Department of Electricity, Ministry of Energy and Mines
Electricité du Laos
Lao People's Democratic Republic

The Study on Power Network System Plan in Lao People's Democratic Republic

Final Report

January 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

Tokyo Electric Power Company, Inc.

Nippon Koei Co., Ltd.

IDD
JR
09-090

PREFACE

In response to a request from the Government of Lao People's Democratic Republic, the Government of Japan decided to conduct "The Study on Power Network System Plan in Lao People's Democratic Republic" which was entrusted to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched between October 2008 and January 2010 a study team headed by Mr. Masaharu YOGO of Tokyo Electric Power Company, Inc. (TEPCO) comprised of TEPCO and Nippon Koei Co., Ltd..

The team held discussions with concerned officials from the Government of Lao People's Democratic Republic and conducted field surveys. Upon returning to Japan, further studies were conducted and a final report was prepared.

The power network system plan up to 2030 has been formulated taking into consideration the situations of both the power sector and LAO PDR's existing power facilities in this study. An evaluation of the prioritization of the projects for power network development has been conducted. The highest prioritized project's, facility design and validity was confirmed and a cost estimation was conducted.

I hope that this report will contribute to power network system planning in the Lao People's Democratic Republic as well as enhancing the friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials representing the Government of Lao People's Democratic Republic for their unwavering cooperation in support of this study.

January 2010

Atsuo KURODA
Vice President
Japan International Cooperation Agency

January 2010

Mr. Atsuo KURODA

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 Power Network System Plan in the Lao People's Democratic Republic (Lao PDR). The contents reflect the comments received from not only the Department of Electricity, Ministry of Energy and Mines (DOE), Electricité du Laos (EdL) but also from other related organizations and institutions in Lao PDR, as well as the advice of related institutions associated with the Government of Japan.

This report puts forth its proposal for the highest prioritized project and provides recommendations regarding a power network system plan for Lao PDR up to 2030. I am convinced that the implementation of this project will be able to realize stable, efficient and far reaching power supply encompassing even those regions where at present there are no sufficient power sources available to compete with high priced imported power. Hence, via astute utilization of the abundant hydropower resources in Lao PDR, the nation can make significant economic progress while promoting rural electrification and that all of this can be achieved minus any consequential strain on the environment. Further, in addition to the implementation of the highest prioritized project, the outcomes of the long term power network planning and the establishment of the power system operating rules should also be taken into consideration when formulating future power sector policy and the power development program in Lao PDR. This will contribute greatly to Lao's public welfare and industry growth.

In closing, I would like to express our sincere appreciation to the officials of JICA, the Ministry of Foreign Affairs and the Ministry of Economy, Trade and Industry. We would also like to express our gratitude to the officials representing the Government of Laos, the Department of Electricity of Ministry of Energy and Mines, Electricité du Laos and other related organizations, notably the JICA Laos Office and Embassy of Japan in Lao PDR for their unwavering cooperation and assistance throughout the field survey.

Very truly yours,

Masaharu YOGO

Team Leader

The Study on Power Network System Plan in Lao People's Democratic Republic

Contents

Tables and Figures

Appendices

Abbreviations

Abbreviation	Words
A/C	Air Conditioner
AC	Aluminum Clad Stranded Wire
ACSR	Aluminum Conductor Steel Reinforced
ADB	Asian Development Bank
AFTA	ASEAN Free Trading Area
AP	Affected Person
ASEAN	Association of South East Asian Countries
ASTM	American Society for Testing and Materials
BS	British Standards
CA	Concession Agreement
cct	Circuit
CEPT	Committee Effective Preferential Tariff
CIF	Cost, Insurance and Freight
CIGRE	International Council on Large Electric Systems
CK/WH	Cooking/Water Heating
COD	Commercial Operation Date
CPI	Consumer Price Index
CSGC	China Southern Power Grid Company Limited
D/D	Detailed Design
DC	Direct Current
DCS	Distributed Control System
deg.	Degree
DEPD	Department of Energy Promotion and Development
DIN	Deutsches Institut fur Normung
DMS	Detailed Measurement Survey
DOE	Department of Electricity in MEM
DPA	District Protected Area
DPRA	Development Project Responsible Agency
DSM	Demand Side Management
EA	Environmental Assessment
EC	Energy Conservation
ECC	Environmental Compliance Certificate
EDL	Electricité du Laos

EDS	Energy Day Stress
EGAT	Electricity Generating Authority of Thailand
EIA	Environment Impact Assessment
EIRR	Economic Internal Rate of Return
EMMU	Environmental Management and Monitoring Units
EMP	Environmental Management Plan
EMU	Energy Management Unit
EO	Environmental Office
ESCC	Environmental and Social Compliance Certificate
ESD	Environment and Social Management Division
ESIA	Environmental and Social Impact Assessment
ESIAD	Environmental and Social Impact Assessment Division
EU	Environmental Unit
EVN	Vietnam Electricity
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
FOB	Free on Board
FS	Feasibility Study
F/S	Feasibility Study
FY	Fiscal Year
GDP	Gross Domestic Product
GMPNDP	Greater Mekong Power Network Development Project
GMSPTP	Greater Mekong Subregion Power Trade Project
GMS	Greater Mekong Sub-Region
GMSPT	Greater Mekong Subregion Power Trade
GNI	Gross National Income
GoL	Government of Lao PDR
GR	Growth Rate
GSW	Galvanized Steel Stranded Wire
HHPC	Houay-Ho Power Company Limited
HP	Hydraulic Power
HPS	Hydropower Station
HV	High Voltage
Hz	Herz
ICB	International Competitive Bidding
IDA	International Development Association
IEC	International Electrotechnical Commission
IEE	Initial Environment Examination

IESE	Initial Environment and Social Examination
IkL	Isokeraunic Level
IPP	Independent Power Producer
IRR	Internal Rate of Return
ISE	Initial Social Examination
IUCN	International Union of Conservation of Nature
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JPY	Japanese Yen
kN	kilo Newton
kV	Kilo-Volt
Lao PDR	Lao People’s Democratic Republic
LC	Local Currency
LDC	Load Dispatching Center
LDC	Least Developed Country
LEPTS	Lao Electric Power Technical Standards
LHSE	Lao Holding State Enterprise
LLDC	Least among Less Development Countries
LNG	Liquid Natural Gas
LOLE	Loss-of- Load Expectation
LPG	Liquefied Petroleum Gas
LPRP	Lao PDR People's Revolutionary Party
LTE	Local Transportation and Erection
LV	Low Voltage
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mines (Lao PDR)
MIH	Ministry of Industry and Handicraft
Mil	Million
MOM	Minutes of Meeting
MV	Medium Voltage
MW	Mega Watt
NBCA	National Bioversity Conservation Areas
NEPE	National Poverty Eradication Programme
NGO	non-governmental organization
NGPES	National Growth and Poverty Eradication Strategy
NPA	National Protected Areas
NPEP	National Poverty Eradication Programme

NPV	Net Present Value
NRA	The National Regulatory Authority for the UXO/Mine Action Sector
NSEDP	National Socio-Economic Development Plan
O & M	Operation & Maintenance
OCC	Opportunity cost of capital
ODA	Official Development Assistance
ODAF	Oil Directed Air Forced
OJT	On the Job Training
ONAF	Oil Natural Air Forced
OPGW	Optical Fiber Ground-Wire
PAP	Project Affected Person
PC	Personal Computer
PCB	Poly-Chlorinated Biphenyls
PCTPC	Provincial Communication Transport Post & Communication
PDA	Development Agreement
PDEM	Provincial Department of Energy and Mines
PDP	Power Development Plan
PDPAT	Power Development Planning Assist Tool
PEA	Provincial Electricity Authority of Thailand
PECC4	Power Engineering Consulting Joint Stock Company 4
PEMC	Project Environmental Management Committee
PLC	Power Line Carrier
PPA	Power Purchase Agreement
PPA	Provincial Protected Area
PSS	Power System Stabilizer
r.m.s	Root Mean Square
RAP	Resettlement Action Plan
REP	Rural Electrification Program
RETICS	Reliability Evaluation Tool for Inter-Connected System
ROW	Right of Way
RUS	Rated Ultimate Strength
S/W	Scope of Work
SCADA	Supervisory Control Data Acquisition
SCF	Standard Conversion Factor
sq.mm	Square Millimeter
SS, S/S	Substation
STEA	Science, Technology, and Environment Agency
SWER	Shield Wire Earth Return

SWL	Shield Wire Line
SwS	Switching Station
TACSR	Thermal-Resistant Aluminum Conductor Steel Reinforced
TBC	Tie-Line Bias Control
TFR	Total Fertility Rate
THB	Thai Baht
THPC	Thuen-Hinboun Power Company Limited
TL	Transmission Line
TOU	Time of Use
TR	Transformer
UN	United Nations
UNOSAT	United Nations Operational Satellite Applications Programme
US	United States
USD	United States Dollar
UTS	Ultimate Tensile Strength
UXO	Unexploded Ordnance
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital
WB	World Bank
WREA	Water Resource & Environment Administration
WTO	World Trade Organization
WTP	Willingness-to-Pay

Existing Laos Transmission System in 2009

as of August 25, 2009

Chapter 1
Introduction

Chapter 1 Introduction

1.1 Background and Objective of the Study

1.1.1 Background of the Study

The national power network system of Lao PDR is divided into four separate regions (the North, Central 1, Central 2 and the South), which reflects the segregated nature of domestic power supply and consumption in the nation. This is a problem the Department of Electric Ministry of Energy and Mines (DOE) and the Electricité du Laos (EDL) have been struggling to solve via interconnecting the four regions. These measures would optimize and stabilize their power network into one system. The transmission line project between the Central 1 and the Central 2 regions planned in collaboration with “The Study on Master Plan of Transmission Line and Substation System in Lao PDR (2001-2002)” has been launched via the aid of a Japanese Government Loan. The project will make it possible to supply power generated at Central 1 to Central 2 power consumers resulting in a reduction of the high prices on energy imported from Thailand.

On the other hand, there are no interconnecting power systems between the Central and South region. The completion of the national power grid via aggressive expansion of the bulk power network system to the south region is being strongly anticipated. It is expected to not only improve the electric power industry’s management by promoting national power interchanges, but will also contribute to the formulization of energy policies that will revitalize the national economy, will lead to the fulfillment of Basic Human Needs and environmental preservation by switching to the electricity as the fuels indispensable to societal sustentation via ingeniously sloughing off wood fuels.

In light of Japan’s abundant experience in working with the Lao PDR in the area of transmission lines and substations, the Government of Laos issued a proposal to the Government of Japan requesting assistance for this study. Subsequent due diligence was undertaken by the Japan International Cooperation Agency (JICA) who carried out the preliminary surveys in July 2008. After JICA reviewed the details of the request with Lao PDR officials, an agreement was reached to which both parties signed the S/W in August 28, 2008.

The implementation of this study is based on this S/W.

1.1.2 Objective of the Study

The purpose of the study is to carry out the following tasks according to schedule.

- Create a 20-year optimal plan from 2011 for a national power network system
- Create a basic design of the prioritized project integrated with the aforementioned plan
- Conduct necessary Technology Transfer to the counterpart staff

1.1.3 Study Area

The Study covers the entire area designated as the Lao PDR territory.

1.2 Methodology of the Works

This study consists of two stages, the “Power System Planning Stage” and the “Basic design

Stage for the most prioritized Power System Projects", respectively. Each stage is comprised of site surveys and the domestic work shown in the following table. This study has focused on the power network system for domestic power supply in Laos and proposed the interconnections as the highest prioritized project.

[A] Power System Planning Stage	[B] Basic design Stage for the most prioritized Power System Projects
· Preparatory Work · First Mission (End of November 2008 – Beginning of December 2008) · First Domestic Task (Middle of December 2008) · Second Mission (End of January 2009 – End of February 2009)	· Second Domestic Task (End of April 2009) · Third Mission (Middle of May 2009 – End of May 2009) · Third Domestic Task (Beginning of June 2009) · Fourth Mission (End of July 2009 – End of August 2009)
	[C] Final Stage
	· Fourth Domestic Task (End of September 2009) · Fifth Mission (Beginning of October 2009) · Fifth Domestic Task (Beginning of November 2009) · Submission of Final Report (January 2010)

1.3 Implementing Agencies of Lao PDR

The experts were selected as shown in Table 1.3-1. Both the "Power Demand Forecast" and the "Power Supply Planning" have treated the data and information on which the power system planning is predicated. "Transmission Line Designing", "Substation Designing" and "Environmental and Social Assessment" have conducted detailed site surveys, designs and environmental impact assessments at "the Basic design Stage for the most prioritized Power System Projects". "Team footing" in which the "Team Leader" and "Administration" coordinate with each other was established so as to manage the team smoothly.

Table 1.3-1 Expertise

Position/ Area of expertise	Name
1. Team Leader/ Power System Planning	Masaharu YOGO
2. Power Demand Forecast	Hiroyuki SHINOHARA
3. Power Supply Planning	Yasuhiro YOKOSAWA
4. Power System Analysis	Yasuharu SATO
5. Transmission Line Designing	Masahiro OGAWA
6. Substation Designing	Junichi FUKUNAGA
7. Economic and Financial Analysis	Atsumasa SAKAI
8. Environment and Social Assessment	Mayumi GOTO
9. Administration	Tomomi AKITA Satoshi KOBAYASHI

The counterparts in Laos consist of the Ministry of Energy and Mines, the Department of Electricity (DOE) and Electricite du Laos (EDL).

The steering committee is under the auspices of the DOE and is composed of the DOE, EDL, Department of Energy Promotion and Development (DEPD), Water Resource & Environmental

Agency (WREA) and the JICA Study Team.

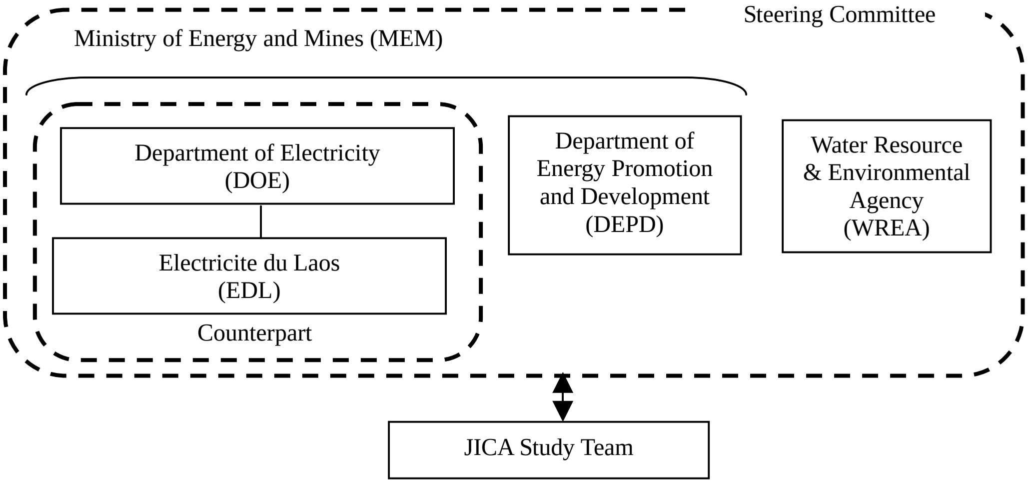


Figure 1.3-1 Organization Structure of the Steering Committee and the Counterpart

1.4 Technology Transfer

Transfer of knowledge and technology is an integral part of the study. Through the inception report, the workshops, and the training with the counterpart staff, the team has endeavored to disseminate the purpose of the study, the approach and the analysis methodology of the existing power system and the formulation of the power system master plan, the design of the transmission line and substations excetera to the counterpart staffs.

Under the counterpart training courses, the trainees from DOE and EDL were dispatched to Japan during June 2009 for a couple of weeks for this study. The training was not only for the planning and designing of power systems, but also included the construction methods for transmission lines and substations, enhancing awareness of the O&M situation through the site survey to witnessing the actual facilities, the equipment manufacturing process, and also Japan's power system operations. The trainees have been scheduled engaged in the FS for hydropower stations and the plan and the implementation of the capacitors respectively by utilizing the outcomes of the trainings after return back to Laos. They are expected to become the trainers for the technical skills regarding the power system planning near future.

The two-day technical transfer seminar was held in EDL in August 2009. The contents of the seminar included not only the methodology of the power system plans but also the detailed methodology of power system analysis and the protection relay settings. The participants for this seminar has been coming not only from the project offices of EDL headquarters but also substations, power stations and branch offices including the candidates of the staff expected engaged in the power system operation in the future National Load Dispatching Center and the power system operation department the training is expected to contribute the improvement in the skills of O&M staff of EDL regarding the power system analysis.

Chapter 2
Lao People's Democratic Republic

Chapter 2 Lao People's Democratic Republic

2.1 Country Overview

The Lao People's Democratic Republic (Lao PDR) is a landlocked country located in the center of the Mekong region. The country stretches out from north to south, bordering Vietnam to the east, Thailand to the west, Cambodia to the south, and China and Myanmar to the north. Mountains and plateaus occupy almost 70% of its land, and the Mekong River flows through over 1,900 km of the country from north to south. The Lao PDR has harnessed its geographical resources such as its potential for hydraulic power towards economic growth. The climate is tropical with two distinct seasons, the rainy season and the dry season. The country is on average muggy throughout the year. In terms of its political context, the Lao PDR has consistently maintained a single-party system led by the Lao PDR People's Revolutionary Party (LPRP). The structure of political power has remained unchanged since the Lao PDR was established in 1975. Although the country had pursued a central economic planning system in its early years, the Lao PDR has since undertaken significant economic reforms to shift itself towards a market economy under the New Economic Mechanisms that were introduced in 1986. Although once in a state of decline due to the Asian financial crisis in 1997, thanks to the robust economic growth of neighboring ASEAN countries, the Lao PDR has been successful in sustaining its own robust economic growth, with a real Gross Domestic Product (GDP) growth rate of 7% or more over the last 5 years. However, the country is positioned as the Least Developed Country (LDC), whose Gross National Income per capita is around 580 USD. The Government of Lao PDR has set as its goal the "freeing of the country from this LDC status by 2020." Table 2.1-1 summarizes the country profile. In terms of social context, more than 90% of citizens are estimated as Buddhist. In general, the character of citizens of Lao PDR is mild.

Figure 2.1-1 Country Map of Lao PDR

(Source: United Nations)

Table 2.1-1 Country Summary

Land	Area	: 236,800 km^2 (Equivalent to the size of Japan's Honshu island)
	Capital	: Vientiane
	Climate	: Tropical monsoon having rainy and dry seasons. High temperature and humid through the year.
Population	Total	: 5,873,616
	Growth rate	: 2.4% per annum
	Population density	: 25 persons per square kilometers
Ave. Life	Expectancy	: 62.5 years old
	Birth Rate	: 32.6 per 1,000 population
	Infant Mortality	: 64.4 per 1,000 population
Labor	Force	: 2.8 million in 2006. Around 80% of the force engages in agriculture (2005).
	Growth rate	: 1.5% per annum (comparison between 2001 and 2006)
Ethnic groups		: Lao: 55%; Khmou: 11%; Hmong: 8%; other about 60 groups.
Religion		: Buddhism (66.8% as of 2005),
Language (official)		: Lao
School enrollment		: Primary enrollment: 84％; Junior high school enrollment: 38%
Literacy		:73% (age over 15 years old)
Currency		: Kip
GDP	2007 Constant	: 39,284,200 million Kip (GDP at market prices)
	GDP/capita	: 6,694 thousand Kip
	Growth Average	: 7.5% (2007)
Access to safe water		: 35% (household base)
Physicians		: 1.3 per 1,000 people
Hospital beds		: 1.18 per 1,000 people

(Source: developed by JICA Study Team based on the website of Japanese Embassy in Lao PDR, and from Lao's socio-economic base)

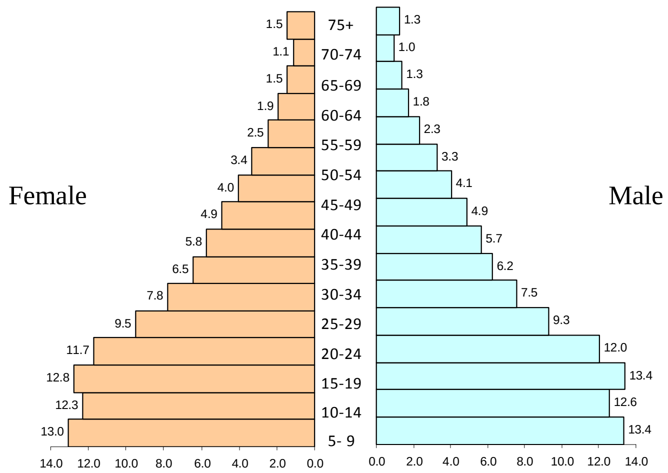
2.1.1 Geography and Population

Mountains cover the northern as well as the eastern parts of the country. Its square area is 236,800 km^2, almost equivalent to that of Japan's Honshu Island. The Mekong River rising from the Tanggula Mountains in China flows vertically through the country transporting various natural bounties to the people. Its ample water resource helps the country to earn foreign income by exporting electricity generated by the water flow. Table 2.1-2 shows the list of main rivers in the Lao PDR. The total population of the country has reached about 5.9 millions as of 2007. Out of this total, the population of the Vientiane Capital comprises 12%, while those of the other power regions, namely the North, Central 1, Central 2, and the South comprise 18%, 41%, 21%, and 20% respectively. The population density nationwide is 25 persons per square kilometer, which gives off a sparse impression compared to Japan's 343 persons per square kilometer (Statistics Bureau, Japan, 2005). Figure 2.1-2 shows the population pyramid of Lao PDR (2007).

Table 2.1-2 The List of Main Rivers in Lao PDR

Name	Flowing by	Length (km)
Mekong	Laos	1,898
Of which:	Laos-Thailand	919
Nam ou	Phongsaly-Luangprabang	448
Nam ngum	Xiengkhuang-Vientiane	354
Nam xebanghieng	Savannakhet	338
Nam tha	Luangnamtha-Bokeo	325
Nam xekong	Saravane-Sekong-Attapeu	320
Nam xebangphay	Khammuane-Savannakhet	239
Nam beng	Oudomxay	215
Nam xedone	Saravane-Champasack	192
Nam xekhanong	Savannakhet	115
Nam kading	Borikhamxay	103
Nam khane	Huaphanh-Luangprabang	90

(Source: Statistical Yearbook 2007 Lao PDR)



units: year-old on vertical axis and % on holizontal axis

Figure 2.1-2 Population Pyramid of Lao PDR (2007)

(Source: Statistical Yearbook 2007 Lao PDR)

2.1.2 Climate

The country's climate is tropical with two distinct seasons, the rainy season from the beginning of May to the end of September and the dry season from October to April. Table 2.1-3 and Figure 2.1-3 show the meteorological data as well as the rainfall data of the four representative locations in Lao PDR, respectively. This data shows that the temperature of the country is mild all through the year, while some mountainous areas in the north record a relatively lower temperature. The record for the southern part of the Lao PDR shows that this area receives more rain than other parts of the country.

Table 2.1-3 Meteorology Data of Lao PDR (2007)

Parameter	Laungprabang (North)	Vientiane Capital (Central 1)	Savannakhet (Central 2)	Pakse (South)
Mean temperature in ℃	25.6	26.5	26.2	27.2
Mean maximum temperature in ℃	31.2	31.0	31.3	31.8
Mean minimum temperature in ℃	20.0	21.9	21.1	22.7
Total rainfall in mm	1,295.0	1,667.5	1,444.7	1,967.5

(Source: Statistical Yearbook 2007 Lao PDR)

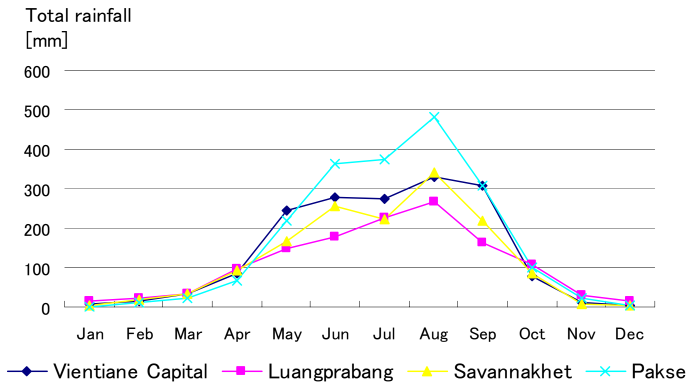


Figure 2.1-3 Monthly Rainfall

(Source: Statistical Yearbook 2007 Lao PDR)

2.1.3 Administrative Structure

The political structure of the Lao PDR is the People's Democratic Republic with the President being the head of a nation in a one-chamber system. Administrative authority has been yielded to the cabinet consisting of the Prime Minister, the deputy Prime Minister, the cabinet ministers, and the chairperson of the national committee. The President under approval of the national assembly appoints the Prime Minister. The present governmental structure of the country is shown in Figure 2.1-4. The country is administratively divided into 16 provinces and the Vientiane Capital.

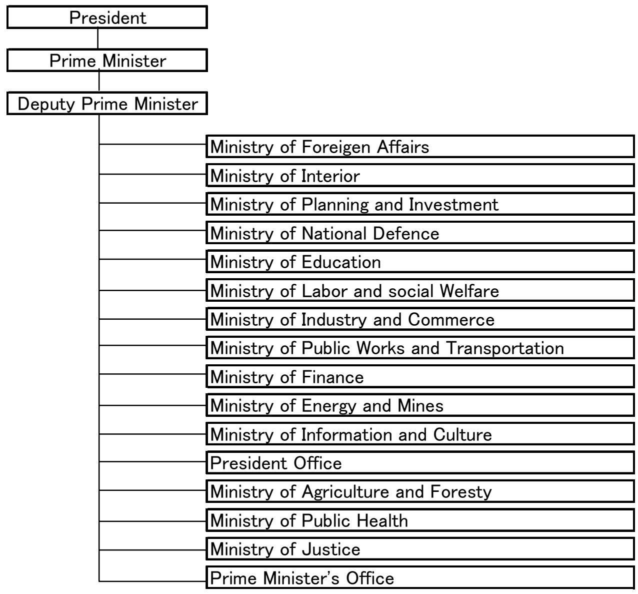


Figure 2.1-4 Administrative Structure

(Source: Lao's socio-economic base)

2.2 Social and Economic Conditions

2.2.1 Overview of Social Aspects

Recently, the Lao PDR's economy has been successful with its real GDP growth rate peaking at 7.1% in 2007, thanks to the introduction of a market economy and an open economy policy under the New Economic Mechanism. However, the country's Gross National Income (GNI) per capita still stands at around 580 USD. This figure's positional status is one of the lowest among Southeast Asian nations (Table 2.2-1).

Table 2.2-1 Social Development Indicators of Lao PDR

Population growth rate	2.4%
Human Development Index ranking (2008)	130th
Average lifetime (2005)	Male: 59 year old Female: 63 year old
Poverty population (2004)	32.7%
Gini Index (2004)	0.37

(Source: "Results from the Population and Housing Census 2005")

In Lao PDR, agriculture is still the main driver of the country's economy, which comprises 40% of the country's GDP and the nation's social aspects have improved quite significantly in recent years. For example, the average life expectancy has increased from 54 years old in 1999 to 63 years in 2007. Infant mortality rate (per 1,000 live births) has declined from 140 in 1999 to 54 in 2006. The country's life standard has also shown steady improvement, although the World Bank's report classifies the country as one of the least developed in East Asia. It is essential to raise the quality of healthcare and the educational system in order to satisfy growing socio-economic development needs. Table 2.2-2 shows the percentage of private households with access to a lifeline infrastructure, while Table 2.2-3 shows the diffusion rate of those who have gained access to the lifeline infrastructure, which has risen dramatically from 1995 to 2005.

Table 2.2-2 The Percentage of Private Households with Access to Lifeline Infrastructure

[Unit: %]

	Safe water	Electricity
Urban	67	90
Rural (with road)	27	43
Total	35	60

(Source: "Results from the Population and Housing Census 2005")

Table 2.2-3 The Improvement of the Infrastructure Penetration

[Unit: %]

Year	Safe water	Electricity
1995	15	25
2005	35	60

(Source: "Results from the Population and Housing Census 2005")

From a regional point of view, the central region and the southern region of the country are relatively wealthy compared to the northern region of the country. According to data prepared by the Asian Development Bank (ADB), the poverty ratio (1997/1998) is 38.6% in total, while in the Vientiane Capital it is 12.2%, 52.5% for the northern region, 34.9% for the central region, and 38.4% for the southern region. Figure 2.2-1 shows the distribution of households with access to lifeline infrastructure.

In order to reduce such poverty, the Lao PDR has intensively focused on the development of a socio-economic infrastructure based on the National Growth and Poverty Eradication Strategy (NGPES, Jan., 2004) and the National Socio-economic Development Plan (2006-2010), Oct. 2006, aiming to liberate itself from the present LDC position by 2020.

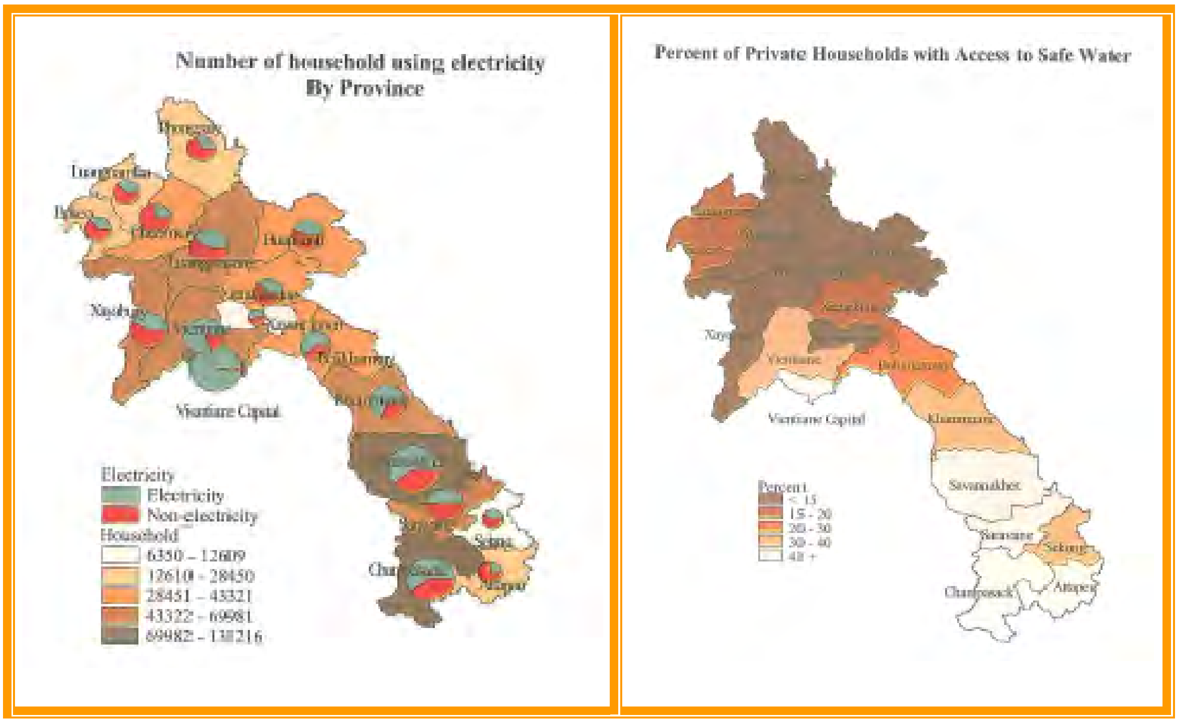


Figure 2.2-1 The Distribution of Private Households with Access to Lifeline Infrastructure (left: electricity, right: safe water)

(Source: "Results from the Population and Housing Census 2005")

2.2.2 Overview of Economic Conditions

The Lao PDR has achieved high economic growth with a rate of over 5% the last decade with its GDP per capita reaching 701 USD. As for trading, partially thanks to its participation in the Association of Southeast Asian Nations (ASEAN), the Lao PDR has a tight relationship with the neighboring countries of Thailand, Vietnam, and recently China, which accounts for the top three nations in export and import turnover. Table 2.2-4 shows the Lao PDR's key economic indicators, while Table 2.2-5 shows its historical trade balance.

Table 2.2-4 Key Economic Indicators

(mainly figures of FY2007)

Indictor	Figure
Nominal GDP	39,300 billion Kip（4.2 billion USD）
GDP per capita	712 USD
GDP structure	Agriculture 40.3%; Industry 34.1%; Service 25.6%
Trade amount	Export (FOB) 9.9 billion USD; Import (CIF) 1.1 billion USD
Key export commodities	Mining 59.9%; Garments 13.7%; Wood products 9.7%; Electricity 9.1%
Key import commodities	Machinery 16.6%; Fuel 16.3%; Construction material 1.9%; Transportation material 10.9%
Direction of trade:	
- Export	Thailand 36.4%; Vietnam 11%; China 6.3%; German 3.6%
- Import	Thailand 70.6%; China 8.6%; Vietnam 5.5%; Singapore 2.1%

(Source: ADB Key Indicators 2007), 1USD=8,544.5Kip=106.11JPY as of Sept. 2008

Table 2.2-5 Trade Balance

[Unit: Million USD]

	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Export	352.6	389.0	455.6	878.0	925.6
Import	551.1	607.0	686.0	931.4	916.4
Balance	-198.5	-218.0	-230.4	-53.4	9.2

(Source.: Lao's socio-economic base)

The main reason for the 2007 positive trade balance can be attributed to the mining development of resources such as gold and copper. The industry accounts for more than 45% of the total export turnover. As seen in the historical real GDP growth rate in Figure 2.2-2, actual GDP growth averaged a robust rate of more than 6% a year over the past decade. The recent economic growth is apparently driven mainly by the mining sector's foreign investment, especially in copper and gold as well as in large-scale hydropower generation projects. Figure 2.2-3 shows the historical exchange rates of the Lao Kip against the USD. Although Laos' local currency Kip has declined in value against the USD after the 1997 Asian financial crisis, the rate has stabilized at around 10,000 Kip/USD over the past five years.

As seen in Figure 2.2-4, in the past the agricultural sector has dominated the structure of Lao PDR's economy. Recently its GDP share has switched places with the industry sector, which has gained its share. Specifically, electricity exports and recently an increased mining sector have contributed to the growth. Tourism in the Services sector has also grown rapidly thanks to the recent world-heritage boom that competes with electricity exports with respect to the national export turnover.

The CPI (Consumer Price Index)-based inflation rate has shifted to a single-digit rate since 2005. In 2008, the rate increased rapidly reaching 10.3% in May (Figure 2.2-5). Global-wide inflation of natural resources and food is said to be one of the reasons underlying such a high inflation rate.

Although Lao PDR's economy has been integrated into the ASEAN economy, its GDP level is not as high as that of other nearby nations such as Thailand and Malaysia. The Lao PDR is also designated as a CVLM country. The acronym stands for Cambodia, Vietnam, Lao PDR, and Myanmar all of which have a similar GDP level. These countries are expected to achieve high economic growth over the next coming years. Table 2.2-6 shows the key indicators of these countries.

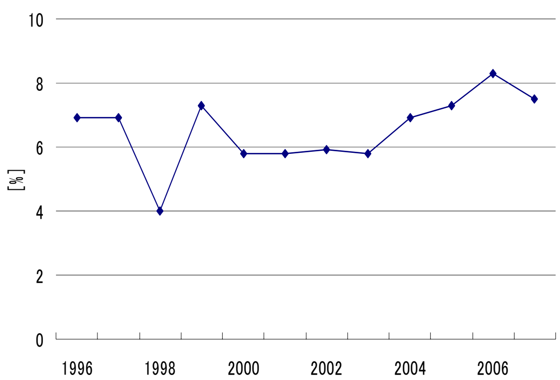


Figure 2.2-2 Real GDP Growth Rate

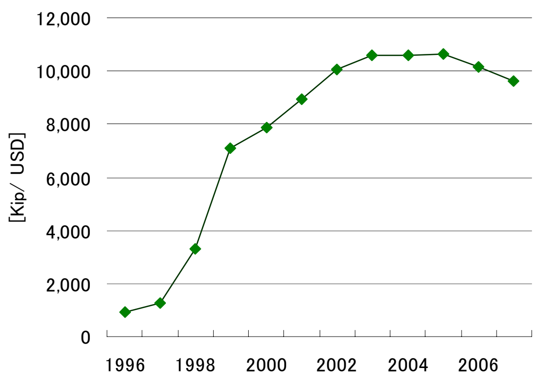


Figure 2.2-3 Lao Exchange Rate

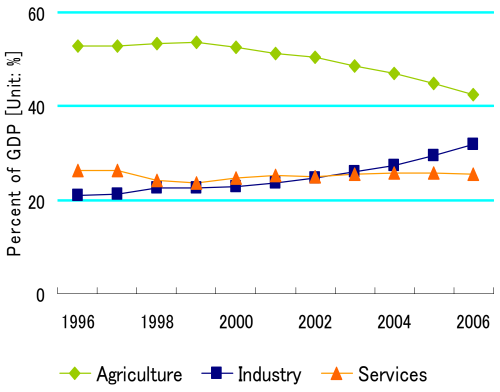


Figure 2.2-4 The Structure of the Economy

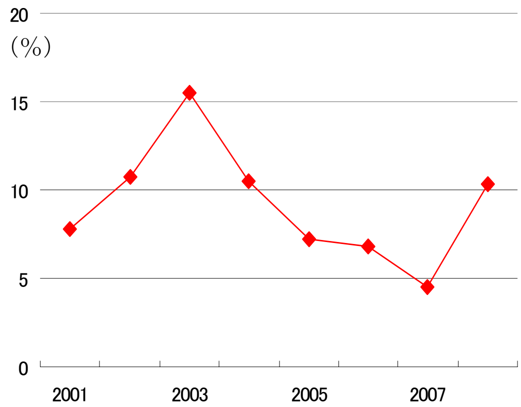


Figure 2.2-5 Inflation (CPI) Rate

(Source: developed from the following materials: ADB Key Indicators 2007, Lao's socio-economic base, and Lao PDR Economic Monitor)

Table 2.2-6 Gross Domestic Production of GMS countries

	Lao PDR	Thailand	Vietnam	Cambodia	Yunnan province of China
Nominal GDP [Mil USD]	656	245,659	70,022	8,604	62,324
GDP per capita [USD/capita]	656	3,737	818	600	1,385
Population [Mil]	6.1	65.7	85.6	14.3	45.1
Area [km^2]	236,800	513,115	331,690	181,035	394,139

(Source: Final report on Project study on Indochina regional cooperation in power sector)

2.2.3 National Development Plan

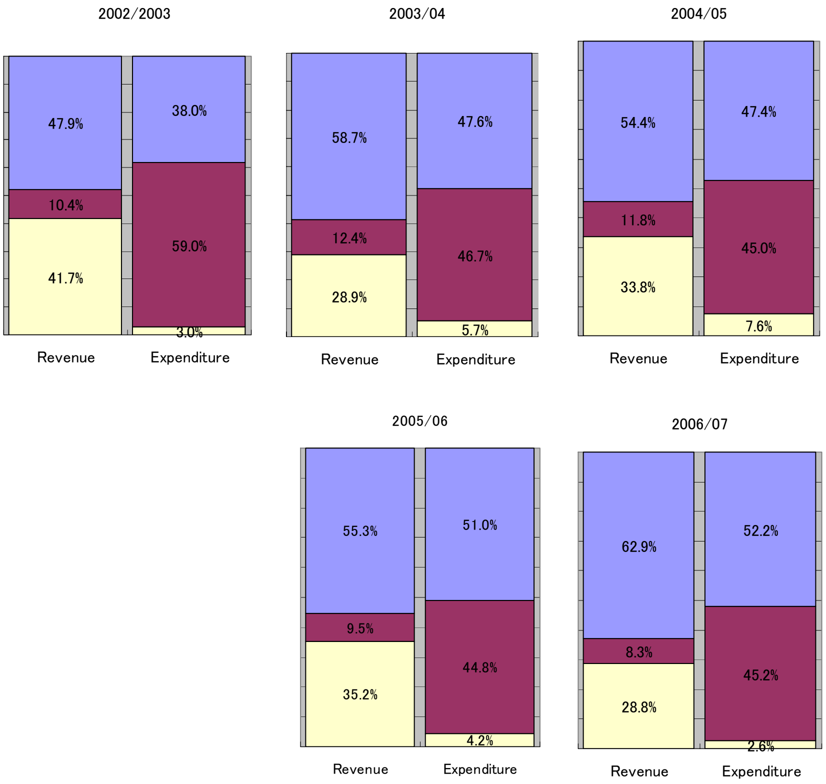
The Lao PDR has implemented its socio-economic development program in accordance with two policies, namely, the National Poverty Eradication Programme (NPEP), renamed as the National Growth and Poverty Eradication Strategy (NGPES) and the National Socio-Economic Development Plan (NSEDP), which is reviewed every five years. In 1996, the Lao PDR has set as its goal in the Sixth Party Congress the objective of lifting the country from the ranks of the Least Developed Countries by 2020. The current Sixth Five-Year National Socio Economic Development Plan (2006-2010), or Sixth Plan, sets the GDP-target at 827 USD per capita with an annual growth rate of around 8% as of year 2010. The plan focuses on poverty reduction, integrating NGPES's policy, and expects further growth, specifically in the areas of electricity, mining, and tourism, backed by a past infrastructure which has been developed in the past. The Sixth Plan employs the following development approaches:

- Sustainable economic growth driven by human development,
- Strengthening the economic competitiveness within the framework of ASEAN and WTO, taking advantage of the country's position with the external environment,
- Enhancing the synergistic effect between economic growth and social development to address social issues like poverty, and
- Promoting the development of an integrated socio-economic infrastructure and completing the establishment of a market-oriented economy with socialist orientation to form the basis for industrialization and modernization.

