976	8.08
North	Minahasa	Manado	1	GM	1954	1.00
South	Pembangkit 1	Tello	1	WESTCAN	1976	14.47
South	Pembangkit 1	Wangi-Wangi	3	SWD	1973	1.61
South	Pembangkit 1	Kolaka	2	SWD	1973	0.67
South	Pembangkit 1	Kolaka	1	GM	1977	0.24
South	Pembangkit 1	Bau Bau	2	SWD	1977	0.67
South	Pembangkit 1	Bau Bau	1	MIRLEES	1973	2.86
South	Pembangkit 2	Majene	2	SWD	1976	
South	Pembangkit 2	Tangkala	1	SWD	1977	0.54
South	Palopo	Pantilang	1	DEUTZ	1977	0.04
South	Bulukumba	Tanuntung	1	CATERPILLAR	1977	0.11
South	Bulukumba	Tolo	1	DAF	1972	0.10
Total			40			37.91

5.6.9 Characteristics of Candidate Power Plants

Table 5.6.7 shows the characteristics of the candidate power plants for the Study. The necessary capacity to be developed will be discussed in generation development plan. In the isolated systems, the Study team gives a condition that the coal-fired steam turbine unit is allowed to install into the systems when 10% of the peak demand reaches to 5MW, which is the smallest size of coal-fired unit in the Crash Program.

Table 5.6.7 Characteristics of Candidate Power Plant in the Study

		Thermal Power Plant					Hydropower Plant
		Steam Turbine	Gas Turbine	Combined Cycle	Diesel Unit	Geothermal	
Rated Capacity (MW)		5-200	25-50	50-100	10	20	Data for Individual Project
Development cost (USD/kW)		1,150～1,500	430	700	680～730	2,000	
Plant Life (year)		30	20	30	15	30	40
Construction Period (year)		2～3	1.5	2.5～3	1	4	Data for Individual Project
Fuel Type		Coal	HSD	Natural Gas	MFO	Steam	
Fuel Price	(USD/ fuel unit)	40 (USD/ton)	0.6 (USD/Liter)	5.0 (USD/MMBTU)	0.6 (USD/Liter)	19 (USD/kWh)	
	(USD/ Gcal)	800	6,098	1,984	5,974		
Heat Rate* (kCal/kWh)		2,324～3,308	2,529	1,792～2,048	2,529		

5.6.10 Development Scenarios

A couple of development scenarios will be created from the viewpoint of strategic environmental assessment (SEA). In this study, we created two (2) scenarios of 1) Economic Oriented Development Scenario and 2) Local Energy Premier Development Scenario. They will be assessed from the viewpoints of national energy policy, environmental and social consideration, rural development program, etc. So-called "Zero Option" was not studied since needs for electricity is high as the Government of Indonesia declared its willingness to promote further electrification in RUKN (National Electricity Development Planning).

(1) Economic Oriented Development Scenario

The scenario will be an Economic Oriented Development Scenario that aims least supply cost without any restriction of power resources. Most of the diesel generators will be replaced with coal thermal power plants.

(2) Local Energy Premier Development Scenario

The scenario will be a Local Energy Premier Development Scenario that put higher priority on hydropower and geothermal power that are local energies existing in Sulawesi Island. This scenario aims to keep CO_2 emission ratio at present revel. Hydropower and geothermal power as well as coal thermal power will be developed in this scenario.

5.7 Power System Interconnection

5.7.1 Interconnection of the power systems in Sulawesi

The power systems in Salawesi Island include, as shown in Figure 6.1.2, (a) two major systems: Minahasa-Kotamobagu system and Sulsel system, (b) small isolated systems (six systems in Sulselbar and 19 systems in Sulttenggo as shown in RUPTL) is and (c) other very small isolated systems. In this Study, interconnection of the power systems in Sulawesi is examined with (a) and (b) in consideration. Here the benefit and cost for interconnection is considered as below.

In considering the interconnection of these power systems, benefits and costs of interconnection will be examined.

The cost and benefit from interconnection are shown below. By comparing the both factors whether an interconnection is economical or not can be determined. This means that the interconnection is economically viable when the cost exceeds the benefit.

Table 5.7.1 Benefit and cost by interconnection

Benefit of interconnection	Cost of interconnection
- Decrease of power source development due to reliability improvement (Decrease of power plant construction cost) - Decrease of power plant O&M cost - Decrease of fuel cost due to economical operation	- Construction cost of transmission line - Transmission loss - O&M cost of transmission line

In Sulawesi there are a lot of power systems: large and small. Different approach should be adopted depend on the type of interconnection. Here, in considering interconnection, types of interconnection are categorized into the following three types:

I) Interconnection between two small isolated systems
II) Interconnection between a large system and a small isolated system
III) Interconnection between two large systems

5.7.2 Interconnection between two small isolated systems

Small isolated power systems in Sulawesi mostly employ diesel generators as their power sources. The peak load of each system is in the range of around 2 - 50MW. The cost and benefit for the connection of these small isolated systems are shown below.

(1) Benefit from the interconnection between small isolated power systems

In case of interconnection between diesel generators, the decrease of fuel cost is not be expected. What can be expected as the benefit is mainly the decrease of stand-by generators. The outline is shown below.

In power generation planning for an isolated power system of PLN, generation planning is formulated so that generators can feed the peak load of the system even in case of simultaneous outage of the largest two generators due to maintenance or contingency. In other words, in an isolated system two stand-by generators should be secured. This means that, as shown in Figure 5.7.1, before interconnection, each isolated system (A and B) needs two stand-by generators: in total four stand-by generators are necessary.

However, when the system A and B are interconnected, two of four stand-by generators can be decreased because whole the interconnected system needs just the two stand-by generators.

This means that the benefit of interconnection is the decrease of installation cost and O&M cost for two generators.

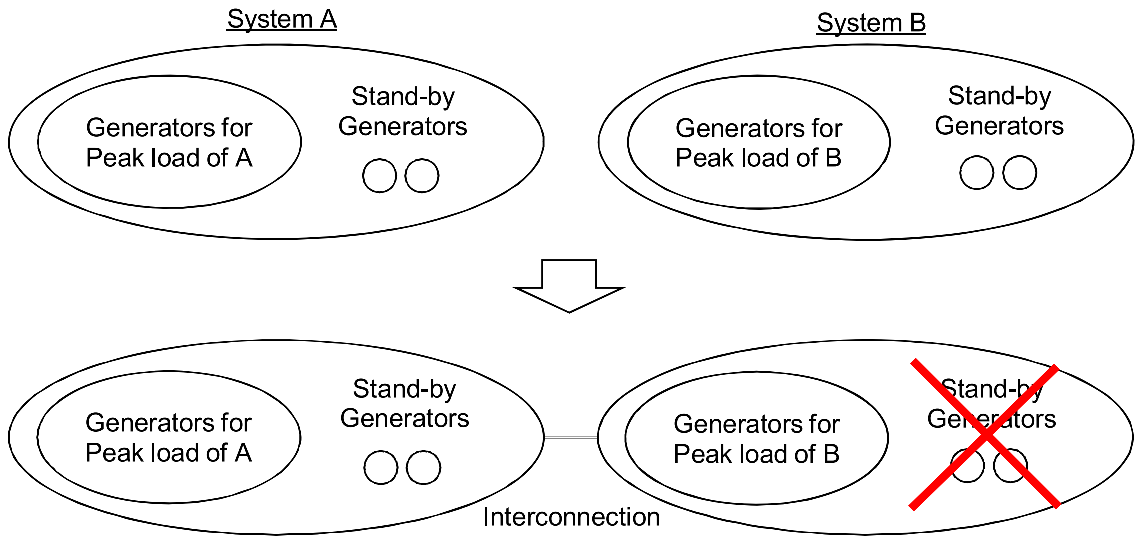


Figure 5.7.1 Decrease of stand-by generators due to interconnection of small isolated power systems

(2) Conditions for the interconnection between isolated small power systems

The benefit from the interconnection of isolated systems is decrease of two generators' installation and O&M cost. The amount of this cost is dependent on the unit capacity of the generator. As unit capacity is proportional to the power system capacity of the isolated system, if the capacity of the isolated power systems is known, the benefit can be calculated.

On the other hand, the cost of interconnection is just dependent on the distance between the isolated systems to be interconnected because the type of transmission line is limited.