Lao PDR has been actively involved in regional and international economic cooperation in order to overcome the restrictions posed as a landlocked nation. Besides the aforementioned state-level development plan, the Lao PDR has participated in the Greater Mekong Subregion (GMS) project mainly led by ADB. The GMS project is an Indochina region-wide development project of which Vietnam, Lao PDR, Cambodia, Myanmar, Thailand, and China's Yunnan Province are members. The project has promoted the development of infrastructure in nine areas like energy. In addition to this project, the Lao PDR is preparing to participate in the AFTA in 2009 and to accede to the WTO, for further involvement in the international economic community.

2.2.4 Government Finance

The Government's fiscal position has continued to remain fragile primarily due to relatively weak revenue performance. The government's budgetary balance has also long remained in deficit, though recently it has been improving. Because the import tax is scheduled for elimination by 2015 under the Common Effective Preferential Tariff (CEPT) promoted by ASEAN Free Trade Area (AFTA), the Government of Laos is under progress to implement the Value Added Tax (VAT) in 2009 to complement the decline in import tax revenue due to AFTA tariff reduction. The unique characteristic of Lao PDR's government finance is that the Lao PDR is highly dependent on external supporters. That is, capital expenditure, the amount of which approximates the current expenditure, is provided via official development assistance such as grants from overseas donors (Figure 2.2-6).



Note: Revenue) ■: Tax revenue, ■: non-tax revenue, ■: deficit
Expenditure) ■: current expenditure, ■: capital expenditure, ■: debt redemption

Figure 2.2-6: Government's Fiscal Revenue and Expenditure

(Source: Developed by Jica Study Team based on the following: Lao's socio-economic base, and ADB Key Indicators)

In FY 2006/2007, donor funding comprised 81% of the total capital expenditure while grants accounted for about 11% of the total government revenue. In order to change the above situation, various measures have been studied; including the upgrading of the domestic financial market. For example, the establishment of the nation's first stock market is scheduled for October 2010, while the prospect of issuing project bonds in Lao PDR is also being analyzed in a study financed by the ADB.

Table 2.2-6 Government Finance

[Unit: billion Kip]

Item	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Revenue (incl. Grants)	2,797.80	3,104.98	3,844.91	5,312.37	6,434.94
Revenue (excl. grants)	2,344.60	2,822.47	3,387.44	4,265.99	5,340.97
- tax income	1,927.50	2,328.87	2,803.10	3,641.12	4,720.66
- non-tax income	417.10	493.60	584.34	624.87	620.31
- grant	453.20	282.51	497.47	1,046.38	1,093.97
Expenditure	4,172.78	3,869.46	5,323.01	6,579.47	7,499.92
Deficit	-1,374.98	-764.48	-1,438.10	-1,267.10	-1,064.98

(Source: Developed by Jica Study Team based on the following: Lao's socio-economic base, and ADB Key Indicators)

According to the ADB, the total external debt is estimated to be about three billion USD as of the end of 2006, which accounts for almost 85% of the country's 2006 GDP. The main creditors are the World Bank and the ADB. Until 2006, this debt had been kept stable by 6 to 8% of total exports of goods and services until 2000, a figure that is expected to rise and stabilize at around 10%.

Table 2.2-7 Foreign Direct Investment & ODA Flow Trend

[Unit: million USD]

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Foreign Direct Investment	160	0	0	0	34	24	25	20	17	28
Overseas Development Assistance	284	315	266	280	268	249	258	279	245	277

(Source: developed from Lao's socio-economic base, and from ADB Key Indicator 2007)

2.3 Energy Sector Overview

2.3.1 Energy Resource

In the Indochina Peninsula, Vietnam is a country rich in natural resources such as crude oil and its inherent hydraulic power potential of which the nation has harnessed. On the other hand, although Lao PDR and Cambodia also possess ample hydraulic power potential, these two countries have not yet taken full advantage of their resources. Table 2.3-1 summarizes the resource potential residing within the Indochina countries. Implementing a variety of economic developments can be advantageous for the region's countries in utilizing its natural resources efficiently: By realizing its undeveloped hydraulic power potential, the Lao PDR will be able to export electricity to countries like Thailand and Vietnam where the electricity demand is skyrocketing.

The Lao PDR is well endowed with natural resources including water resources as well as forests and land resources. Electricity exports harnessing water resources has become one of the key sources to bringing foreign income into the country, while forest resources have served to provide for the nation's major domestic energy needs essential to household cooking and heating.

Table 2.3-1 Estimated Energy Resource Potential in Indochina Countries

	Lao PDR	Cambodia	Myanmar	Thailand	Vietnam
Hydraulic power (available hydraulic potential)	18,000 MW	8,600 MW	39,600 MW	(15,606 MW)[1]	17,700 MW
Coal (estimated potential)	600 mil. Ton	10 mil. Ton	260 mil. Ton	2,160 mil. Ton	4,000 mil. Ton
Oil (proven reserve)	0	50-100 mil. Barrel	84.6 bill. Barrel	700 mil. Barrel	3.1 bill. Barrel
Gas (proven reserve)	0	1.5～3.5 Tri. Cf	120 Tri. Cf	34 Tri. Cf	8.3 Tri. Cf

(Source: Final report on Project study on Indochina regional cooperation in power sector)

(1) Hydraulic Power

A number of rivers from the highlands flow into the Mekong River crossing from the north to the south of the country. The country is extraordinarily rich in hydraulic power potential. Theoretically, the hydropower potential in the country is estimated to be approximately 26,000 MW excluding the mainstream of the Mekong River. The Mekong Secretariat estimated that a total installed capacity of around 12,470 MW could be developed in the basins shown in Table 2.3-2. The fluctuation of the Mekong River's water level in the rainy season compared to the dry season amounts to a whopping 10 m difference throughout the year. Because some rivers including the Mekong River are international rivers, which flow through countries in Indochina Peninsula, it is essential for Lao PDR to discuss and cooperate with upstream as well as downstream countries over the use of water resource holding meetings like by the Mekong River Commission. The Lao PDR has strategically utilized its ample hydraulic power potential as one of the most effective measures to earn foreign income. Because the Lao PDR is located adjacent to Thailand and Vietnam, both of whose energy demand is rapidly increasing, the physical realization of its hydraulic power potential appears to be a wise option.

The Government sets its energy sector goals as follows:

- Earn foreign income through electricity exports utilizing private investment.
- Promotion of domestic electrification.

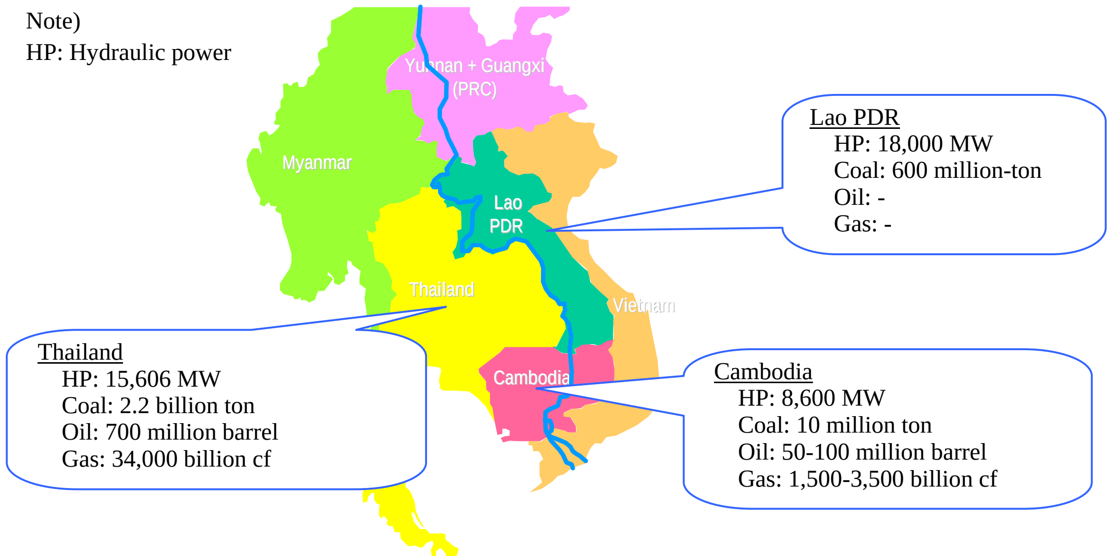


Figure 2.3-1 Resource Distribution in Indochina Peninsula

(Source: developed from Final report on Project study on Indochina regional cooperation in power sector, and from Lao's socio-economic base)

[1] Hydraulic power resources in Thailand are virtually unavailable due to environmental regulations.

Table 2.3-2 Hydraulic Power Potential

Rivers	Installation (MW)	Annual Energy (GWh)
Xe Kong	4,026	21,147
Tnam Theun	3,345	17,783
Nam Ou	1,350	7,008
Nam Ngum	1,624	16,889
Nam Nhiep	921	4,836
Xe Bang Hieng	70	43
Xe Done	2	1
Nam Tha	230	1,183
Nam Khan	355	1,883
Nam Suang	275	1,445
Xe Bang Phay	16	88
Nam Mang	52	263
Nam Sane	85	438
Nam Hinboun	70	377
Nam Beng	50	253
Total	12,471	73,637

(Source: Statistical Yearbook 2007 Lao PDR)

(2) Oil and gas

As of today, the existence of reserves of oil or gas has not been confirmed in Lao PDR. In 1996, an oil-well investigation was conducted in the Champasak province. After that, western companies have also carried out other pre-excavation surveys for oil and natural gas. However, the results have not been released to public.

(3) Coal

Coal deposits have been confirmed in the provinces of Phongsaly, Vientiane, Xieng Khuang, both located in the northern region, Vientiane in the central region and Khammouan and Saravan, both located in the southern region. An estimated 400 million tons of high quality lignite deposits has also been discovered in the Hongsa district of Xayabuly province near the border of Thailand. The development of lignite is expected to start under a joint investment with Thailand. According to Asian Development Bank, there are sufficient reserves for about 2,000 MW of installed capacity, which can be utilized for power generation.

The coal confirmed in the Lao PDR is largely categorized into two types, anthracite and lignite. Anthracite yielded from the Vientiane province is mostly consumed domestically, specifically at cement factories. Lignite is produced in the Luang Namtha province by Thailand enterprises to be exported back to Thailand. Table 2.3-3 shows the production and sales of lignite, while Figure 2.3-2 shows its chart.

Table 2.3-3 Production and Sales of Lignite (2000-2006)

[Unit: ton]

Year	Production	Sales
2000	214,086	197,304
2001	179,773	179,773
2002	233,923	209,973
2003	212,819	208,386
2004	332,907	332,907
2005	332,934	332,934
2006	432,421	432,421

(Source: United Nations Energy Statistics Database's website)

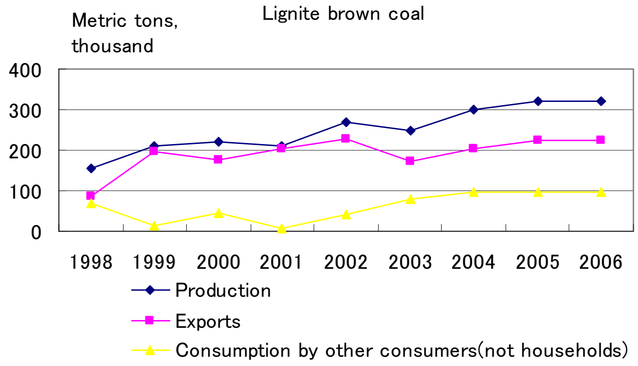


Figure 2.3-2 Lignite Coal Production of Lao PDR

(Source: United Nations Energy Statistics Database's website)

(4) Fuel wood

Lao PDR's forest resources are abundant which comprises almost half the land. Non-commercial energy still plays a substantial role in Lao PDR, because a commercial infrastructure covering energy supply for the entire nation has yet to be developed (Figure 2.3-3).

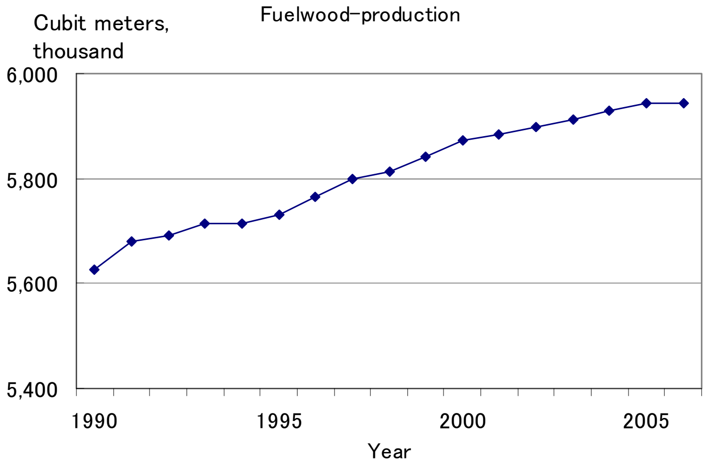


Figure 2.3-3 Production of Fuel Wood

(Source: United Nations Energy Statistics Database's website)

Recently, forest areas have recently been decreasing due to timber exports, slash-and-burn cultivation and illegal deforestation. The forest share in the total country has declined from 70% in the 1940s to 46 % in 1992, and 41.5% in 2002 (Lao PDR Environemtal Monitor 2007, World Bank). In order to restore the forestry to its original condition, the Government of Lao PDR has established development corporations in the northern, central and southern regions to regulate illegal deforestation and smuggling of logs and for controlling annually allotted amounts of trees that are cut down. In addition, the Government has tried protecting existing forests by examining a plan to put off-grid power generators in remote mountainous areas, such as micro-hydro, diesel, and solar types, all of which do not require fuel wood as an energy resource.

(5) Renewable Energy

Because residential areas of many ethnic groups are scattered across the mountainous areas through Lao PDR, it is supposed to be unfeasible to supply electricity through an electricity grid. Therefore, the instalment of an off-grid type renewable energy system in such areas is expected to be a strong solution for electrification of such localities and remote areas. First, the potential of solar energy and annual solar radiation received in Lao PDR is about 1,800 kWh/m^2. The total installed capacity as of year 2005 amounts to 296 kW, partially due to foreign assistance. As for wind energy, the mean wind velocity deems to be 1.0 m/s in Laungprabang and Vientiane, although a higher velocity is expected in mountainous areas. Regardless, velocity in the country is not adequate for wind generation.

2.3.2 Demand and Supply

Table 2.3-4 shows the energy demand and supply for Lao PDR. As is evident from the table, Lao PDR has exported electricity generated from ample water resources, while the country relies fully on imports for liquid fuel such as the gasoline necessary for the transportation sector.

Table 2.3-4 Historical Commercial Energy Consumption

[Unit: 1,000toe]

Year	Primary Energy Consumption			Import	Export	Domestic Energy Consumption			
	Solid fuel	Electricity	Total			Solid fuel	Liquid fuel	Electricity	Total
1993	1	74	75	93	54	1	91	21	113
1994	1	74	75	101	55	1	98	22	121
1995	1	86	87	107	61	1	104	29	134
1996	1	104	105	115	67	1	111	41	153
1997	1	101	102	120	66	1	116	39	156
1998	1	102	103	127	67	1	123	39	163
1999	127	102	229	138	63	127	123	54	304
2000	15	102	117	139	61	158	123	56	337
2001	196	104	300	144	63	196	128	57	381
2002	203	107	310	149	64	203	133	59	395

Note: According to the UN's definition, Solid fuel includes coal and cokes while liquid fuel includes crude oil, oil products, and LNG.

(Source: United Nations Energy Statistics Database's website)

According to the UN's definition, Solid fuel includes coal and cokes while liquid fuel includes crude oil, oil products, and LNG. Table 2.3-5 separates the percentage of households by energy source for cooking. As shown, classical biomass such as fuel wood and charcoal still dominates in this area. This fact also tells that there is large potential demand for electricity in future.

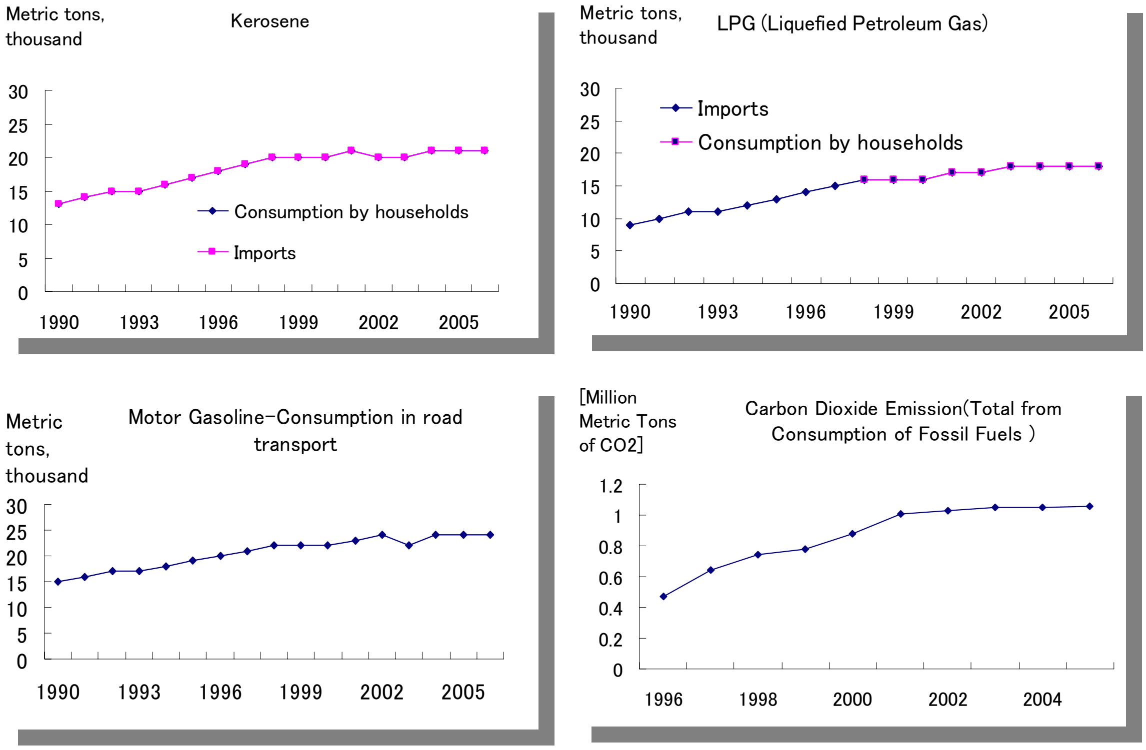
Table 2.3-5 The Percentage of Households by Energy Source for Cooking

[Unit: %]

	1995			2005		
	Urban	**Rural**	**Total**	**Urban**	**Rural**	**Total**
Electricity	10.4	0.1	1.9	3.8	0.1	1.1
Fuel Wood	67.3	97.7	92.7	55.1	88.5	79.1
Charcoal	10.0	1.6	4.3	34.6	7.4	14.9
Sawdust	2.7	0.3	0.7	0.3	0.0	0.1
Others	1.6	0.3	0.5	6.2	4.0	5.8
Total	100	100	100	100	100	100

(Source: Results from the Population and Housing Census 2005)

Figure 2.3-4 summarizes the historical energy demand by type and CO2 emission.

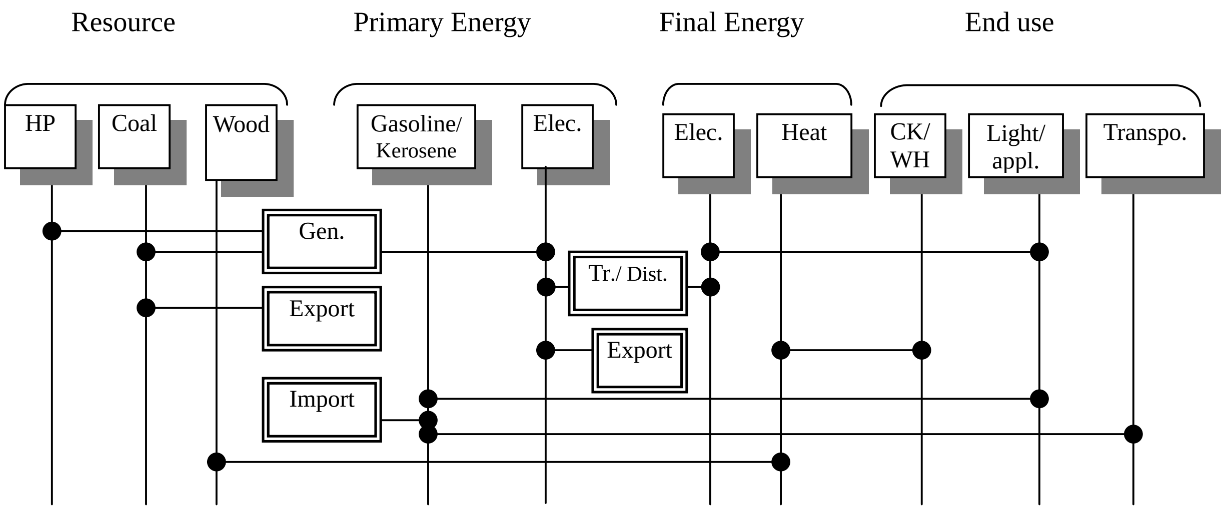


Note: As for LPG, only data since 1998 are available for Consumption by households.

Figure 2.3-4 Energy Consumption by Energy Source and CO_2 Emission in Lao PDR

(Source: United Nations Energy Statistics Database's website)

Figure 2.3-5 shows the energy chain of Lao PDR



Note: HP: Hydraulic power; Gen.: power generation; Tr./ Dist.: power transmission/ distribution; Elec.: electricity; CK/WH: cooking/ water heating; appl.: appliances; Transpo: transportation.

Figure 2.3-5 Energy Chain of Lao PDR

(Source: developed by JICA Study Team based on the interview with EDL)

Chapter 3
Outline of Power Sector

Chapter 3 Outline of Power Sector

3.1 General Information

The electric power demand of Laos has grown at around an average 14% per year from 2000 to 2006. The maximum power demand increased at the ratio of around 2.5 times from 2000 to 2007 and the averaged growing ratio was recorded at over 12%. The electrification rate of households reached 58% in 2007. The Government of Lao PDR has set a 90% electrification rate target by 2020. The power demand for mining industry development such as copper or bauxite has been anticipated for both the middle and long term. The sound formulation of power source development plans and power network development plans is essential to meet the domestic growing power demand. The theoretical hydropower resources in the territory are estimated at around 26,000 MW. The hydropower resources around 12,470 MW are deemed to have development potential. The power generation of Laos mostly depends on hydropower.

Laos, a country adjacent to the abundant energy consuming nations of Thailand and Vietnam, is promoting power exports via strategic utlilization of its abundant hydropower resources. The Government of Lao PDR has a basic policy for the power sector that aims to acquire foreign currencies by exporting electric energy to its neighboring countries utilizing investment funds received from the private sectors as well as to raise the aforementioned rate of electrification. Thus, power development has been promoted by IPPs including the development of international interconnections and in some cases, encompassing the power system independent of the domestic power system, which has led the power sector in Laos into a bit of chaos.

Given the above situation, shrewd management of the power sector is required to strike and maintain a harmonious balance between the conflicting interests of power production for domestic needs amd power production for exports leading to the acquisition of foreign currency. In order to realize compability between these two objectives, the systematic development of a power system for the whole country is expected.

In the Power Sector Policy Statement issued on March 15th 2001, the Government of Lao PDR has created the basic policies below:

- Stable and continuous domestic power supply at a reasonable price will be maintained and expanded to promote economic and social development.
- Power source development for power exports is to be promoted to realize a sufficent amount of income to meet governmental development policies.

3.2 Outline of Power Sector

The Department of Electricity (DOE) of the Ministry of Energy and Mines (MEM) governs the power sector of Lao PDR. Electricité du Laos (EDL) is the power utility owned by the Government of Lao PDR and governed by DOE covering power generation, transmission and distribution, managing the domestic power supply and power imports and exports. The joint management of the foreign companies and Lao PDR organizes the IPPs shouldering large scaled power exports through the export-oriented power transmission lines.

Figure 3.2-1 shows the organization chart of the power sector and the oullines of each organization is descrtibed below.

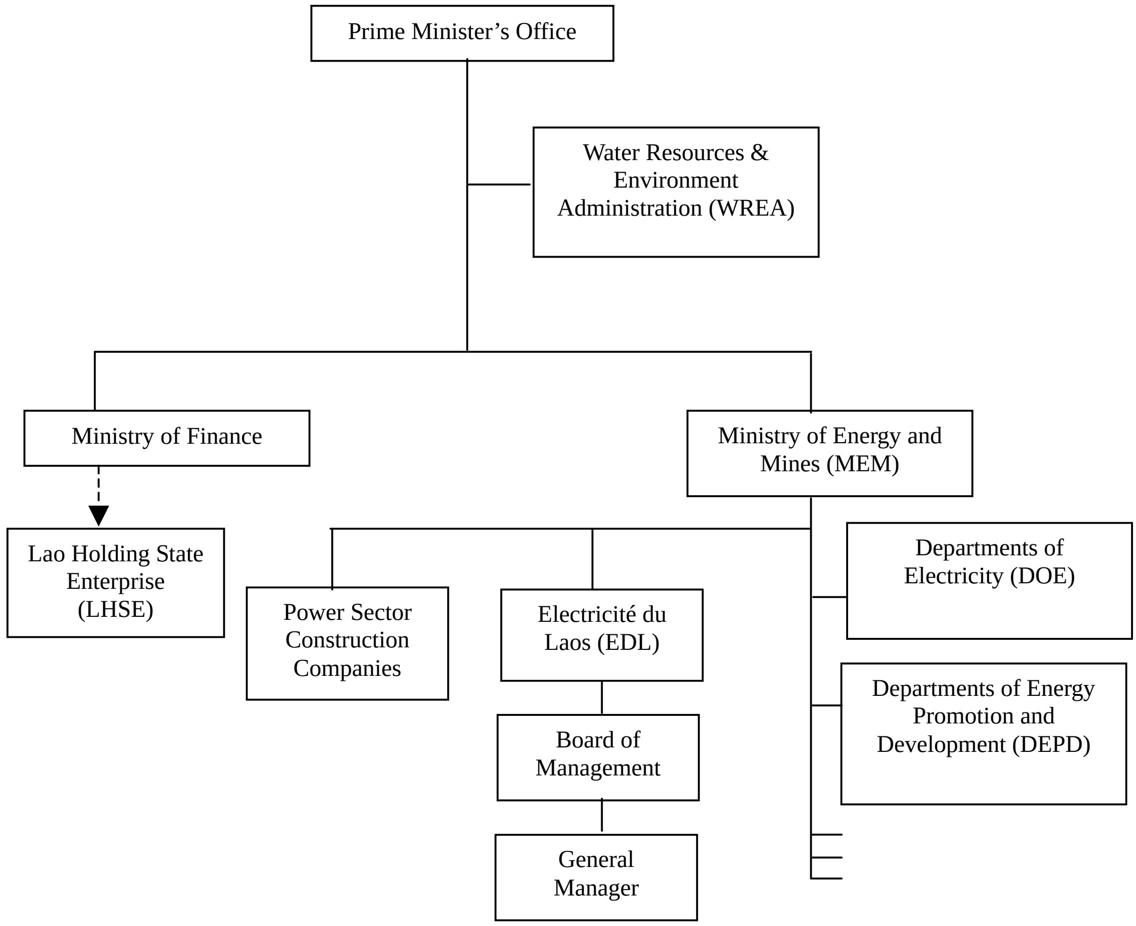


Figure 3.2-1 The Organization Chart of the Power Sector

(1) Ministry of Energy and Mines (MEM)

The predecessor of the Ministry of Energy and Mines (MEM) is the Ministry of Industry and Handicrafts (MIH) that was established as the governmental organization for the power sector in 1975 when the Lao PDR become independent. The Ministry of Commerce covering the areas of the industry and handicrafts was separated from the MIH and the MEM was established in 2006 that specializes in the areas of energy and mining.

(2) Department of Electricity (DOE)

Department of Electricity (DOE) is a department under the MEM. It is in charge of the planning and the management aspects of the power sector such as the policy establishment, the formulation of medium/long term power development plans and the planning and the supervision of the power sector. This department's predecessor is the former DOE established in MIH. The DOE has the divisions of Power Sector Planning, Regulator/Electricity ESI Management, Rural Electrification, Environmental & Social Management and Administration.

(3) Departments of Energy Promotion and Development (DEPD)

The Departments of Energy Promotion & Development (DEPD) is a department in the MEM. It is in charge of the implementation aspects of the power sector such as the development of the framework for the promotion of investment regarding the energy sector, project supervision and the promotion of the other projects connected with the energy sectors.

(4) Water Resource and Environment Administration (WREA)

The Water Resource and Environment Administration (WREA) is a regulating organization in charge of the planning and the management of environmental policies. Environmental protection law determines the obligations of the WEREA.

(5) Provincial Department of Energy and Mines (PDEM)

The Provincial Department of Energy and Mines (PDEM) belongs to the provincial governments and is not the organization under the MEM. It takes charges of energy administration in the provinces. According to the electricity law, the PDEM has the permit and license rights to install power generation facilities under 2,000 kW.

(6) Electricité du Laos (EDL)

Electricité du Laos (EDL) is the national power utility owned by the Government of Lao PDR and governed by the DOE. It covers power generation, transmission and distribution manages the domestic power supply as well as power imports and exports. In 1959 when Laos was still under French jurisdiction, it was established as the electricity department under the Ministry of Public Utilities. The power system of EDL is connected to the Thailand system for power exports of surplus energy and power imports for energy shortage and the power supply to Laos through the distribution lines on the national borders of Thailand, Vietnam and China. EDL invests money in IPP projects aiming at power exports to Thailand. The operating conditions of IPP projects in Laos include accepting investments from the Government of Lao PDR. For the existing Theun Hinboun and Houay Ho power stations, the EDL invests money. Those IPPs are operated not only for power exports but also for domestic power supply in Lao PDR that is purchased by EDL to supply to general domestic power consumers.

(7) Lao Holding State Enterprise (LHSE)

The Lao Holding State Enterprise (LHSE) is a national stock-holding company that was established in February 2005 aimed at pumping investments into one of the IPPs, Nam Thuen 2 hydropower stations. The investments for these existing IPPs, Thuen Hinboun and Houay Ho can be considered transferred from EDL.

(8) Independent Power Producer (IPP)

The existing IPPs in Laos are the Theun Hinboun Power Company and the Houay Ho Power Company. Although a portion of the produced energy is supplied to domestic consumers, a majority of the energy is exported to Thailand. Thuen Hinboun Company started the power station with 210 MW as an IPP aimed at exporting to Thailand in 1998. Houay Ho Power Company started the power station with 150 MW in 1999. EDL respectively possesses 60% (Theun Hinboun Power Company) and 20% (Houay Ho Power Company) shares of the generated energy of the IPPs.

The IPP projects follow the aforementioned important policy of “Power sources developments for power export are promoted to create enough income to meet governmental development policy” and the MOMs regarding power import/export contracted between nations containing the following:

- Between Laos and Thailand: 7,000 MW up to 2020
- Between Laos and Vietnam: 5,000 MW up to 2020
- Between Laos and Cambodia: Power trade on the Border

Currently (as of February 2008), the Nam Theun 2 power station and the Xekaman 3 power station are under construction as new IPPs. Aside from those projects, the IPPs such as Nam Ngiep 1, Nam Ngum 3 are being promoted. Some IPPs are being planned not only for power export, but also for domestic power supply.

3.3 Record of Power Demand and Supply

3.3.1 Electricity Consumption Record

Figure3.3-1 shows records of generating, consuming, importing and exporting electricity in Lao PDR. The blue colored line represents the record of the consumption. According to this, consumption has reached approximately 1,100 GWh. The growth rate during the period 1996-2006 is more than 11% and shows quite a sizable portion of Lao PDR's electricity consumption.

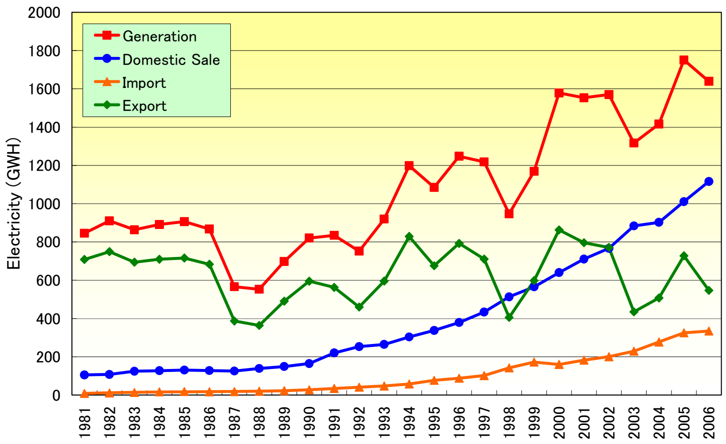


Figure 3.3-1 Electricity Consumption Record

(Source: Annual Report 2006 EDL)

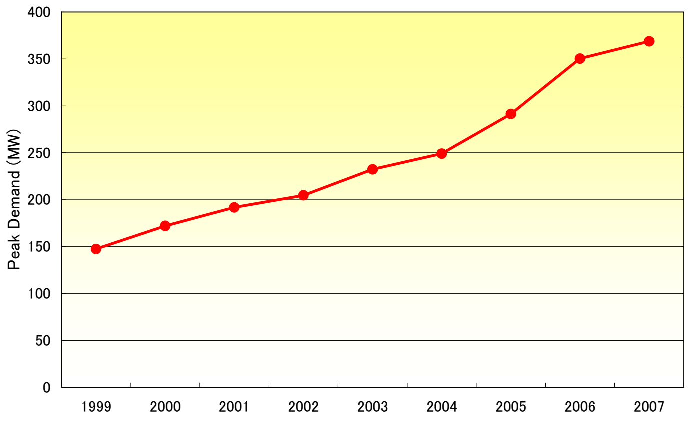


Figure 3.3-2 Record of Peak Power Demand

(Source: Information from EDL)

3.3.2 Peak Power Demand Record

Figure3.3-2 shows the record of peak power demand in Lao PDR. The peak power recorded 369 MW in 2007. Power demand of 2007 grew 2.5 times higher than that in 1999 and the growth rate was 12% during the period 1999-2007.

3.3.3 Electricity Consumption by Sector

Figure3.3-3 and 3.3-4 show electricity consumption and the growth rate of consumption sectors by sector respectively. After 2004, the electricity consumption in the industrial, service, and residential sectors has been growing steadily. Particularly, in the residential and service sectors, growth has been increasing at 10% and 20% rate respectively.

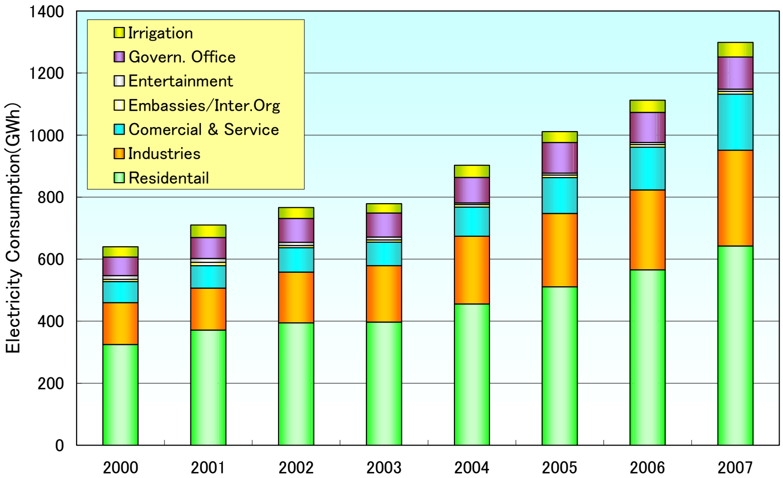


Figure 3.3-3 Electricity Consumption by Sector

(Source: Information from ELD)

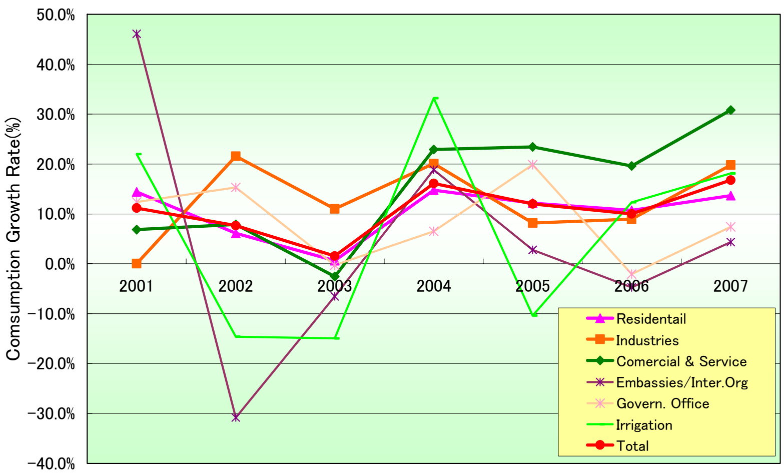


Figure 3.3-4 Growth Rate of Electricity Consumption by Sector

(Source: Information from EDL)

3.3.4 Electric Power Generation for Domestic Use in Lao PDR

Historical records of electricity generation including power exports have been illustrated in the table and figure below which are quoted from documents of the Department of Electricity (DOE) in Ministry of Energy and Mines (MEM).

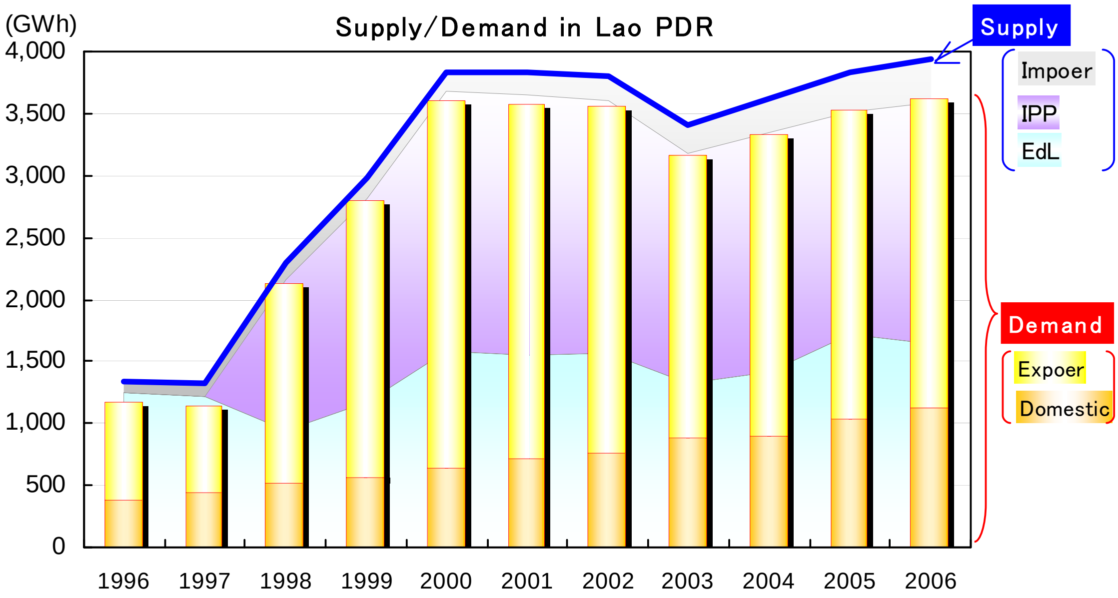
Electricity generation records grew as much as 11%/year from 1996 to 2006. Outputs from IPP development for electric power exports increased significantly. There is a 10% difference in electricity generation between the rainy year of 2000 and the dry year of 2003. The records of

IPP are aggregated generation records from the Theun Hinboun hydropower plant and the Houay Ho hydropower plant.

Table3.3-1 Electric Generation in Lao PDR

(Unit: GWh)

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
EDL	1,248	1,219	948	1,169	1,579	1,554	1,570	1,317	1,416	1,715	1,640
Import	88	101	142	172	160	184	201	229	278	329	339
IPP	-	-	1,209	1,637	2,101	2,100	2,034	1,861	1,931	1,794	1,956
TOTAL	1,336	1,320	2,299	2,978	3,840	3,837	3,805	3,408	3,625	3,839	3,935



Source Statistics of Electricity (DoE)

* "Supply" indicates the power supply at the generation ends (including transmission & distribution loss and houseuse). "Demand" indicates the power consumption at the end users. "Supply" includes IPP and export.

Figure 3.3-5 Historical Records of Generating Power in Lao PDR

Electricity imports increased in step with the demand growth of the Vientiane system. The amount of imported electric power increased four times as the amount of power imported in 1996. The electric power imported in 2006 was equivalent to 20% of EDL generation. The supply at peak demand was frequently dependent on the import power from Thailand. The black out in Vientiane system occurred on the 23rd of February 2009 because the supply from Thailand was interrupted by a failure in their system. Regarding the blackout, EDL requested to curtail energy consumption of large-scale customers such as factories. This showed that the outage occurred due to deteriorating system reliability causing overdependence on the import of electricity supply from the neighboring country in dry seasons when the power severe supply demand balancing expected during the peak demand period of time.

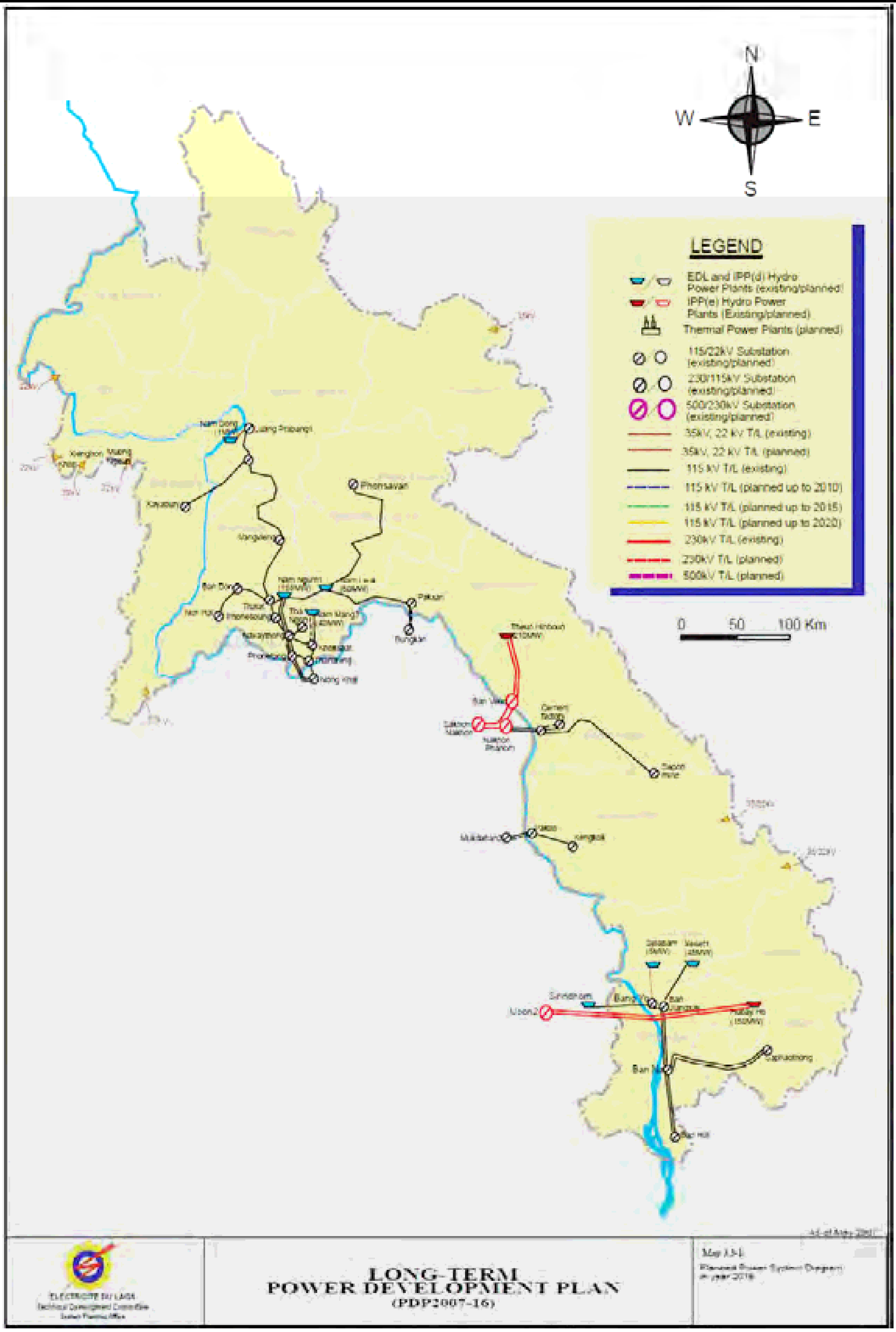
3.4 Situation on System Interconnection

3.4.1 Interconnection with Thailand

According to the EGAT, their demand forecast has been revised to low growth scenario due to serious economic conditions in 2009. The demand forecasts have been reduced to 2,455 MW in 2011, 3,295 MW in 2021 from the previous forecasts. EGAT will rearrange the power development projects to meet the reduced demand forecasts on a priority basis. This rearrangement could affect the projects located in the Lao PDR. EGAT will continue to execute projects that have been agreed on with the PPA such as Nam Theun 2, Nam Ngum 2 and Theun Hinboun Extension. However their commission could be delayed a few months. The other projects will be renegotiated.

The interconnection projects should be changed in accordance with the rearrangement of the IPP projects. The 500 kV Nam Theun 2 – Roi Et 2 transmission project has been completed and finished undergoing the final inspection. The 500 kV Nabon - Udon3 transmission and substation project is expected to continue on schedule. In addition, the 500 kV transmission from Hongsa lignite thermal power to Mae Moh of the Thailand project located in northern Lao PDR could be delayed because the Hongsa thermal plant could be delayed as much as a few years. The feasibility study on the 500 kV transmission line project from Chanpasack in the southern Lao PDR to Ubon Rachatani in Thailand was conducted in 2006 and supported by the ADB. The project has been suspended because the power development projects are insufficient to recover their transmission line investment.

The reinforcement of 115 kV transmission line from Thanaleng to Nong Khai has been planed to strengthen the interconnection from the Thailand system.



(Source: EDL)

Figure3.4-1 Existing 115 kV Interconnection with Thailand System

3.4.2 Interconnections to Vietnam

The interconnections to Vietnam as of February 2009, are all distribution lines, are listed in Table 3.4-1. They supply power to the area around the border between Vietnam and Laos. The interconnections that are planned or under construction are listed in Table 3.4-2.

Table 3.4-1 Current Interconnections between Vietnam and Laos

Laos	Vietnam	Voltage
Moc Chau substation	Son La substation-Xam Neua district	35 kV
Lac Xao district	Ha Tinh province	0.4 kV
Xepon district	Lao Bao substation	35 kV
Xa Muoi district	La Lay border (Quang Tri province)	35 kV

Table 3.4-2 Plans of Interconnections between Vietnam and Laos

Laos	Vietnam	Voltage
Nam Mo power station	Ban Ve substation	220 kV
Nam Theun 2 power station	Ha Tinh substation*1)	500 kV
Ban Sok substation	Pleiku substation*2)	500 kV
Xekaman3 power station	A Vuong substation	220 kV

*1) Not yet promoted due to a failure to come to an agreement with the Nam Theun 2 Company
*2) A Pre FS had been carried out by EVN through PECC 4 and submitted to DOE in March 2007. ADB also carried out a Pre FS in 2007.

The power generation projects in which the Vietnam side might potentially invest money are as follows. All the projects are expected to be the IPPs that will export power to Vietnam.

- Nam Kan hydropower station 66 MW
- Xekong upper stream hydropower station 150 MW
- Xekong lower stream hydropower station 100 MW
- Dak E Meul hydropower station

3.4.3 Plan of Interconnection to China

The EDL power grid is adjacent to the power system of the Yunnan Power Grid Corporation, which is a subsidiary of the China Southern Power Grid Company Limited (CSGC). However, power trade has been currently limited to the power supply portion of the northern part of Laos via distribution systems from China. The construction of the 115 kV transmission line connecting to the EDL domestic power grid has begun via China and operational commencement is expected by year 2009. The power transmission travels between Mao La substation (Yunnan) to the Na Mo substation (Laos) and the initial power supply areas will originate from Luang Nam Tha and Udonxai. However, as of August 2009, the power purchase agreement is still pending mainly due to the delay in the confirmation of the expected power supply. The initial agreement will be valid until 2012. According to information received from the CSGC, large-scaled power trade was planned from Laos to China through DC transmission lines connected between the Nam Ou and Pak Beng power station (A total of 5,000 MW). The DOE in Laos stated that the export markets of those power stations had not yet been decided.

3.5 Law on Electricity

3.5.1 Overview of Law and Regulation on Electricity in Lao PDR

Table 3.5-1 shows the list of laws related to electricity business in Lao PDR.

Table 3.5-1 The List of Laws Related to Lao's Electricity Business

	Name	Year established
1.	The Law on Electricity	Apr. 1997 Amended in Dec. 2008
2.	Lao Electric Power Technical Standards	Feb. 2004
3.	Guideline on Operation and Managing Lao Electric Power Technical Standards	May 2007
4.	Safety Rules for Operation and Maintenance of Electrical Facilities	May 2007
5.	Environmental Management Standard for Electricity Projects	Oct. 2001
6.	Environmental Management Standard Documents	
7.	Regulation on Implementing the Environmental Assessment for Electricity Projects in Lao PDR	Nov. 2002
8.	Decree on Enforcement of Electricity Law	Sep. 2002
9.	Law on the Promotion and Management Foreign Investment in the Lao PDR	Mar. 1994
10.	Forest Law	Oct. 1996
11.	Land Law	Apr. 1997
12.	Law on Water and Water Resources	Oct. 1996
13.	Law on Environmental Protection	Apr. 1999

(Source: Developed by the JICA Study Team based on the following materials: Electricity Statistics Yearbook 2006 Lao PDR, and Lao's industrial base)

The Law on Electricity serves as the basis of regulation governing the electricity business in Laos. The law was promulgated in 1997, amended in December 2008 and consists of 11 chapters and 82 articles. It stipulates on electricity-related matters such as the approval of the electricity business and power development, environmental concerns, electrical power technical standards, electricity import/ exports, rural electrification projects, and the role of electricity administration (inspection agencies). "Environmental Management Standard for Electricity Projects" has been established by Department of Electricity covering environmental assessment. Besides the above, the "Law on Water and Water Resources" stipulates matters on power development and business operations, including rights, obligations, and procedures in mainly hydropower development. The "Lao Electric Power Technical Standards" also mentions dams for power generation use. The "Land Law" contains articles pertaining to the allocation/ transfer of land for resettled residents due to hydropower development. The "Law on the Promotion and Management Foreign Investment in the Lao PDR" stipulates matters concerning independent power producers funded by foreign capital. Accounting regulations for the electricity business has not been established yet.

3.5.2 Amendment of Law on Electricity

The Law on Electricity was promulgated in 1997, and was amended as of December 8, 2008. Table 3.5-1 shows the structure of the law before and after the amendment.

The amendment was due to the gap between the former law and today's circumstances surrounding electricity business. The amendment aimed to clearly articulate the following points:

- Clear development and investment plans on energy should be available;
- An identical standard should apply to both state enterprises and the private sector;
- Roles and responsibilities of the Electricite du Lao (EDL) should be clearly defined as related to the society;
- Electrical price should be clearly defined in consideration of state policy and other issues that need to be reconfigured in accordance with the manual o n establishment of legislation promulgated by the National Assembly;

- To the important point, the existing laws are not widely, thoroughly, and strictly executed.

According to a comment that appeared in a local newspaper dated November 28, 2008, Mr. Khammany, the Director of EDL, stated that if *"the current laws were neither aligned with national development goals, nor covered all the aspects of the electricity sector, e.g. issues relating to national transmission lines. The law needs to be amended to facilitate management processes while encouraging domestic and foreign investment in the area."*

Table 3.5-1 The Structure of Law on Electricity before and after Amendment

Before amendment	After amendment
Chapter 1. General Provisions (Article 1 –7)	**Chapter 1.** General Provisions (Article 1-8)
Chapter 2. Operations Relating to Electricity (Article 8-9)	**Chapter 2.** Activity of Electricity (Article 9-23)
Chapter 3. Concessions for Operations relating to Electricity (Article 10-20)	**Chapter 3.** Electrical Business Operations (Article 24-42)
Chapter 4. Installation and Determination of Electricity Equipment Standards (Article 21-23)	**Chapter 4.** Development of Rural Electricity (Article 43-46)
Chapter 5. Electricity Production (Article 24 & 25)	**Chapter 5.** Price of Electricity (Article 47-49)
Chapter 6. Electricity Transmission (Article 26-29)	**Chapter 6.** Right, Function and Obligation of Electrical Producer, Supplier and Consumer (Article 50-52)
Chapter 7. Electricity Distribution (Article 30-34)	
Chapter 8. Electricity Export and Import (Article 35-37)	
Chapter 9. Electricity Development in the Localities and in Rural Areas (Article 39-41)	**Chapter 7.** Prohibition (Article 53-56) **Chapter 8.** Dissolution of Disputation (Article 57-62)
Chapter 10. Electricity Administration and Inspection Agencies (Article 42-49)	**Chapter 9.** Management and Inspection (Article 63-72)
Chapter 11. Policies towards Persons with High Achievement and Measures Against Violators (Article 50-54)	**Chapter 10.** Policy of Good-working Behavior and Measure of Violator (Article 73-79)
Chapter 12. Final Provisions (Article 55 & 56)	**Chapter 11.** Final Provision (Article 80-81)

(Source: unofficial English translation of "Law on Electricity, Dec. 2008")

3.5.3 The Articles Relevant to This Study

The particular articles related to this study are (1) articles for electric power equipment and facilities (Article 14, 16, 17, 21-23); (2) those for power export and import (Article 19); (3) those for environmental matters (Article 32); and (4) those for power tariffs (Article 47-49). The following subsections summarize the main points of these articles:

(1) Electric Power Equipment and Facilities

(a) Electric Power Technical Standards (Article 21-23)

The Ministry of Energy and Mines (MEM) shall be responsible for the quality of all types of electrical equipment including electrical transmission lines in order to ensure that all the electrical equipment fulfils the Electric Power Technical Standards of Lao PDR.

(b) Construction and Electrical Installation (Article 14)

Construction and electrical installation shall insure the safety from limitation and damage to nature and personal property. Construction and electrical installation shall be conducted in adherence of the Electric Power Technical Standards of Lao PDR.

(c) Transmission Facilities (Article 16)

Power transmission from a country to another country via Lao territory should be made through the Lao's transmission network. The international transmission system should satisfy the following conditions:

- Suppress environmental impact and damage to inhabitants;

- Fulfil payment of transit and other service charges, including the repayment of all damages caused by the installation of the transmission line system; and
- Allow the Government of Lao PDR to use the transmission lines when deemed necessary.

(d) System of National Transmission Line (Article 17)
Minus certain special exceptions, all sources of electrical production shall transmit electricity through the national transmission lines.

(2) Electricity Tariffs (Article 47-49)
Electricity tariff is classified into two categories: domestic tariff and import/ expoert tariff. Electricity tariffs shall be set by consumer category, taking into account the nation's social-economic conditions. The Government shall approve electricity prices periodically. Prices of rural electricity shall be researched by the Ministry of Energy and Mines to offer a price in agreement with the concerned local authority.

(3) Electricity Export and Import (Article 19)
Electricity export to the foreign countries sufficiently insures the supplying priority for domestic consumption, including industrial expansion and national social-economic development. The import of foreign electricity into Lao PDR is accepted under the conditions that the government has approved and that it has been deemed necessary for Laos PDR's socio-economic development.

(4) Environmental Impact Assessment (Article 32)
Along with the feasibility study, the investors shall undertake an environmental impact assessment, which shall comprise the following:

a) Assessment of the potential environmental impact for each case, accompanied by proposals of methods and measures for solving or mitigating any adverse impacts on the environment, ecology, society and wildlife habitats;

b) An estimate of the damage and resettlement [costs] of people who will need to relocate their production activities somewhere else due to the electricity project;

c) Measures to limit the downstream impact posed by a hydropower dam, which is a major direct contributor to increased flooding during the rainy season, by excavating a drainage ditch to divert the water if necessary or by some other means;

d) Calculation of expenses for restoration of the impacts provided for in paragraphs 1, 2 and 3 of this Article shall be incorporated into the project cost.

3.6 Electric System Standards

3.6.1 System Reliability Criterion

24-hour Loss-of-Load Expectation (LOLE) is adopted into the Lao PDR system as system reliability criterion.

Table 3.6-1 System Reliability Criterion

	Loss of Load Expectation (LOLE)
Lao PDR system	24 hour

The LOLE is defined as the following equivalent, when Pi is the probability at Ai (MW) that is the amount of the variation aggregated generation plant failure, the hydropower output and demand fluctuation and Hi is duration related on demand duration curve at Ai if the system has R (MW) of reserve margin capacity.

$$LOLE = \Sigma Hi \times Pi \text{ (hour)}$$

Here, Pi denotes the probability of a given fluctuation quantity at a point on the total fluctuation probability distribution, which comprises the probability distribution of supply capacity-side fluctuation factors such as the forced outage rate of the generating unit and water flow fluctuations in hydropower, together with the probability distribution of the demand-side fluctuations, and Hi denotes the power deficiency hours that occur at a given fluctuation quantity (Figure3.6-1).

By calculating and successively varying the value of the reserve capacity, the relationship between the reserve margin and the LOLE in an isolated system is determined. Also in an interconnected system, the system reliability is calculated in the same way. The difference between the isolated and interconnected system is that the latter can expect to use power exchange. When it occurs that an amount of fluctuation (the supply shortage from the demand load) whose probability on the total fluctuation probability distribution is Pi, the power deficiency is reduced if we take into account the availability of the power exchange from other systems. This decreases the power deficiency hours, Hi, and the LOLE value even if the interconnected system has the same reserve margin as an isolated system.

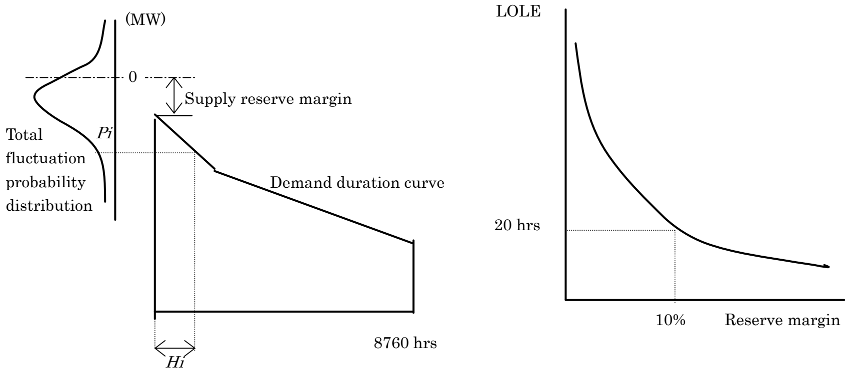


Figure 3.6-1 Definition of LOLE and Relation with Reserve Margin

3.6.2 Technical Standards for Transmission and Substation Facilities

Since power facilities in Laos were designed and constructed in accordance with a myriad of standards originating from different countries and these technical specifications were not unified, serious hindrances affecting the facilities future safety. Therefore, “JICA Lao Electric Power Technical Standards Preparation Project” (2000-2003) was implemented urged by the requests of the Lao government, and then the Lao Electric Power Technical Standards (LEPTS) were prepared with the Lao DOE and EDL counterparts. LEPTS consists of 184 technical articles to maintain the safety for Civil and Electric Hydropower Plant Facilities, Substation Facilities, Transmission Line Facilities, Distribution Line Facilities and User’s Sites Electrical Facilities.

Articles for the Substation and Transmission Line Facilities are as follows.

- General Electrical Facilities (24 articles)
- Overhead Transmission Line Facilities (26 articles)
- “Conductors”, “Insulators”, “Dielectric Strength”, “Supporting Structures”, “Regulations

for Installation", "Particulars of Installation at Adjacency to and Crossing with Other Objects", "Protection against Lightning and Falling Trees"

- Substation Facilities (18 articles)
- "Insulation", "Particularities of Equipment", "Protection, Monitoring and Control Systems", "Earthing Arrangement"

LEPTS were enforced as a ministerial ordinance in 2004. However, as administrations and power sector owners could not operate and manage LEPTS, the "JICA LEPTS Promotion Project"(2005-2008) was commenced continuously, and then the preparation of necessary documents, training for DOE and EDL staff, establishment of regulatory organizations in the DOE, etc. were carried out.

As results, the "Guideline on Operating and Managing LEPTS" by administrations that regulates the nomination of chief engineers, the design approval before construction, the facilities inspection before operation, etc. and the "Safety Rules for Operation and Maintenance" by power sector owners that regulate safety education, patrol and inspection, measures against accidents, etc. were prepared and enforced in 2007. Nowadays, the LEPTS is being applied to design, construction and maintenance works for new power facilities under control by LEPTS Regulatory Units in the DOE.

3.7 Electricity Tariff System

According to Article 32 of the Law on Electricity, the government of Lao (GoL) must periodically approve on all electricity tariffs for domestic customers and for export/import businesses. In fact, the tariffs are laid down according to the following process: first, Electricite du Laos (EDL) prepares the draft tariff, then the Ministry of Energy and Mines (MEM) examines it, and finally the GoL (Prime Minister) approves it.

Regarding EDL's operating environment, first, one of the unique characteristics of Laos's electricity sector compared with that of other countries is that the electricity is supplied by a state owned enterprise, EDL, whose business integrates generation, transmission and distribution to supply electricity to the whole nation. Secondly, EDL spends vast capital investment not only to supply electricity for rapidly-increasing domestic electricity demand thanks to the country's high economic growth, but also to export electricity, which is now one of the important things to bring foreign income into the country. Third, on the other hand, some parts of Lao PDR import electricity from neighboring countries because the development of a nation-wide network is still in progress. Finally, the Government also allows private participation in power development to meet the skyrocketing electricity demand. Reflecting these circumstances, Lao PDR's electricity tariff system is largely classified into three systems, namely retail tariffs for domestic customers, export/ import tariffs, and wholesale tariffs by Independent Power Producers (IPP). The following subsections describe the detail of each system[1].

3.7.1 Retail Tariff for Domestic Customers

There are two retail tariff systems for domestic customers: the one set by EDL which is uniform nationwide, and the other set by local governments for customers in remote areas where EDL does not provide its service. EDL's tariff level has been set politically low, which gradually increased since the latter half of the 1990s. In 2005, under the World's Bank Study, GoL

[1] During the study period, a new tariff system was proposed at the Stakeholder Workshop of the World Bank's study in May 2009 (Tariff Study Update Project, Final Report, June 2009). Because the prospect whether the new system will be adopted or not was not certain at the time of this report's development, this report mentions the current tariff system only.

approved the current tariff system. The rate is set to increase by 5% every year until 2011, reflecting substantial inflation. The rates for medium voltage customers are set 15% lower than those for low voltage customers. The tariff system neither adopts the time of use/ day rate nor fuel adjustment fee, mainly because the backbone of EDL's power generation source is hydraulic power. Table 3.7-1 shows EDL's retail tariff system, and Table 3.7-2 shows an example of retail tariffs for off-grid customers.

Table 3.7-1 Historical EDL's Electricity Tariff for Domestic Customers

[unit: Kip/kWh]

Consumer Category	2006	2007	2008	2009	2010	2011
Residential						
0-25 kWh	133	154	175	201	231	266
26-150 kWh	276	284	290	298	307	316
> 150 kWh	773	773	765	765	765	765
None – Res. Low voltage: 400 V						
Agriculture/ irrigation	313	329	341	359	377	395
Government office	703	694	677	667	658	649
Industries	634	625	610	601	593	584
Commercial	835	835	826	826	826	826
Embassies/ International organizations	1,077	1,077	1,066	1,066	1,066	1,066
Entertainment	1,106	1,106	1,095	1,095	1,095	1,095
Medium voltage: 22 kV						
Agriculture/ irrigation	266	279	290	305	320	336
Industries	539	531	518	511	504	497
Government office	598	590	575	567	559	551
Commercial	709	709	702	702	702	702

(Source: Developed by the JICA Study Team based on the following: Electricity Statistics Yearbook 2007 Lao pDR, EDL Annual Report 2007, and interview with EDL)

Table 3.7-2 Example of Electricity Tariff for Off-Grid Customers

Generation type	Representative price	Note
Micro hydropower generation	150 - 300 [Kip/kWh]	(Equal to or more than 5 kWh)
Diesel power generation	6,000 – 7,500 [Kip/month]	(Less than 5 kWh)

(Source: Electricity business in the world)

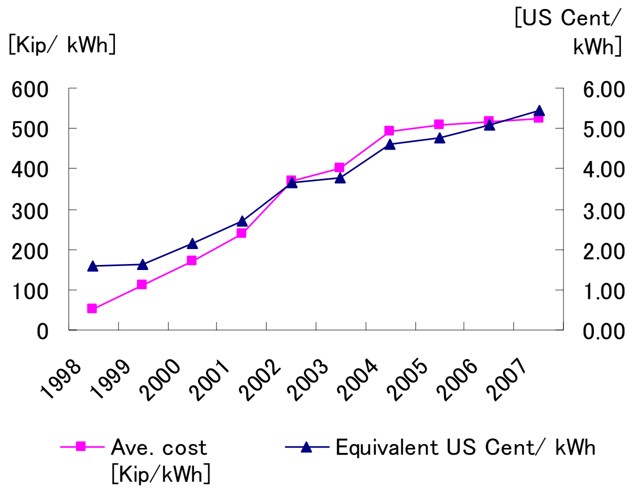


Figure 3.7-1 Historical EDL's Average Domestic Electricity Tariffs

(Source: EDL Annual Report 2007)

With the World Bank's instruction, EDL reviews its tariff system about every five years. The company has begun its review activity again since last fall.

The uniqueness of EDL's retail tariff system is that it employs an energy charge system[2] that calculates the fee in accordance to energy consumption in kWh, which is measured by metering. That is, there is no capacity charge based on the contract power, which is supposed to recover fixed costs. This tariff system assumes that there are few differences in load factors among customers. In generally, the Energy charge system like the one EDL has adopted has several advantages: 1) the system reflects actual electricity usage, avoiding waste of usage; 2) its calculation method is simpler than other tariff systems like the basic charge system[3]. On the other hand, its disadvantage is that the system cannot recover fixed costs related to supply facilities in the event of low consumption.

The tariff system has seven categories divided by customer type. As seen in Table 3.7-1, the rates for Residential and Agriculture have been set lower than those for Entertainment and the Government office. The GoL is implementing a strategy to lift utility tariffs to cost-recovery levels, minimizing cross-subsidy among customer categories as well as keeping EDL's financial status solid. Figure 3.7-1 shows EDL's historical average electricity tariff from 1998 to 2007.

3.7.2 EDL's Export and Import Tariffs

Lao PDR exports surplus electricity to Thailand as one of the means to earn foreign income, although the country also imports electricity, depending on supply-demand balance during a given year. Further, remote areas in Laos close to its national borders are supplied electricity by neighboring countries such as Thailand, Vietnam, and China through their distribution lines. Tariffs for energy export and import have been determined through regular negotiations with the related authorities of the partner countries. The current tariffs are shown in Table 3.7-3 and Table 3.7-4.

As seen in the tables, the import tariffs from the Electricity Generating Authority of Thailand (EGAT) are set higher than those of exporting to EGAT (Figure 3.7-2). Further, the import tariffs from the PEA (Provincial Electricity Authority of Thailand) and EVN (Vietnam Electricity) are set at further higher rates than those for EGAT.

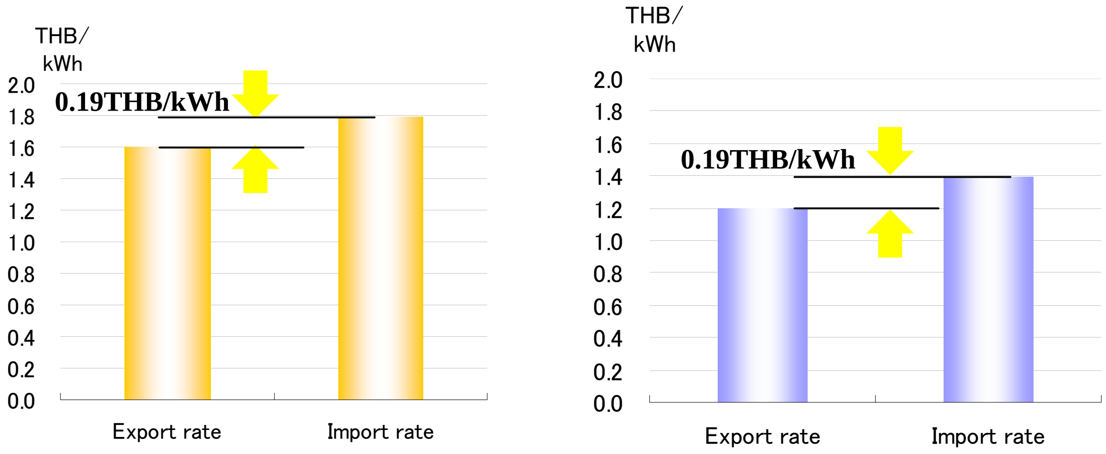
3.7.3 Wholesale Tariffs to EDL

In Lao PDR, two independent power producers (IPPs), Theun-Hinboun Power Company Limited (THPC) and Houay Ho Power Company Limited (HHPC) sell electricity to EDL. Power rates for IPP projects are determined through negotiation between EDL and corresponding IPP. The 2009 rates by THPC and HHPC are planned to be 0.0519 USD/kWh and 0.0429 USD/kWh respectively. Both rates are planned to increase by 1% annually. Besides these two IPPs, several new IPPs like the producer of the Nam Theun 2 hydropower plant are planning to commence its operation in the coming years according to EDL's current Power Development Plan.

---

[2] This tariff system assumes that there are few differences in load factors among customers. In generally,the Energy charge system like the one EDL has adopted has several advantages: 1) the system reflects actual electricity usage, avoiding waste; 2) its calculation method is simpler than other tariff systems like the basic charge system, which is utilized in Japan. On the other hand, its disadvantage is that the system cannot recover fixed costs related to supply facilities in the event of low consumption

[3] The basic charge system: Because the gap of load factors tend to be large among customers in reality, specifically in developed countries, it would be difficult to keep fairness in the collection of electricity tariff only either by an energy chargey system or by an demand charge system (which charges tariff for the demand capacity, kW). The basic charge system is developed to solve this problem. The system is composed of two parts, namely basic rate calculated based on demand capacity (kW9 and energy charge rate calculated based on consumed electricity (kWh). The system is also called two-part tariff, and is most popular in the world.



(left: Peak time, right: off-peak time), [Unit: Thai Baht/ kWh]

Figure 3.7-2 Import/ Export Electricity Tariff for EGAT

Table 3.7-3 Import Tariffs (1/2)

Import source	Transmission voltage	Consumption areas	Rate	Note
EGAT (Electricity Generating Authority of Thailand)	115 kV	Vientiane, Bolikhamxai, Khammouan, Savannaket, Bangyo	Time of Use (TOU) rate 1.79 Thai Baht (THB)/ kWh 1.39 THN/ kWh 1.60 THB/ kWh 1.20 THB/ kWh	(Normal) : Peak Time : Off-Peak Time (Emergency) : Peak Time : Off-Peak Time
EVN（Vietnam Electricity）	35 kV 35/22 kV	Houaphanh Province Xepone, Samouay, Dakchung	0.06 USD/kWh 0.06 USD/ kWh	Flat rate Flat rate
PEA（Provincial Electricity Authority）	22 kV	District Houayxai/Bokeo Province, Districts Kenthao & Ngeun, Kop/ Xaiyabouli Province	- Demand charge: 132.93 THB/ kW - Service charge: 228.17 THB/ kWh - Ft: 0.6611 THB/ kWh (will vary according to fuel price) In addition to the above: TOU rate 2.695 THB/ kWh 1.1914 THB/ kWh 1.1914 THB/ kWh	 : Peak Time (09:00-22:00h, Monday-Friday) : Off-Peak Time (22:00-09:00h, Monday-Friday) : Off-Peak Time (Saturday, Sunday, and Thailand public holidays)
China	10 kV 35 kV	Boten in Luangnamtha Province Muang Sing (Pangthong) in Luangnamtha Province	0.62 Yuan/ kWh 0.0769 USD/ kWh	

(Source: EDL Annual Report 2007)

Table 3.7-3 Import Tariffs (2/2)

Import source	Transmission voltage	Consumption areas	Rate	Note
EGAT	115 kV	Xepone cupper/ gold mines, cement factories, Thakek (For industrial customers: mines and factories)	- Demand charge: 74.14 THB/ kW - Service charge: 228.17 THB/ kWh - Ft: 0.6644 THB/ kWh(will vary according to fuel price) In addition to the above: TOU rate 2.7595 THB/ kWh 1.3185 THB/ kWh 1.3185 THB/ kWh	 : Peak Time (09:00-22:00h, Monday-Friday) : Off-Peak Time (22:00-09:00h, Monday-Friday) : Off-Peak Time (Saturday, Sunday, and Thailand's public holidays)

Table 3.7-4 Export Tariffs

Export sources	Transmission voltage	To:	Rates	Note
Nam ngum 1, Xeset 1	115 kV	EGAT	1.60 THB/ kWh	: Peak Time (09:00-22:00h, Monday-Friday)
			1.20 THB/ kWh	: Off-Peak Time(22:00-09:00h, Monday-Friday; All day, Saturday, Sunday, and public holidays)

(Source: EDL Annual Report 2007)

3.8 Environmental Legislations

3.8.1 Organizations on Environmental Administration

(1) Water Resources and Environment Administration (WREA)

The WREA was established under the Prime Minister Office in 2007. It comprised of the the Department of Environment and the Environmental Research Institute, which both had been part of the Science, Technology, and Environment Agency (STEA)[4], the Department of Water Resources, the Department of Metrology, and the Lao National Mekong Committee Secretariat. In August 2008, the Division of Environmental Impact Assessment under the Department of Environment became the Department of Environmental and Social Impact Assessments (ESIAD)[5].

WREA is the principal Government agency for formulating and guiding environmental policy in the Lao PDR. It develops environmental strategies, policies, regulations, programs and projects, implements Environmental Impact Assessments and monitoring and conducts research and training activities. Figure 3.8-1 shows the organizational chart of the WREA.

The ESIAD is responsible for reviewing the EA report submitted by the Development Project Responsible Agency (DPRA) (for transmission projects, the DPRA is the Department of Electricity, Ministry of Energy and Mines) issuing Environmental Compliance Certificates to project owners and supervises monitoring activities managed by project owners according to the Environmental Management Plan in the EA report. The ESIAD comprises of a Director, three Deputy Directors and a total of 72 full-time staff spread out among six divisions; the Division of Planning and Finance, the Division of Registration and Information, the Division of Environmental and Social Impact Assessment (ESIA) for the Energy Sector, the Division of ESIA for Infrastructure, the Division of ESIA for Agriculture and the Forestry Sector and the Division of the ESIA for the Mining & Industry Sector.