In this way whether the interconnection is economically viable or not can be determined from the two factors: the capacities of and the distance between the isolated systems to be interconnected. In this section whether interconnection is economically viable or not is examined depending on the assumptions shown in Table 5.7.2.

Table 5.7.2 Assumptions for benefit and cost calculation for the interconnection isolated systems

Item	Assumption
Type of Generator	System A: Diesel System B: Diesel
Unit size of Generator	7% of Peak Load on Isolated Power System
Cost of Generator	108,309(US$/MW-year)
O&M Cost (Fixed)	20,400(US$/MW-year)
O&M Cost (Variable)	0.35 (US cent/kWh)
Construction Cost of Transmission Line	9,999.86(US$/km-year)
Construction Cost of Substations	6,965.18(US$/year)

The result of the examination is shown in Figure 5.7.2.

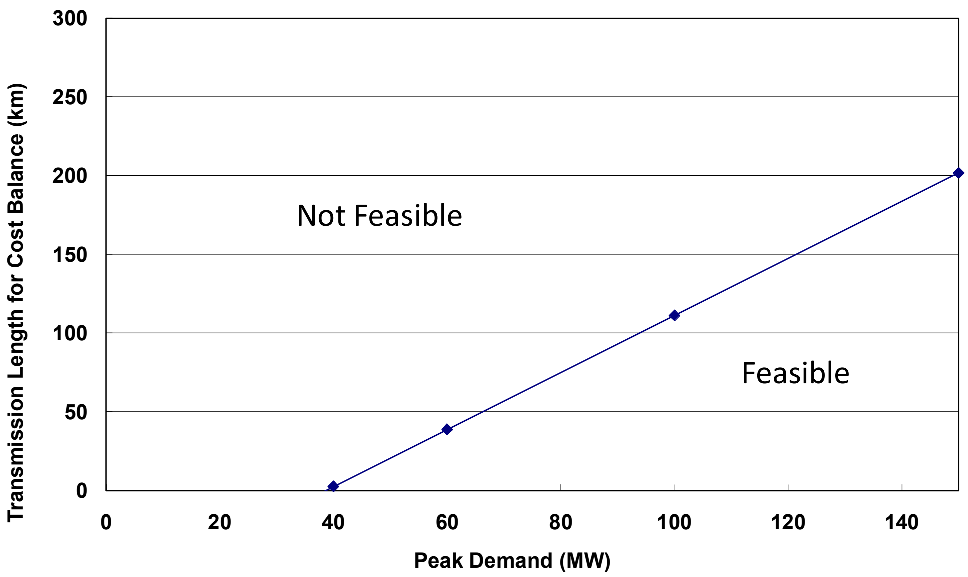


Figure 5.7.2 Economic viability of the interconnection between small isolated systems

As shown in this figure, in case of the interconnection of the two isolated systems around 100 km distant, interconnection is economically viable only when each system has capacity of around more than 100MW. This means that interconnection is not viable for most cases between small isolated systems (diesel systems) in Sulawesi.

5.7.3 Interconnection between a large system and a small isolated system

Small isolated power systems in Sulawesi mostly employ diesel generators as power sources. The peak load for each system is in the range of two (2) - several dozen MW in 2006. On the other hand, for larger power systems, Minahasa-Kotamobagu system and Sulsel system, low-cost generators such as large hydro or coal power plant are available, which are expected to be main power sources in the future. The benefit and cost of when the large system and small system are interconnected is shown below. However, the case of Kendari or Palu will be examined separately in another section because these systems are relatively large among small isolated systems and coal power plants are expected to be installed.

(1) Benefit of interconnection between a large system and small isolated system

The benefit connecting a small isolated system to a large system is the following two:

- Decrease of operation cost
- Decrease of installation cost for stand-by generators

Compared with diesel generation in the small isolated system coal power generation in the large power system is far more cost effective in operation. So when connecting the large system and the large system, the cost for operation (mainly fuel) can be decreased by stopping diesel generators with high operation cost in the small power system and by, on the other hand, increasing the output of a coal power plant in the large power system. In this case, two stand-by generators needed as an isolated system are not necessary anymore because power is supplied from the large system. Therefore the benefit of interconnection in this case is larger compared with the case between two small isolated systems.

(2) Conditions for interconnection between a large system and a small isolated system

The benefit of interconnection between a large system and a small isolated system is the following:

- Decrease of installation (and maintenance) cost for two stand-by generators
- Decrease of operation cost (mainly fuel) by shifting the output from diesel power to coal power

The former is dependent on the capacity of the isolated system, and the latter is dependent on the unit generator capacity of the isolated system. Both benefits can be calculated from the capacity of the isolated system because the unit generator capacity is proportional to the capacity of the isolated system.

The cost of interconnection is dependent on the distance because the type of line is limited.

Therefore whether the interconnection is viable or not can be determined by the capacity of the isolated system to be connected and the distance of the interconnection. The viability is examined based on the assumption shown in Table 5.7.3.

Table 5.7.3 Assumptions for benefit and cost calculation for the interconnection between a large and small isolated system

Item	Assumption
Type of Generator	System A: Coal System B: Diesel
Unit size of Generator	7% of Peak Load on Isolated Power System
Load Factor	System A: 45% System B: 30%
Cost of Generator (Diesel)	108,309(US$/MW-year)
O&M Cost (Fixed)	System A: 37,200(US$/MW-year) System B: 20,400(US$/MW-year)
O&M Cost (Variable)	System A: 0.23 (US cent/kWh) System B: 0.35 (US cent/kWh)
Fuel Cost	System A: 2.5 (US cent/kWh) System B: 16.8 (US cent/kWh)
Construction Cost of Transmission Line	9,999.86(US$/km-year)
Construction Cost of Substations	6,965.18(US$/year)

The result of the examination is shown in Figure 5.7.3. In this case the interconnection can be easily economically viable even if the isolated system is very small. For example, an interconnection of 10MW isolated system with 200 km distance could be viable. In this case, most of interconnection to an isolated system is economically viable in 2027.

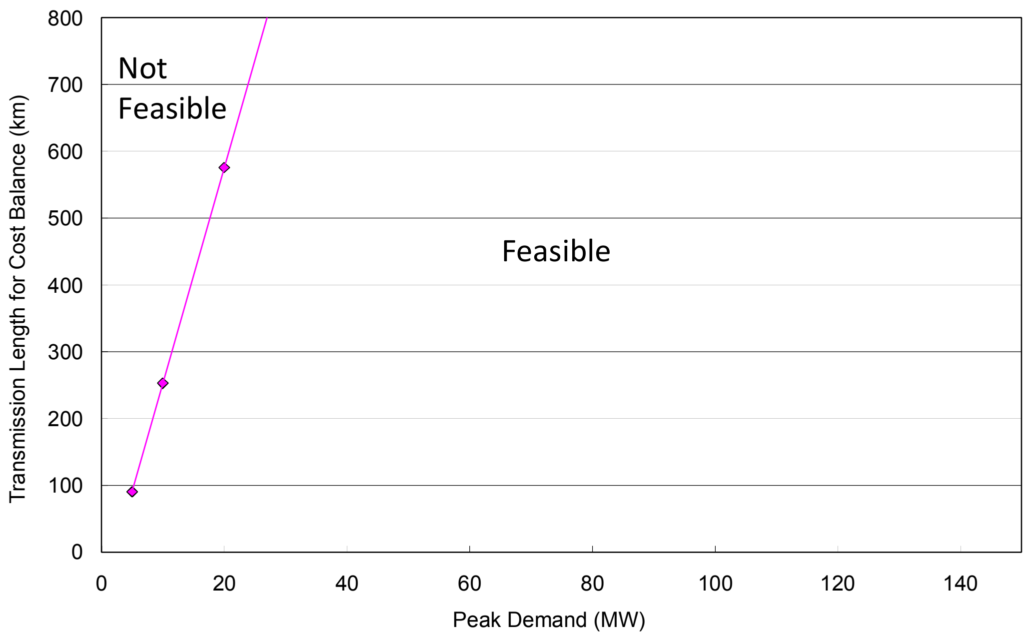


Figure 5.7.3 Economic viability of the interconnection between a large system and small isolated system

5.7.4 Timing of Interconnection of Small Isolated Systems

The study so far proved that interconnection of small isolated systems should be to a large system in order to decrease operation costs. In this section, appropriate timing of the connection for each isolated system is examined (connection to the edge of a large system). The timing of the connection is basically decided as when the benefit of connection exceeds the cost, and then corrected considering information on when neighboring power sources are installed and lines are connected. The results are shown in Table 5.7.4.

In case of the isolated systems (Kendari and Palu) where coal power generators are included (or planned to be installed), the benefit of connection will not be simply the difference between coal power generation and diesel generation. Therefore, for these two cases, the interconnection years is decided considering coal power plants currently in operation or planned to be installed soon.

Table 5.7.4 Interconnection Year of Small Isolated Systems

Isorated System	Nearest point of Large system	Distance (km)	Transmission Cost (US$)	Peak Load (2007)	Interconnection year in terms of economy	Interconnection year
Gorontalo	Buroko	94	15,148,300	25.87	As soon as possible	2010 (in conjunction with coal power plant)
Marisa	Isimu (Between Golontaro and Buroko)	118	17,785,900	6.72	As soon as possible	2011 (after connection of Gorontalo-Minahasa)
Buroko	Bintauna	40	9,213,700	2.05	2009	2010 (in conjunction with Gorontaro coal power plant)
Palu+Parigi	Poso	102	16,027,500	43.06	As soon as possible	2010 (in conjunction with Poso)
Poso	Poso Hydro	37	8,884,000	5.28	As soon as possible	2010 (in conjunction with Poso)
Toli-Toli	Leok	99	15,697,800	6.01	As soon as possible	2014 (after connection of Leok)
Moutong-Kotaraya-Palasa	Marisa	84	14,049,300	5.05	As soon as possible	2012 (after connection of Marisa)
Leok	Gorontalo Coal Power Plant	148	21,082,900	3.84	2013	2013
Kolondale	Poso Hydro	90	14,708,700	1.78	2016	2016
Bangkir	Toli-Toli	98	15,587,900	1.03	2023	2023
Luwuk	Ampana	165	22,951,200	8.7	As soon as possible	2012 (after connection of Ampana)
Ampana	Poso	123	18,335,400	1.84	2018	2011 (after introduction of Poso)
Molibagu	Otam	70	12,510,700	2	2014	2014
Bintauna	Lolak	41	9,323,600	1.6	— [38]	2010 (in conjunction with Gorontaro coal power plant)
Kendari+Kolaka	Wotu	300	47,969,100	46.1	As soon as possible	2011 (in conjunction with Kendari coal power plant)
Kolaka	Kendari	135	22,101,500	9.7	As soon as possible	2011 (in conjunction with Kendari coal power plant)

[38] Interconnection line with Gorontalo Golontalo also goes through thisa area. So, though interconnection of Bintauna itself is not generate merits, it would be beneficial for the northern system as a whole.

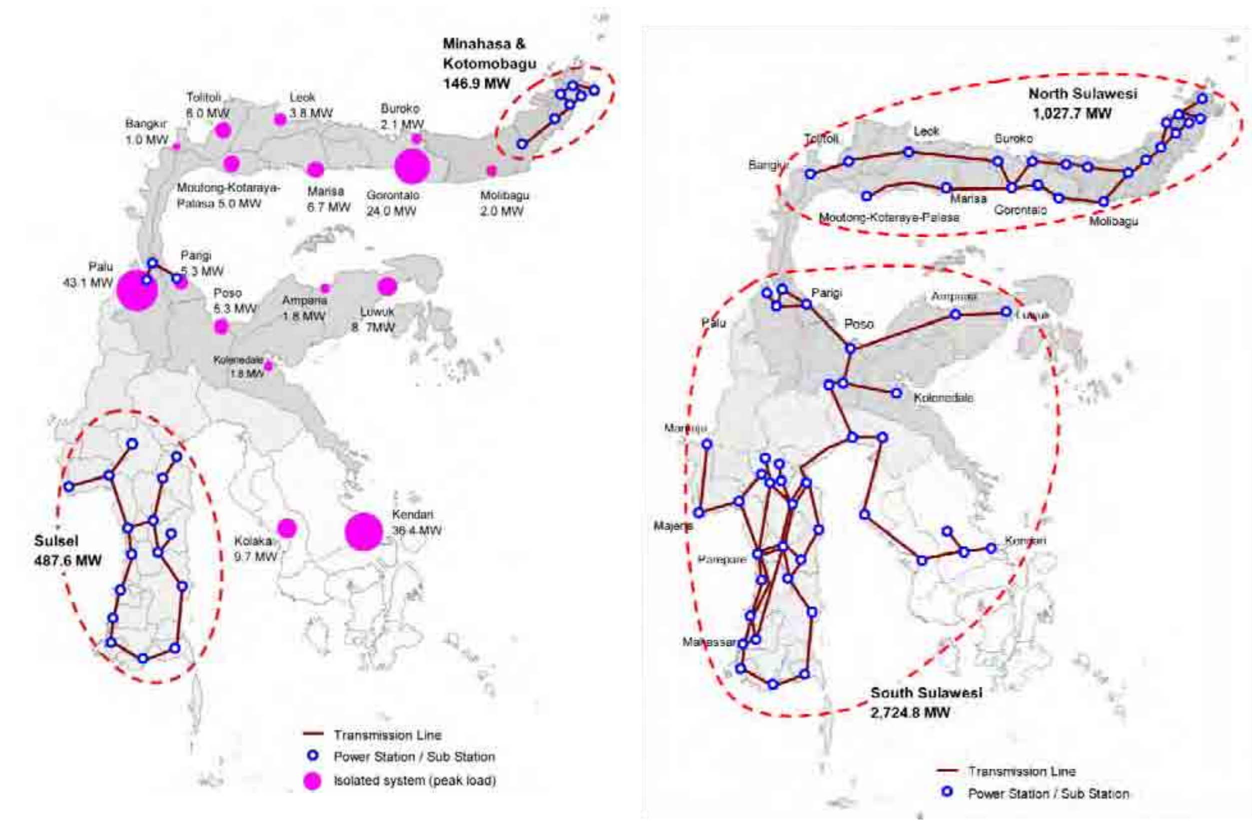
5.8 Long-term Generation Development Plan

5.8.1 Development Scenarios

The Study team set two (2) Scenarios. One is Economic Oriented Development Scenario, which aims to minimize the supply cost without limitation on power sources. Diesel generators, which bear high fuel cost, will be replaced with coal thermal power plants.

The other scenario is Local Energy Premier Development Scenario, which put higher priority on local energies in Sulawesi; hydropower and geothermal power. Unit CO_2 emission will be kept at present level. In this scenario, hydropower and geothermal power will be developed as well as coal thermal powers.

Small independent system nearby will be interconnected to Minahasa-Kotamobagu system or Sulsel system at the time it will be economical. The outline of Sulawesi power systems in 2007 and 2027 are shown in Figure 5.8.1.



(a) As of Year 2007 (existing) (b) As of Year 2027 (future)

Figure 5.8.1 Exisiting and Future Outline of Sulawesi Power System

5.8.2 Generation Development Capacity and Power Sources

(1) North Sulawesi System

Table 5.8.1 to Table 5.8.3 show the generation development capacity and power sources of two development scenarios. The required generation development capacities by 2027 are

1,105MW for Economic Oriented Development Scenario and 1,110MW for Local Energy Premier Development Scenario. In Economic Oriented Development Scenario, 53% of the generation development is coal thermal plants and the remainders are oil thermal, geothermal and hydropower. In Local Energy Premier Development Scenario, coal thermal is 26% and geothermal and hydropower, which are local energy, are introduced relatively much.