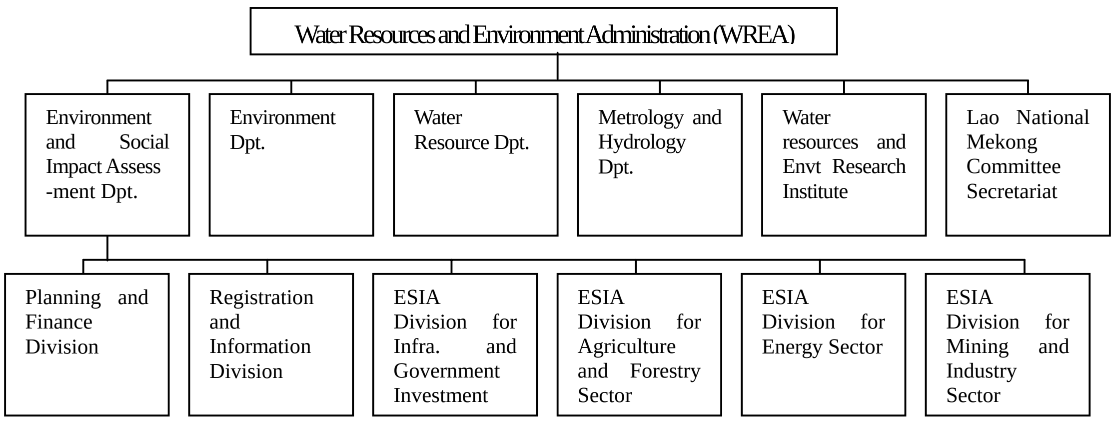


Figure 3.8-1 Organization Chart of WREA

4 STEA does not exist after the establishment of WREA.
5 Decree on Establishment of ESIA Department, No149/PM August 2008.

(2) The Environment and Social Management Division of the Department of Electricity (DOE), Ministry of Energy and Mines (MEM)

The following are the Environment & Social Management Division's main tasks:

i) Develop environmental policy and standards for electricity projects based on environmental legislation.

ii) Review and approve the Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA) submitted by the project owner.

iii) Submit an IEE or an EIA to the WREA, which was handed out by the project owner for applying for the Environmental Compliance Certificate.

iv) Supervise monitoring activities by the project owner according to its EMP.

Figure 3.8-2 shows the organizational chart of the Environment & Social Management Division in the DOE. Presently, there are six full-time staff and two temporary staff working in this Division.

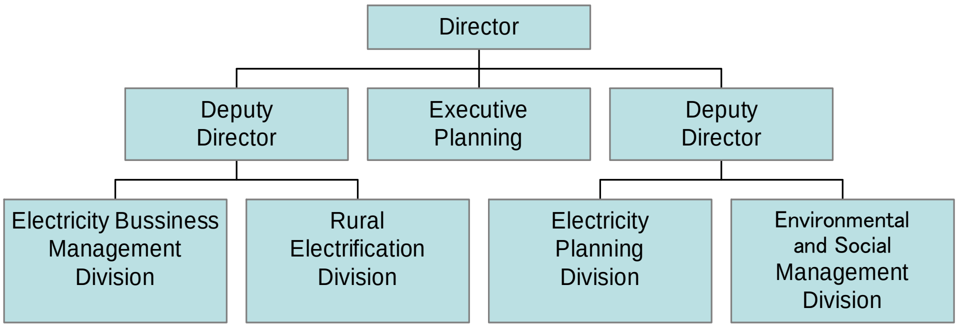


Figure 3.8-2 Organization Chart of Department of Electricity (DOE)

(3) Environmental Office, Technology Department in Electricité du Laos (EDL)

The EDL is a company owned by the Government. The environmental office under the Deportment of Technology is in charge of implementing environmental and social considerations for the electricity project. With regards to the EA, the EDL acts as the project owner and conducts IEE or EIA based on the policies and regulations developed by the DOE. Figure 3.8-3 shows the organizational chart of the EDL Environmental Office. The office consists of a manager, a deputy manager and 10 staff. Most of the staff possesses a background in either environmental or social studies and they are highly experienced in the fileds of EA.

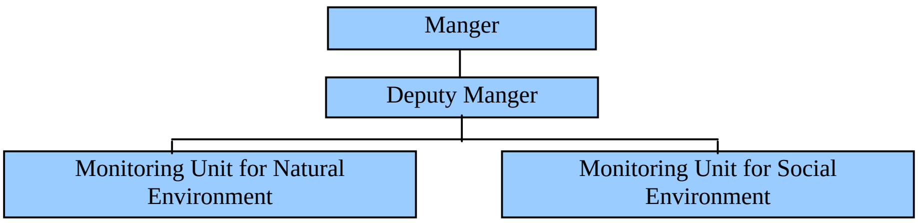


Figure 3.8-3 Organization Chart of Environmental Office in EDL

(4) Other Organizations

The followings are the organizations and their respective areas of responsibility with regards to the transmission line project.

Ministry of Agriculture and Forestry (MAF)

Protected areas (Protected Forests) and Conservation areas (NBCA, Conservation Forest): In order to prevent the transmission line from passing through designated protected and conservation areas at the national, provincial and district level, it is necessary to examine the exact location of those areas. Considering the fact that a map of the districts to be protected and conservation areas has not yet been made, it is important to inquire of the location of those areas at a provincial or district branch office of the MAF in the transmission line route areas.

Clearing of trees: It is stipulated in article 18 of the Forest Law that a tree with a circumference of over 15 cm needs to have its species surveyed. Accordingly the trees applied to this condition in the area of the transmission line route needs to be surveyed and approved by the district or provincial branch officer in the MAF before cutting.

Endangered species: At present, a habitat map of the endangered species has not yet been developed. It is necessary to inquire about the habitats of these species at a district or provincial forest branch office of the MAF in the areas of the transmission line route.

Land Management Authority

Land acquisition: The information on the category and owner of land use rights as well as the application for the land conversion needs to be retreived at the branch office of the land management authority in the area of the transmission line route.

National Regulatory Authority for the UXO/Mine Action Sector (NRA)

UXO: The NRA is a Government institution responsible for the coordination of all operators in the country working on the impact of un-detonated bombs, artillery shells, grenades, landmines, and etcetera. In order to inquire into the detailed situation of the UXO in the project area, it is necessary to refer to the UXO map developed by the NRA. National and provincial level UXO maps are available and the UXO information is up-dated frequently at the NRA.

3.8.2 Legal Framework

(1) Laws, Regulations, and Standards Related to the Transmission Line Project

The IEE has been required for all the development projects in the Lao PDR. Accordingly, it needs to conduct IEE for the basic design of the prioritized project in this development study. The following summarizes the legislations needs to be referred to in implementing the IEE. Table 3.8-1 shows the list of laws and regulations that need to be reviewed for the study on environmental and social considerations.

(a) Laws and regulations pertaining to the environment and society

The following are the key features among the listed legislations in the Table.

i) Enviromnetal Protection Law

Enviromnetal Protection Law is a fundamental law specifying principles, rules and measures to manage, monitor, restore and protect the environment, natural resources and biodiversity ensuring sustainable socio-economic development.

ii) Regulation on Environmental Assessment

The Regulation on Environmental Assessment establishes uniform environmental assessment (EA) requirements and procedures and stipulates the requirements needed to obtain an Environmental Compliance Certificate (ECC) through the EA for all development projects in Lao PDR. It outlines the requirements pertaining to the establishment of Environmental Management and Monitoring Units (EMMU) in the Development Project Responsible Agency

(DPRA). The DPRA can be a Ministry or local government depending on the development project type. For transmission line projects, the Department of Electricity (DOE) under the Ministry of Energy and Mines (MEM) is the DPRA and the Environment and Social Division under the DOE is the EMMU. In addition, the regulation assigns the Water Resources & Environment Administration (WREA) under the Prime Minister's Office as the primary institution responsible for environmental management and monitoring. The ECC is issued when the results of the EA has been approved by the WREA.

The revision of this regulation is under progress. In reviewing the working draft for the regulation, remarks made indicated that the following points would most likely undergo revision[6].

- Screening by the Table entitled "Types and scales of projects that need to be undertaken IEE and EIA" in order to judge the requirements of the IEE or the EIA for the project at the initial feasibility study.
  - Unlike conventional regulations that require the IEE for all development projects at the initial feasibility study level in order to decide whether the project needs to move on to EIA or not, the revised one makes the decision at the screening process by the type and scale of the project addressed in the Table. Accordingly, the possibility to conduct an EIA without the IEE during the initial feasibility study exists depending on the type and scale of the project.[7]
- Requirement to submit two reports, the IEE and Initial Social Examination (ISE)
  - Conventional regulation includes examining the social impact in the IEE report. However, the revised one requires an initial natural environment examination as the IEE and the initial examination on society as the ISE. In order to obtain the certificate, submission of these two reports is required by the WREA.
- Certificate name change from the ECC to the Environmental and Social Compliance Certificate (ESCC)
  - The name of certificate issued by the WREA will be changed from ECC to ESCC.
- Requirements for domestic consulting firms to register at WREA
  - Domestic consulting firms are required to apply for a registration certificate at the WREA in order to conduct an EA[8].
- Longer period is set for obtaining ESCC
  - Under conventional regulations, at a minimum, it normally takes only about 47 days to obtain the ECC after the submission of the EE. However, under revised regulations, it now takes about 95 days at its minimum to obtain an ESCC because the period for reviewing the IEE at the WREA has been set longer.

As mentioned, regulation revision is under way and the description above is based on the latest draft of the regulation. In addition, approval of the regulation is still pending. Thus it is important to remain vigilant during the process of this regulation.

iii) Decree on the Compensation and Resettlement of the Development Project

Decree on the Compensation and Resettlement of the Development Project defines principles, rules, and measures on compensation and resettlement resulting from the development project.

---

[6]Regulation on Environmental and Social Assessment (Working Draft 18 dated 26 October 2008)

[7]As for the transmission line project, the length of proposed transmission line determines the scale of the project. The length of transmission line less than 50 Km is required for conducting IEE and a length exceeding 50Km is required for conducting EIA. This critria has been under discussion between the energy sector and the WREA.

[8] The official registration of the domestic consulting firm has been in practice since 2008. Accordingly, the consulting firm for conducting the IEE of this project is to be selected from the list of officially registered consulting firms

It stipulates in article 6 that "project owners shall compensate those in full or in part, those who have lost rights to land usage and other fixed assets (structures, crops, trees etcetera). It also articulates the principles underlying the rehabilitation measures, grievance redress mechanisms, reporting and documentation requirements, and monitoring on compensation and resettlement of the development project. Regulation for Implementing Decree No.192/PM on the Compensation and Resettlement of People Affected by Development Projects purposes to provide detailed definition stipulated in the Decree on Compensation and Resettlement No.192/PM. Further, it emphasized the effectivity of the Technical Guidelines on Compensation and Resettlement in the Development Project such as "Article 1 The object of the Regulation is … and to properly comply with the Technical Guidelines for Compensation and Resettlement" and "Article 2 The project owner must strictly and properly comply with the provisions determined in the Decree on Compensation and Resettlement and the Technical Guidelines on Compensation and Resettlement". Technical Guidelines on Compensation and Resettlement in Development Projects gives instructions for implementing social impact assessments of development projects especially focusing on the principles and procedures on compensation and resettlement. Chapter 7 provides a filed survey method in order to grasp the socio-economic situation of affected peoples and Chapter 8 gives detailed criteria for the compensation entitlements and methods for the assessment of.

iv) Regulation on the Development and Promotion of Long Term Plantation

Regulation on the Development and Promotion of Long Term Tree Plantation provides principles and measures for the development of tree plantation. It requires the government to compensate for the losses of tree plantation of the affected peoples due to the development project. Also, it provides a formula for calculating compensation for the loss of a tree. The formula presented in the regulation is for the losses of tree plantation, however, it has served as a basis for calculating the compensation rate for the loss of trees arising from transmission line projects.

v) Land Law

Land Law states establishment of Land Management Authority under the Prime Minister's Office as the responsible institution for managing land use right including responsibility for issuing land-use certificates. It gives permission to land requisition for the public purposes and requires the compensation to the affected peoples for the loss.

vi) Foresty Law

Forestry Law defines principles, regulations and measures on forest and forest resources. It classifies forest into three categories 1) Protection Forests, 2) Conservation Forests, 3) Production Forests, all for the purpose of preservation and development. National Biodiversity Conservation Area (NBCA) belongs to the conservation forest category. In principle, construction activities are prohibited in both protected forests and conservation forests with two exceptions; 1) in the event that the forest category of a given forest is changed from a protection forest or a conservation forest to a production forest was endorsed by the Standing Committee of National Assembly, 2) in the event that the changing of conservation forest has been deemed to be in the best public's interest. In addition, it requires conducting a survey of all tree species having a circumference of over 15 cm, which could potentially necessitate that such a tree be cut down to satisfy the conditions required by infrastructure construction.

vii) Wildlife and Aquatic Animals Law

The Wildlife and Aquatic Animals law provides principles and measures to protect and manage wildlife and aquatic animals. It classifies wildlife and aquatic animal into three categories; 1) Prohibition category, 2) Management and control category and 3) Common and generally category for protection and management purposes. It affirms that the listed species in the category are endangered species and that the habitat of those species must be protected.

(b) Laws and Regulations Relevant to Environmental and Social Consideration

The following are the principal legislative instruments relevant to the project.

Electricity Law requires the licensing approval from the Government for electricity enterprises engaged in electricity production, transmission, distribution, exports, imports, or the development of electricity. In applying for licensing approval, the investor has to submit cost estimates, preliminary assessments, investment proposals, proposal reviews, agreement signatures, surveys, economic-technical analysis, environmental impact evaluations and licensing reviews. The environmental impact evaluation is required to include following components.

- Description of all potential damages to the environment along with potential strategic solutions in reducing such detrimental consequences to the environment, the ecological system, society and natural wildlife habitat.
- Estimated costs of potential damages and relocation of local residents who may be affected as a result of such electricity projecst

The licensee is responsible for ensuring that the environment is protected and compensated for damages that affect the living conditions and properties of residents and/or the relocation costs of residents.

The revised electricity law is submitted to the National Assembly for endorsement (as of November 2008). According to the final draft of the law, there were no revisions or new stipulations added pertaining to environmental and social considerations.

Regulation on Implementing Environmental Assessment for Electricity Projects aims to integrate the requirements and procedures of the EA from the provisions contained in the Electricity Law, the Law on Environmental Protection, the Decree on Implementing Environmental Protection and the Regulations on Environmental Assessment into all types of electricity projects. It assigns the Department of Electricity (DOE) of MEM as the overseeing institution in charge of all types of electricity projects to the Development Project Responsible Agency (DPRA) and the Environment and Social Division under DOE as the Environment Management and Monitoring Unit (EMMU).

Instruction and Information on Compensation for Power Transmission Line Project provides principles, procedures and processes on compensation arising from the power transmission line project. It aims at bringing these instructions and information regarding compensation in the past EA practices together into uniformed legislation. The finalization of the legislation has been under progress (as of Feb 2009).

There is no legislation stipulated for Transmission Line Right of Way (ROW). However, the following clearance policies for 115kv Transmission Line ROW have been practiced in EDL.

- 115 kV Transmission Line ROW is 25 m (12.5 metres from the centre line).
- Fixed assets, more than 3 metre tall is not allowed within ROW and tall trees within 12.5 m are on both sides needs to be trimmed and pruned at or below 3 metres.
- Trees and other agricultural assets less than 3 metres tall such as rice paddy are allowed in ROW.
- On government land, any trees that have the potential to grow above 3m needs to be cleared.
- On private land, trees that can survive at less than 3 m need to be pruned and maintained

below this height.

Table 3.8-1 Laws and Regulations Relevant to Environmental and Social Consideration

Law	Enacted No. and Year	Key Contents
Constitution	No.25/NA May 2003	States responsibility for all organization and citizen to protect the natural environment and natural resources of the State
Environmental Protection Law	No. 02-99/NA April 1999	Specifies principles, rules and measures to manage, monitor, restore and protect the environment, natural resources and biodiversity Ensures sustainable socio-economic development
Regulation on Environment Assessment	No.1770/STEA October 2000	Establishes uniform environmental assessment requirements and procedures for all development projects
Decree on the Compensation and Resettlement of the Development Project	No.192/PM July 2005	Defines principles, rules, and measures on compensation and resettlement on the development project
Water and Water Resources Law	No.02-96/ NA October 1996	Regulates the management, exploitation, development, protection and sustainable use of water and water resources
Regulation for Implementing Decree No.192/PM on Compensation and Resettlement of People Affected by Development Projects	No.2432/STEA November 2005	Defines principles, rules and measures on compensation and resettlement of the development project
Technical Guidelines on Compensation and Resettlement in Development Projects	Prime Minister's Office STEA November 2005	Gives instructions for implementing social impact assessment of development project focusing on the principles and procedures on compensation and resettlement
Land Law	No.04/NA Oct 2003	Provides rules on management, protection and use of land
Forestry Law	No.01-96/NA December 2007	States principles, regulations, and standards for the use of forestlands and resources Promotes the conservation and rehabilitation of forest resources Defines roles and authorities of forest management and inspection organizations
Law on Aquatic and Wild Life	No.07/NA December 2007	Provides principles and measures to protect and manage wildlife and aquatic animals
Regulation on Development and Promotion of Long Term Tree Plantation	No.0196/MAF August 2000	Regulates the management, exploitation, and development for tree plantation
Law on National Heritage		Determines the principles, regulations and measures for the administration, use, protection, conservation, restoration, rehabilitation of the national culture, history and natural heritage
Electricity Law	No.03/NA Nov 2008	Requires the minimization of impact on natural environment and society in design, construction and operation phase of electricity development project Instructs the necessity for conducting Environmental Assessment (EA) for the development project
Environmental Management Plans for Electricity Project	No. 584/MIH. DOE October 2001	Provides requirements for developing Environmental Management Plan as a part of EA process
Environmental Impact Assessment for Electricity Projects	No.585/MIH. DOE October 2001	Provides the minimum requirements of an Environmental Impact Assessment for electricity project in accordance with the Environmental Protection Law and the Regulation for EA
Regulation on Implementing Environmental Assessment for electricity Projects	No.447/ MIH. October 2001	Provides uniform EA requirements and procedures of the Regulation on EA for electricity projects Stipulates the requirements and procedures for EA and institutional responsibilities to conduct EA for electricity projects.
Environmental Management Standards for Electricity Project	No.0366/MIH. DOE June 2003	Provides minimum requirements of the Environmental Screening, Social Impact Assessment, Environmental Impact Assessment, Environmental Management Plan, Resettlement Action plan for electricity projects Stipulates Environment and Social Management Division, Department of Electricity is the responsible institution conducting above tasks
Electric Power Technical Standards	No.052/MIH February 2004	Provides technical standards for electricity project Specifies necessity of clearance area under the transmission line in order to secure the transmission line from falling trees
Instruction and information on compensation for power transmission line project	(Draft)	Provides principles, procedures and process for compensation resulting from power transmission line project.

3.8.3 Procedure on Environmental Clearance System

(1) EA Procedure and Process

According to the Regulation on Environmental Assessment, all development projects are required to obtain the Environmental Compliance Certificate (ECC) by the WREA. An environmental Assessment needs to be implemented in order to obtain the Certificate. An IEE must be conducted at the F/S phase and then an EAI is required in case the impacts resulting from the project were anticipated to be severe. As for the transmission line project, IEE requirements have been restricted to the past with no EIA requirements for transmission line projects.

The environmental assessment process for the electricity sector in Lao PDR is shown in Figure 3.8-4 and the format of the IEE report is shown in Figure 3.8-5. As it was described in a previous part of this report, the task of the STEA in Figure 3.8-4 was taken over by the WREA since 2007. For the IEE, it takes about 90 days at the shortest to obtain the Certificate after submitting the project description to the DOE. In addition, it takes about two to three months to conduct an IEE depending on the project scale.

(a) Public Involvement

With respect to the legislation "Environmental Management Standard for Electricity Projects", information gathering, information dissemination, consultation and participation are required for public involvement. The DOE of the MEH and the project owner are responsible for undertaking public involvement activities during Screening, IEE and project implementation phases.

Public involvement includes the following activities:

- Disseminating information concerning the project and its impacts to all stakeholders,
- Providing consultation to the parties affected,
- Harmonizing the agreement pertaining to compensation at the time of the consultation meeting among all stakeholders
- Responding to the affected parties' concerns during project planning and implementation,
- Providing opportunity for public comments at the time of project approval, and
- Enhancing the participation of affected parties for implementing the project.

In general, the consultation meetings are conducted at the village and provincial level at the proposed project area between all parties involved as well as related institutions through conducting IEE. Regarding the prioritized project, the stakeholder's meeting is planned through conducting an IEE in order to fulfill the requirements of public involvement. In-cooperating with the counterpart institutions, public involvement activities implemented by local consulting firm are to be supervised and assisted. The results of the meetings are to be addressed in an IEE report and also reflected in the project planning.

(b) Monitoring

Monitoring purposes to constantly oversee the implementation processes of the EMP and RAP, adjust the plans as appropriate and ensure the project's impacts on natural and social environment are minimized. A monitoring plan is required to be developed as a part of the EMP and RAP.

(c) Environmental Management Plan (EMP)

The EMP needs to be developed as a part of the IEE. The EMP is a plan to set managerial modalities regarding mitigation or preventive measures to environmental and social impacts with a monitoring plan. It needs to include mitigation or preventive measures on environmental and social impacts, implementation procedures, an institutional arrangement, a time frame and a budgetary plan.

(d) Resettlement Action Plan (RAP)

All electricity projects need to develop an implementation plan on compensation and it should be integrated into the EMP report or formulate a separate report such as the RAP. The RAP needs to include information on socio-economic conditions restricted to within the project area, an asset loss of land inventory, buildings, crops, commercial trees and other assets, a census of all affected persons, compensation measures, RAP procedures, institutional arrangements, a monitoring plan and a budgetary plan. The compensation principles are stipulated in the "Decree on the Compensation and Resettlement of the Development Project" as follows:

- Project owners must compensate those affected by the project for their lost rights to land usage and for lost assets (structures, crops, trees and other fixed assets) in full or in part, or at replacement cost.
- The significantly affected land by the project must be compensated on a "land for land" basis.
- Partially affected houses and the remaining area that is less than the minimum house size must be compensated for the entire structure at replacement cost minus depreciation or deductions for salvaged materials. In case the remaining structure is still usable, project owners must provide compensation for the lost portion and assistance in cash or material for restoration of the remaining structure.
- The loss of net income, damaged assets, crops, and trees in temporarily occupied land by the project must be compensated.
- Affected peoples not having any legal Land Use Certificates or any other acceptable proof are entitled to be compensated for their loss at full replacement costs and be provided additional assistance to ensure that they are not worse-off due to the project.

In addition, the social impact examination on land acquisition and resettlement is required based on the Environmental Management Standard for Electricity Projects. Through the assessment, economic and social conditions, assets loss inventory for land, structures, crops, trees and other fixed assets and vulnerable groups such as those severely affected through loss of land, those with low income, single-women households or ethnic minorities are identified in proposed projected areas. The results of the above assessment and its mitigation plan such as the means of compensation need to be integrated into the RAP.

3.8.4 Scoping on Environmental and Social Considerations

Table 3.8-2 and Table 3.8-3 are screening measures to be developed based on relevant legislation of Lao PDR, the JICA Guidelines for environmental and social considerations, the provisional scoping results of the preparatory study for this project, information gathered at the site study and previous IEE reports of the transmission line project conducted by the World Bank, the Asian Development Bank and the JICA. Potential negative environmental and social impacts arising from the construction of the transmission line as well as the substation are summarized in the Tables. These screening measures are applied for assessing prioritized projects. The mitigation plan for minimizing the impact needs to be developed as appropriate.

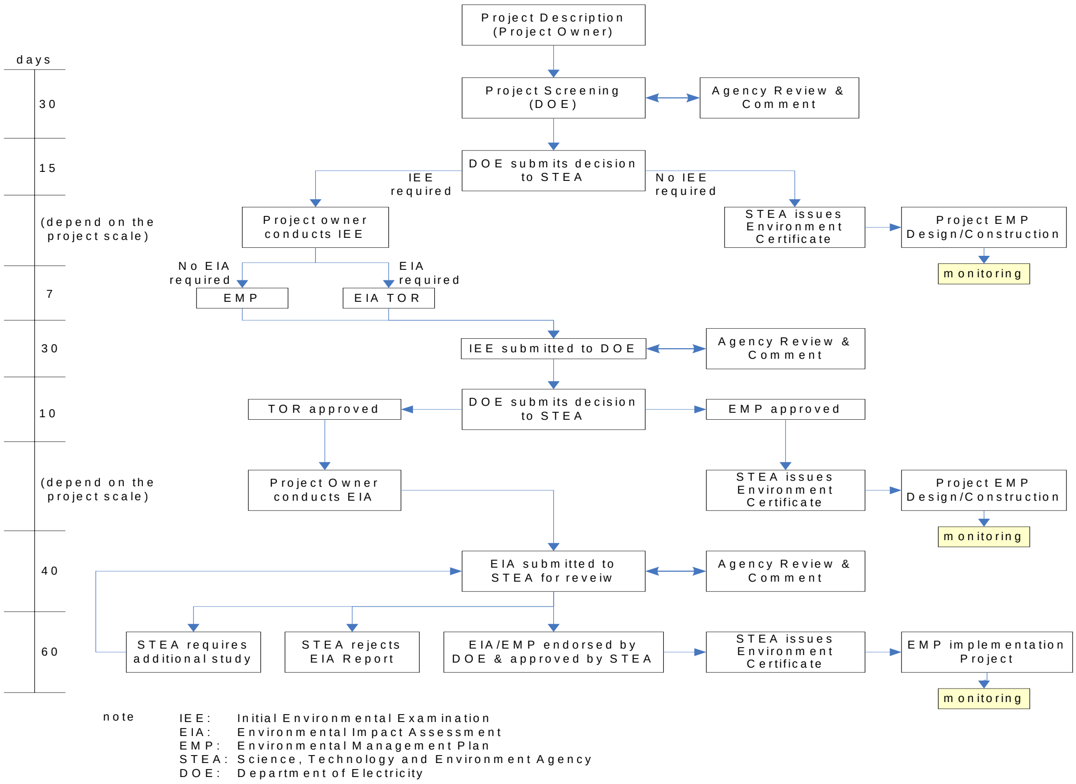


Figure 3.8-4 EA Process and Procedure in Lao PDR

(Source: Regulation on Environment Assessment in Lao PDR)

General Contents and Format of an IEE Report for Development Projects in the Lao PDR

1. Introduction
    - Name and address of project owner
    - Name, address and affiliation of the author of the report
    - Purposes of the report
    - Purposes of the project
2. Project Description
    - Type, size and location of project
    - Project activities and their timing/sequence
        - I. construction period
        - II. operation period
        - III. closure period
    - Quantity and quality of raw material to be used
    - Quantity and quality of waste products generated by the project
    - Project costing
3. Environmental description of project area (baseline data)
    - Physical;
    - Biological;
    - Economic;
    - Social
4. Environmental Impacts
    - Impacts during project construction period
        - Physical (air, water, land)
        - Biological (fauna and flora)
        - Economic
        - Social
    - Impacts during project operation period
        - physical (air, water, land)
        - biological (fauna and flora)
        - economic
        - social
    - Impacts during project closure phase
        - physical (air, water, land)
        - biological (fauna and flora)
        - economic
        - social
5. Environmental Management Plan or draft TOR for an EIA

If the project is not required to undertake an EIA, the EMP must contain:

- protective or reductive measures for environmental impacts
- compensation measures (if any)
- institutional arrangements, timing and budgets for implementation of EMP
- environmental monitoring programme

6. Description of public involvement activities during IEE
7. Conclusions and Recommendations

Figure 3.8-5 Format of IEE

(Source: Regulation on Environment Assessment in Lao PDR)

Table3.8-2(a) Possible Impacts in Design and Construction Phases

No.	Impact	Rating	Brief Description
	Social Environment		
1	Resettlement and loss of agricultural lands	B	Depending on the Transmission Line route (TL route), some impact is anticipated. Based on information collected through the IEE, the TL route needs to be reviewed and if necessary re-aligned in order to avoid settlement areas.Regarding a loss of agricultural land, minor impact is anticipated in order to acquire some land for constructing a transmission tower base.
2	Deterioration of local economy	B	Land acquisition for constructing a transmission tower base affects agricultural land. However, only a minor impact is anticipated.
3	Disturbance to social infrastructures and services	B	During the construction phase, some social infrastructure disturbance is expected due to the tower and substation construction. However, the impact will be temporary and anticipated to be minor.
4	Interruption to residential activities	B	During the construction phase, some residential activity interruption due to the tower and substation construction is to be expected. However, the impact is temporary and anticipated to be minor.
5	Increase the risk of infectious diseases such as HIV/AIDS	C	A temporary influx of migrant labor during the construction period increases the risk of sexual transmitted diseases incidents in the project area. Through conducting an IEE, information on infectious diseases needs to be collected.The extent of the impact is unknown at this stage.
6	Disturbance to water Usage or Water Rights and Rights of Common	B	In case a large amount of surface water is used during the construction phase, some impact is to be expected.
7	Loss of historical, cultural and archeological properties and heritages	C	Depending on the Transmission Line route (TL route), some impact is expected. Base on information collected through IEE, the TL route needs to be reviewed and if necessary re-aligned in order to avoid those areas. The extent of impact is unknown at this stage.
8	Increase disadvantage of vulnerable people such as ethnic people, single headed female household etc.	C	Some impact is to be expected from those households affected by land acquisition. Through conducting on IEE, information on where people's needs are vulnerable must to be collected. The extent of the impact is unknown at this stage.
	Natural Environment		
9	Disturbance to wild life and Biodiversity	C	The TL route is designed to avoid national protected areas. In conducting the site survey, information on a habitat of endangered species and protected areas at provincial and district level needs to be collected. The extent of the impact is unknown at this stage.
10	Clearing of forest or bushes	B	Some impacts are not to be avoided in order to construct transmission lines. Based on second source information, affected forest lands on the route were small and anticipated impact ie minor. Through the IEE, detail information on the land use within the project area needs to be collected.
11	Destruction of landscape	B	A TL is to be constructed along National Route 13 and National Route 15. Thus impact on landscape is anticipated. However, based on second source information, no scenic spot have been confirmed on the route and only minor impact is to be anticipated. Through the IEE, detail information on the area needs to be collected.
12	Soil erosion	B	Soil erosion resulting from clearing forest is expected. Based on second source information, affected forest lands on the route were small and the anticipated impact is to be minor.
13	Disturbance to grand water	C	For construction works that require a large amount of grand water, impact is to be expected. Through the IEE, the information on water use in the project area needs to be collected. The extent of the impact is unknown at this stage.

Table3.8-2(b) Possible Impacts in Design and Construction Phases

No.	Impact	Rating	Brief Description
	Pollution		
14	Air pollution	B	During the construction phase, air pollution such as exhaust fumes from earthmoving equipment as well as construction vehicles associated with the tower and substation construction is anticipated. However, the impact is temporally and anticipated to be minor.
15	Water pollution	B	During construction phase, waste water discharge associated with the tower and substation construction is anticipated. However, the impact is temporary and anticipated to be minor.
16	Soil contamination		Uses of materials containing PCB affects soil quality, however, those materials are prohibited in Lao PDR thus no soil contamination is anticipated.
17	Waste generation associated with construction and waste generation at workers' camps	C	During the construction phase, generation of materials resulting from construction activities and generation of litter due to the presence of the Project employees and contractors are to be expected. Through IEE, information on local waste treatment needs to be collected. The extent of the impact is unknown at this stage.
18	Disposal of construction debris	C	During construction phase, vegetation waste resulting from forest clearance is anticipated. Through the IEE, information on vegetation within the project area needs to be collected. The extent of the impact is unknown at this stage.
19	Dust emission	B	During the construction phase, dust emissions associated with the tower and substation construction is anticipated. However, the impact is temporally and anticipated to be minor.
20	Noise and vibration	B	During construction phase, noises that are ni and vibration associated with the tower and substation construction is anticipated. However, the impact is temporally and anticipated to be minor.
21	Injury or sickness of residents or workers	C	During the construction phase, increased risk of accident associated with the tower and substation construction is expected. Through the IEE, the information on population concentration needs to be collected. The extent of the impact is unknown at this stage.
22	Disposal of construction debris		Usage of PCB contained materials affects soil quality. However, those materials are prohibited in Lao PDR thus no soil contamination resulting from construction debris is anticipated.
23	Accidents caused by UXO	C	Through IEE, information on UXO contamination within the project area needs to be collected. The extent of the impact is unknown at this stage.

Rating:
A: Serious impact is anticipated
B: Some impact is anticipated
C: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses)
No Mark: No impact is anticipated

Table3.8-3 Possible Impacts in Operation Phase

No	Impact	Rating	Result Brief Description
	Social Environment		
1	Inadequate resettlement and compensation for loss of land	B	Depends on the TL route, resettlement is to be avoided. Regarding compensation for loss of agricultural land, appropriate implementation of RAP is to minimize the impact.
	Natural Environment		
2	Disturbance to wild life and biodiversity near NBCA	B	Via appropriate monitoring and mitigation measures, impact is to be minimized.
	Pollution		
3	Water and soil contamination	B	Use of herbicide for ROW clearing causes water and soil contamination. With appropriate management plan stipulating prohibition of herbicide use, the impact is to be minimized.
4	Noise and vibration	B	Noise and vibration resulting from substations are to be minimized in terms of constructing facilities a safe distance away from residential areas.
5	Interference with local residents' communication	B	Communication line interference via an electrostatic induced current is expected. With appropriate monitoring and mitigation measures such as the installation of additional antennas the impact is to be minimized.
6	Injury or sickness of local residents		With mitigation plans such as the installation of "keep out" boards at each transmission tower, impacts are to be avoided.
	Social Environment		
1	Inadequate resettlement and compensation for loss of land	B	Depends on the TL route, resettlement is to be avoided. Regarding compensation for loss of agricultural land, appropriate implementation of RAP is to be minimized the impact.
	Natural Environment		
2	Disturbance to wild life and biodiversity near NBCA	B	With an appropriate monitoring and mitigation measure, the impact is to be minimized.
	Pollution		
3	Water and soil contamination	B	Use of herbicide for ROW clearing causes water and soil contamination. With appropriate management plan stipulating prohibition of herbicide use, the impact is to be minimized.
4	Noise and vibration	B	Nuisance noise and vibration resulting from substation are to be minimized in terms of constructing facility well distance from residential area.
5	Interference with local residents' communication	B	Interference on communication line by electrostatic induced current is anticipated. With appropriate monitoring and mitigation measures such as installation of additional antennas the impact is to be minimized.
6	Injury or sickness of local residents		With mitigation plans such as installation of "keep out" board at each transmission tower, the impacts are to be avoided.

Rating:
A: Serious impact is anticipated
B: Some impact is anticipated
C: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses)
No Mark: No impact is anticipated

3.9 Financial Analysis of EDL

Electricite du Laos (EDL), registered as state-owned enterprise, runs an electricity business that integrates generation, transmission, and distribution to supply electricity to the whole nation. It owns power generation facilities minus those owned by independent power producers (IPPs). This section analyzes its financial conditions through a review of its financial statements. Although EDL currently adopts its own accounting policy, the company asks internationally-renowned auditors to carry out the audit of their financial records in accordance with international accounting standards in order to facilitate loan appraisal for its capital investments by the International Development Association (IDA).

3.9.1 Financial Status at a Glance

The electricity demand is estimated to grow at around 10% on the condition that the country's economy grows at 8%, which the Sixth Five-Year National Socio Economic Development Plan sets as targets. In this case, the electricity demand in year 2016 is estimated to become four times as big as the same figure for 2006. The challenge is how to finance such vast investment. EDL's financial statements show that its capital investment mostly relies on long-term borrowing from multilateral/ bilateral development donors. Therefore, it is essential for EDL to keep its financial status solid. This sub-section aims to analyze EDL's financial capability to secure its power development plan.

(1) Insufficient Domestic Sale as Revenue Source

Figure 3.9-1 and Figure 3.9-2 show EDL's historical turnover and profit over the past five years, and the breakdown of the turnover, respectively.

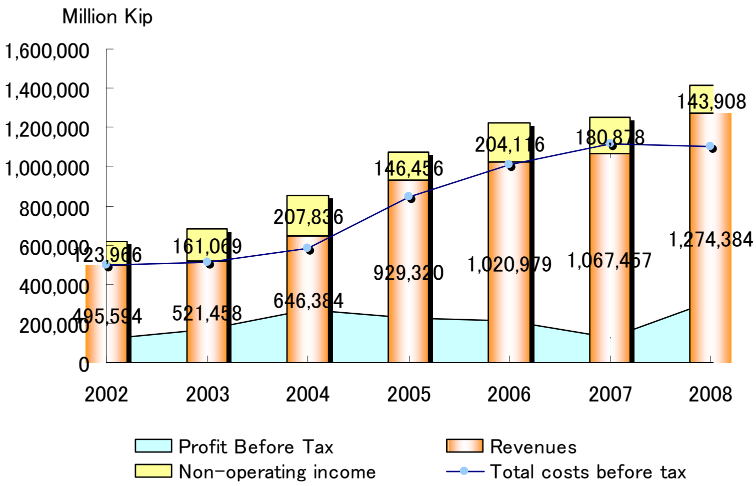


Figure 3.9-1 Revenues and Profit

(Source: EDL's Financial Statement)

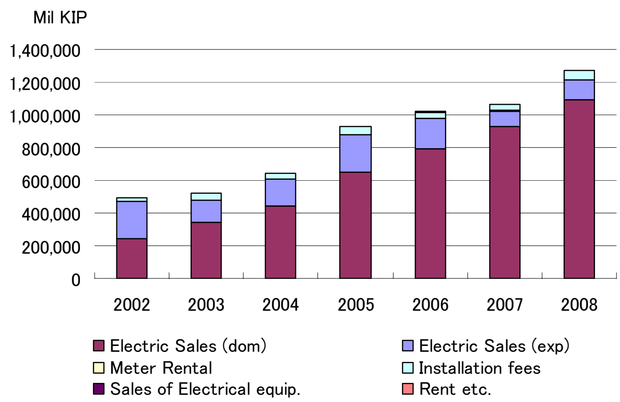


Figure 3.9-2 The Breakdown of Operating Revenue

(Source: EDL's Financial Statement)

EDL's revenue constantly increases, while its profit decreases these past few years. The key issue seen from these figures is the fact that operating income does not fully cover the supply cost and therefore EDL does not make sufficient profit from its core business of electricity supply (operating income includes revenues from electricity export operation too). Non-operating income like dividend income from the two IPPs, plays a substantial role in bringing profit to EDL. In a word, total financial performance has made EDL's domestic performance unclear. The loss which domestic business has posted consistently has been offset by profits from export business and dividend income from IPP. The fact might partly attribute to the current domestic tariff system. The average domestic tariff rate is set around 10% lower than required to recover full cost. Further inefficiencies are created by cross subsidization among customer categories, e.g. residential and agricultural customers.