Table 5.8.1 Generation Development Plan in North Sulawesi System

Year	Peak (MW)	Economic Oriented Development Scenario						Local Energy Premier Development Scenario					
		ST			GT	CCG	Hydro	ST			GT	CCG	Hydro
		10	25	50	25	20		10	25	50	25	20	
2006	132	--	--	--	--	--	--	--	--	--	--	--	--
2007	147	--	--	--	--	--	--	--	--	--	--	--	--
2008	161	--	--	--	--	--	--	--	--	--	--	--	--
2009	175	--	--	--	--	--	--	--	--	--	--	--	--
2010	223	--	25	--	50	--	--	--	25	--	75	--	--
2011	256	10	100	--	--	--	--	10	50	--	25	--	--
2012	285	--	--	--	25	--	--	--	--	--	25	--	--
2013	314	--	--	--	25	--	20	--	25	--	--	--	20
2014	355	--	--	--	50	--	--	--	--	--	25	20	--
2015	384	--	25	--	--	--	--	--	25	--	--	--	--
2016	415	--	25	--	--	--	--	--	--	--	25	20	--
2017	449	--	25	--	25	--	--	--	25	--	--	--	--
2018	485	--	25	--	25	--	--	--	--	--	50	20	--
2019	525	--	50	--	--	--	--	--	--	--	25	20	--
2020	567	--	25	--	25	--	--	--	25	--	--	20	--
2021	615	--	50	--	--	--	--	--	--	--	25	20	--
2022	667	--	25	--	50	--	--	--	25	--	25	20	--
2023	731	--	75	--	--	--	--	--	--	--	75	20	--
2024	796	--	50	--	25	--	--	--	25	--	25	20	--
2025	867	--	50	--	50	--	--	--	25	--	50	20	--
2026	944	--	25	50	--	--	--	--	--	--	50	40	--
2027	1,028	--	--	50	50	--	--	--	25	--	25	40	--
No. of Units		1	23	2	16	--	1	1	11	--	21	14	1
		43						48					
Capacity (MW)		10	575	100	400	--	20	10	275	--	525	280	20
		1,105						1,110					

Table 5.8.2 Generation Development Plan in North Sulawesi System (Economic Oriented Development Scenario)

Items	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Forecasted Demand																							
Energy Production	GWh	694.8	775.0	849.4	922.8	1,175.0	1,401.5	1,561.4	1,720.1	1,941.3	2,100.1	2,272.0	2,455.9	2,656.3	2,872.5	3,106.3	3,369.1	3,795.0	4,155.5	4,525.1	4,927.7	5,366.1	5,843.7
Peak Load	MW	131.7	146.9	161.0	174.9	229.7	256.0	285.2	314.2	354.6	383.6	415.0	448.6	485.2	524.7	567.4	615.4	667.4	730.8	795.8	866.6	943.7	1,027.7
Load Factor	%	60.2	60.2	60.2	60.2	58.4	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	64.9	64.9	64.9	64.9	64.9	64.9
Existing Capaticy																							
Installed Capacity	MW	156.2	156.2	156.2	156.2	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	89.7	89.7	89.7	89.7	88.7	75.7	74.7	73.7	73.7	73.7
Derating Capacity	MW	20.0	20.0	20.0	20.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.8	0.8	0.8	0.8	0.6	0.3	0.2	--	--	--
Available Capacity	MW	136.2	136.2	136.2	136.2	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	89.0	89.0	89.0	89.0	88.1	75.5	74.6	73.7	73.7	73.7
Existing Plant PLN																							
PLTA/PLTM	MW	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
PLTP	MW	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
PLTD	MW	62.5	62.5	62.5	62.5	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	16.0	16.0	16.0	16.0	15.0	2.0	1.0			
Sewa PLTD HSD	MW	20.0	20.0	20.0	20.0																		
Project PLN																							
Mobuya	PLTM			3.0																			
Lobong	PLTM				1.6																		
Lahendong II	PLTP		20.0																				
Lahendong III	PLTP				20.0																		
Lahendong IV	PLTP																						
Lahendong	PLTP																						
Kotamobagu	PLTP																						
Poigar 2	PLTA							30.0															
Sawangan	PLTA								20.0														
Poigar 3	PLTA																						
New Hydro (ROR)	PLTA																						
New PLTG (Manado)	PLTG					50.0				50.0													
New PLTG (Bitung)	PLTG												25.0	25.0							25.0		25.0
New PLTG (Kotamobagu)	PLTG							25.0	25.0											25.0	25.0		
New PLTG (Likupang)	PLTG																	50.0					
Other PLTG	PLTG															25.0							25.0
Sulut Perpres	PLTU					25.0					25.0												
Amurang	PLTU						110.0																
Other Coal	PLTU												25.0		25.0	25.0	50.0	25.0	75.0	25.0	50.0	50.0	
Project IPP																							
Koneba	PLTU											25.0											
TLA/YTL	PLTU													25.0	25.0					25.0		25.0	
Kema	PLTU																						
Sulut II (Infra Summit)	PLTU																						50.0
New Connected Plant																							
Moribagu										5.6													
Gorontalo						66.0																	
Marisa							13.3																
Buroko						4.6																	
Bintauna						4.0																	
Leok									7.0														
MKP								10.7															
Toli-Toli										14.5													
Bangkir																			5.6				
Total Capacity	**MW**	**136.2**	**156.2**	**159.2**	**180.8**	**290.2**	**413.5**	**479.2**	**531.2**	**601.3**	**626.3**	**651.3**	**701.3**	**744.3**	**794.3**	**844.3**	**894.3**	**968.4**	**1,036.4**	**1,110.5**	**1,209.6**	**1,284.6**	**1,384.6**
Reserve Margin	**%**	**3.4**	**6.3**	**(1.1)**	**3.4**	**26.3**	**61.5**	**68.0**	**69.1**	**69.6**	**63.3**	**56.9**	**56.3**	**53.4**	**51.4**	**48.8**	**45.3**	**45.1**	**41.8**	**39.5**	**39.6**	**36.1**	**34.7**

Table 5.8.3 Generation Development Plan in North Sulawesi System (Local Energy Premier Development Scenario)

Items	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Forecasted Demand																							
Energy Production	GWh	694.8	775.0	849.4	922.8	1,175.0	1,401.5	1,561.4	1,720.1	1,941.3	2,100.1	2,272.0	2,455.9	2,656.3	2,872.5	3,106.3	3,369.1	3,795.0	4,155.5	4,525.1	4,927.7	5,366.1	5,843.7
Peak Load	MW	131.7	146.9	161.0	174.9	229.7	256.0	285.2	314.2	354.6	383.6	415.0	448.6	485.2	524.7	567.4	615.4	667.4	730.8	795.8	866.6	943.7	1,027.7
Load Factor	%	60.2	60.2	60.2	60.2	58.4	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	64.9	64.9	64.9	64.9	64.9	64.9
Existing Capaticy																							
Installed Capacity	MW	156.2	156.2	156.2	156.2	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	89.7	89.7	89.7	89.7	88.7	75.7	74.7	73.7	73.7	73.7
Derating Capacity	MW	20.0	20.0	20.0	20.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.8	0.8	0.8	0.8	0.6	0.3	0.2	--	--	--
Available Capacity	MW	136.2	136.2	136.2	136.2	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	89.0	89.0	89.0	89.0	88.1	75.5	74.6	73.7	73.7	73.7
Existing Plant PLN																							
PLTA/PLTM	MW	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
PLTP	MW	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
PLTD	MW	62.5	62.5	62.5	62.5	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	16.0	16.0	16.0	16.0	15.0	2.0	1.0			
Sewa PLTD HSD	MW	20.0	20.0	20.0	20.0																		
Project PLN																							
Mobuya	PLTM			3.0																			
Lobong	PLTM				1.6																		
Lahendong II	PLTP		20.0							20.0				20.0	20.0							20.0	20.0
Lahendong III	PLTP				20.0							20.0						20.0	20.0			20.0	20.0
Lahendong IV	PLTP																						
Lahendong	PLTP																						
Kotamobagu	PLTP															20.0	20.0			20.0	20.0		
Poigar 2	PLTA							30.0															
Sawangan	PLTA								20.0														
Poigar 3	PLTA																						
New Hydro (ROR)	PLTA																						
New PLTG (Manado)	PLTG					50.0	25.0								25.0				50.0				
New PLTG (Bitung)	PLTG					25.0						25.0											
New PLTG (Kotamobagu)	PLTG							25.0											25.0				
New PLTG (Likupang)	PLTG									25.0				25.0			25.0				25.0	25.0	
Other PLTG	PLTG													25.0				25.0		25.0	25.0	25.0	25.0
Sulut Perpres	PLTU								25.0		25.0												
Amurang	PLTU						110.0																
Other Coal	PLTU															25.0							
Project IPP																							
Koneba	PLTU																				25.0		25.0
TLA/YTL	PLTU																						
Kema	PLTU												25.0					25.0		25.0			
Sulut II (Infra Summit)	PLTU																						
New Connected Plant																							
Moribagu										5.6													
Gorontalo						66.0																	
Marisa							13.3																
Buroko						4.6																	
Bintauna						4.0																	
Leok									7.0														
MKP								10.7															
Toli-Toli										14.5													
Bangkir																							
Total Capacity	**MW**	**136.2**	**156.2**	**159.2**	**180.8**	**290.2**	**438.5**	**504.2**	**556.2**	**621.3**	**646.3**	**691.3**	**716.3**	**779.3**	**824.3**	**869.3**	**914.3**	**983.4**	**1,071.4**	**1,140.5**	**1,234.6**	**1,324.6**	**1,414.6**
Reserve Margin	**%**	**3.4**	**6.3**	**(1.1)**	**3.4**	**26.3**	**71.3**	**76.8**	**77.0**	**75.2**	**68.5**	**66.6**	**59.7**	**60.6**	**57.1**	**53.2**	**48.6**	**47.3**	**46.6**	**43.3**	**42.5**	**40.4**	**37.6**

(2) South Sulawesi System

Table 5.8.4～Table 5.8.6 show the generation development capacity and power sources of two development scenarios. The required generation development capacities by 2027 are 2,870 MW for Economic Oriented Development Scenario and 3,293 MW for Local Energy Premier Development Scenario. In the Economic Oriented Development Scenario, 81% of the generation development is coal thermal plants and the balance are gas fired thermal and hydropower. In the Local Energy Premier Development Scenario, coal thermal is 36% and hydropower, which are local energy, are introduced. There are no geothermal potential in the Sulsel system region.

Table 5.8.4 Generation Development Plan in Sulsel System

Year	Peak (MW)	Economic Oriented Development Scenario						Local Energy Premier Development Scenario					
		ST			GT	CCG	Hydro	ST			GT	CCG	Hydro
		10	25	50	50	50		10	25	50	50	50	
2006	445	0	0	0	0	0	0	0	0	0	0	0	0
2007	488	0	0	0	0	0	0	0	0	0	0	0	0
2008	525	0	0	0	0	0	0	0	0	0	0	0	0
2009	576	10	0	0	0	0	0	10	0	0	0	0	0
2010	687	30	0	350	0	0	180	30	0	350	0	0	180
2011	810	0	0	50	0	0	0	0	0	0	0	0	0
2012	889	0	0	50	0	0	0	0	0	0	0	0	243
2013	962	0	0	200	0	0	0	0	0	0	0	0	0
2014	1,040	0	0	100	0	0	0	0	0	50	0	0	0
2015	1,117	0	0	50	0	0	0	0	0	0	0	200	0
2016	1,199	0	0	100	0	0	0	0	0	50	0	50	0
2017	1,291	0	0	100	0	0	0	0	0	100	0	0	0
2018	1,386	0	0	50	0	0	0	0	0	50	0	50	0
2019	1,488	0	0	100	0	0	0	0	0	100	0	50	0
2020	1,597	0	0	100	0	50	0	0	0	0	0	50	126
2021	1,724	0	0	150	0	0	0	0	0	100	50	50	0
2022	1,862	0	0	100	0	50	0	0	0	0	0	50	180
2023	2,009	0	0	150	50	0	0	0	0	0	0	150	0
2024	2,168	0	0	150	50	0	0	0	0	150	0	50	0
2025	2,340	0	0	150	0	50	0	0	0	50	100	0	100
2026	2,525	0	0	150	0	50	0	0	0	0	50	100	174
2027	2,725	0	0	200	50	0	0	0	0	150	50	50	0
No. of Units		4	0	46	3	4	1	4	0	23	5	17	6
		58						55					
Capacity (MW)		40	0	2,300	150	200	180	40	0	1,150	250	850	1,003
		2,870						3,293					

Table 5.8.5 Generation Development Plan in South Sulawesi System (Economic Oriented Development Scenario)

Items	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Forecasted Demand																							
Energy Production	GWh	2,616.8	2,867.3	3,085.5	3,388.9	3,663.5	4,370.4	5,148.3	5,148.3	5,655.8	6,567.3	7,050.1	7,592.9	8,151.5	8,751.9	9,389.9	10,139.7	10,949.4	11,815.6	12,750.6	13,759.7	14,848.2	16,023.1
Peak Load	MW	445.0	487.6	524.7	576.3	687.1	809.5	889.2	961.8	1,040.3	1,116.8	1,202.8	1,291.2	1,386.2	1,488.3	1,596.8	1,724.3	1,862.0	2,009.3	2,168.3	2,339.9	2,525.0	2,724.8
Load Factor	%	67.1	67.1	67.1	67.1	60.9	61.6	66.1	61.1	62.1	67.1	66.9	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1
Existing Capaticy																							
Installed Capacity	MW	530.7	530.7	543.3	543.3	415.6	415.6	415.6	415.6	415.6	414.8	348.0	348.0	348.0	347.0	347.0	345.3	345.3	344.5	343.4	342.6	342.6	342.6
Derating Capacity	MW	22.7	25.3	25.3	25.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	0.9	0.9	0.5	0.5	0.3	0.1	--	--	--
Available Capacity	MW	508.1	505.5	518.1	518.1	414.3	414.3	414.3	414.3	414.3	413.7	346.9	346.9	346.9	346.1	346.1	344.8	344.8	344.2	343.2	342.6	342.6	342.6
Existing Plant PLN																							
PLTA/PLTM	MW	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6
PLTG	MW	108.3	108.3	108.3	108.3	66.8	66.8	66.8	66.8	66.8	66.8												
PLTD	MW	58.9	58.9	71.5	71.5	6.2	6.2	6.2	6.2	6.2	5.4	5.4	5.4	5.4	4.4	4.4	2.7	2.7	1.9	0.7			
IPP PLTGU PT Sengkang	MW	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0
IPP PLTD PT MP	MW	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Sewa PLTD HSD	MW	21.0	21.0	21.0	21.0																		
Project PLN																							
Tenga & Rantabella	PLTM			11.2																			
PLTG Mobile TM	PLTG			20.0																			
PLTD Sewatama (Tello 2)	PLTD			70.0																			
Poso	PLTA					180.0																	
Poko	PLTA																						
Bakaru 2	PLTA																						
Bonto Batu	PLTA																						
Malea	PLTA																						
New PLTG (Tello)	PLTG																						
New PLTG	PLTG																		50.0	50.0			50.0
Barru	PLTU							50.0	50.0														
Jeneponto (Espanyol)	PLTU					100.0	100.0																
Nil Tanasa	PLTU				10.0	30.0																	
New PLTU	PLTU								50.0	100.0	50.0	100.0	100.0	50.0	100.0	100.0	100.0	50.0	50.0	150.0	50.0	50.0	200.0
Project IPP																							
PLTG PT Sengkang	PLTG				50.0																		
Sengkang (New)	PLTGU																	50.0			50.0	50.0	
Takalar	PLTU					50.0	50.0																
Bosowa	PLTU					100.0			100.0														
Majene	PLTU																50.0	50.0			100.0		
Tallo Lama	PLTU																		100.0				
Takalar Baru	PLTU																					100.0	
New Connected Plant																							
Palu						95.5																	
Poso						11.9																	
Kolendale												5.7											
Ampana							4.4																
Luwuk								22.2															
Kendari							79.3																
Kolaka							19.2																
Total Capacity		**508.1**	**505.5**	**619.3**	**679.3**	**1,142.9**	**1,395.8**	**1,468.0**	**1,668.0**	**1,768.0**	**1,817.4**	**1,856.3**	**1,956.3**	**2,006.3**	**2,105.5**	**2,205.5**	**2,354.2**	**2,504.2**	**2,703.6**	**2,902.6**	**3,102.0**	**3,302.0**	**3,552.0**
Reserve Margin		**14.2**	**3.7**	**18.0**	**17.9**	**66.3**	**72.4**	**65.1**	**73.4**	**70.0**	**62.7**	**54.3**	**51.5**	**44.7**	**41.5**	**38.1**	**36.5**	**34.5**	**34.6**	**33.9**	**32.6**	**30.8**	**30.4**

Table 5.8.6 Generation Development Plan in Sulsel System (Local Energy Premier Development Scenario)