Figure 3.9-3 Major Cost Factors and Uncollected Bill

(Source: EDL's Financial Statement)

In order to turn improve this financial structure, the three parties of EDL, GoL and IDA have agreed to "The Action Plan for Financial Sustainability of the Power Sector" in 2005, as shown below.

- Adjustment of electricity tariffs from 2005 to 2011, increase tariffs to cost-recovery levels.

- Settlement of government areas owed to EDL, for past electricity consumption.
- Design and implementation of EDL loss reduction activities.

(2) Limited Option for Financing Capital Investment

As mentioned above, EDL's capital investment relies immensely on long-term debt from overseas development agencies, except power generation development, which are left to private participants like IPP. Figure 3.9-4 shows EDL's high dependency on long-term debt, which occupies more than 80% of the total liabilities. The figure indicates the scarcity of financing options. The debt ratio (= liability/ equity) keeps around 60%. The long-term debt as of December 2008 includes two loans of around 23 million USD from IDA, and eight loans of around 100 million USD from Asian Development Bank (ADB). Most of these borrowing are originally lent from the financial institutes to the Ministry of Finance (MOF), and then MOF lends the funds to EDL. It is not announced by EDL how much the company would be able to borrow from financial institutions. The amount to be borrowed for projects is examined individually.

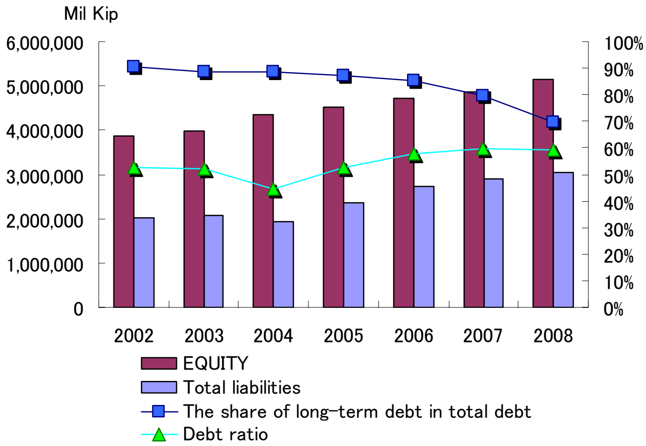


Figure 3.9-4 The Share of Long-term Debt in Total Liabilities

(Source: EDL's Financial Statement)

Table 3.9-1 shows the major financing schemes for capital investment in general. Because Lao's domestic financial markets such as the equity and bond market is still under development, EDL's choice would be limited to long-term borrowing, specifically ones from multinational financial institutes like the IDA, not from commercial banks.

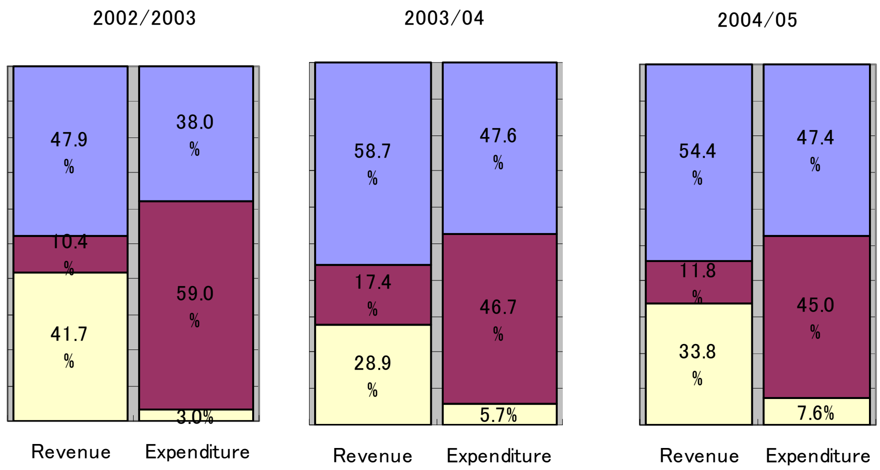
Table 3.9-1 Major Financing Schemes

1) Internal financing	a. Retained earning	Cost of Equity	
	b. Depreciation etc.	Weighted Average Cost of Capital	
2) External financing	a. Equity finance	Cost of Equity	Direct: capital increase (share issue)
	b. Debt finance	Cost of Debt	Direct: corporate bond, commercial paper
			Indirect: Borrowing
	c. Asset finance		

(Source: Accounting for Electricity Business)

In autumn of 2010, establishment of the Lao PDR stock market is scheduled for the first time in its history, while the possibility of the project bond's issuance has also been examined with the assistance of the Asian Development Bank (ADB). For reference, the majority of financing for electricity infrastructures in Japan after World War II was also long-term debt from Japanese government. As time goes by, its share has decreased, while the share of other schemes such as corporate bond and borrowing from commercial banks have increased. Depending on the progress of Lao's financial market, similar shift might occur in Lao PDR, too.

Although EDL is a state-owned enterprise, the story is different when it comes to infrastructure development. It is not feasible for EDL to rely financially on GoL for its facility development, as the government's budget does not afford capital investment including power facilities. As seen in Figure 3.9-5, which summarizes the government's financial status. The sum of tax and non-tax revenues falls short of the total expenditure. Specifically, there is a scarce amount of revenue necessary for capital expenditure, which is mainly for capital investment (shown in red in the Expenditure column). Instead, overseas development assistance has funded such capital expenditure in the past.



Note:
Revenue) ■: Tax revenue, ■: non-tax revenue, ■: deficit
Expenditure) ■: current expenditure, ■: capital expenditure, ■: debt redemption

Figure 3.9-5 Breakdown of Government Finance

(Source: Lao's socio-economic base)

3.9.2 Financial Risk Analysis

The analysis above shows that long-term debt is the main financing source for EDL's capital investment. Therefore, this subsection analyzes EDL's financial strength to be eligible for planned borrowing. Firstly, EDL's long-term solvency is analyzed by calculating its equity ratio (= equity/ asset). Figure 3.9-6 shows its historical figures.

It is generally said to be free of solvency risk for an entity with figures exceeding 40%. The figure shows that the ratio of the EDL has kept over 60% since 2002, and therefore, it concluded that EDL is eligible to be financed by means of long-term borrowing. Secondly, we analyzed EDL's short-term liquidity, whose parameter, current ratio (= current asset/ current liability), is shown also in Figure 3.9-6. It is also generally said to be financially -solid for an entity to be with high figures[9]. While the current ratio of EDL shows a decreasing trend, the figure still has to be kept high. Therefore, it has been concluded that the short-term liquidity of an EDL is also positive.

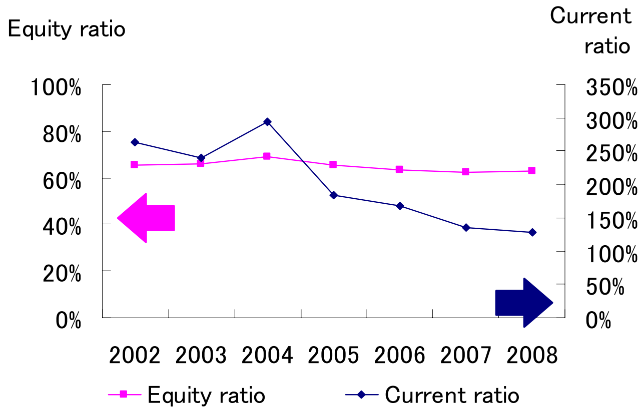


Figure 3.9-6 Major Financial Index

(Source: EDL's Financial Statement)

As seen above, EDL's financial status shows its solid long-term solvency for further loans for future investment, while there still remains a foreign exchange risk as long as the company is largely dependent on foreign currency loans. EDL was severely affected by 1997's Asian financial Crisis, where Lao's local currency, the Kip, declined in value against the USD. The rate for the year of 1997 was around 2,000 Kip/USD, fell to around 8,000 Kip/USD in year 2000. While EDL's revenues are largely in Kip, the costs of debt servicing are mainly in USD. The fall of local currency value has affected severely the repayment of debt in USD.

For these reasons, to make the EDL's Power Development Plan (PDP) financially viable, multilateral creditors like IDA has requested EDL to maintain its present loan policy (Table 3.9-2) when EDL borrows from them.

Table 3.9-2 Loan Policy

Self Financing Ratio ≥ 30%
Debt to Equity Ratio ≤ 1.5
Debt Service Coverage Ratio ≥ 1.5

Note: Self Financing Ratio approximately equals to Net Cash Flows from Operation Activities divided by Average Capital Investment over 3 years. Debt to Equity Ratio approximately equals to Non-current Liabilities divided by Total Equity. Debt Service Coverage Ratio approximately equals to Operating profit before Tax and Dividend divided by Annual Repayment of Principal on Long-term Debt and Interest.

(Source: EDL PDP 2007-16)

[9] Although the ratio can be interpleted that an entity with the ratio less than 100% might suffer from the short of cash next fiscal year to repay its short-term debt, the number can be also high when the majority of current asset is account receivable. Therefore one needs to check the breakdown of asset to conclude the liquidity condition.

3.9.3 Conclusion

Table 3.9-3 shows EDL's planned figures corresponding to the IDA's parameters set in the loan policy (Table 3.9-2). Although the figures of the Self Financing Ratio from 2010 to 2013 do not meet the requirements, mainly due to large-scale power generation development, correspondent figures of Debt to Equity Ratio as well as those of Debt Service Coverage Ratio maintain the policy. The figures of Self Financing Ratio after 2013 also mostly recover to exceed 30%. As for the prospect of EDL's financial status, the status is expected to improve strongly if the new tariff system proposed by the aforementioned World Bank's Tariff Update Study as the new system provides enough rates for EDL to recover the supply cost of electricity. For these reasons, EDL's financing plan in PDP is concluded to be viable.

Table 3.9-3 Planned Figures in EDL's Power Development Plan

Parameter	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Self Financing Ratio	31%	24%	29%	-8%	-1%	5%	1%	40%	-16%	103%
Debt to Equity Ratio	0.5	0.6	0.9	1.0	1.1	1.2	1.4	1.4	1.2	0.8
Debt Service Coverage Ratio	1.9	2.4	2.3	1.3	1.0	1.1	1.1	1.5	1.1	1.2

(Source: EDL PDP 2007-16)

As reference, Table 3.9-4 and Table 3.9-5 summarize the EDL's financial statements for the past three years.

Table 3.9-4 Income Statement

[Unit: million Kip]

Item	2005	2006	2007	2008
Revenue	1,075,776	1,225,095	1,248,335	1,418,292
Cost	849,193	1,010,834	1,117,275	1,104,104
Profit before tax and interest	225,583	214,261	131,060	314,188
Tax	45,579	31,199	26,728	27,346
Net profit (loss)	181,004	183,062	104,332	286,842

(Source: EDL's Financial Statement)

Table 3.9-5 Balance Sheet

[Unit: million Kip]

Item	2005	2006	2007	2008
ASSETS				
Current assets	558,353	673,461	695,103	877,666
Non-current assets	6,320,663	6,786,819	7,072,886	7,287,468
Total assets	**6,879,016**	**7,460,280**	**7,767,989**	**8,165,134**
EQUITY AND LIABILITIES				
Non-current liabilities	2,064,658	2,330,865	2,391,767	2,341,999
Current liabilities	304,181	401,623	511,419	688,091
Total liabilities	2,368,839	2,732,488	2,903,186	3,030,090
Equity	4,510,196	4,727,793	4,864,803	5,135,044
Total equity and liabilities	**6,879,016**	**7,460,281**	**7,767,989**	**8,165,134**

(Source: EDL's Financial Statement)

Chapter 4
Existing Facilities of Transmission Lines and Substations

Chapter 4 Existing Facilities of Transmission Lines and Substations

4.1 Power System Configuration

4.1.1 Domestic Power System

Domestic electric power in Laos is separately supplied to four regions, North, Central 1, Central 2 and South.

The Central 1 grid has three hydropower stations, the Nam Ngum 1 (155 MW), Nam Leuk (60 MW) and Nam Mang 3 (40 MW). Between Thailand and Laos, there are 115 kV circuits consisting of two circuits in Phonetong-Nongkhai, two circuits in Thanaleng-Nongkhai and one circuit in Pakxan-Bungkan to carry on power trade. There are substations in Central 1 supplying power to the Vientiane Capital such as Phonetong, Thanaleng and Khoksaad. The Central 1 system has a power supply delivering 115 kV to Luang Prabang from the Thalat substation neighbour to the Nam Ngum Power Station through the Vangvieng substation.

The Central 2 grid consists of two systems, the system including the Thakhek substation and the system including the Pakbo substation. Each system imports power from Thailand through the 115 kV interconnections. The system including the Thakek substation has large power consumers such as Sepon Mining or a cement factory. The 115 kV interconnections are operated with the two circuits between Thakhek and Nakhon Phanom and two circuits between Pakbo and Mukdahan.

The South grid has the Xeset 1 hydropower station (45 MW) and the Selabam hydropower station. The 115 kV interconnections are operated with the two circuits between Bang Yo and Sirindhom for power import and export to Thailand.

There are no 115 kV substations in the Northern region. The Northern region distributes its power supply from distributed power stations or through the distribution lines from Central 1 grid, China and Vietnam.

The interconnections of the medium voltage distribution lines containing 35 kV and 22 kV are operated at the three points between Vietnam and Laos, the two points between Thailand and the northern part of Laos, the four points in the Xayabuly province from Thailand, one point from China to Luang Namtha. The capacity of each connection point is around several MW.

Figure 3.4-1 shows the existing power system.

4.1.2 International Interconnections

The interconnections in Laos are categorized into the transmission lines connected to the domestic power grids and the transmission lines without connection to the domestic girds directly from the export-oriented IPPs, Thuen Hinboun and Hoay Ho hydropower stations. Each IPP supplies power directly to Thailand through the international interconnections. Other international interconnections are the transmission lines connected to the 115 kV domestic grid of Laos or the distribution lines supplying power to the regions around the narional borders. Figure 4.1-1 shows the existing international interconnections.

Table 4.1-1 International Interconnections

No.	Location		Voltage	Circuit		Conductor Size	Length
	Lao PDR	Thailand/Vietnam/China	(kV)	Design	Install	(mm^2)	(km)
1	Theun Hinboun	Sakhonnakhon (EGAT)	230	2	2	644	176
2	Houay Ho	Ubon2 (EGAT)	230	2	2	644	230
3	Phontong	Nongkhai (EGAT)	115	2	2	240	25.7
4	Thanaleng	Nongkhai (EGAT)	115	1	1	95	10.9
5	Pakxan	Bungkan (EGAT)	115	2	1	240	11
6	Thakhek	Nakhonphanom (EGAT)	115	2	2	169	10.3
7	Pakbo	Mukdahan2 (EGAT)	115	2	1	240	13.7
8	Bang Yo	Sirindhon (EGAT)	115	1	1	240	61
9	Xam Neua (Pahang)	Mokchao (EVN)	35	1	1	150	30
10	Bokeo	Xiengkhong (PEA)	22	1	1	185	0.7
11	Kenthao	Thali (PEA)	22	1	1	240	0.35
12	Savannakhet (Dansavan)	Vietnam (EVN)	22	1	1	95	0.75
13	Pangthong	Muong Mang	22	1	1	150	28.6
14	Muong Khop	Ban Huak	22	1	1	120	1.52
15	Muong Ngeun	Houaykone	22	1	1	120	1
16	Ban Mai	Amperxongquare	22	1	1	120	1.3
17	Saravan	Lalai (EVN)	22	1	1	150	2
18	Luangnamtha	China	22	1	1	90	3.4

4.2 Existing Generation Plants

Existing installed generation plants are listed in the table below. All generation plants are hydropower plants. The Theun Hinboun power plant and the Houay Ho power plant are IPP hydropower plants for power export. They also have a share of domestic supply. The Theun Hinboun power plant has 8 MW and the Houay Ho power plant has 2.1 MW for domestic supply. 318.8 MW of capacity comprises the domestic supply capacity.

Table 4.2-1 Existing Power Plant in Lao PDR

Plant	Capacity (MW)	Generation (GWh)	COD	Location	Owner
Nam Dong	1.0	4.0	1960	Luangprabang	EDL
Selabam	5.0	30.0	1969	Champasak	EDL
Nam Ngum 1	155.0	966.0	1970	Vientiane	EDL
Xeset 1	45.0	180.0	1994	Saravan	EDL
Nam Ko	1.5	6.0	1997	Oudomxai	EDL
Theun Hinboun	210.0	1,645.0	1998	Khammouane	Theun Hinboun Power Co.
Nam Song	-	-	1998	Vientiane	EDL
Houay Ho	152.1	490.7	1999	Attapeu	Houay Ho Power Co.
Nam Leuk	60.0	184.0	2000	Vientiane	EDL
Nam Ngai	1.2	6.0	2004	Phonsali	Provincial
Nam Mang 3	40.0	133.5	2005	Vientiane	EDL
TOTAL	670.8				

(Source: EDL)

4.3 Transmission Lines

Main transmission system voltage for domestic supply in the country is 115 kV. Currently, there are four separate 115 kV transmission systems operating that are not interconnected with each other.

(1) Nam Ngum 115 kV System

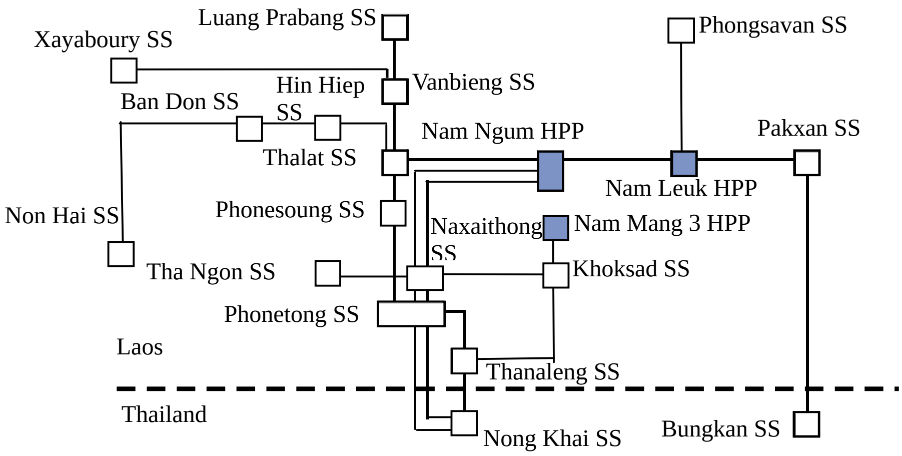


Figure 4.3-1 Nam Ngum 115 kV Transmission System (as of 2009)

The system has three (3) major hydropower plants; the Nam Ngum 1 with 155 MW, the Nam Leuk with 60 MW and the Nam Mang 3 with 40 MW. At present, this 115 kV system is the largest system in the country and supplies energy to the Vientiane Capital, Vientiane, Bolikhamxay, Xieng Khuang, Xayaboury and the Luang Prabang Provinces.

Energy delivery to the Vientiane Capital is achieved through the Phone Tong and Thanaleng, and other substations. While, energy delivery to the Vientiane, Xayaboury and Luang Prabang Provinces is achieved through the Non Hai, Vanvieng, Xayaboury, Luang Prabang and other substations. In addition, the single circuit lines from the Num Leuk power station supply energy to the Pakxan substation in Bolikhamxay and the Phonsavan substation in Xieng Khuang.

Three (3) circuits of 115 kV lines are operated from the Nam Ngum 1 power station to the Phonetong substation extending to the EGAT power system in Thailand for power export. Out of the three circuits, a single circuit line is dropped at the Phonesoung substation and is conected to the Phonetong substation and the Thanaleng substation on the way to Thailand. The remaining double circuits line from the Nam Ngum 1 power plant are connected to the Phonetong substation via the Naxaitong substation and the EGAT system. The single circuit line from the Nam Mang 3 power station supplies power to the Khoksad substation and is connected to Naxaithong substation and the Thanaleng substation. The single circuit line leaving at the Thalat substation is connected to the Luang Prabang substation over 212 km via the Vangvieng substation. The line leaving at the Xieng Ngun switching yard is connected to the Xayaboury substation. The other single circuit line leaving at the Thalat substation is connected to the Non Hai substation via the Hin Hiep substation and the Ban Dong substation.

(2) Thakhek 115 kV System

A 115 kV transmission line with double circuits is operated for energy imports from Thailand to the Thakhek town between EGAT's Nakhon Phanom substation and the Thakhek substation in the Khammouan province. Import energy is transmitted to the Sepon Gold & Copper Mine in Savanakhet province by single circuit line.

(3) Savannakhet 115 kV System

The Savannakhet 115 kV system with a 115/22 kV Pakbo substation receives power from the

EGAT system of Thailand through a 115 kV single line for energy imports to the Savannakhet town due to the present unavailability of the domestic power supply system. The imported energy is transmitted to the Kengkok substation located 52 km away from the Pakbo substation by a single circuit line.

(4) Xeset 115 kV System

There are two power plants in the area; the Xeset 1 (45 MW) and the Selabam (5 MW) power stations. The system supplies power to the Saravane, Champasak and Attapeu provinces. A single circuit line from the Xeset 1 power station branches out from the Bang Jianxai switching yard via a double circuit line and is connected to the Bang Ha substation in the southern Champasak province. The line also branches out from the Ban Na substation on the way and transmitts power to the Attapeu substation by a single circuit line. The surplus energy of this system is exported to Thailand. The Xeset 1 power station is a run-off river plant, and a considerable amount of imported energy from Thailand is required during dry season, for which this 115 kV line is utilized.

4.4 Substations

The four 115 kV power girds of EDL are operated for the domestic power supply and partly for power imports and exports. The following table shows the existing 115/22 kV substations and switching stations owned by EDL connected to the transmission system.

4.5 Telecommunication System and Dispatching Center for Power System

(1) Telecommunication System for Power Sector

Currently, there are four grids being operated in Laos. For power system operation and management, the Nam Ngum grid has the power line carrior system (PLC) and power systems. There are four power systems operated in the country. For operating and managing the system, the Nam Ngum 1 power system is provided with a PLC (power line carrier communications) system in addition to radio communications, covering all power station and 115 kV substations in the network. The communications among the 115 kV substations and the 22 kV distribution substations in the Vientiane city and its suburbs are also made through the PLC and the radio facilities. The Xeset power system is operated and managed through the PLC in the section of the power station and the Bang Yo substation. While, the other two systems use a public telephone system for their operations, though their supply areas are limited. Communications among these four-power systems are made through a public telephone, because the systems are not interconnected but operate independently.

(2) Central Load Dispatching Center

At the present, no load-dispatching center covering the whole system is in the country.

The 115 kV Phonetong substation in Vientiane and the Nam Ngum 1 power station are controlling and managing operations at the Nam Ngum power system including energy exports to Thailand.

A control room in EDL’s Sisaket substation has a mimic board to display the real time operating situation of the 115 kV Phonetong, Luang Prabang and Thanaleng substations and all 22 kV distribution substations in the municipality. The board indicates the on-off positions of the main switchgear and displays other electricity conditions such as the voltage, frequency, bus voltage, active and reactive power etcetera for each substation. A data logger operating in the room stores all of the operational data and is capable of automatic data print-out of relevant data at 24:00 hours. The operational elements are transmitted from the substations to the room through the PLC system. Two 22 kV substations (Dongnasok and Thatluang) are operated by a remote control mechanism from the Sisaket control room. There is no central dispatching/controlling center in Laos except for supervising the system in Vientinae City. In expanding the national power grid, a comprehensive dispatching center is indispensable.

Table 4.4-1 The Existing 115/22 kV Substations and Switching Stations (As of May 2009)

ID	Name of substations and switching station	Province	Number of Transformer/ Unit Capacity	Total capacity of transformers
North Area				91 MVA
1	Luang Namtha	Luang Namtha	1 x 20 MVA	20 MVA
2	Oudomxai	Oudomxai	1 x 20 MVA	20 MVA
3	Pakmong	Luang Prabang	1 x 10 MVA	10 MVA
4	Luang Prabang	Luang Prabang	2 x 12.5 MVA	25 MVA
5	Xieng Ngen S/S	Luang Prabang	-	-
6	Xayabury	Xayabury	1 x 16 MVA	16 MVA
Central 1 Area				422 MVA
7	Vanvieng	Vientiane	2 x 16 MVA	32 MVA
8	Thalat	Vientiane	1 x 30 MVA	30 MVA
9	Hin Heup S/S	Vientiane	-	-
10	Ban Don	Vientiane	1 x 16 MVA	16 MVA
11	Non Hai	Vientiane	1 x 16 MVA	16 MVA
12	Phonesoung	Vientiane	1 x 22 MVA	22 MVA
13	Naxaythong	Vientiane Capital	2 x 30 MVA	60 MVA
14	Tha Ngon	Vientiane Capital	1 x 22 MVA	22 MVA
15	Khoksaat	Vientiane Capital	2 x 22 MVA	44 MVA
16	Phonetong	Vientiane Capital	4 x 30 MVA	120 MVA
17	Thanaleng	Vientiane Capital	2 x 30 MVA	60 MVA
Central 2 Area				208 MVA
18	Pakxan	Bolikhamxai	2 x 16 MVA	32 MVA
19	Phonesavan	Xieng Khuang	1 x 16 MVA	16 MVA
20	Thakhek	Khammouan	2 x 30 MVA	60 MVA
21	Pakbo	Savannakhet	2 x 20 MVA	40 MVA
22	Kengkok	Savannakhet	2 x 10 MVA	20 MVA
23	Mahaxai	Khammouan	2 x 20 MVA	40 MVA
South Area				152 MVA
24	Bang Yo	Champasak	1 x 16 + 2 x 8 MVA	32 MVA
25	Ban Na	Champasak	2 x 30 MVA	60 MVA
26	Ban Hat	Champasak	2 x 20 MVA	40 MVA
27	Jiangxai S/S	Champasak	-	-
28	Attapeu	Attapeu	2 x 20 MVA	40 MVA
			Total	903 MVA

(Source: EDL PDP 2007-16)

4.6 O&M of Transmission System

4.6.1 Present O&M Organization of EDL

(1) Hydropower Stations

The operation and maintenance of six EDL hydropower stations (Nam Ngum 1, Nam Leuk, Xelabam, Xeset 1, Xeset 2 and Nam Mang 3) are responsible for each power station under control of the Generation Department in the head office. The Dam Maintenance Office under the Generation Department is responsible for maintenance of each dam.

It has been noted that the diesel generating plants in the provincial towns are operated and maintained by EDL's local service centers under EDL's jurisdiction.

(2) 115 kV Transmission Lines and Substations

The Distribution Department in the head office is responsible for managing and controlling the existing 115 kV transmission lines, substations and distribution lines of each province dividing the whole country into three areas, i.e. the North area (nine provinces except the Vientiane Capital), the Vientiane Capital (six districts) and the South area (seven provinces).

Each section of the transmission lines are operated and maintained by the following branch offices organized under the department.

a) Nam Ngum 1-Nam Leuk - Phonetong - Thanaleng- the border with Thailand, Nam Mang 3 - Khoksaad - Naxaitong, Khoksaad - Thanaleng and Nam Leuk-Pakxan 115 kV transmission lines and substations - by the Vientiane Capital branch office,

b) Thalat - Vangvieng and Hin Hip - Ban Don - Non Hai 115 kV transmission line - by Vientiane Province branch office,

c) Vangvieng - Luang Prabang 115 kV transmission line and substation - by Luang Prabang branch office,

d) Luang Prabang - Xayabury 115 kV transmission line and substation - by Luang Prabang and Xayabury branch office,

e) Nam Leak - Phonsavan 115 kV transmission line and substation - by Vientiane and Xien Khuang branch office,

f) Thakhek - Mahaxay - Nam Teun 2 115 kV transmission line and substation - by Thakhek branch office,

g) Xeset 1 - Pakse - the border with Thailand, Xeset 2 - Paksong、Ban Janxai - Bang Na – Saphaothong, Bang Na - Bang Hat 115 kV transmission line and substation - by Champasak branch offices.

Operators and maintenance staffs of each substation are responsible for daily O&M including routine checks and inspections and minor repairs of the substation facilities. The Substation Maintenance Office in the head office is responsible for large-scale repairs and purchase of spare parts.

EDL's branch offices in each province are responsible for operations and maintenance of the local HV (High Voltage), MV (Medium Voltage) and LV (Low Voltage) networks including inter-connection MV lines with the neighboring countries. It has been noted that the province-owned MV and LV networks are managed by the Department of Electricity (DOE) of each province.

4.6.2 Present O&M Manuals for Power Facilities

The power facilities of EDL's power stations, transmission lines, substations and distribution lines are operated and maintained according to instructions contained in the manuals provided at its commissioning time by the consultants and/or contractors concerned. There is no EDL official O&M manual for each power facility. EDL reported that no serious issues had occurred during actual operation and maintenance of the power facilities since the facility was commissioned, except for minor issues concerning spare materials shortage.

LV distribution systems of both EDL and provincial authorities are operated and maintained in accordance with EDL's manuals. Technical Service Office under the Distribution Department provides the standard O&M manuals for the MV and LV distribution networks.

4.6.3 Education and Training of EDL Employees

EDL operates its own training center in Vientiane City. The center provides education and training pertaining to power facilities such as power stations, substations, and distribution networks to its own employees as well as employees of provincial authorities and IPP per demand. The Center employs 22 permanent staffs and 4 fulltime trainers. The Organization of the Center as of July 2009 is shown in Figure 4.6-1. The center educates approximately 300 persons per year using model facilities for generation, substations and distribution installed in the classrooms and training facilities for transmission lines, distribution lines and the user's site installed indoors and outdoors. EDL further endeavors to upgrade its lecturers' technology through education in foreign countries; Practical training couses at existing power stations, substations and distribution lines are also scheduled in the curriculums.

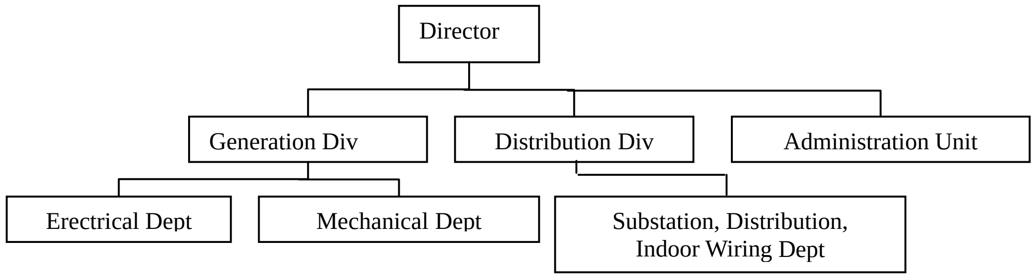


Figure 4.6-1 Organization Chart of the Training Center

There are no training courses for transmission line facilities at the Center, but practical training is conducted by experienced staff who work at each branch office. Thus, the Center plays an important role in upgrading its employees' technical knowledge pertaining to power facilities. Training courses for the Center in 2009 are shown in Table 4.6-1. Furthermore, for training purposes, a JICA senior volunteer was dispatched in September 2009 where they will direct long-term appropriate training programs for the Center's staff.

4.6.4 Costs of O&M of Transmission System

The breakdown of the O&M costs of EDL for the transmission lines and substations are not available at present. The present accounting system of EDL for its performance is prepared for each year by an EDL provincial agency. However, O&M costs of each agency were recorded as a lump sum amount including the transmission lines, substations, the MV distribution network, and the low voltage networks in its area, but not separately accounted for.

The corporate planning office of the Administration and Finance Department in the EDL head office explains that a new accounting system is to be introduced in EDL from the year 2002 and then after that more details for each performance including the O&M expenditures for each system activity will be analyzed.

Table 4.6-1 Training Course in 2009

Course	Period/Course	Contents of Training	Trainees
Comprehension of Lao Electrical Power Technical Standards (LEPTS)	1 week	Contents of LEPTS, method of design examination, method of Inspection before commencement	All EDL engineer for civil, power station, transmission, substation and distribution
Practice of substation & distribution facilities	4 week	Up gradation of maintenance skills	EDL young engineers for substation and distribution facilities
Practice of power station operators	4 weeks	Up gradation of operation skills	EDL young P/S operators
General Electrical Engineering	2 weeks	Electrical calculation method, Instllation and caliblation of power mete, etc.	EDL new employers within 3 years
IPP operatos training	12 weeks	Up gradation of IPP operation skills	Operation staff of Nam Teun 2 P/S

4.6.5 Issues of O&M for Transmission Lines and Substations

Through the team's interview to various EDL O&M sections, the following issues are found.

a) Periodical patrol and maintenance for the lines should be performed strictly in adherence of the O&M manuals to prevent preventable faults.

b) Since computer operated Distributed Control Systems (DCS) have been introduced in some substations and operation records such as the voltage, current, power factor, load, etc. are automatically logged at the substations, log sheets are recorded in handwriting at most of the substations and human errors are sometimes observed. Introducing the automatic log system and training for accurate meter reading to enhance the understanding of the equipment functions and meters in the substations by operators need to be implemented immediately.

c) Spare parts for the facilities, in particular, for distribution equipment are not sufficient for proper repair. Common parts from other damaged equipment are used for parts of other equipment for repaired.

d) EDL's official O&M manuals for transmission lines, substations and distribution lines need to be prepared promptly.

e) According to the responsible persons of EDL's repair center, the tools and meters necessary for the center are insufficient.

f) Capability of persons in charge of operations and maintenance of all fields of the power sector are necessary for upgrades.

4.7 Prioritized Porjects Selected in JICA Master Plan of Transmission Lines and Substations in 2002

The candidates of the highest prioritized project in the JICA Master Plan of Transmission Lines and Substations in 2002 were the projects shown in the following (1)-(4). The names of the substations remain the same as the original ones.

(9) "Pakxan SS ~ Thakhek SS ~ Pakbo SS" were selected as the highest prioritized project. It has been promoted and is now under construction through a Japanese government loan. Among the remaining candidates from (1) to (8) and (10) to (14), (1), (2), (3), (4), (6), (12) has been already completed. (5) and (10) are scheduled to be completed in 2009.

(8) is now under construction and scheduled to be completed in 2010.

The construction of (13) and (14) have been already started and a portion of the projects has been completed. The original plan of connecting to the Pakson substation has been revised to the plan minus connection to Palson.

(7) “Thalat SwS - Vangvieng SS” has been changed to the plan of constructing the transmission line of the “Hin Heup-Vangvieng SS. Fund sources are still pending. The fund sources of (11) “Kengkok SS - Xepon SS” has not yet been determined.

As stated above, all the candidates of the highest prioritized project in JICA Master Plan of Transmission Lines and Substations in 2002 has been completed or under construction except “Hin Heup - Vangvieng SS” and “Kengkok SS - Xepon SS”.

Table 4.6-2 Candidates of the Highest Prioritized Project in JICA Master Plan of Transmission Lines and Substations in 2002

	Projects	Status in year 2009
(1)	Xieng Nguen SwS ~ Xayaboury SS	Completed
(2)	Thalat SwS ~ Ban Dong SS ~ Non Hai SS	Completed
(3)	Nam Leuk PS ~ Phonsavan SS	Completed
(4)	Pakbo SS ~ Kengkok SS	Completed financed by WB
(5)	Thakhek SS ~ Nam Theun 2 PS	Scheduled to be completed in 2009
(6)	Nam Mang 3 PS ~ Lakxaosi SS ~ Thanaleng SS	Completed financed by China
(7)	Thalat SwS ~ Vangvieng SS	Changed to Hin Heup – Vanvieng SS Financial sources not yet determined
(8)	Luang Prabang SS ~ Oudomxai SS	Scheduled to be completed in 2010
(9)	Pakxan SS ~ Thakhek SS ~ Pakbo SS	Construction already started financed by Japan
(10)	Nam Theun 2 PS ~ Xaibouathong SS	Scheduled to be completed in 2009
(11)	Kengkok SS ~ Xepon SS	Construction not yet started Financial sources not yet determined
(12)	Lakpet SwS ~ Ban Boun SS ~ Thakho SS	Completed financed by India
(13)	Xeset 2 PS ~ Pakson SS	Construction already started
(14)	Xeset 2 PS ~ Xeset 1 PS	Construction already started

Chapter 5
Conceptual Design

Chapter 5 Conceptual Designs

5.1 Basic Design Criteria

5.1.1 National Standards and Regulations

National technical standards, regulations or codes for electric facilities in Lao PDR have been issued as ministerial ordinances as stated in Section 3.6.2. They are the 2004 “Lao Electric Power Technical Standards (LEPTS)”, the 2007 “Guideline on Operating and Managing LEPTS” and the 2007 “Safety Rules for Operation and Maintenance”. The Team determines various criteria and design conditions of the recommended systems and facilities for the national power networks on the basis of information received from the LEPTS and the international standards such as IEC.

5.1.2 Climatic Conditions

Climatic conditions were applied to the conceptual design of the national transmission system are as seen below

(1) Atmospheric Temperature

Maximum air temperature: 45 ℃
Minimum air temperature: 0 ℃
Annual mean air temperature: 25 ℃

(2) Air Density

0.12 kgf・s^2/m^4

(3) Wind Velocity (Conformity to LEPTS)

10 minutes mean wind velocity is 35 m/s at 10 m height

(4) Wind Pressure (Conformity to LEPTS)

Conductor: 790 N/m^2
Insulator string: 1,100 N/m^2
Tower: 2,290 N/m^2

(5) Stringent (the most severe design) Condition and EDS (Every Day Stress) Condition

The conditions were determined as follows.

Condition	Temperature	Wind
Stringent	10 ℃	35 m/s
EDS	25 ℃	Still air

(6) Maximum Annual Rainfall

4,000 mm based on the actual circumstances in Laos

(7) Isokeraunic Level (IKL)

140 days based on the actual circumstances in Laos

(8) Seismic Condition

The International Seismological Center in Berkshire, UK reports that Lao PDR is not a seismically active country. For transmission line towers, the wind load is usually heavier than the seismic load. Therefore, it is not necessary to take into consideration seismic loads at the structural design stage.

(9) Other Conditions Assumed
Maximum humidity: 100%
Pollution level: Light

5.1.3 Design Particulars for Transmission Lines

Design particulars applied to the conceptual design of the transmission line of the Project are mentioned below.

(1) Conductors
Conductor for the transmission lines under the study is the Aluminum Conductor Steel Reinforced (ACSR) pursuant to the IEC standard 61089, which has been employed and planned for use in the HV lines in the Lao PDR. Since contamination by salt and/or other chemical substances is not expected in the country, the standard ACSR has been deemed appropriate. Conductors for the planned lines were selected from the internationally available sizes as examined in the system analysis in Section 5.2.1.

(2) Overhead Ground-Wires
Galvanized steel stranded wire (GSW) and aluminum clad stranded wire (AC) complying with the IEC 60189 were selected as the overhead earthwires for all the lines. Optical fiber ground-wire (OPGW) complying with the IEC60794-4-1may be selected, if necessary.

(3) Insulators
Standard disc type insulators of porcelain are utilized for transmission lines of up to 230 kV. The insulators adopted are to comply with the latest IEC 60120, IEC 60305, IEC 60372, IEC 60383 and IEC 60437.

(4) Towers
Towers are of self-supporting and broad base lattice type steel towers with concrete foundations. Materials are to comply with the latest ISO 630 or JIS G3101 and shall be hot-dip galvanized.