Items	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Forecasted Demand																							
Energy Production	GWh	2,616.8	2,867.3	3,085.5	3,388.9	3,663.5	4,370.4	5,148.3	5,148.3	5,655.8	6,567.3	7,050.1	7,592.9	8,151.5	8,751.9	9,389.9	10,139.7	10,949.4	11,815.6	12,750.6	13,759.7	14,848.2	16,023.1
Peak Load	MW	445.0	487.6	524.7	576.3	687.1	809.5	889.2	961.8	1,040.3	1,116.8	1,202.8	1,291.2	1,386.2	1,488.3	1,596.8	1,724.3	1,862.0	2,009.3	2,168.3	2,339.9	2,525.0	2,724.8
Load Factor	%	67.1	67.1	67.1	67.1	60.9	61.6	66.1	61.1	62.1	67.1	66.9	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1
Existing Capaticy																							
Installed Capacity	MW	530.7	530.7	543.3	543.3	415.6	415.6	415.6	415.6	415.6	414.8	348.0	348.0	348.0	347.0	347.0	345.3	345.3	344.5	343.4	342.6	342.6	342.6
Derating Capacity	MW	22.7	25.3	25.3	25.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	0.9	0.9	0.5	0.5	0.3	0.1	--	--	--
Available Capacity	MW	508.1	505.5	518.1	518.1	414.3	414.3	414.3	414.3	414.3	413.7	346.9	346.9	346.9	346.1	346.1	344.8	344.8	344.2	343.2	342.6	342.6	342.6
Existing Plant PLN																							
PLTA/PLTM	MW	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6	147.6
PLTG	MW	108.3	108.3	108.3	108.3	66.8	66.8	66.8	66.8	66.8	66.8												
PLTD	MW	58.9	58.9	71.5	71.5	6.2	6.2	6.2	6.2	6.2	5.4	5.4	5.4	5.4	4.4	4.4	2.7	2.7	1.9	0.7			
IPP PLTGU PT Sengkang	MW	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0
IPP PLTD PT MP	MW	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Sewa PLTD HSD	MW	21.0	21.0	21.0	21.0																		
Project PLN																							
Tenga & Rantabella	PLTM			11.2																			
PLTG Mobile TM	PLTG			20.0																			
PLTD Sewatama (Tello 2)	PLTD			70.0																			
Poso	PLTA					180.0																	
Poko	PLTA						234.0																
Bakaru 2	PLTA															126.0							
Bonto Batu	PLTA																				100.0		
Malea	PLTA																	180.0					
Mapili	PLTA																					174.0	
Lalindu	PLTA																						
New PLTG (Tello)	PLTG																50.0				100.0	50.0	50.0
New PLTGU	PLTG																						
Barru	PLTU				50.0	50.0																	
Jeneponto (Espanyol)	PLTU					50.0				50.0		50.0								50.0			100.0
Nil Tanasa	PLTU				10.0	30.0																	
New PLTU	PLTU												100.0				100.0						
Project IPP																							
PLTG PT Sengkang	PLTG																						
Sengkang (New)	PLTGU										200.0												
Takalar	PLTU															50.0	50.0	50.0		50.0		100.0	50.0
Bosowa	PLTU					100.0	100.0																
Majene	PLTU																			100.0			
Tallo Lama	PLTGU											50.0		50.0	50.0				150.0				
Takalar Baru	PLTU													50.0	100.0						50.0		50.0
New Connected Plant																							
Palu						95.5																	
Poso						11.9																	
Kolendale												5.7											
Ampana							4.4																
Luwuk								22.2															
Kendari							79.3																
Kolaka							19.2																
Total Capacity	**MW**	**508.1**	**505.5**	**619.3**	**679.3**	**1,092.9**	**1,529.8**	**1,552.0**	**1,552.0**	**1,602.0**	**1,801.4**	**1,840.3**	**1,940.3**	**2,040.3**	**2,189.5**	**2,365.5**	**2,564.2**	**2,794.2**	**2,943.6**	**3,142.6**	**3,392.0**	**3,716.0**	**3,966.0**
Reserve Margin	**%**	**14.2**	**3.7**	**18.0**	**17.9**	**59.1**	**89.0**	**74.5**	**61.4**	**54.0**	**61.3**	**53.0**	**50.3**	**47.2**	**47.1**	**48.1**	**48.7**	**50.1**	**46.5**	**44.9**	**45.0**	**47.2**	**45.6**

5.8.3 Generated Power

(1) North Sulawesi System

Table 5.8.7 and Fig.5.8.2 show generated power and power sources in Minahasa-Kotamobagu system. In Economic Oriented Development Scenario, Coal thermal power generates most of the power. In Local Energy Premier Development Scenario, renewable energies such as Geothermal and Hydropower will be developed as well as Coal thermal so that power source composition is not changed.

(2) South Sulawesi System

Table 5.8.8 and Fig.5.8.3 show generated power and power sources in Sulsel system. In Economic Oriented Development Scenario, Coal thermal power generates most of the power. In Local Energy Premier Development Scenario, Hydropower will be developed as well as Coal thermal so that power source composition is not changed.

Table 5.8.7 Generated Power in North Sulawesi System

(Economic Oriented Development Scenario) (unit: GWh)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hydro	213	213	226	233	233	233	364	452	452	452	452	452	452	452	452	452	452	452	452	452	452	452
Coal	0	0	0	0	149	534	515	525	578	681	806	931	1,063	1,293	1,477	1,760	2,058	2,477	2,798	3,154	3,308	3,693
GT	0	0	0	0	231	71	83	110	208	182	198	233	281	256	303	283	411	357	374	420	705	797
Geothermal	146	291	291	437	437	437	437	437	437	437	437	437	437	437	437	437	437	437	437	437	437	437
Diesel	317	256	304	233	85	127	162	197	266	349	378	403	423	435	437	437	437	432	464	464	464	464
Total	676	760	821	903	1,135	1,402	1,561	1,721	1,941	2,101	2,271	2,456	2,656	2,873	3,106	3,369	3,795	4,155	4,525	4,927	5,366	5,843

(Local Energy Premier Develoment Scenario) (unit: GWh)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hydro	213	213	226	233	233	233	364	452	452	452	452	452	452	452	452	452	452	452	452	452	452	452
Coal	0	0	0	0	138	380	362	452	457	569	569	697	700	715	826	852	1,020	1,075	1,233	1,408	1,448	1,602
GT	0	0	0	0	287	213	217	173	239	229	250	272	317	361	333	402	473	617	644	715	820	851
Geothermal	146	291	291	437	437	437	437	437	583	583	730	730	876	1,022	1,167	1,313	1,459	1,604	1,749	1,895	2,189	2,480
Diesel	317	256	304	233	65	138	181	206	211	269	271	305	312	323	329	351	392	409	447	457	457	459
Total	676	760	821	903	1,160	1,401	1,561	1,720	1,942	2,102	2,272	2,456	2,657	2,873	3,107	3,370	3,796	4,157	4,525	4,927	5,366	5,844