(5) Safety Factors
Required minimum safety factors for facilities of transmission lines were determined as follows.

(a) Conductor/Ground-Wire
- 2.5 to UTS (Ultimate Tensile Strength) for stringent condition
- 5.0 to UTS for EDS condition at supporting point

(b) Insulator string
- 2.5 to RUS (Rated Ultimate Strength) for maximum working tension at supporting point

(c) Tower
- 1.5 to yield strength of material under Normal Condition (= stringent condition)
- 1.0 to yield strength of material under Broken-wire Condition (= normal condition + one ground-wire or one phase conductor breakage)

(d) Foundation
- 2.0 under Normal Condition

- 1.33 under Broken-wire Condition

5.1.4 Design Particulars for Substation Equipment

LEPTS and IEC standards are applied to the design of new and/or reinforcement of substation equipment.

(1) Insulation Co-ordination

IEC-60071[1] and IEC-60694[2] are applied to the insulation design of the substation equipment as shown in the table below. The minimum clearance values listed in the table have been extracted from the LEPTS.

Table 5.1-1 Insulation Co-ordination

Nominal system voltage	230 kV	115 kV	34.5 kV	22 kV
Rated Frequency	50 Hz	50 Hz	50 Hz	50 Hz
Rated voltage (r.m.s. value) (Highest voltage for equipment)	245 kV	123 kV	40.5 kV	24 kV
Rated short-duration power frequency withstand voltage (r.m.s. value)	395 kV	230 kV	80 kV	50 kV
Rated lightning impulse withstand voltage (peak value)	950 kV	550 kV	190 kV	125 kV
Minimum clearance, line-to-earth (*)	1,900 mm	1,100 mm	350 mm	270 mm
Minimum clearance, phase-to-phase (*)	2,450 mm	1,400 mm	450 mm	350 mm

(*): IEC TC99 and LEPTS

(2) Standards Applied to Equipment Designs

The following latest and relevant IEC standards/recommendations have been applied to the design of the substation equipment.

Table 5.1-2 Standards Applied to the Design

Equipment	Standard Applied	
Transformers	IEC-60076:	Power transformers
Circuit breakers	IEC-60056:	High voltage alternating-current circuit breakers
Disconnectors	IEC-60129:	Alternating current disconnectors and earthing switches
Current Transformers	IEC-60185:	Current transformers
Voltage Transformers	IEC-60186:	Voltage transformers
Lightning Arresters	IEC-60099:	Surge arresters

5.2 Preliminary Design of 115 kV Transmission Lines

In order to examine the optimum transmission system and to estimate the appropriate construction costs of the planned transmission lines, the preliminary design of the 115 and 230 kV transmission line was carried out based on the flow on Figure 5.2-1. Climatic conditions and route selection were examined and summarized in Sub-section 5.1.2. The examinations of each element were achieved on the basis of design criteria discussed in Sub-section 5.1.3. The results of the element examinations are detailed in the succeeding sections together with the preliminary estimated quantities of 115 and 230 kV transmission lines. It has been noted that the design elements discussed in this Section will also be applied to the preliminary design for the highest priority project.

[1] IEC-60071: Insulation co-ordination

[2] IEC-60694: Common Specification for high-voltage switchgear and control gear standards

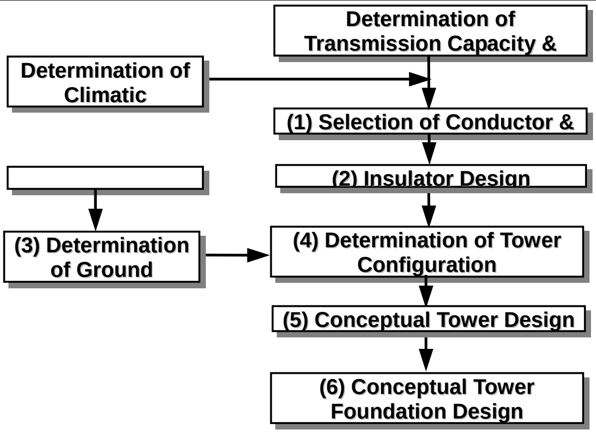


Figure 5.2-1 Flow of Preliminary Design of 115 and 230 kV Transmission Line

5.2.1 Selection of Conductor and Ground-wire

The transmission capacity and voltage for each section of the national transmission network were determined in collaboration with the system analyses detailed in Chapter 7. The sizes of the conductors and ground wires were determined by transmission capacity and voltage, and the working tensions of the conductors and ground-wires were worked out based on local climatic conditions.

(1) Conductor and Ground-Wire

A system analysis of up to 2016 proved that the ACSR 240 mm^2 and ACSR 410 mm^2 were appropriate for the 115 kV national transmission system and the ASCR 610 mm^2 is appropriate for the 230 kV system. The technical characteristics of the conductors and ground-wire are shown in Tables 5.2-1 and 5.2-3.

Table 5.2-1 Characteristics of Conductors

Type	Conductors		
	ACSR 240 mm^2 (ASTM: Hawk)	ACSR 410 mm^2 (ASTM: Drake)	ACSR 610 mm^2 (ASTM: Bittern)
Component of stranded wires	Al: 26/3.439 mm St: 7/2.675 mm	Al: 26/4.442 mm St: 7/3.454 mm	Al: 45/4,270 mm St: 7/2,847 mm
Total area of aluminum wires	280.8 mm^2	468.6 mm^2	689.0 mm^2
Overall diameter	21.78 mm	28.13 mm	34.16 mm
Weight	976.5 kg/km	1,628 kg/km	2,133 kg/km
Ultimate tensile strength	86.7kN	140.1kN	151.9 kN
Modulus of elasticity	82,000 N/ mm^2	82,000 N/ mm^2	189,300 N/ mm^2
Coefficient of linear expansion	19.0*10^{-6}/℃	19.0*10^{-6}/℃	11.5*10^{-6}/℃
DC resistance at 20℃	0.1196 Ω/km	0.07167 Ω/km	-

Table 5.2-2 Characteristics of Ground-Wires

Type	Ground Wires		
	GSW 50 mm^2 (ASTM: GSW 3/8)	AC 70 mm^2 (ASTM: A220)	OPGW 70 mm^2 (ASTM: Type A)
Component of stranded wires	St: 7/3.05 mm	AC: 7/3.5 mm	AC: 8/3.2 mm OP unit: 1/5.0
Total area of solid wires	51.05 mm^2	67.35 mm^2	77.89 mm^2
Overall diameter	9.144 mm	10.5 mm	11.4 mm
Weight	406 kg/km	426.5 kg/km	470.1 kg/km
Ultimate tensile strength	48.1 kN	77.3 kN	80.2 kN
Modulus of elasticity	189,300N/ mm^2	149,000N/ mm^2	142,000N/ mm^2
Coefficient of linear expansion	11.5x10^{-6}/℃	12.9*10^{-6}/℃	13.8x10^{-6}/℃
DC resistance at 20℃	-	1.12 Ω/km	0.834 Ω/km

(2) Allowable Current of Conductors

The allowable current of the conductor was computed from the "CIGRE WG 22.12; The Thermal Behaviour of Overhead Conductors (1992)" under the following climatic conditions.

- Heat absorption of conductor: 1,100 W/m^2
- Wind velocity: 0.6 m/s
- Conductor temperature: 80 ℃
- Ambient temperature: 45 ℃
- Allowable current:
  - ACSR 280 mm^2 (Hawk): 484 A
  - ACSR 470 mm^2 (Drake): 680 A
  - ACSR 690 mm^2 (Bittern): 840 A

(3) Safety Factors of Conductors and Ground-Wires

Maximum working tensions of conductors were computed from the following safety factors. The same safety factors were also applied to ground-wires.

Table 5.2-3 Minimum Safety Factors of Conductors and Ground-Wires

Loading condition	Wind velocity	Wind pressure	Conductor temperature	Safety factors
Stringent condition	35 m/sec	790 N/m^2	20 ℃	2.5（40%UTS）
EDS condition	0 m/sec	0 N/m^2	25 ℃	5.0（20%UTS）

(4) Maximum Working Tension and Every Day Stress (EDS) of Conductors and Ground-Wires

Table 5.2-4 Maximum Working Tension and Every Day Stress (EDS) of Conductors

Conductor Size (Code Name)	ACSR 240 mm^2 (ASTM: Hawk)	ACSR 410 mm^2 (ASTM: Drake)	ACSR 610 mm^2 (ASTM: Bittern)
Ultimate Tensile strength	86.7 kN	140.1 kN	151.9 kN
Maximum tension (SF=2.5)	Under 34.7 kN	Under 56.0 kN	Under 60.8 kN
EDS (SF=5.0)	Under 17.3 kN	Under 28.0 kN	Under 30.4 kN

Table 5.2-5 Maximum Working Tension and Every Day Stress (EDS) for Ground-Wires

Ground-Wires Type (Code Name)	GSW 50 mm^2 (ASTM: GSW 3/8)	AC 70 mm^2 (ASTM: A220)	OPGW 70 mm^2 (ASTM: Type A)
Ultimate Tensile Strength	48.1 kN	77.3 kN	80.2 kN
Maximum tension (SF=2.5)	Under 19.2 kN	Under 30.9 kN	Under 32.1 kN
EDS (SF=5.0)	Under 9.6 kN	Under 15.5 kN	Under 16.0 kN

(5) Sags and Tensions of Ground-Wires

Sags of ground-wires under EDS conditions must be below 80% of the conductors' sag at the standard span length for avoiding a reverse flashover from the ground-wire to the conductors and/or a direct lightning stroke to the conductors. The tensions of the ground wires were determined to satisfy the safe separation of conductors and ground-wires in the mid-span

(6) Standard Span Length

The standard span length of 115 and 230 kV transmission lines between towers was assumed to be 350 m.

5.2.2 Insulator Design

(1) Insulator Type and Size

(a) Type
Insulator unit applied to the transmission lines is a standard disc type porcelain insulator with a ball and socket, complying with IEC 60305.

(b) Size

Table 5.2-6 Insulator Size

Size	Height	Diameter	R.U.S. (*)
250 mm disc	146 mm	255 mm	120 kN (for ACSR 280 mm^2) 160 kN (for ACSR 470 mm^2 and ACSR 690 mm^2)

(*: RUS: Rated Ultimate Strength)

(2) Number of Insulator Units per String

(a) Pollution Level
Since the atmosphere in the country is not much polluted, the pollution level was assumed to be "Light" classified in the IEC 60071-2 (Table I). 115 and 230 kV lines require a creepage distance/phase to phase voltage for the level is 16 mm/kV for the "Light".

(b) Standard Lightning Impulse Withstandable Voltage
Standard Lighting Impulse withstandable voltage for 115 kV equipment is 550 kV and the minimum clearance at 550 kV is 1,100 mm as classified in IEC 60071-2.

Standard lighting impulse withstandable voltage for 230 kV equipment is 1,050 kV and the minimum clearance at 1,050 kV is 2,100 mm as classified in IEC 60071-2.

(c) Number of Insulator Units per String
For 115 kV, from the necessary creepage distance of insulators, number of insulator units per string of the standard set needs 7 units. While, from the standard lightning impulse withstandable voltage, the number of insulator units per string of the standard set needs 8 units. Therefore, number of insulator units per string for a 115 kV line was determined to be 10 units by alloting 2 units for maintenance.

For 230 kV, from the necessary creepage distance of insulators, the number of insulator unit per string of the standard set needs 12 units. While, from the standard lightning impulse withstandable voltage, the number of insulator units per string of the standard set needs 14 units. Therefore, the number of insulator units per string for a 230 kV line was determined to be 16 units by alloting 2 units for maintenance. The standard insulator sets applied for the existing and planned 230 kV lines in the Lao PDR have also 10 units per string.

(3) Mechanical Strength of Insulator

(a) Safety Factors of Insulator:
Mechanical strengths of insulator sets were determined so as to satisfy the following minimum safety factors.

Table 5.2-7 Minimum Safety Factors of Insulator Sets

Loading condition	Safety factors
Stringent condition	2.5（40%RUS）

(b) Number of Insulator Strings per Set:

The number of insulator strings per set is either single or double, which was determined in accordance with the line crossing places and based on the safety factors shown in Table 5.2-7.

5.2.3 Ground Clearance

It is assumed that the most severe state for the ground clearance of conductors will occur when conductor's temperature rises to 80 ℃ under still air conditions. The minimum conductor's height above ground at the 115 and 230 kV level was determined as shown below.

Table 5.2-8 Minimum Conductor's Height above Ground

Classification	115 kV	230 kV
Areas where people rarely enter or will enter, such as mountains, forests, waste fields, etc.	7.0m	8.0 m

5.2.4 Tower Configuration

Basic dimensions of suspension and tension type towers were decided in examining the conductor clearance diagrams.

(1) Insulation Design

The standard gap and the abnormal state gap for the 115 and 230 kV systems were obtained as shown below. These gap lengths are used for clearances between the conductor and tower, between conductors and between the conductor and ground wire.

Table 5.2-9 Insulation Gaps of 115 kV Line

Characteristic	Items	Values	Reasons
Voltage	Nominal voltage	115 kV	Complying with IEC60038
	Highest voltage	123 kV	Complying with IEC60038
Lightning Impulse	Length of 250 mm insulator	1,460 mm	146 mmx10 units=1,460 mm
	Arcing horn gap	1,240 mm	Insulator strings length*0.85≒1,240 mm (85% of length of insulator string)
	Standard insulation gap	1,400 mm	Arcing horn gap x 1.115≒ 1,400 mm (111.5% of arcing horn gap)
Commercial frequency	Abnormal state insulation gap	200 mm	Complying with IEC60071-1, 60071-2
	Abnormal state phase gap	400 mm	Complying with IEC60071-1, 60071-2

Table 5.2-10 Insulation Gaps of 230 kV Line

Characteristic	Items	Values	Reasons
Voltage	Nominal voltage	230 kV	Complying with IEC60038
	Highest voltage	245 kV	Complying with IEC60038
Lightning Impulse	Length of 250 mm insulator	2,336 mm	146 mmx16 units=2,336 mm
	Arcing horn gap	1,985 mm	Insulator strings length*0.85≒1,985 mm (85% of length of insulator string)
	Standard insulation gap	2,200 mm	Arcing horn gap x 1.115≒ 2,200 mm (111.5% of arcing horn gap)
Commercial frequency	Abnormal state insulation gap	400 mm	Complying with IEC60071-1, 60071-2
	Abnormal state phase gap	800 mm	Complying with IEC60071-1, 60071-2

(2) Clearance Design

(a) Clearance between the conductor and the tower

Lengths of cross-arms and the vertical separation between the cross-arms were determined from conductor clearance diagrams by applying the figures in Tables 5.2-9, 5.2-10 as illustrated in Figure 5.2-2.

Table 5.2-11 Swinging Angle of Conductor and Applied Clearance

Wind Velocity	10 m/sec	35 m/sec
Swinging angle of conductor	10 deg	60 deg.
Applied clearance	Standard clearance	Abnormal clearance

Table 5.2-12 Values of Clearance Diagram for 115 kV Tower

Tower type	Item	Formulas and values
Suspension tower	Insulator assembly length	146 mmx10units+500 mm(Assembly length) ≒2,000 mm
Tension tower	Jumper conductor depth	1,240 mm (Arcing horn length)x1.2 + 100 mm (Margin for changing the shape of jumper conductor)≒1,600 mm
Suspension and tension tower	Standard clearance (Swinging angle 10 deg)	1,400 mm (Standard insulation gap) + 150 mm (Step bolts length) = 1,550 mm
	Abnormal clearance (Swinging angle 60 deg)	200 mm (Abnormal state insulation gap) + 150 mm (Step bolts length) = 350 mm

Table 5.2-13 Values of Clearance Diagram for 230 kV Tower

Tower type	Item	Formulas and values
Suspension tower	Insulator assembly length	146 mmx16units+500 mm(Assembly length) ≒2,840 mm
Tension tower	Jumper conductor depth	1,985 mm (Arcing horn length)x1.2 + 100 mm (Margin for changing the shape of jumper conductor)≒2,500 mm
Suspension and tension tower	Standard clearance (Swinging angle 10 deg)	2,400 mm (Standard insulation gap) + 150 mm (Step bolts length) = 2,5 50 mm
	Abnormal clearance (Swinging angle 60 deg)	400 mm (Abnormal state insulation gap) + 150 mm (Step bolts length) = 550 mm

(b) Separation between the Conductors and between the Conductor and the Ground-wire

The minimum separation between the two conductors and between the conductor and ground-wire were determined to satisfy the following values when the conductors are physically swayed by the wind.

[115 kV Line]
- Between two conductors: 450 mm
  (Abnormal state phase gap; 400 mm + conductor’s diameter; around 50 mm)
- Between conductor and ground wire: 250 mm
  (Abnormal state insulation gap; 200 mm + conductor’s and ground wire’s diameter around; 50 mm)

[230 kV Line]
- Between two conductors: 850 mm
  (Abnormal state phase gap; 800 mm + conductor’s diameter; around 50 mm)
- Between conductor and ground wire: 450 mm
  (Abnormal state insulation gap; 400 mm + conductor’s and ground wire’s diameter around; 50 mm)

(3) Insulation Design of Ground-Wires
Number and shielding angle of ground-wires were determined as below:

- Number: 115 kV Line; 1, 230 kV Line; 2
- Maximum shielding angle: 1 wire; 30 deg, 2 wires; 5 deg

(4) Tower Configurations
The configurations of the following six standard types of towers were determined based on the above insulation design conditions.

Configurations of the tower for the ASCR 240 mm^2 and ACSR 410 mm^2 are similar, because these conductors' sags are almost equal as seen in Table 5.2-14.

Table 5.2-14 Typical 115 kV Tower Configurations

	115 kV*1cct		115 kV*2cct		Sag of conductors (under 80℃, still air, span length 350 m)
	Suspension (0-3 deg)*	Tension (0-15 deg)*	Suspension (0-3 deg)*	Tension (0-15 deg)*	
ACSR 240 mm^2 (Hawk)	Figure 5.2-3	Figure 5.2-4	Figure 5.2-5	Figure 5.2-6	11.2 m
ACSR 410 mm^2 (Drake)					11.6 m

*: Line horizontal deviation angle specified to towers

Table 5.2-15 Typical 230 kV Tower Configurations

	230 kV*2cct	
	Suspension (0-3 deg)*	Tension (0-15 deg)*
ACSR 610 mm^2 (Bittern)	Figure 5.2-7	Figure 5.2-8
ACSR 610 mm^2 ×2 (Bittern)		

*: Line horizontal deviation angle specified to towers

5.2.5 Preliminary Tower Design

Design conditions were determined as mentioned above, and the conceptual design of the towers was carried out. The loads from the towers to their foundations were computed.

(1) Tower Design Conditions
The following design conditions were for conceptual tower designs for the typical six standard towers as shown in Tables 5.2-14, 5.2-15.

(a) Wind Pressure
Conductor 790 N/m^2
Insulator strings 1,100 N/m^2
Tower 2,290 N/m^2

(b) Standard span length
350 m

(c) Loading conditions and safety factors

Table 5.2-16 Loading Conditions and Safety Factors

Loading conditions	Loads	Safety factor
Normal condition	Maximum load (35 m/sec)	1.5 to yield strength of material
Abnormal condition (Broken wire condition)	Maximum load + one ground wire or one phase conductor breakage load	1.0 to yield strength of material

(2) Results of preliminary tower design

Following is summary of the results of preliminary tower design.

Table 5.2-17 115 kV Tower Weights and Foundation Loads Transferred from Towers

		115 kV, 1cct		115 kV, 2cct	
		Suspension (0-3deg)	Tension (0-15deg)	Suspension (0-3deg)	Tension (0-15deg)
ACSR 240 mm^2 (Hawk)	Tower weight	4.0 t	4.8 t	4.9 t	5.8 t
	Foundation load (compression)	150 kN	250 kN	250 kN	440 kN
TACSR 240 mm^2 (T-Hawk)	Tower weight	-	-	5.6 t	6.9 t
	Foundation load (compression)	-	-	250 kN	440 kN
ACSR 470 mm^2 (Drake)	Tower weight	5.0 t	6.0 t	6.5 t	7.6 t
	Foundation load (compression)	200 kN	330 kN	330 kN	570 kN

Table 5.2-18 230 kV Tower Weights and Foundation Loads Transferred from Towers

		230 kV*2cct	
		Suspension (0-3deg)	Tension (0-15deg)
ACSR 610mm^2 (Bittern)	Tower weight	8.2 t	9.6 t
	Foundation load (compression)	400 kN	680 kN
ACSR 610 mm^2 *2 (Bittern)	Tower weight	11.9t	13.2 t
	Foundation load (compression)	600 kN	1020 kN

5.2.6 Preliminary Design of Foundation

The preliminary concrete volumes of the pad and chimney type foundations were computed under the loads from superstructures to foundations.

Such hard soil as red continental sand stones and clay spreads widely in the country, and the soil bearing capacity around the foundation was assumed to be firm, accordingly.

Table 5.2-19 Concrete Volumes of Pad and Chimney Type Foundations for 115 kV Tower

		115 kV*1cct		115 kV*2cct	
		Suspension (0-3deg)	Tension (0-15deg)	Suspension (0-3deg)	Tension (0-15deg)
ACSR 240 mm^2 (Hawk)	Tower weight	4 m^3	7 m^3	7 m^3	12.4 m^3
	Foundation load (compression)	150 kN	250 kN	250 kN	440 kN
TACSR 240 mm^2 (Hawk)	Tower weight	-	-	7 m^3	12.4 m^3
	Foundation load (compression)	-	-	250 kN	440 kN
ACSR 410 mm^2 (Drake)	Tower weight	7 m^3	7 m^3	7 m^3	12.4 m^3
	Foundation load (compression)	200 kN	330 kN	330 kN	570 kN

Table 5.2-20 Concrete Volumes of Pad and Chimney Type Foundations for 230 kV Tower

		230 kV*2cct	
		Suspension (0-3deg)	Tension (0-15deg)
ACSR 610 mm^2 (Bittern)	Tower weight	12.4 m^3	12.4 m^3
	Foundation load (compression)	400 kN	680 kN
ACSR 610 mm^2 *2 (Bittern)	Tower weight	12.4m^3	31.3m^3
	Foundation load (compression)	600 kN	1,020 kN

5.2.7 Standard Quantities of 115 kV Transmission Lines

Standard quantities of 115 and 230 kV transmission lines were estimated based on the results of the preliminary design.

(1) Assumed Number of Towers

The numbers of 115 and 230 kV towers were estimated for a typical terrain of plain and mountainous areas on the assumed 10 km line length.

Table 5.2-21 115 and 230 kV Tower Type and Tower Number per 10 km Long

	Suspension	Tension	Total	Assumption
Plain area	27 units	3 units	30 units	- Length: 10km - 90% suspension tower and 10% Tension tower - Average span length: 350 m
Mountainous area	21 units	9 units	30 units	- Length: 10km - 70% suspension tower and 30% tension tower - Average span length: 350 m

(2) Average Quantities of Line Materials

Quantities of a 115 and 230 kV transmission line per 10 km were estimated in Table 5.2-21.

(3) Work Quantities of Each Sub-Project

Work quantities of each 115 and 230 kV transmission line will be estimated in such a way as to have its route length (km) multiplied by the work quantities per km to be worked out from the above Table 5.2-22, 5.2-23.

Table 5.2-22 Average Quantities of 115 kV Transmission Lines per 10 km Long

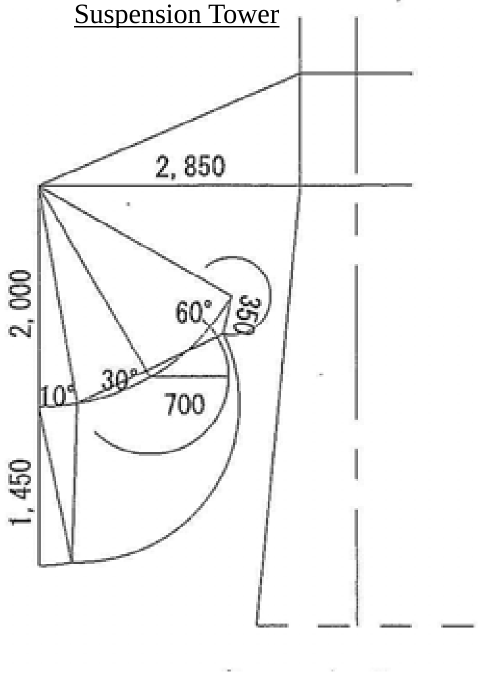
		115 kV*1cct		115 kV*2cct	
		Plain	Mountain	Plain	Mountain
ACSR 240 mm^2 (Hawk)	Tower	123 t	128 t	150 t	156 t
	Conductor	30 km	30km	60 km	60 km
	Ground wire	10 km	10 km	10 km	10 km
	Suspension insulator string	81 sets	63 sets	162 sets	126 sets
	Tension insulator string	18 sets	54 sets	36 sets	108 sets
	Foundation (Concrete volume)	140 m^3	147 m^3	227 m^3	262 m^3
TACSR 240 mm^2 (T-Hawk)	Tower	-	-	172 t	-
	Conductor	-	-	60 km	-
	Ground wire	-	-	10 km	-
	Suspension insulator string	-	-	162 sets	-
	Tension insulator string	-	-	36 sets	-
	Foundation (Concrete volume)	-	-	227 m^3	-
ACSR 410 mm^2 (Drake)	Tower	153 t	159 t	201 t	205 t
	Conductor	30 km	30km	60 km	60 km
	Ground wire	10 km	10 km	10 km	10 km
	Suspension insulator string	81 sets	63 sets	162 sets	126 sets
	Tension insulator string	18 sets	54 sets	36 sets	108 sets
	Foundation (Concrete volume)	210 m^3	210 m^3	227 m^3	262 m^3

Table 5.2-23 Average Quantities of 230 kV Transmission Lines per 10 km Long

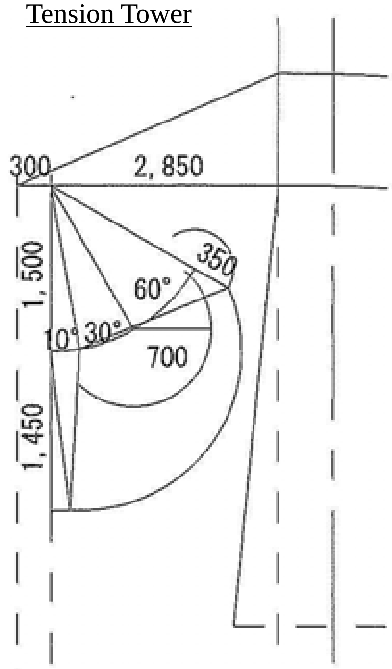
		230 kV*2cct	
		Plain	Mountain
ACSR 690 mm^2 (Bittern)	Tower	251 t	259 t
	Conductor	60 km	60 km
	Ground wire	20 km	20 km
	Suspension insulator string	162 sets	126 sets
	Tension insulator string	36 sets	108 sets
	Foundation (Concrete volume)	372 m^3	372 m^3
ACSR 690 mm^2 *2 (Bittern)	Tower	361 t	369 t
	Conductor	120 km	120 km
	Ground wire	20 km	20 km
	Suspension insulator string	162 sets	126 sets
	Tension insulator string	36 sets	108 sets
	Foundation (Concrete volume)	429 m^3	543 m^3

○115kV

Suspension Tower

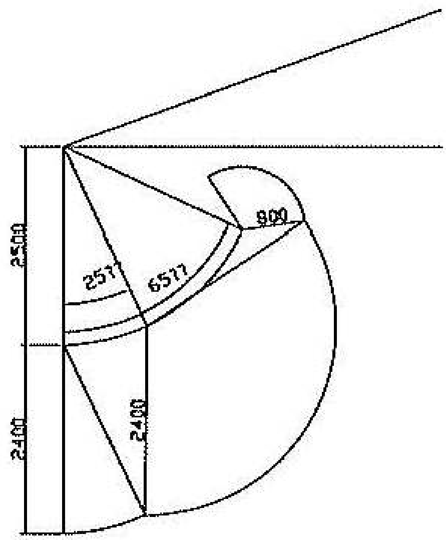


Tension Tower

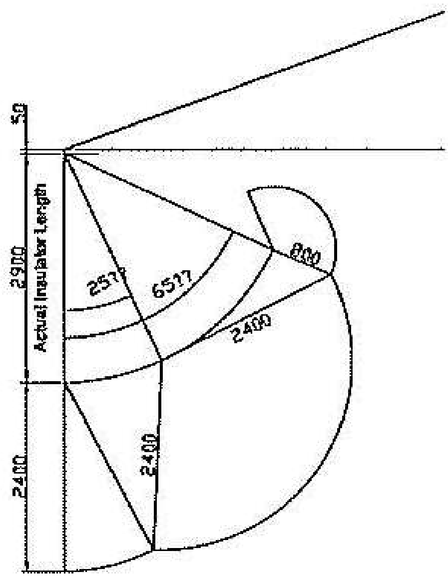


○230kV

Suspension Tower



Tension Tower



Figire5.2-2 Clearance Diagrams for 115, 230kVTransmission Lines

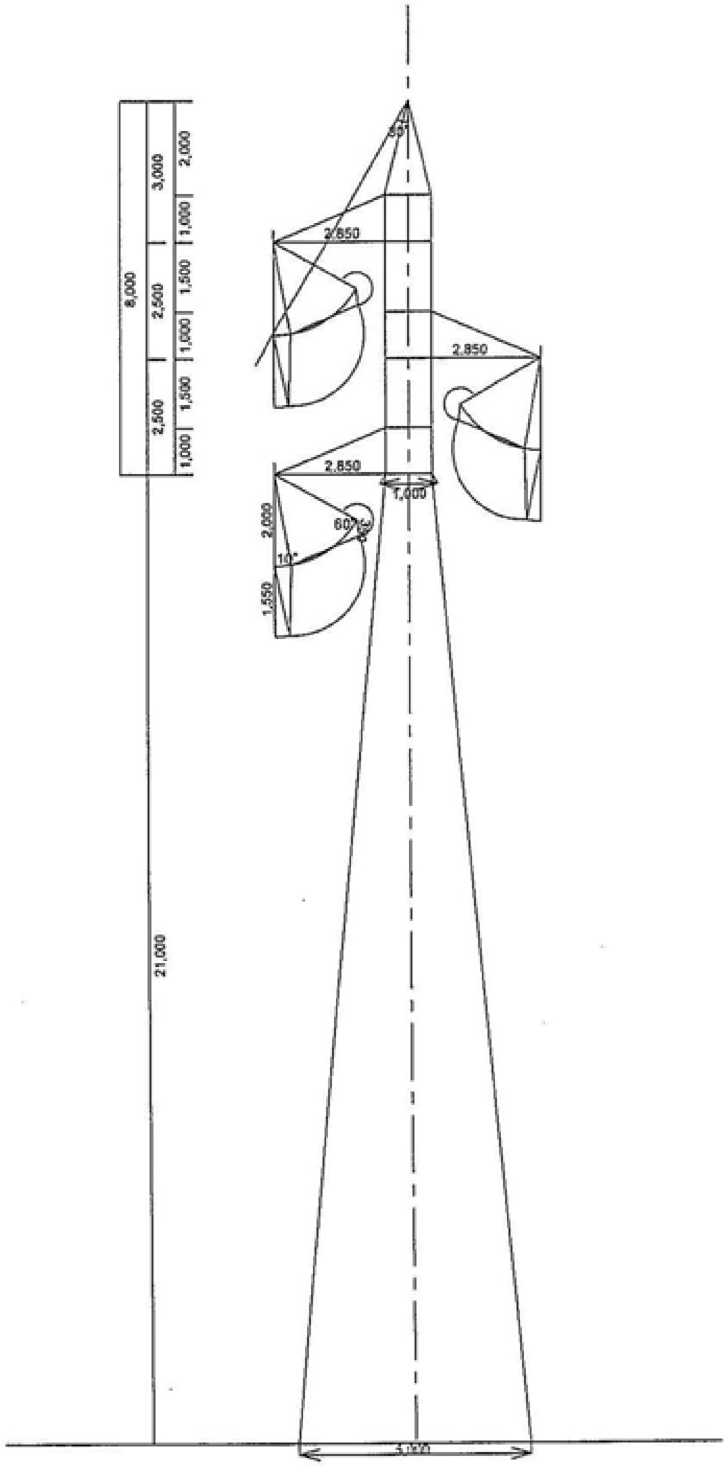


Figure 5.2-3 115kV, 1cct: ACSR 280 sq.mm, 470 sq.mm, Suspension Tower (Horizontal Angle: 0-3 deg.)

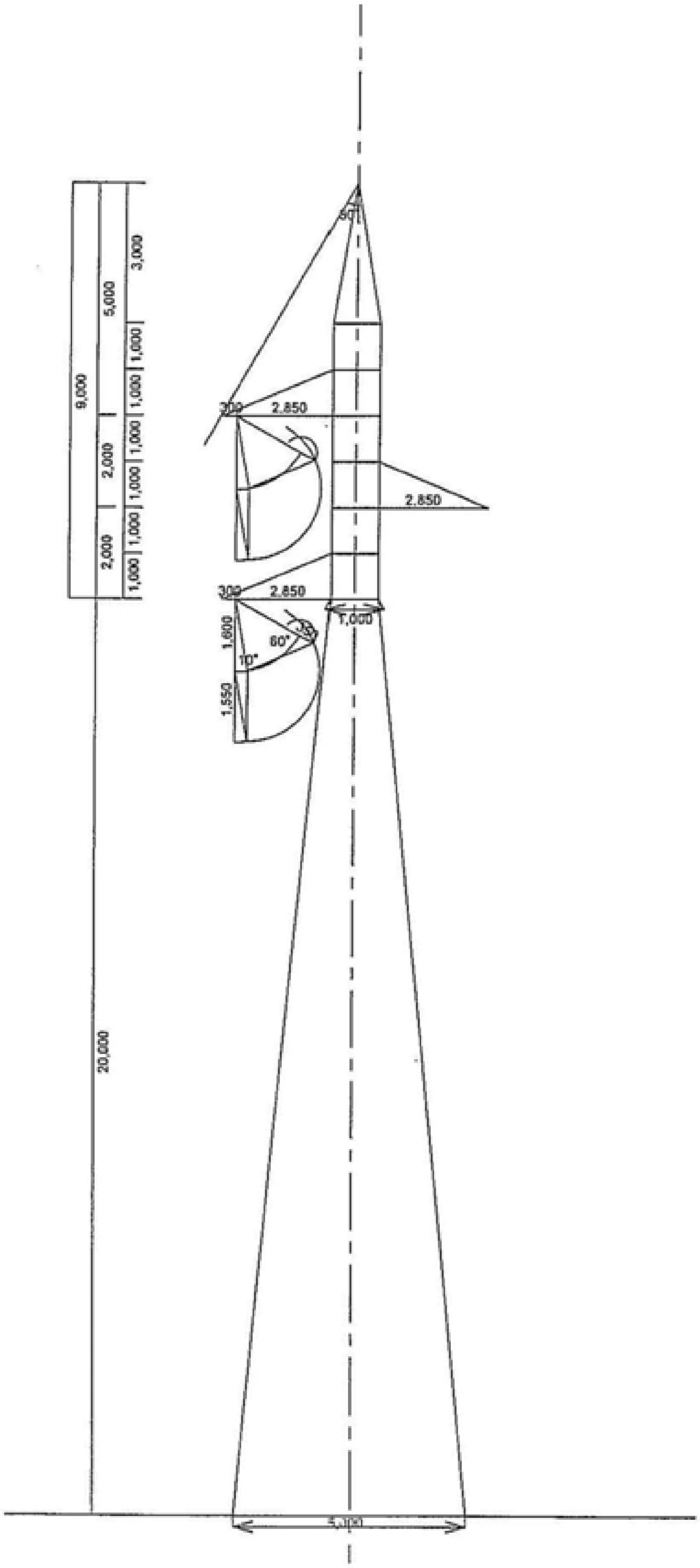


Figure5.2-4 115kV, 1cct: ACSR 280 sq.mm, 470 sq.mm, Tension Tower (Horizontal Angle: 0-15 deg.)

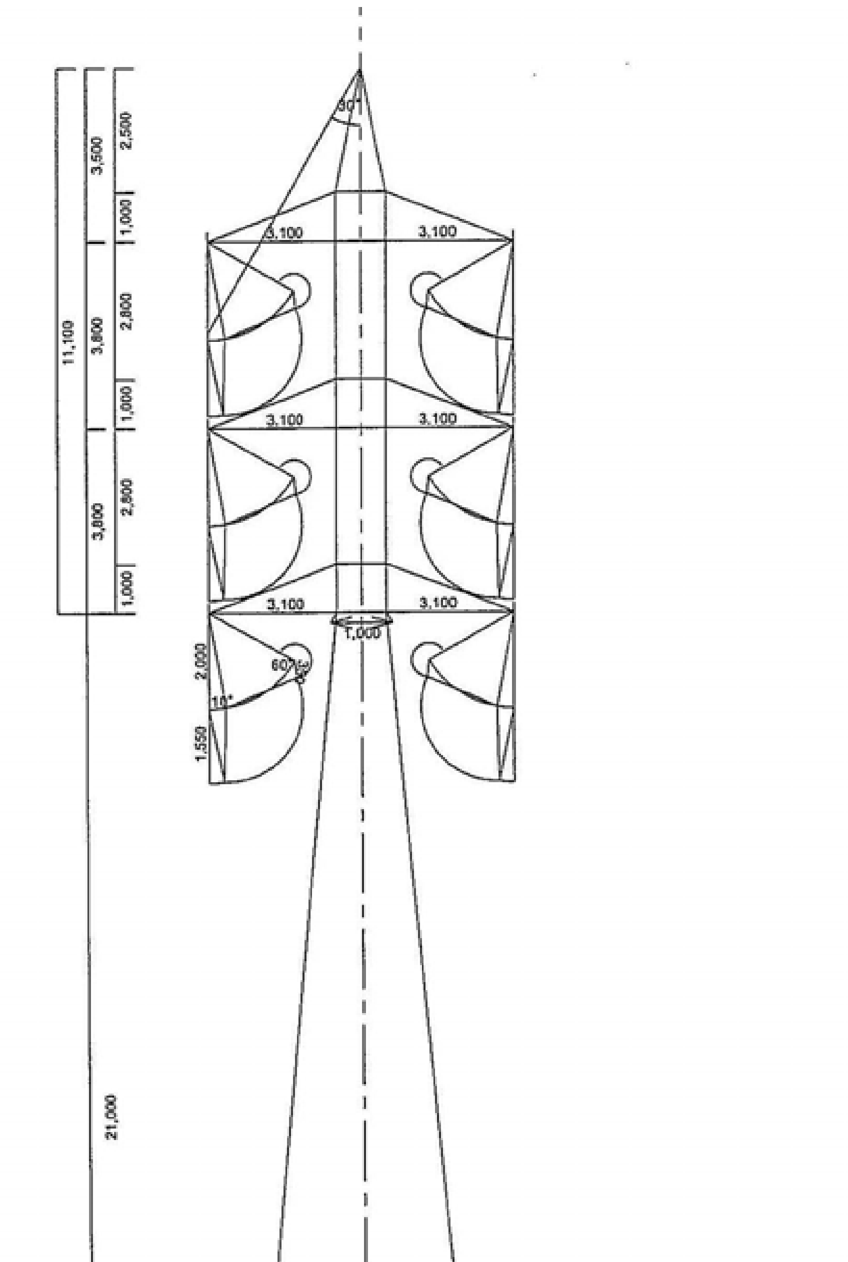


Figure 5.2-5 115kV, 2cct: ACSR 280 sq.mm, 470 sq.mm, Suspension Tower (Horizontal Angle: 0-3 deg.)