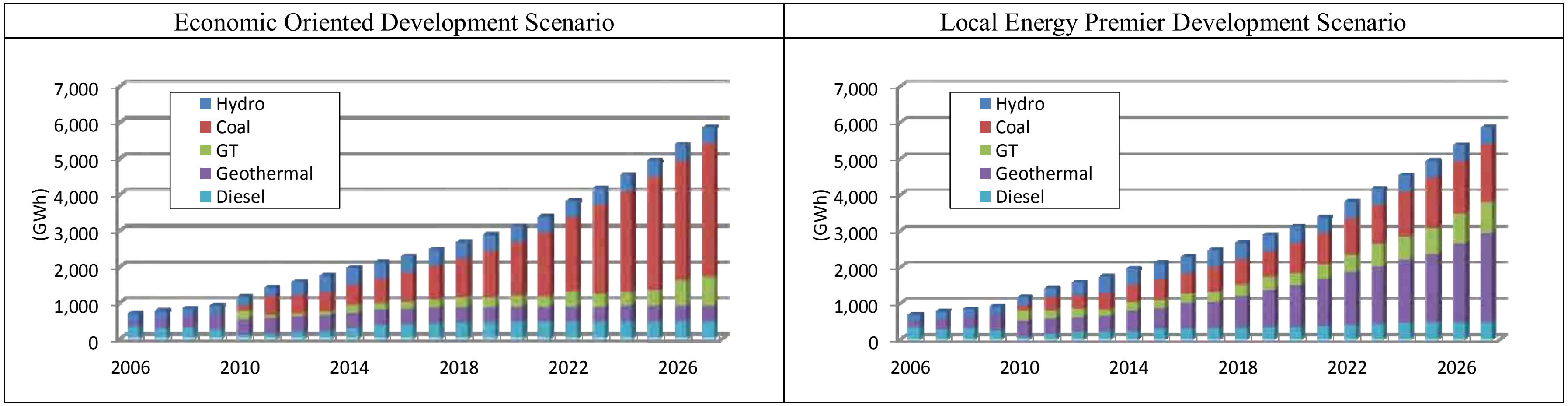


Figure 5.8.2 Generated Power in North Sulawesi System

Table 5.8.8 Generated Power in South Sulawesi System

(Economic Oriented Development Scenario) (unit: GWh)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hydro	745	745	794	794	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583
Coal	0	0	0	68	1,586	2,080	2,732	2,661	3,177	3,847	4,370	4,906	5,404	6,015	6,632	7,421	8,172	9,044	9,962	10,937	11,969	13,145
GT	384	455	465	752	124	220	273	4	4	43	30	25	43	42	32	21	19	30	49	41	42	55
Combined Cycle	889	937	909	920	302	362	404	139	108	202	177	159	186	177	218	191	251	238	236	279	333	321
Diesel	590	694	914	852	69	126	156	760	783	892	890	921	935	935	925	923	924	921	920	920	921	919
Total	2,608	2,831	3,082	3,386	3,664	4,371	5,148	5,147	5,655	6,567	7,050	7,594	8,151	8,752	9,390	10,139	10,949	11,816	12,750	13,760	14,848	16,023

(Local Energy Premier Develoment Scenario) (unit: GWh)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hydro	745	745	794	794	1,583	1,583	3,014	3,014	3,015	3,015	3,015	3,015	3,015	3,015	3,567	3,567	4,667	4,667	4,667	5,280	6,042	6,042
Coal	0	0	0	68	2,000	2,000	1,289	1,626	1,648	1,990	2,353	2,902	3,329	3,943	3,977	4,675	4,488	4,873	5,826	6,143	6,221	7,250
GT	384	455	465	752	259	259	35	145	61	54	42	38	40	22	18	22	16	41	29	58	57	64
Combined Cycle	889	937	909	920	380	380	151	285	195	637	755	720	841	851	908	956	864	1,313	1,310	1,363	1,615	1,754
Diesel	590	694	914	852	148	148	659	77	736	870	884	918	927	921	920	919	914	921	919	916	914	913
Total	2,608	2,831	3,082	3,386	4,370	4,370	5,148	5,147	5,655	6,566	7,049	7,593	8,152	8,752	9,390	10,139	10,949	11,815	12,751	13,760	14,849	16,023

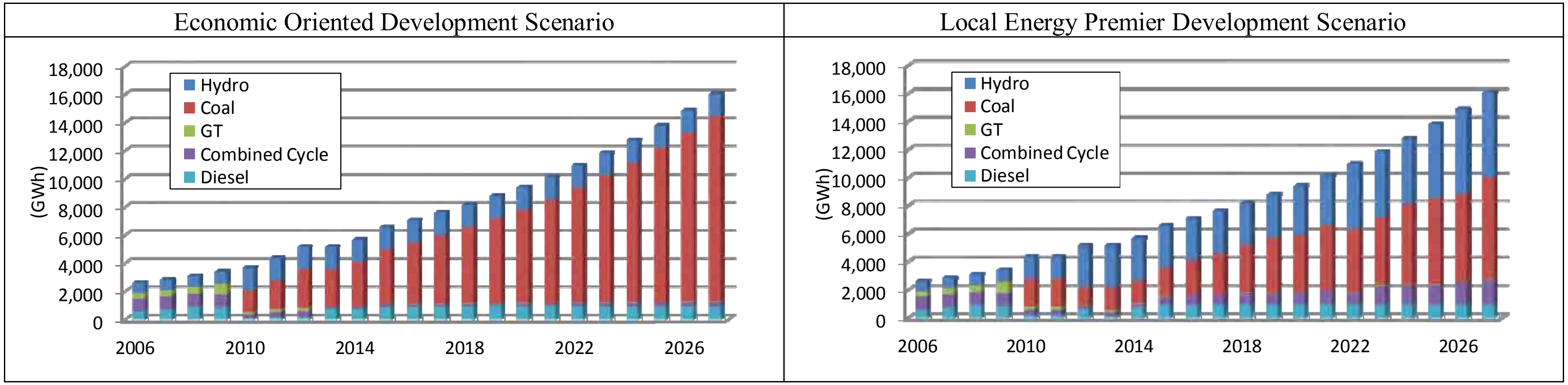


Figure 5.8.3 Generated Power in South Sulawesi System

5.8.4 Fuel Consumption and CO_2 Emission

(1) North Sulawesi System

Table 5.8.9 and Table 5.8.10 show the fuel consumption and CO_2 emission in North Sulawesi system by scenarios. In Economic Oriented Development Scenario, CO_2 emission will increase drastically. Unit CO_2 emission will decrease first when geothermal and hydropower will be developed. Then Unit CO_2 emission will increase to 0.8 kg-CO_2/kWh as coal thermal will be developed. In the Local Energy Premier Development Scenario, unit CO_2 emission will be 0.5 kg-CO_2/kWh level by developing geothermal and hydropower.

Table 5.8.9 Fuel Consumption in North Sulawesi System

(Economic Oriented Development Scenario)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Coal (kilo ton)	0	0	0	0	81	293	282	288	318	374	442	510	582	708	809	963	1,126	1,355	1,530	1,724	1,795	1,992
HSD (kilo liter)	83	67	79	60	75	21	23	29	52	45	50	57	66	60	71	67	96	82	86	97	162	183
MFO (kilo liter)	0	0	0	0	0	30	42	52	71	94	102	110	117	121	121	121	121	121	130	130	130	130

(Local Energy Premier Development Scenario)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Coal (kilo ton)	0	0	0	0	76	210	200	249	252	313	313	383	384	393	453	467	560	589	676	772	793	877
HSD (kilo liter)	83	67	79	60	83	55	54	43	59	56	61	66	74	85	78	94	110	142	148	165	189	196
MFO (kilo liter)	0	0	0	0	0	33	47	54	55	72	73	82	86	89	91	97	108	115	126	128	128	129

Table 5.8.10 CO_2 Emission in North Sulawesi System

(Unit: million ton)

	Economic Oriented Dev. Scenario (1)	Local Energy Premier Dev. Scenario (2)	(3)=(2)-(1)	(3)/(1)
2006	283	283	0	0%
2007	228	228	0	0%
2008	271	271	0	0%
2009	206	206	0	0%
2010	418	432	14	3%
2011	741	698	▲ 43	▲6%
2012	759	716	▲ 43	▲6%
2013	819	799	▲ 20	▲2%
2014	1,012	860	▲ 152	▲15%
2015	1,170	1,019	▲ 151	▲13%
2016	1,343	1,038	▲ 305	▲23%
2017	1,525	1,222	▲ 303	▲20%
2018	1,721	1,265	▲ 456	▲26%
2019	1,959	1,326	▲ 633	▲32%
2020	2,198	1,428	▲ 770	▲35%
2021	2,488	1,529	▲ 959	▲39%
2022	2,911	1,800	▲ 1,111	▲38%
2023	3,317	1,985	▲ 1,332	▲40%
2024	3,703	2,209	▲ 1,494	▲40%
2025	4,125	2,464	▲ 1,661	▲40%
2026	4,489	2,589	▲ 1,900	▲42%
2027	4,951	2,781	▲ 2,170	▲44%

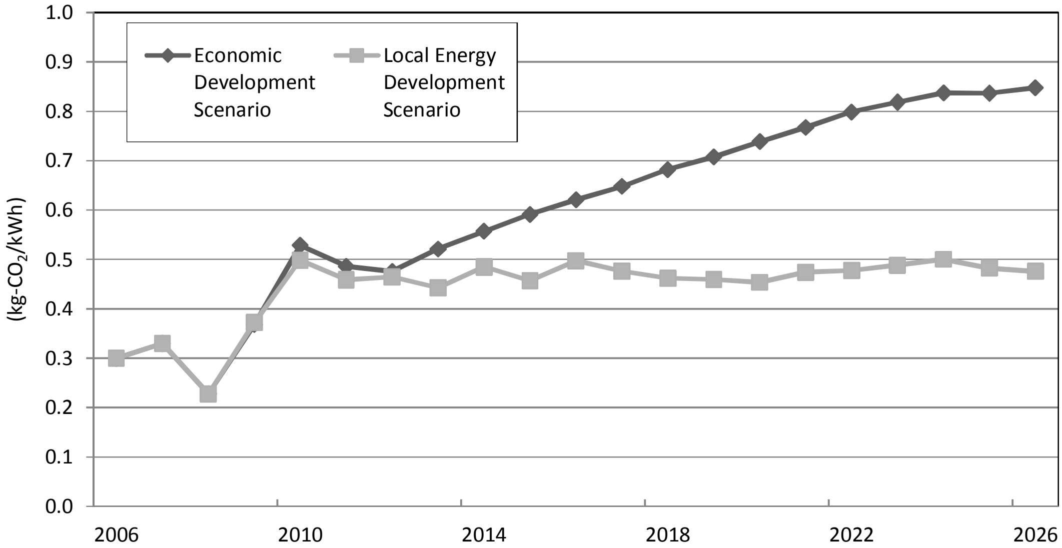


Figure 5.8.4 Unit CO_2 Emission in North Sulawesi System

(2) South Sulawesi System

Table 5.8.11 and Table 5.8.12 show the fuel consumption and CO_2 emission in South Sulawesi system by scenarios. In Economic Oriented Development Scenario, CO_2 emission will increase drastically. Unit CO_2 emission will increase to 0.9 kg- CO_2/kW in 2027 from 0.5 kg-CO_2/kWh in 2005 as coal thermal will be developed. In Local Energy Premier Development Scenario, unit CO_2 emission will be 0.5 kg- CO_2/kWh level by developing hydropower.

Table 5.8.11 Fuel Consumption in South Sulawesi System

(Economic Oriented Development Scenario)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Coal (kilo ton)	0	0	0	41	816	1,067	1,400	1,356	1,615	1,957	2,220	2,491	2,744	3,052	3,364	3,762	4,142	4,583	5,047	5,541	6,063	6,658
Gas	6	7	6	10	3	4	4	1	1	2	2	1	2	2	2	2	2	2	2	2	3	3
HSD (kilo liter)	174	206	194	186	11	31	41	0	0	2	0	0	0	0	0	0	0	3	6	5	6	9
MFO (kilo liter)	102	121	202	185	22	38	46	214	220	251	250	259	263	263	260	260	260	259	259	259	259	259

(Local Energy Premier Development Scenario)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Coal (kilo ton)	0	0	0	41	186	1,028	835	660	844	1,021	1,205	1,482	1,699	2,010	2,027	2,381	2,285	2,483	2,965	3,125	3,165	3,686
Gas	6	7	6	10	3	4	3	1	2	5	6	6	7	7	7	8	7	11	10	11	13	14
HSD (kilo liter)	174	206	194	186	11	39	19	1	4	2	0	0	0	0	0	2	2	4	2	8	8	10
MFO (kilo liter)	102	121	202	185	22	44	23	186	208	245	249	258	261	259	259	259	257	259	259	258	257	257

Table 5.8.12 CO_2 Emission in South Sulawesi System

(Unit: million ton)

	Economic Oriented Dev. Scenario (1)	Local Energy Premier Dev. Scenario (2)	(3)=(2)-(1)	(3)/(1)
2006	1,314	1,314	0	0%
2007	1,499	1,499	0	0%
2008	1,683	1,683	0	0%
2009	1,899	1,899	28	0%
2010	1,916	1,916	▲623	0%
2011	2,575	2,558	▲276	▲ 1%
2012	3,325	1,973	▲1,139	▲ 41%
2013	3,377	1,945	▲1,513	▲ 42%
2014	3,895	2,415	▲1,459	▲ 38%
2015	4,734	3,099	▲1,131	▲ 35%
2016	5,232	3,527	▲1,058	▲ 33%
2017	5,779	4,081	▲905	▲ 29%
2018	6,320	4,583	▲890	▲ 27%
2019	6,925	5,187	▲721	▲ 25%
2020	7,549	5,249	▲1,198	▲ 30%
2021	8,316	5,978	▲1,071	▲ 28%
2022	9,100	5,732	▲1,965	▲ 37%
2023	9,972	6,386	▲1,997	▲ 36%
2024	10,903	7,327	▲1,780	▲ 33%
2025	11,897	7,691	▲2,263	▲ 35%
2026	12,962	7,901	▲2,878	▲ 39%
2027	14,142	9,012	▲2,714	▲ 36%

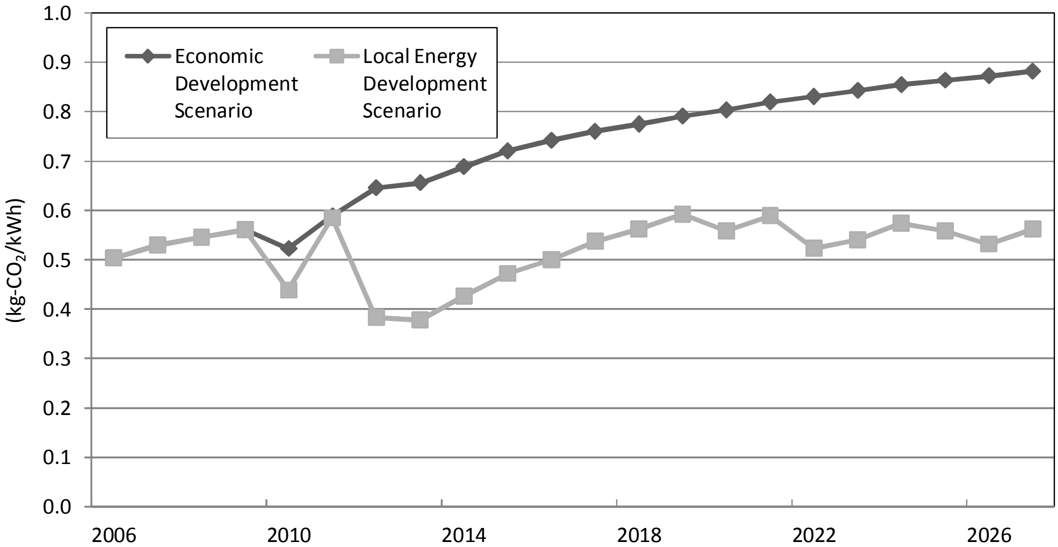


Figure 5.8.5 Unit CO_2 Emission in South Sulawesi System

5.8.5 Investment Cost

Table 5.8.13 shows investment cost until 2027 by the Scenarios. Local Energy Premier Development Scenario investment cost is 14 % higher than that of Economic Oriented Development Scenario.

Table 5.8.13 Investment Cost

North Sulawesi System

	2008-2012	2013-2017	2018-2022	2023-2027	Total
Economic Oriented Development Scenario	267	199	342	511	1,320
Local Energy Premier Development Scenario	260	197	282	464	1,203

South Sulawesi System

	2008-2012	2013-2017	2018-2022	2023-2027	Total
Economic Oriented Development Scenario	1,125	507	874	1,263	3,769
Local Energy Premier Development Scenario	1,227	709	1,226	1,430	4,591

All Sulawesi (North Sulawesi system and South Sulawesi system)

	2008-2012	2013-2017	2018-2022	2023-2027	Total
Economic Oriented Development Scenario	1,392	705	1,216	1,775	5,088
Local Energy Premier Development Scenario	1,488	906	1,508	1,893	5,795

5.8.6 Comparison between Economic Oriented Development Scenario and Local Energy Premier Development Scenario

Economic Oriented Development Scenario develops much coal thermal power plants. Investment cost of the scenario is estimated 12% less than Local Energy Premier Development Scenario but the amount of CO_2 emission and unit CO_2 emission are higher than those of Local Energy Premier Development Scenario.

Considering the consistency with national power development policy, such as best mix of the power source, introduction of renewable energy and local energy utilization, and contribution to local economy, Local Energy Premier Development Scenario will be given higher priority.