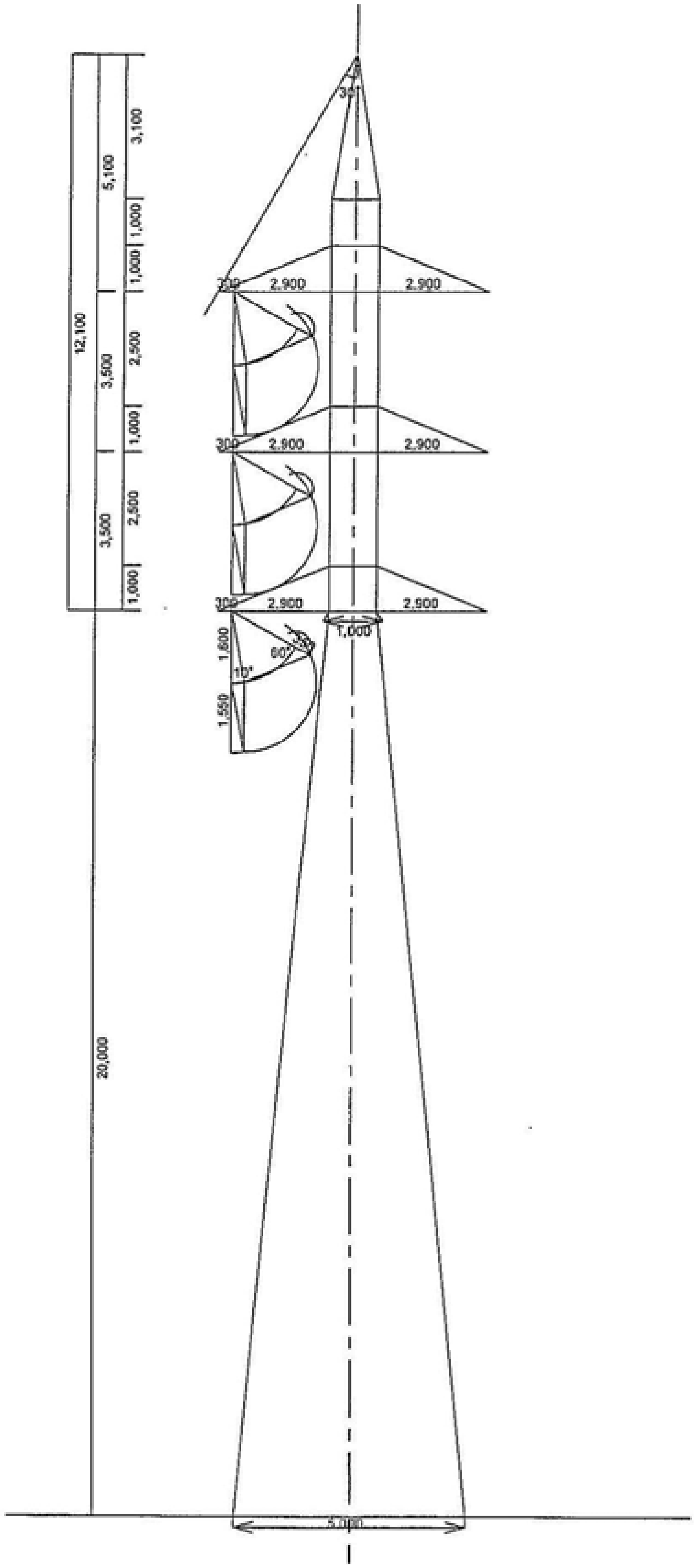


Figure 5.2-6 115kV, 2cct: ACSR 280 sq.mm, 470 sq.mm, Tension Tower (Horizontal Angle: 0-15 deg.)

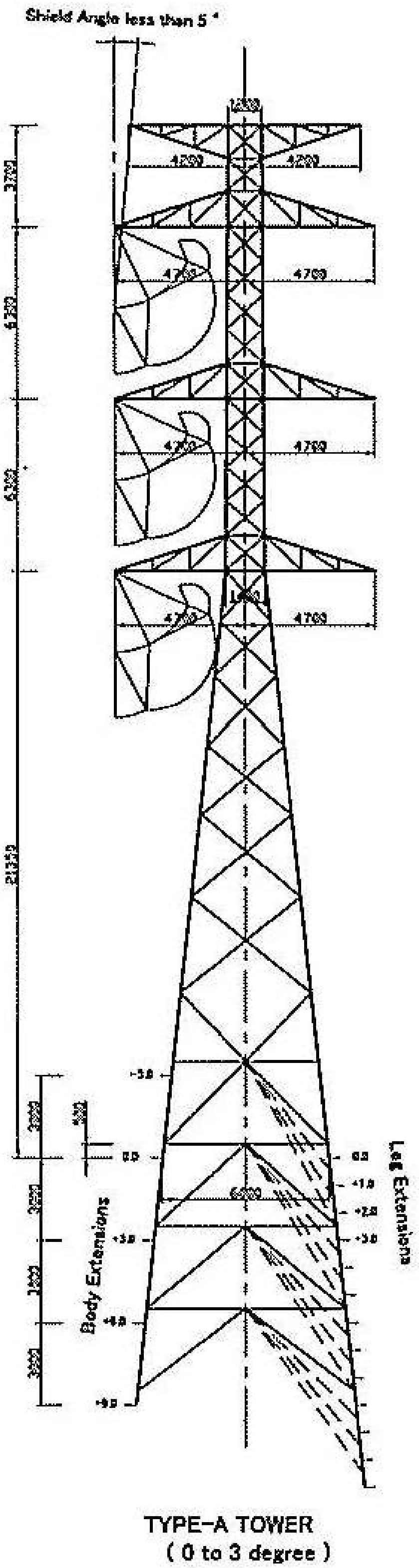


Figure 5.2-7 230kV, 2cct: ACSR 690 sq.mm, Suspension Tower (Horizontal Angle: 0-3 deg.)

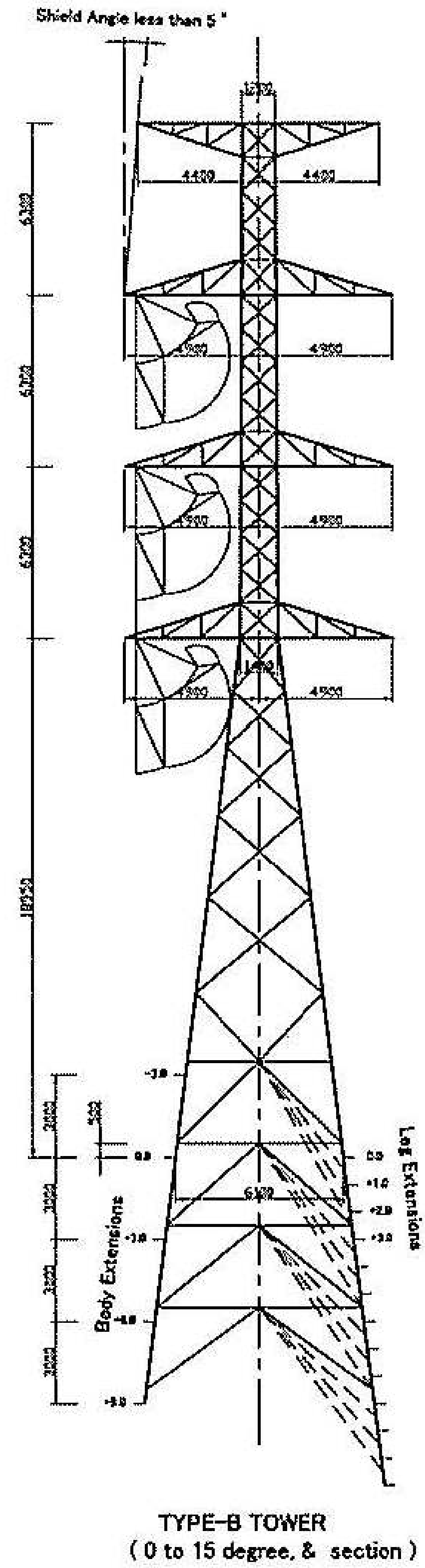


Figure 5.2-8 230kV, 2cct: ACSR 690 sq.mm, Tension Tower (Horizontal Angle: 0-15 deg.)

5.3 Design Example of 500 kV Transmission Line Facilities in Laos

Since the construction costs of 500 kV transmission lines vary contigent on topographic and environmental conditions of the areas of passage, optimum designs should be carried out by each facility. The design example of the 500 kV Nam Teun 2 line is introduced in this paragraph.

This IPP line was designed in accordance with EGAT standards, because the design was already started before 2004, which was the year of LEPTS legislation.

5.3.1 Conductor and Ground Wire Design

(1) Conductors and Ground-wire

ACSR 410 mm^2 (Condor), four bundles for the conductor, GSW 80 mm^2 and OPGW 80 mm^2 for ground-wire are applied for to this project. The technical characteristics of the conductor and ground-wire are shown in Tables 5.3-1 and 5.3-2.

Table 5.3-1 Technical Characteristics of Conductor

Type	ACSR 410 mm^2 (ASTM: Condor)
Component of stranded wires	Al: 54/3.08 mm St: 7/3.454 mm
Total area of aluminum wires	454.95 mm^2
Overall diameter	27.72 mm
Weight	1,524 kg/km
Ultimate tensile strength	125.4 kN
Modulus of elasticity	66,600 N/ mm^2
Coefficient of linear expansion	21.3*10^{-6}/℃
DC resistance at 20℃	0.0719 Ω/km

Table5.3-2 Technical Characteristics of Ground-wire

Type	GSW 80 mm^2	OPGW 80 mm^2
Component of stranded wires	St: 7/3.683 mm	27AC: 7/3.8 mm OP unit: 1/5.2
Total area of solid wires	74.57 mm^2	79.38 mm^2
Overall diameter	11.05 mm	12.8 mm
Weight	594 kg/km	528.5 kg/km
Ultimate tensile strength	64.5 kN	73.6 kN
Modulus of elasticity	147,000 N/ mm^2	132,200 N/ mm^2
Coefficient of linear expansion	15.0x10^{-6}/℃	14.1x10^{-6}/℃
DC resistance at 20℃	-	0.619 Ω/km

(2) Safety Factors of Conductor and Ground-wire

The maximum working tensions of the conductors were computed from the following safety factors. The same safety factors were also applied to ground-wires.

Table 5.3-3 Minimum Safety factors of Conductors and Ground-Wires

Loading condition	Conductor temperature	Safety factors
Stringent condition	26 ℃	2.43 （41%UTS）
EDS condition	26 ℃	4.55 （22%UTS）

(3) Standard Span Length

The standard span length between towers applied was 450 m.

5.3.2 Insulator Design

(1) Insulator Type and Size

(a) Type

The insulator unit applied to the transmission lines is a standard disc type porcelain insulator with ball and socket and is in compliance with the IEC 60305.

(b) Size

Table 5.3-4 Insulator Size

Size	Height	Diameter	R.U.S. (*)
280 mm disc	146 mm	280 mm	160 kN

(*: RUS: Rated Ultimate Strength)

(2) Number of insulator units per String

(a) Pollution level

Since the country’s atmosphere is relatively free of pollution, the pollution level was assumed to be “Light” classified in the IEC 60071-2 (Table I). For 115 and 230 kV lines, the required creepage distance/phase to phase voltage for the level is 16mm/kV for the “Light”.

(b) Number of insulator unit per string

For the suspension tower, the number of insulator units per string of the standard set applies to 27 units. While, for the tension tower, the number of insulator units per string of the standard set applied 29 units, considered over lap by arcing horns.

(3) Mechanical strength of insulator

(a) Safety factors of insulator:

The mechanical strength of the insulator sets were determined so as to satisfy the following minimum safety factors.

Table 5.3-5 Minimum Safety Factors of Insulator Sets

Loading condition	Safety factors
Stringent condition	2.5（40%RUS）

(b) Number of insulator strings per set:

Number of insulator string per set is either single or double, which was determined in accordance with the line crossing places and based on the safety factors shown in Table 5.3-5.

5.3.3 Ground Clearance

Minimum conductor’s height above ground level was applied as below when conductor’s temperature rises 75 ℃ under still air conditions.

Table 5.3-6 Minimum Conductor's Height above Ground

Classification	500 kV
Areas where people rarely enter or will enter, such as mountains, forests, waste fields, etc.	9.5 m

5.3.4 Tower Configuration

(1) Clearance Design

Clearance design was carried out in accordance with EGAT Standards.

Table 5.3-7 Swinging Angle of Conductor and Applied Clearance

Wind Velocity	10 m/sec	35 m/sec
Swinging angle of conductor	14 deg	58 deg.
Applied clearance	Standard clearance	Abnormal clearance

Table 5.3-8 Values of Clearance Diagram for Tower

Tower type	Item	Values
Suspension tower	Insulator assembly length	5,047 mm
Tension tower	Jumper conductor depth	4,498 mm
Suspension and tension tower	Standard clearance (Swinging angle 14 deg)	4,000 mm
	Abnormal clearance (Swinging angle 58 deg)	1,300 mm

(2) Insulation Design of Ground-Wires

Number and shielding angle of ground-wires were determined as below:

Number: 2

Maximum shielding angle: 0 deg

(3) Tower Configurations

Configurations of the suspension tower (Applied horizontal angle; 0-5 deg) and the tension tower (Applied horizontal angle; Under 15 deg) are shown on Figs 5.2-1 and 5.2-2.

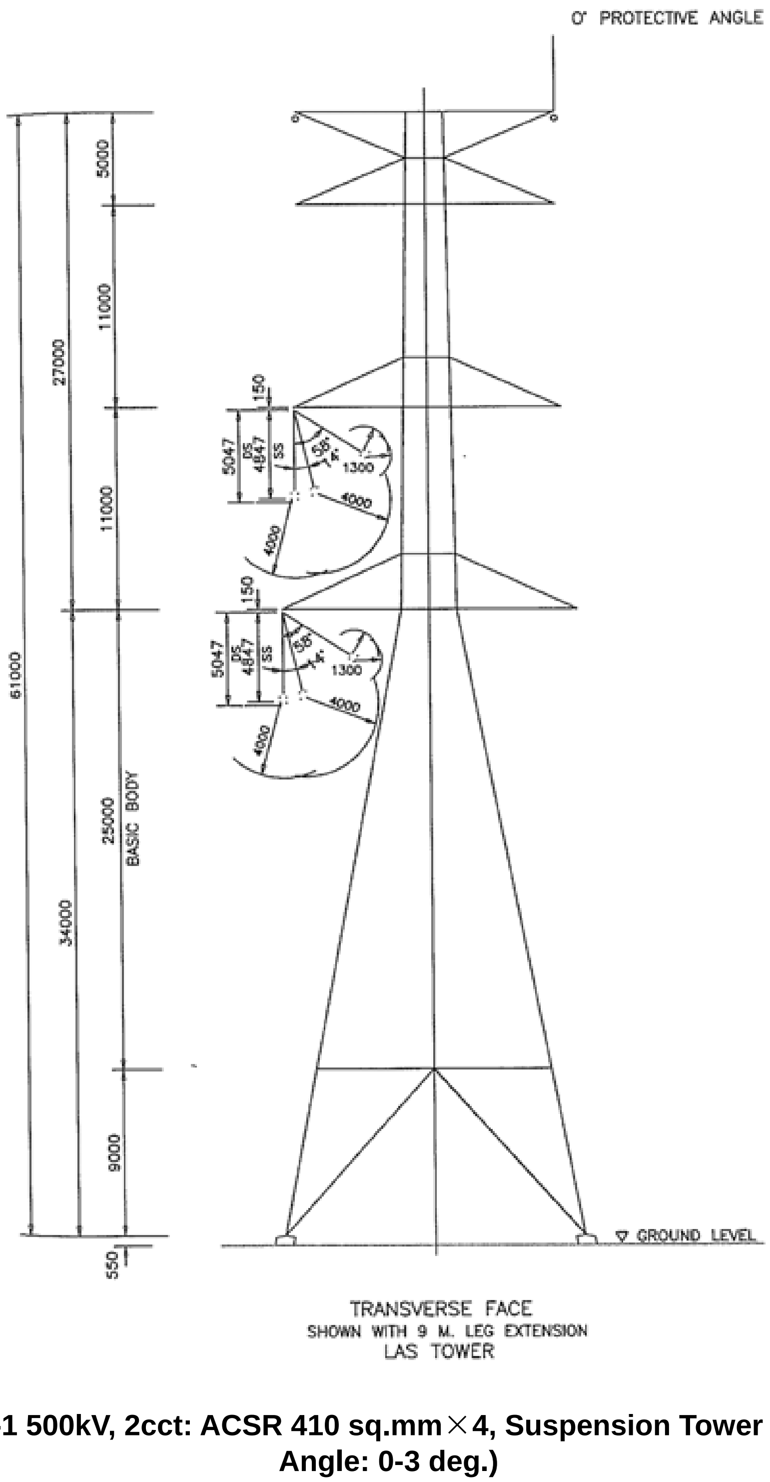


Figure 5.3-1 500kV, 2cct: ACSR 410 sq.mm×4, Suspension Tower (Horizontal Angle: 0-3 deg.)

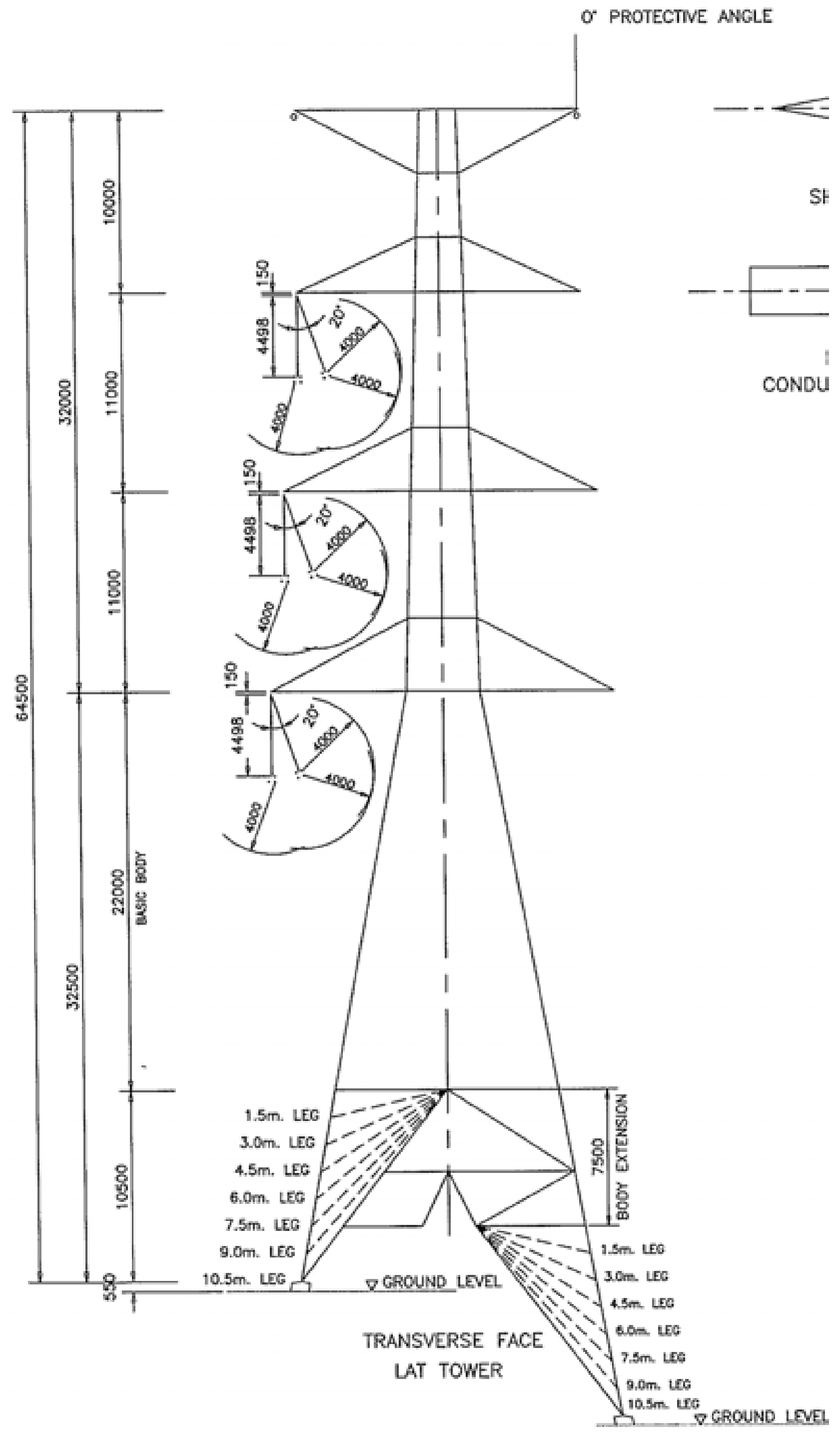


Figure 5.3-2 500kV, 2cct: ACSR 410 sq.mm×4, Tension Tower (Horizontal Angle: 0-15 deg.)

5.3.5 Foundation Configuration

Examples of foundation configulation are shown on Fig. 5-3.3 Most of the foundations were of the applied pad type, but some of them were of the applied pile type at weak-soil condition areas whose soil bearing capacity was under 250 kN.

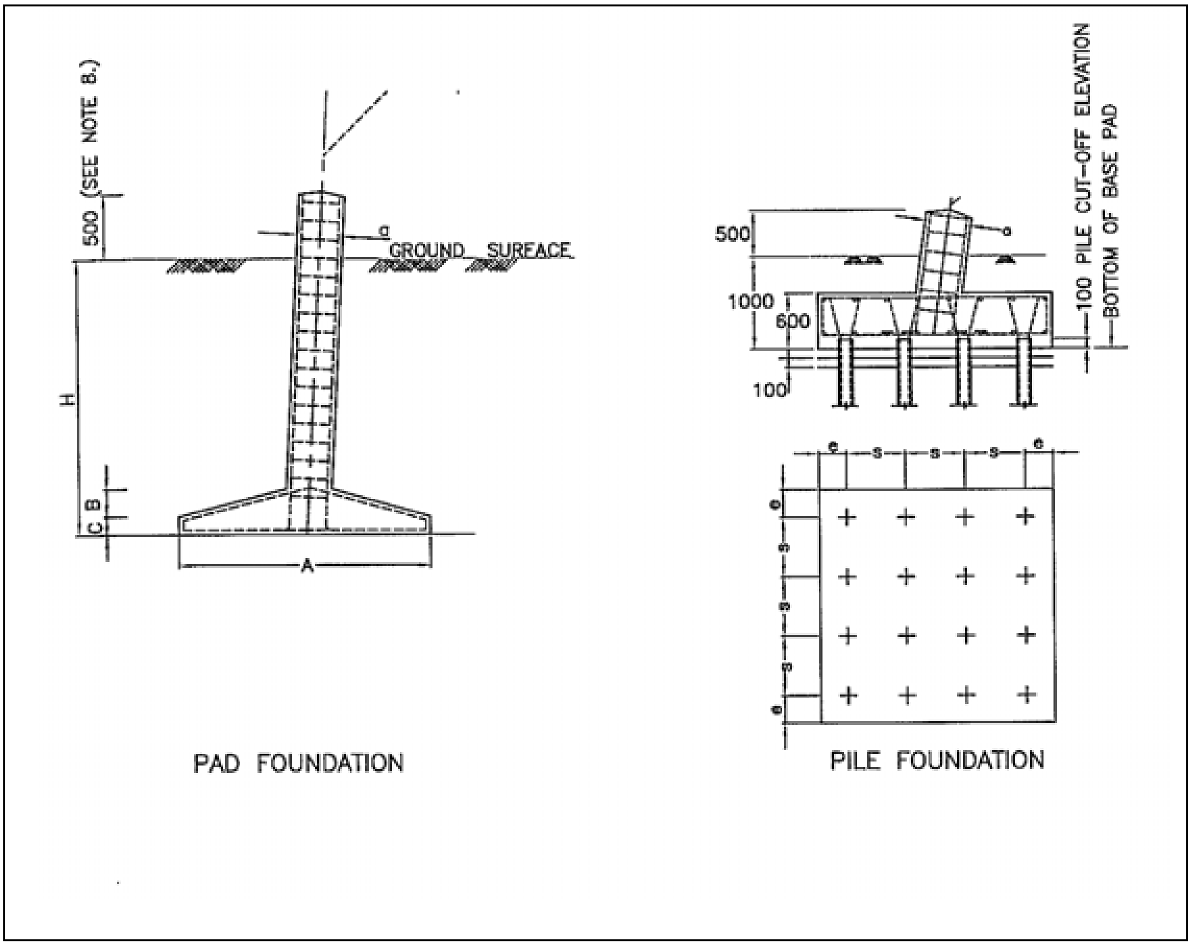


Figure 5.3-3 500kV, Tower Foundation (Pad and Pile Type)

5.4 Preliminary Design of Substations

This preliminary design is carried out for the planning of new 230 kV and 115 kV substations and reinforcement/augmentation of the existing substations of the Optimum Transmission System. Upon the agreement with EDL, the SWL (Shield Wire Line) system and the SWER (Shield Wire Earth Return) system are not considered to the Optimum Transmission System formulated by the Team.

5.4.1 Design Concept

(1) Reliability Concept

The ‘N-1’ criteria is to be applied to 115 kV substations in Vientiane Capital after the year 2011. All substations in the whole country should, in principle, have two or more transformer units. However, One transformer unit is installed in such substations that loads in 2030 would be less than 10 MW.

(2) Type of Substations

The standard substation is in principle an outdoor type with conventional equipment. The outdoor type substation refers to a substation whose major facilities as main transformers, switchgear instruments, etc. are installed in the open air.

At a substation having no space for additional installations of outdoor type 22 kV switchgear, cubicle type 22 kV switchgear is to be installed in the station buildings.

(3) Connection of Substation Equipment

The connections of substation equipment are designed as as to maximize the functions of the substation inside the overall power system, taking into account the following considerations;

a) Daily operations and maintenance shall be performed safely according to protocol.

b) The connection shall be as simple as possible without affecting the proper performance of installed substation equipment.

c) In the event that a fault occurs in a substation, its influence shall be minimized as much as possible, and necessary switching operations for shifting loads to other substations shall be performed quickly without hesitation and trouble.

d) Considerations must be paid to easiness in future reinforcements and/or augmentations when necessary.

e) Designs must be technically viable and economically feasible.

(4) Earthing System

In the switchyard of a new substation, an underground earthing system should be properly laid out in the form of a meshed grid. In the event of adding an extension to the existing substation, new earthing system should be connected to the existing system.

All equipment installed in a substation should be connected to an earthing system effectively. The resistance of the earthing system should be less than 10 ohm.

(5) Countermeasures for Disasters

a) Dust/salt Pollution

Where a substation is constructed in an area affected by dust contamination, appropriate countermeasures should be incorparated into the design based on the level of pollution. In the Lao PDR, salt pollution is not a design factor that needs to be taken into consideration.

b) Lightning

For the protection of substation equipment from lightning, appropriate measures shall be taken in the design to bring out the required network reliability and site-specific conditions. Especially for the surge arresters to be installed at the main transformer bays and the transmission line bays.

c) Flood

If a substation must be constructed in an area that will inevitably be affected by an unavoidable flood, appropriate measures should be taken to minimize equipment trouble and restore function to the station as fast as possible.

d) Fire

Appropriate fighting measures should be provided to protect operators and equipment from fire or explosion and, at the worst, to localize the fire within a limited area.

e) Earthquake
In the preliminary design of substations, earthquake influence will not be considered, as is the case with transmission line design.

(6) Consideration for the Environment
a) Noise
Where a substation is to be newly constructed or expanded, necessary measures should be planned to keep the noise within a reasonable level.

b) Vibration
Necessary measures should be planned to limit the vibration level of substation to be constructed or expanded within an acceptable range the as recognized in the country.

c) Harmony with the Environment
Where a substation is to be constructed or expanded, special attention should be paid to the protection and preservation of the natural environment in surrounding areas and such as the sunshine, scenery, radio interference, etc., as well as efforts made to harmonize with the regional community.

5.4.2 Busbar Arrangement

The busbar systems for 115 kV and 230 kV substations are selected in coordination with the related existing network taking into account supply reliability, operations and maintenance, and other factors. The ‘main and transfer’ busbar system is applied to the 115 kV busbar system of the standard substation (see Figure 5.4-1). While, the single busbar system is applied to such rather small substations that provides with the limited numbers of HV feeders and/or transformers and less frequency of network switching operation (see Figure 5.4-2).

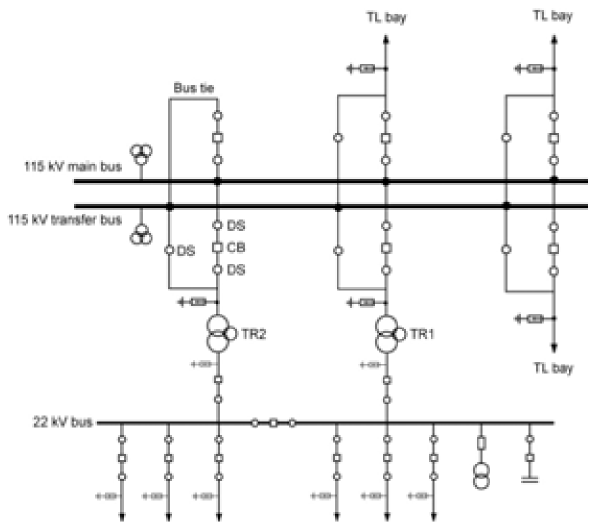


Figure 5.4-1 115 kV Main and Transfer Busbar

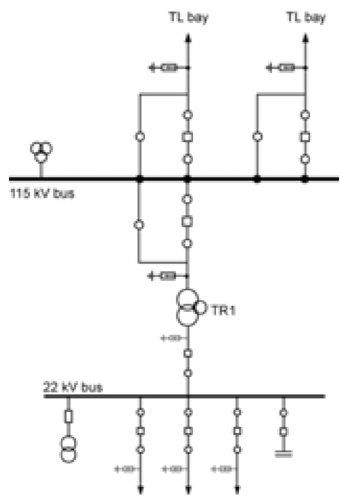


Figure 5.4-2 115 kV Single Busbar

There is no 230 kV substation being operated by EDL in Lao PDR as of February 2009. Thus, the 230 kV busbar system shall be carefully decided for future standardization with consideration of the followings:

- supply reliability and security
- operational performance and flexibility

- capital costs
- maintenance and repair aspects
- space requirements
- standards of neighboring countries
- outage rates of busbar scheme and failure rates for circuit breakers

As a result of careful examination and a course of discussions with EDL, the “one-and-a-half circuit breaker scheme” as illustrated in Figure 5.4-3 is applied for the new 230 kV switchyard under the Study for the following reasons:

a) high reliability and flexibility for system operation and switching
b) easy operation and maintenance
c) standard design of EGAT substations
d) most common (worldwide) standard design for air-insulated switchgear
e) higher costs are offset by the above advantages

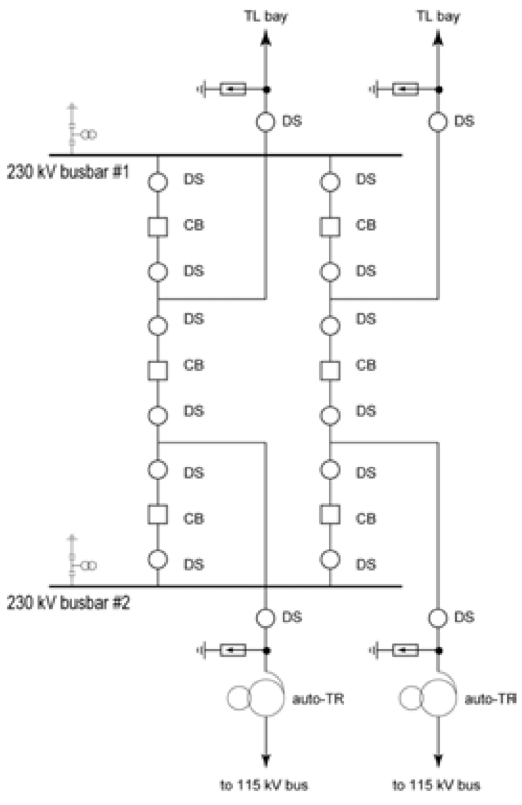


Figure 5.4-3 One-and-a-Half CB Busbar System

The single busbar system is applied to the 22 kV busbar. 22 kV busbars in the substations provided with two or more main transformers would be operated in parallel through such a bus-coupler as a circuit breaker or a load break switch under normal operation conditions.

The standard clearances of busbars are as follows:

Table 5.4-1 Standard Clearance of Busbars

Highest voltage for equipment	Clearance of Phase to Earth	Clearance of Phase to Phase
24 kV (outside)	400 mm	700 mm
24 kV (inside)	300 mm	450 mm
123 kV	1,400 mm	2,300 mm
245 kV	2,300 mm	3,600 mm

(Source: Article 88 of the LEPTS)

5.4.3 Main Power Transformers

(1) Type of Transformers

The 115 kV and 230 kV main power transformers are to consist of three phases, the oil immersed type with on load tap changer (OLTC). The ONAF (Oil Natural Air Forced) and the ODAF (Oil Directed Air Forced) cooling systems are applied for 115 kV and 230 kV main transformers, respectively. 115 kV main power transformers are to be three-winding star-star-delta (Y-Y-Δ) connection transformer types. The 230 kV main power transformers are to be of the three-phase auto-transformer type.

(2) Unit Capacity and Number of Units of Main Transformers

The unit capacity and number of main transformer units in a substation are determined, taking into comprehensive account the demand forecast, economic feasibility, system reliability, voltage regulation, land acquisition, plan of equipment shift, etc. It is preferable to select the unit capacity and number of transformer units so that the healthy units can meet the required peak load conditions even when any one transformer is out of service (‘N-1’). According to the system planning criteria, the ‘N-1’ criteria are applied to the existing and new substations located in Vientiane Capital from the year 2011. For the other substations, ‘N-1’ criteria are not applied. Further, the substation in the rural area might be provided with one transformer unit for minimizing total construction costs if influence due to loss of the unit is not so serious.

a) New Substations

For a new substation, the unit capacity and number of transformers were determined to meet the forecasted load by 2030. The unit capacity was selected from 10, 20 and 30 MVA ratings. The application of transformers for new substations is shown in the following table.

Table 5.4-2 Transformer Arrangement for a New 115 kV Substation

Location of Substation	Scale
High load density area	30 MVA x 2 units, Max. 4 units
Urban area	20 MVA x 2 units, Max. 4 units
Rural area	10 MVA x 1 unit, Max. 2 units

The unit capacity of 230 kV main power transformers is to be selected from 100 MVA or 200 MVA taking into account the load flow situations. The transformer unit numbers are to be one or two in consideration of the importance of the substation.

b) Existing Substations

A variety of unit capacities of 115 kV transformers of unit capacity of 5, 8, 10, 12.5, 16, 20, 22 and 30 MVA respectively are installed in the existing substations. To allow for the parallel operation of the transformers, windings and impedance of the transformers are to be considered. For the effective use of presently available transformers, a replacement program of transformers among the substations is to be prepared in consideration of such factors as demand forecast, available land, construction costs, and the age of transformers. The replacement program oftransformers is to be examined in Section 10.2.

(3) Number of 22 kV Outgoing Feeders

The numbers of 22 kV outgoing feeders per transformer are, in principle, assumed to be three in consideration with the unit capacity of a transformer and an operational load in a feeder.

5.4.4 Switchgear and Other Equipment

(1) Circuit Breakers

Circuit breakers are to be of the SF6 type and installed on both the sending and receiving ends of the 115 kV and 230 kV transmission lines. The circuit breakers will also be installed on both the primary and secondary sides of the main transformers. The 22 kV outgoing feeders would be connected to a 22 kV busbar through a circuit breaker provided for each circuit.

The rated normal currents of circuit breakers are to be selected from the short time overloading capacity of the connected transmission lines or transformers. The rated short-circuit breaking currents of circuit breakers are to be selected from the standard ratings based on the results of fault calculation under various system conditions. The standard rated normal currents and rated short-circuit breaking currents for each voltage level are shown in the following table.

Table 5.4-3 Standard Ratings of Circuit Breakers

Highest voltage for equipment	Rated normal current	Rated short-circuit breaking current
245 kV	1,600 A, 2,000 A	40 kA, 50 kA
123 kV	1,250 A, 1,600 A	25.0 kA, 31.5 kA
24 kV	800 A, 1,250 A	25.0 kA, 31.5 kA

(2) Standard Constitution of Equipment

The standard constitutions of electrical equipment for each transmission line bay, transformer bay and bus coupler are shown in Figures 5.4-1, 5.4-2 and 5.4-3.

(3) Static Capacitors and Shunt Reactors

In principle, 22 kV static capacitors for 115/22 kV substations are to be planned to regulate the system voltage within appropriate level. Total capacity and unit capacity of capacitors required for substations are to be determined referring to the results of power system analysis. The capacitors shall be connected to the 22 kV bus.

One bank of capacitors consists of a number of small units provided with load switches capable of switching on and off the units automatically under energized conditions. A circuit breaker set is to be provided for each bank. The standard capacities of capacitor units are as follows;

Table 5.4-4 Unit Capacity of Static Capacitor

Type	Highest voltage for equipment	Unit Capacity (MVAR)
Static Capacitor Bank	24 kV	2.5, 5, 10

Shunt reactors are to be installed in 230 kV substations to keep the system voltage within the appropriate level and to avoid generator voltage rise. The shunt reactors are to be connected to the tertiary (22 kV) side of the main power transformers. The unit capacity and necessary numbers of units of shunt reactors in a substation are to be determined taking into account the result of the system analysis.

(4) Protective Relay System
The following protection system is required for each section of the substation.

a) 115 kV and 230 kV line protection
- Distance protection
- Directional earth fault protection
- Over-current and earth fault protection
- Automatic re-closing

b) 115 kV and 230 kV transformer protection
- Differential protection
- Earth fault protection
- Over-current protection
- High temperature protection, winding and oil
- Buchholz relay
- Low impedance protection

c) 115 kV and 230 kV busbar protection
- Differential protection
- Under voltage protection

d) 22 kV line protection
- Over-current protection
- Earth fault protection

e) 22 kV busbar protection
- Differential protection
- Under voltage protection

f) 22 kV capacitor and reactor bank protection
- Over current protection
- Unbalanced protection

(5) Communications System
Optic fiber communications system is to be installed at new substations for tele-communications between substations or planned Central/Regional Load Dispatching Centers and for the protection system. In case there is no optic fiber communications system in the existing substation on the opposite side of the new substation, the system is to be installed in the existing one.

(6) Distributed Control System
The Distributed Control System (DCS) is to be installed in the new substations to control the switchgear and main power transformers through the PC.

Chapter 6
Power Demand Forecast

Chapter 6 Power Demand Forecast

6.1 Power Demand Forecast in PDP 2007-2016

Figure 6.1-1 shows the latest demand forecast, which EDL carried out in PDP 2007-2016 published in March 2008.

It is estimated that the peak demand will grow to about 1,400 MW, which is about 4 times more than the 350 MW recorded in 2006. The growth rates during the period 2006-2010, 2006-2015 and 2006-2020 are 17%, 15% and 11% respectively. The reason why the growth rate of the first period is the highest is that this forecast takes into account many specific loads by newly developed industries such as mining companies.

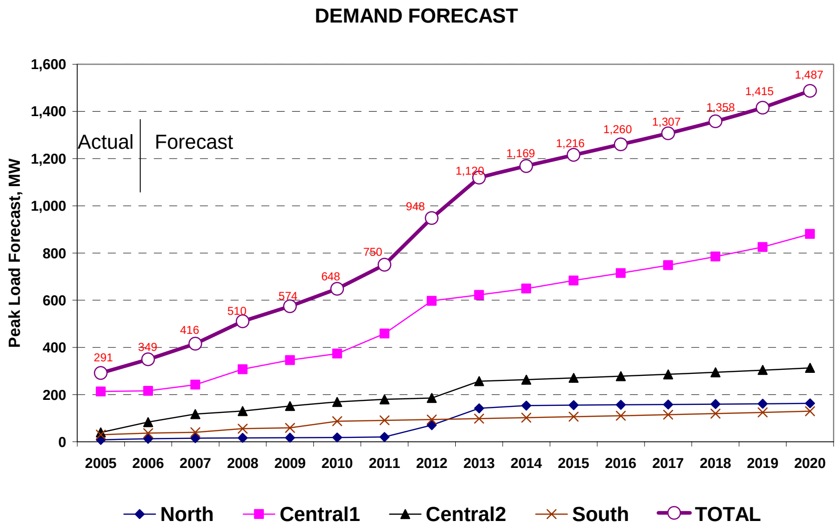


Table 2.5-4: Summary of Demand forecast for whole country

in the main report

Descriptions	Actual 2006	Forecast → 2007	2010	2015	2020	Growth Rate 2006-10	2006-15	2006-20
Energy Demand , GWh	1,400.6	1,711.4	3,034.3	6,358.0	7,770.7	21%	18%	13%
System Losses, GWh	326.3	365.0	458.8	651.5	778.3			
	19%	18%	13%	9%	9%			
Energy Demand (Including system losses), GWh	1,726.9	2,076.4	3,493.2	7,009.5	8,549.0	19%	17%	12%
Peak Load, MW	349.4	415.6	648.3	1,216.2	1,486.8	17%	15%	11%
Load Factor	56%	57%	62%	66%	66%			

Figure 6.1-1 Power Demand Forecast of EDL

(Source: PDP 2007-16 EDL)

6.2 Existing Methodology of Demand Forecast

The existing methodology of demand forecast was introduced to EDL by JICA the study team who implemented the "Study on Master Plan of Transmission Line and Substation System" (in 2002) and EDL has been utilizing this method ever since. In this method, electricity consumption is classified into four (4) sectors, namely residential, industrial, agricultural and the service sector. First, consumption in each sector by province is forecasted. After that, the aggregate of the each sector's consumption amount leads to a nationwide prospectus.

In terms of the residential consumption, consumption of already electrified households is forecasted by multiplication between the consumption in a benchmark year (which is 2006 in this case) and the exponentiation of some growth rates. Regarding unelectrified housholds, a prediction of the number of housholds to be electrified is made first and then the consumption of the households is estimated by multiplication between electricity consumption per household and the household number.

In respect of the Industrial, agriculture and service sector, consumption is forecasted by multiplication between the consumption in a benchmark year and exponentiation of the growth rate in each sector at first and then for electricity which is consumed by followers is added to it. 1) villages to be electrified in future, 2) large industries to be newly developed, 3) irrigation pumps to be newly introduced

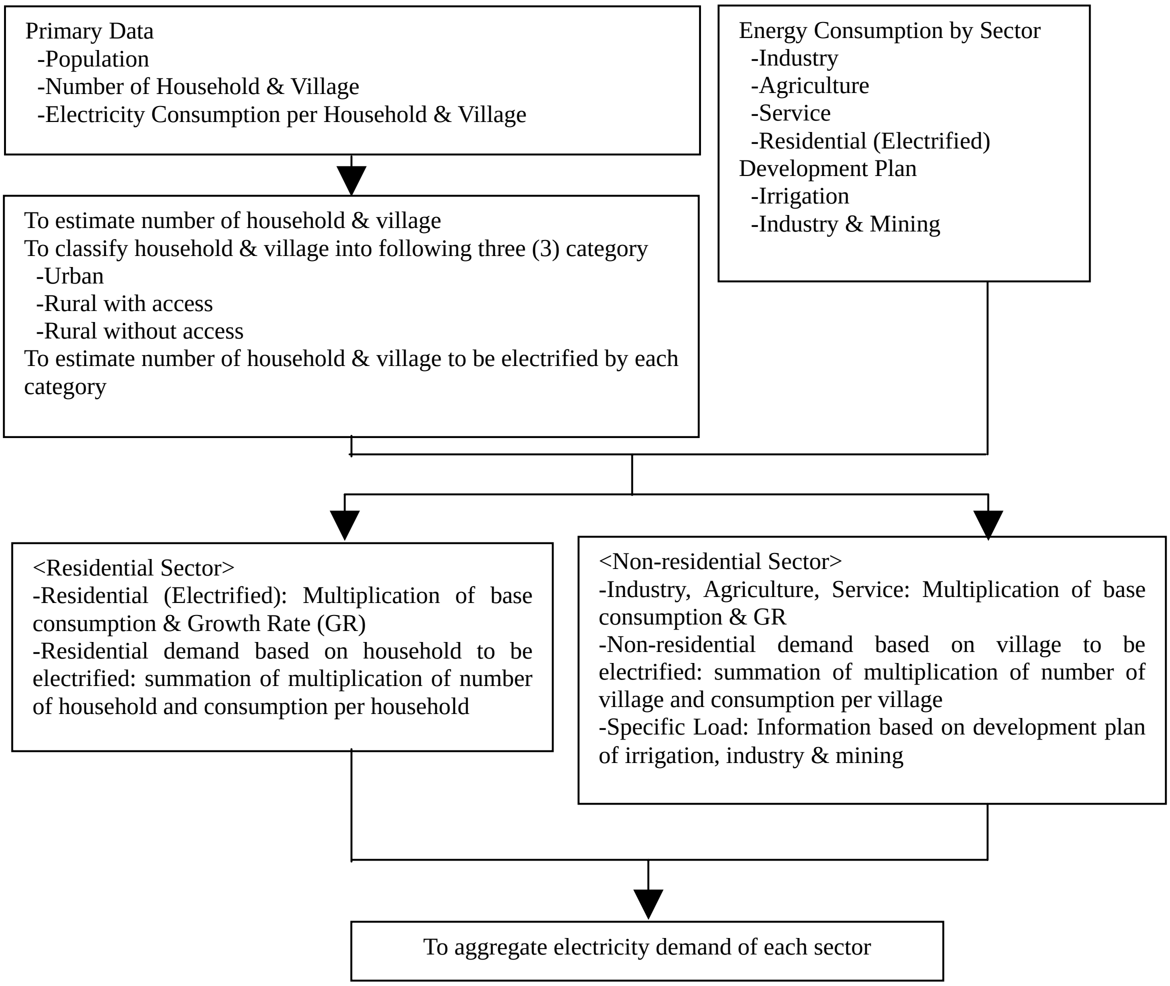


Figure 6.2-1 Existing Methodology of Demand Forecast

6.3 Policy on Demand Forecast for This Study

What are required in this power demand forecast are as follows;

- To implement long term power demand forecasts until 2030

- To make multiple power demand scenarios
- To make some scenarios including specific loads by industries to be developed during the period

If scenario studies should be carried out, generally power demand forecasts shall be implemented based on some macro analyses on correlation between economic indices and electricity consumption. On the other hand, if the prospect of the demand in this study appears much different from that of EDL's forecasts, which seems to be based on micro analyses rather than macro analyses, EDL's power network plan could not be consistent with a plan which this study is making. And it must make some difficulties. In order to avoid them, it's necessary to ensure consistency of power demand forecasts by both methods.

Taking into consideration of these points, this study will take following steps.

- To conduct some macro analyses on correlation between economic indices and electricity consumption of Lao PDR and neighboring countries
- To estimate the ELD's forecasts with macro analyses results to ensure consistency of power demand forecasts
- To make power demand scenarios with some new assumptions

In this study, the demand forecasts of the Lao PDR shall be carried out based on some macro analyses in correlation between the economic indices and the electricity consumption of Lao PDR and neighboring countries. Figure 6.3-1 briefly shows the analysis flow of this study.

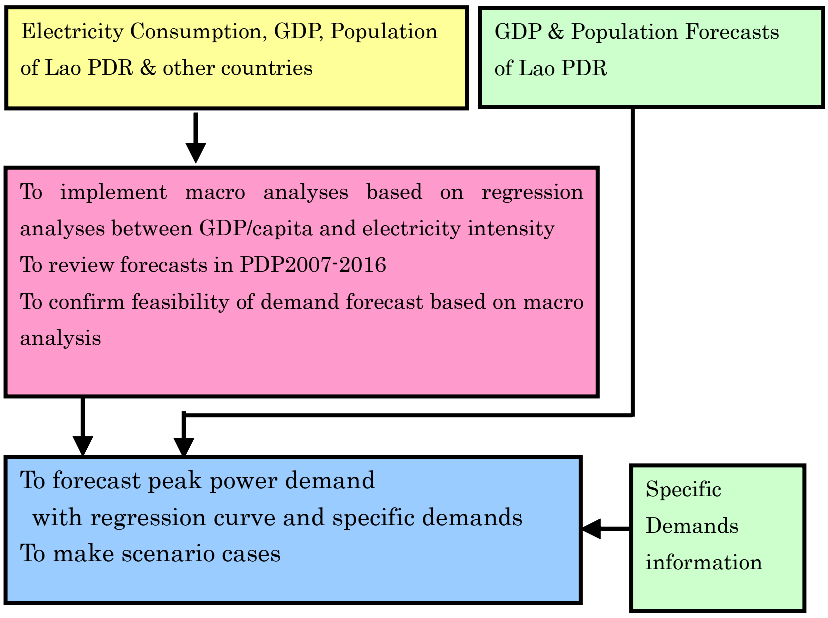


Figure 6.3-1 Analysis Flow of Demand Forecast

6.4 Regression Analysis Accomplishment between GDP and Energy Intensity

Figure 6.4-1 shows the correlation between the GDP/capita and the energy intensity of Lao PDR and neighboring countries. In this case GDP is based on prices and exchange rates in

2000.According to the GDP/capita of Lao PDR, it is at the same level as that of Cambodia, Vietnam and Bangladesh. On the other hand the energy intensity of Laos PDR is at the same level as that of Vietnam and Sri Lanka.

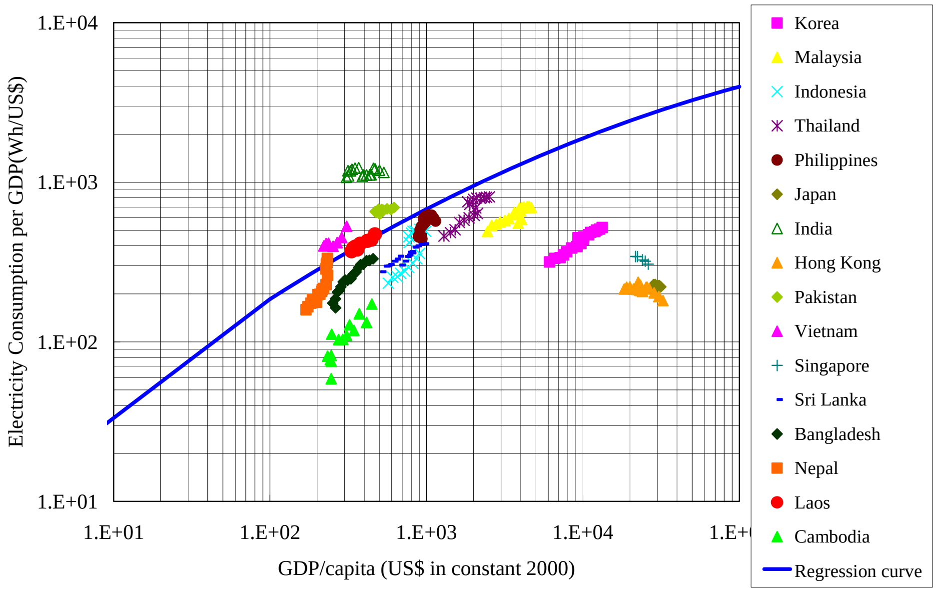


Figure 6.4-1 Correlation between GDP per Capita & Energy Intensity

(Source: Key Indicator ADB, Government Information regarding Lao PDR & Japan)

Regarding the correlation between the GDP/capita and the energy intensity, at a low level of GDP, as the GDP/capita is increasing, energy intensity is increasing rapidly. However at a level, which may be the level of middle developed country, energy intensity is not increasing yearly and causes a slowdown. For developed countries levels such as Japan, it may be decreasing as the GDP/capita is increasing.

This status can be generally explained by a change in the nation's industrial structure. Specifically, as a country's economy is growing, the industrial structure is shifting from primary industries such as agriculture to secondary industries or heavy industries, which consume much energy and ultimately reach tertiary industries such as financial and service industries, which consume less energy.

Regression analysis based on these data of GDP/capita and the energy intensity of Lao PDR gives the correlation shown in Fomula 6.4-1 and Figure 6.4-2. This formula illustrates that the energy intensity incrementally slows down as the economy grows.

$$\log(\mathit{Electricity\ consumption/GDP}) = 0.777 + 0.865\ \log(\mathit{GDP/capita}) - 0.060\log(\mathit{GDP/capita})^2$$

Formula 6.4-1

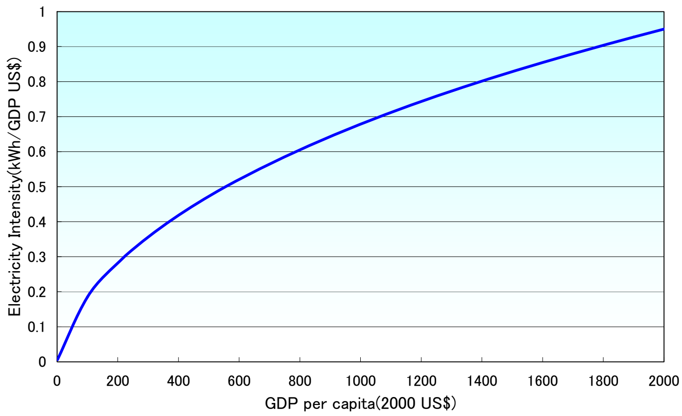


Figure 6.4-2 Regression Curve Energy Intensity & GDP

6.5 Comparison of Demand Forecast by Macro Analysis & EDL

6.5.1 Assumption of GDP Growth Rate

The GDP growth rate was recorded between 5.8 and 8.3% during the period from 2001 to 2007 and showed a stable situation. However in September 2008, a global finance crisis occurred and it cannot yet be foreseen how this incident will affect the economy of Lao PDR. Even if the global economic situation is taken into account, 7% and 9% of the GDP growth rate should be assumed as the Base Case and High Case respectively. In this study, because the study deals with an infrastructure development plan and power demand forecasts over the ultra long term, it may neglect short-term factors. Incidentally, the "6th National Socio-Economic Development Plan" targets 8% of the GDP growth rate and the "Asian Development Outlook 2008" of ADB anticipates the GDP growth rate in Lao PDR could potentially be 7.8% in 2009. Taking this into consideration, 7% of the GDP growth rate may be much more acceptable for this study if the effects posed by the global financial crisis are eliminated.

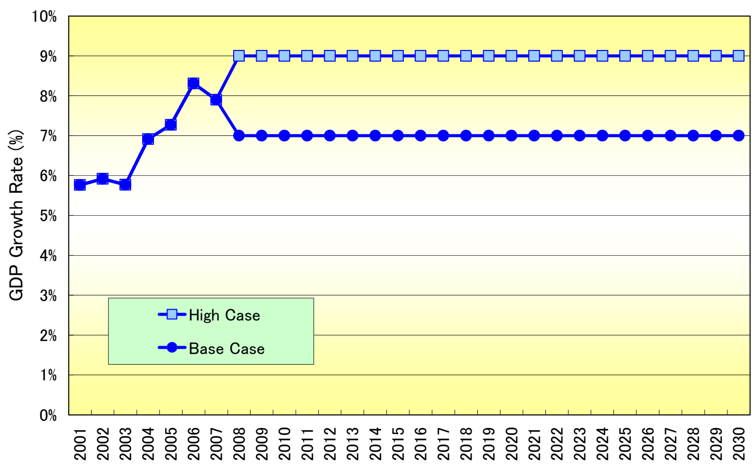


Figure 6.5-1 Assumption of GDP Growth Rate

6.5.2 Assumption of Population

The census in March 2005 estimates the total population of Lao PDR to be 5,621,982. The census document: "Results from the Population and Housing Census 2005" (Steering Committee for Census of Population and Housing) shows population forecasts during the period until 2020. According to this, the population of Lao PDR shall exceed seven million in 2020. Forecast assumptions are as follows;

- Total fertility rate (TFR) declines from 4.5 in 2005 to 2.1 in 2020
- Life expectancy for males and females increase from 59 and 63 in 2005 to 70 and 74 years in 2020, respectively
- Infant mortality decreases from 70 per 1000 in 2005 to 34.2 per 1000 in 2020
- Net migration is assumed to increase from -15,000 persons per year to -20,000 persons in 2020
- The annual number of births would decrease from about 190,000 in 2005 to about 136,000 in 2020
- The crude birth rate decrease from about 34 per 1000 in 2005 to about 19 per 1000 in 2020

Since power demand forecasts during the period until 2030 are required in this study, population forecasts during the same period are also necessary. The population forecasts after 2021 shall be calculated based on the population growth rate in "World Population Prospects" (United Nations 2007). Figure 6.5-2 summarizes the population forecast above.

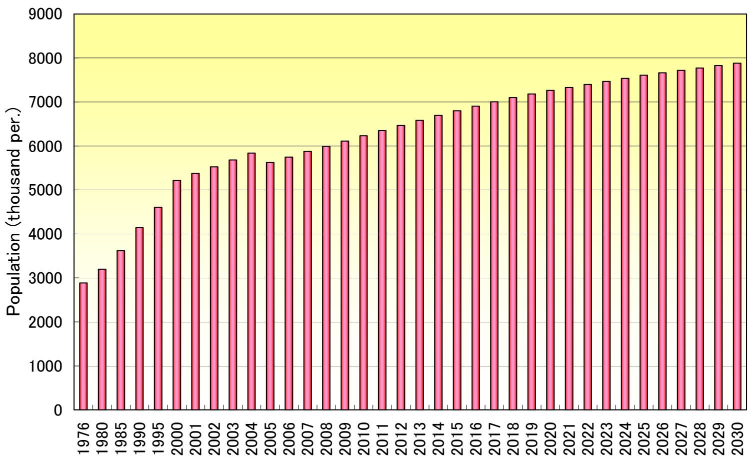


Figure 6.5-2 Population Forecast of Lao PDR

(Source: "Results from the Population and Housing Census 2005" Steering Committee for Census of Population and Housing for value until 2020 "World Population Prospects" United Nations for value after 2021)

6.5.3 Assumption of Line Loss Rate

This study shall adopt line loss rates, which are the same as those in the PDP 2007-2016 of EDL. This data is configured so that the line loss of 15% in 2020 is targeted and during the period from 2008 to 2019 it is calculated by a linear interpolation. On the other hand, it shall be assumed that the line loss rate shall continue at 15% after 2021 in this study.

Table 6.5-1 Assumption of Line Loss Rate

Year	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘17	‘18	‘19	’20-30
Line Loss Rate (%)	21.4	20.8	20.4	19.8	19.3	18.7	18.2	17.7	17.1	16.6	16.1	15.5	15.0

(Source: PDP 2007-2016 EDL)

6.5.4 Assumption of System Load Factor

This study shall also adopt a system load factor, which is the same as that in PDP 2007-2016 of EDL. This data is configured so that the line loss of 60% in 2020 is targeted and during the period from 2008 to 2019 it is calculated by linear interpolation. On the other hand, during the period after 2021, the load factor is assumed to reach 70% in 2030. This level is the same as the current level in a neighboring country, Thailand. Other data shall also be obtained by linerpolation.

Table 6.5-2 Assumption of System Load Factor

Year	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘17	‘18	‘19
Load Factor (%)	44.3	45.6	46.9	48.2	49.5	50.8	52.1	53.4	54.8	56.1	57.4	58.7
Year	‘20	‘21	‘22	‘23	‘24	‘25	‘26	‘27	‘28	‘29	‘30	
Load Factor (%)	60.0	61.0	62.0	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0	

(Source: PDP 2007-2016 EDL)

6.5.5 Estimation of Power Demand Forecast in PDP 2007-2016

Figure6.5-3 shows the power demand forecasts calculated based on the results of macro analyses and other assumptions. The red colored solid line represents the PDP 2007 forecast and the red colored dotted line refers to the demand forecast minus specific industrial demands indentified as of 2007. The blue and green colored dotted lines represent demand forecasts based on macro analyses with a GDP growth rate of 7% and 9%, respectively. The blue and green colored dotted lines refer to demand forecasts, which comprise the macro analysis results and the specific demands. This figure shows the macro analysis results in the Base Case (which is based on 7% of the GDP growth rate) is coincident with the demand forecast of PDP 2007-2016. This means that the demand forecast of EDL is reasonable and demand forecasts based on macro analyses shall be all the more acceptable.

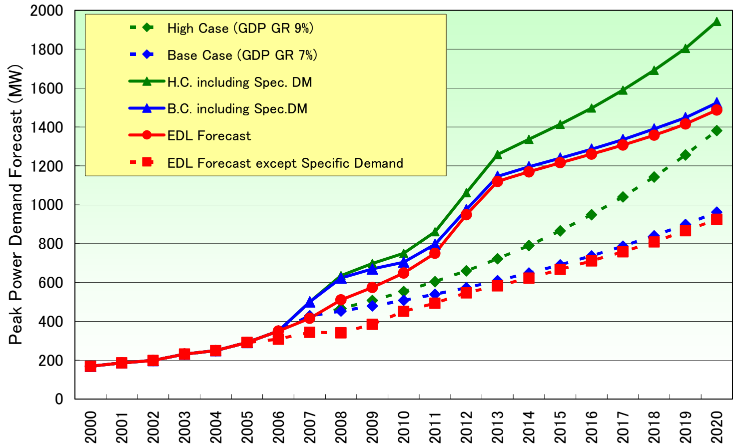


Figure 6.5-3 Comparison between Forecast by Macro Analysis & EDL Forecast

6.6 Scenario Case for Power Demand Forecast

According to EDL consultants, demand forecasts shall be implemented in three (3) scenario cases, namely the Base Case, the High Case and the Base+SLACO[1] Case. They shall be carried out by macro analyses. Those in the Base Case and the Base+SLACO Case shall be based on a 7% GDP growth rate and that in high case shall be based on 9%. In Base and High Cases, demand forecasts consist of the calculation via macro analyses and specific power demands excepting SLACO, which is an industry processing aluminum and mentioned in the next section and in the Base+SLACO Case, it comprises the calculation by macro analyses and all specific power demands.

Table 6.6-1 Configuration for Each Scenario Case

Case Name	GDP G.R.	Specific Load
Base Case	7%	Except SLACO
High Case	9%	Except SLACO
Base+SLACO Case	7%	ALL

6.6.1 Specific Power Demand Identified as of February 2009

Table 6.6-2 shows the specific demands indentified at the EDL and DOE research hearing as of Feb. 2009 and Figure 6.6-1 represents the specific demand in cumulative value.

Figure 6.6-1 makes it clear that the specific demand shall increase by 1,000 MW totally in 2013 and 2014. The commissioning of the aluminum-processing factory, SLACO is the cause. Compared with the current peak power of Lao PDR, which is less than 400 MW, it may be too huge for this country to take account of this load and deal with it. As a result, the PDP 2006-2016 neglected this specific demand.

This study shall deal with SLACO's demand not in Base and High Cases but in the Base+SLACO Case.

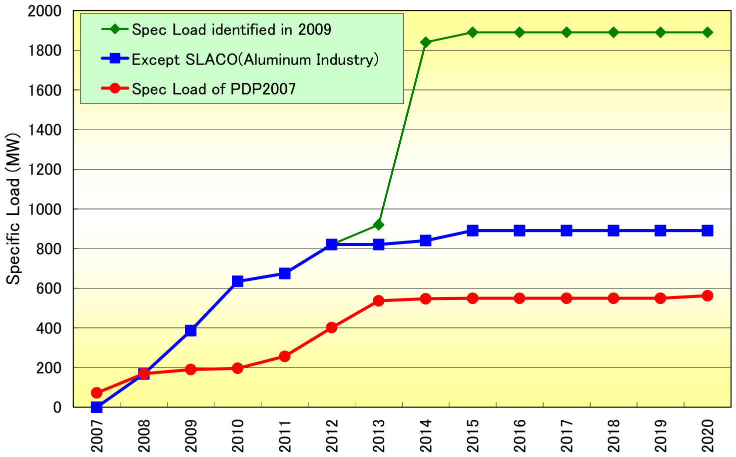


Figure 6.6-1 Specific Demand in Cumulative Value

[1] SLACO: A predicted large power consumer for producing aluminum in the South area.

Table 6.6-2 Specific Demand of Lao PDR (as of Feb.2009)

year	Company name	Name of Project	MW	Name of Place(Location)	Note
2008	Phou Bear Mining	Coppor-Phau Bear	49.1	Phoubear, Vientiane Prv.	increase to 52MW in 2012
	Sinno Lao	Salt Potash	20	Vien ThongMang, Saythany Dt. Vientiane Capital	
	Lao cement industry	Cement	17	Ban Nakham, Thakhek Dt. Khammuane Prv.	
	Lao Younesin Mining Development	Tin	5	Ban Nam Pang, Namor Dt. Oudomxay Prv.	
	Iron/coal Mining	Metal	12	Vangvieng Dt. Vientiane Prv	increase to 13.5MW in 2009
	Steel Making Plant	Metal	64.5	Xaythany Dt. Vientiane Capital	increase to 85.5MW in2009
2009	Lao-China Development Mining	Copper	10	Ban Houa More, Long Dt. Luangnamtha Prv.	
	Vinakomin Lao Co.	Metal	10	Ban Natore, Khoune Dt. Xjengkhuang Prv.	
	Vang Vient Mining Co.	Metal	12	Kasy Dt. Vientiane Prv.	
	Vientiane Commerce	Gold	5	Ban Khok Pheug, Sangthong Dt. Vientiane Capital	
	Many Companies	Lead	20	Ban Nong Seurn-Bo Nang, Hinboon Dt. Khammuane Prv.	
	Lanxang Mineral	Gold-copper,Xaponh	74	Vilabuly Dt. Savannakhet Prv.	
	Chaugyang EC Unan	Cement	25	Ban Talen, Saravane Dt. Saravane Prv.	
	Lao Aluminium Industry	Alumina	40	Ban Dark Lan, Darkcheug Dt. Sekong Prv.	
	Iron/coal Mining	Metal	13.5	Vangvieng Dt. Vientiane Prv	increase to 34MW in 2010
	Steel Making Plant	Metal	85.5	Xaythany Dt. Vientiane Capital	increase to 224MW in2010
2010	Lao cement industry	Cement	60	Ban Nakham Thakhek Dt. Khammuane Prv.	
	UC Xaunglong Co. Laos	copper	10	Nhot ou Dt. Phongsaly Prv.	
	cement factory	Cement	9.5	Ban Phonhmany, Nambak Dt. Luangprabang Prv.	
	United	Gold	10	Phapon, Park ou Dt. Luangprabang Prv.	
	Iron/coal Mining	Metal	34	Vangvieng Dt. Vientiane Prv	
	Steel Making Plant	Metal	224	Xaythany Dt. Vientiane Capital	
2011	Deuktian	Copper	40	Ban Pang Kham, Parklai Dt. Xayabury Prv.	
2012	Sinoma	Alumina mining	8	Paksxong Dt. Champasak Prv.	
	Sinoma	Alumina Processing Plants	20	Attapeu Prv.	
	Chinhourdow Chinher	Metal	25	Ban Namxan, Xaysomboon DT. Veintiane Prv.	
	Phou Bear Mining	Gold-copper	52	Phou Bear, Vientiane Prv.	
	Dow Lao	Gold-copper	40	Ban Mai Park Thoun, Xanakharm Dt. Vientiane Prv.	
	C Xaune Koden Element Chemical	Cement	10	Ban Nathong, Namor Dt. Oudomxay Prov.	
	Unan Mining Copper Industry Oudomxay Mine	Copper	20	Ban Keavchep-Namkhem, Namor Dt. Oudomxay Prov.	
	Toun Haung Lao-China Mining	Metal	10	Ban Pouthen, La Dt. Oudomxay Prv.	
	Lao Jongxaig Mine and Magnet	Metal	10	Ban Gnoutpeng, Pek Dt. Xienkhouang Prv.	
2013	SLACO	Alumina mining	100	Paksxong Dt. Champasak Prv.	
2014	SLACO	Alumina Processing Plants	900	Sanamxay Dt. Attapeu Prv.	
	UC Xaunglong Co. Laos	copper	20	Nhot ou Dt. Phongsaly Prv.	
2015	Army Mining company	Gold-copper	50	Ban Vangtat, Sanxay Dt. Attapeu Prv.	

6.6.2 DSM Target & Activities

EDL has been struggling to DSM and mainly carrying out energy conservation (EC). However, it's supposed that they might not have any EC target in energy amount. EC activities being promoted are as follows;

- Efficiency Operations of the Electricity Lift (by setting up a time switch, switching it off during weekends & holidays, coordinating the operations for those waiting & gathering to ride, etc.)
- EC for Air Conditioner (A/C) (automatic switch-off when nobody physically present, maintaining the room's airtightness, setting the A/C temp. at 25℃, periodic maintenance every 3 months, etc.)
- EC for Electric Fan (by switching off when unnecessary, refreshing air by opening windows, etc.)

- EC for Copy Machine (switching-off & unplugging when not in use, located separately from the A/C, photocopying only important documents)
- EC for Electric Light (switching off when not necessary, using EC type bulbs, etc.)
- EC for Computer (switching-off & unplugging when not in use, installing a screen saver system, etc.)
- EC for Electric Pot (unplugging when unnecessary, etc.)

6.6.3 Peak Power Demand Forecast for This Study

Figure 6.6-2 shows the peak power demand forecasts calculated for this study. This figure illustrates that the peak power in the Base Case shall reach 1,852 MW in 2020, which shall be four times more than the current demand and 3,065 MW in 2030 which shall be seven times more than the current one. The peak power in the High Case and Base+SLACO Case shall grow to 2,272 MW and 2,851 MW in 2020, and 4,951 MW and 4,065 MW in 2030. This means that the peak power in the High Case shall have left that in the Base+SLACO Case behind.

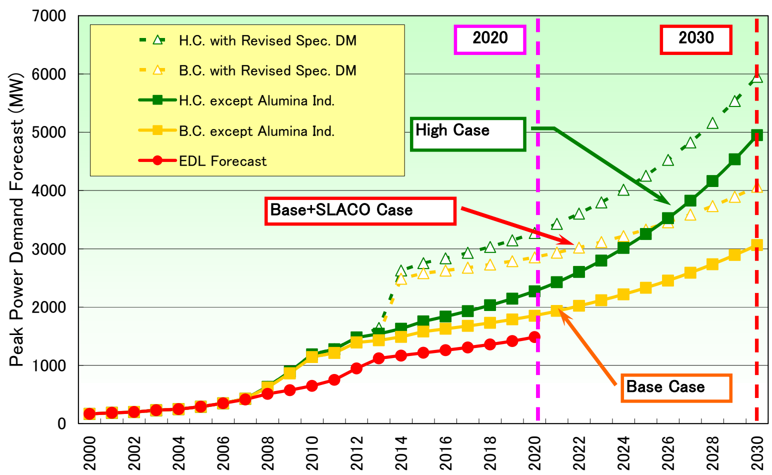


Figure 6.6-2 Peak Power Demand Forecasts by Case

Table 6.6-3 Peak Power Demand Forecasts in 2020, 2030 by Case

Case Name	2020	2030
Base Case (MW)	1,852	3,065
High Case (MW)	2,272	4,951
Base+SLACO Case (MW)	2,851	4,065

6.6.4 Peak Demand Forecast by Region

Since the main purpose of this study is to plan for the construction of interconnection lines between different regions, the implementation of regional demand forecasts, which cover some province, shall be required in order to examine whether or not the lines are necessary. In this case, we shall assume that the regions shown in Table 6.6-4 would have some large size grids, and shall divide the forecasted demands into these four regions. Figures 6.6-3 to 6.6-5 lists the demand forecasts by region.

Table 6.6-4 Correlation between Region and Province

Region Name	Province
Northern	Huaphanh, Phongsaly, Luangnamtha, Oudomxay, Bokeo
Central 1	Vientiane Capital, Vietiane, Luangprabang, Borikhamxay, Xayabury, Xiengkhouang
Central 2	Khammuane, Savannakhet
Southern	Saravane, Sekong, Attapeu,Champasack

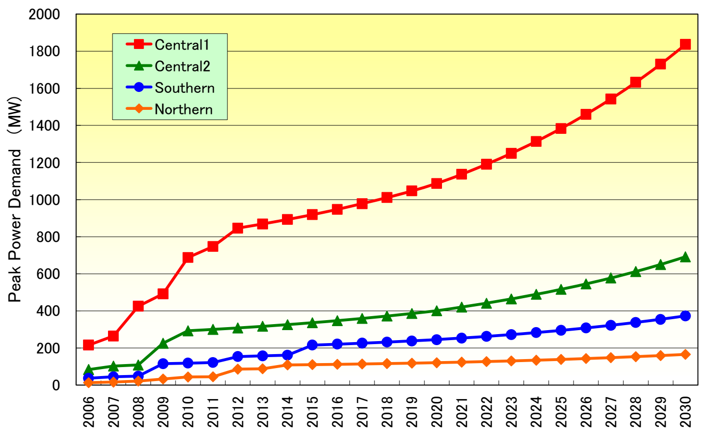


Figure 6.6-3 Demand Forecast by Region (Base Case)

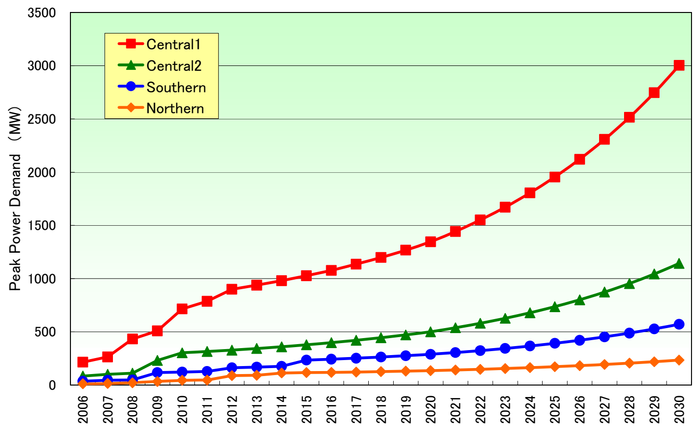


Figure 6.6-4 Demand Forecast by Region (High Case)

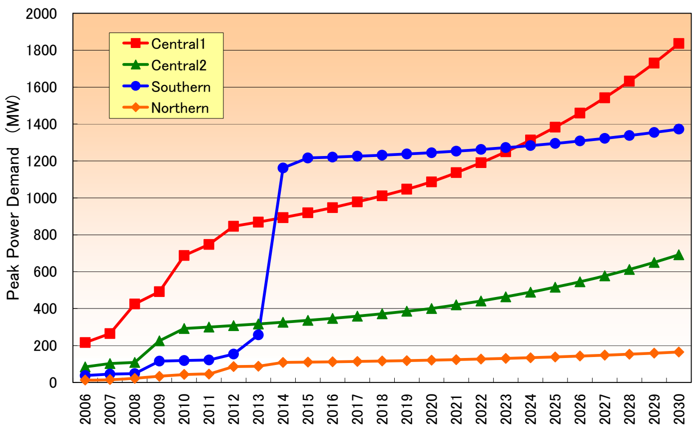


Figure 6.6-5 Demand Forecast by Region (Base+SLACO Case)

6.7 Demand Forecast for Substations

The power demand forecast for the whole of Laos was discussed in the macroeconomic manner of forecasting in the previous sections. Forecasting the power demand for each 115/22 kV substation and 115 kV requires special customers for making power system plans. The methodologies and the results of the demand forecast of each substation in the whole country are described in this section.

6.7.1 Methodology of Demand Forecast for Substations

EDL has forecasted the power demand of the 115/22 kV substations based on the methodology introduced through the JICA Study on the Master Plan of Transmission Line and Substation System in 2004. The demand forecast in this study has been carried out also based on the methodology taken in the JICA Master Plan study in 2004 in accordance with the procedures shown below.

(1) Laos's power demand supplied from 115/22 kV substations was categorized into residential, industrial, commercial, irrigation and government demands.

(2) The power demand forecast of the whole of Laos supplied from the 115/22 kV substations was based on each sectors power demand record in 2007.

(3) The power-demand growing ratio of the whole of Laos supplied from 115/22 kV substations was used based on the ratio predicted from the data of the expected population and the GDP of Laos.

(4) The peak demand forecast for each substation was based on the records of the peak power demand for each substation in 2008.

(5) The power demand for each substation was forecasted based on the regional power demand predicted from the power demand forecast of Laos supplied from the 115/22 kV substations that were based on the expected provincial population.

(6) Only the identified power demand was reflected as the power demand of special consumers. The difference between the power demand of the whole of Laos and the demand forecast based on the GDP was set out as the power demand for special consumers in the later years.

6.7.2 Actual Power Demand

Table 6.7.1 shows the actual power demand recorded in 2007 categorized into each sector. Table 6.7.2 shows the actual peak power demand recorded in 2007 and 2008 categorized into each substation.

Table 6.7-1 Actual Power Demand in 2007 for Each Sector

Substation	(Unit: kWh)
Residential	642,490,509
Commercial	187,973,852
Gov	112,330,907
Irrigation	46,862,476
Industries	308,753,930
Sub Total (KWh)	1,298,411,674
Xepon Mining	290,356,191
Cement	27,146,850

Table 6.7-2 Actual Peak Power Demand in 2007 and 2008 for Each Substation

No.	Name	Location	2007 (MW)	2008 (MW)
1	Phongsaly	Phongsaly	0.45	0.45
2	Bokeo	Bokeo	2.8	3.85
3	Luangnamtha	Luangnamtha	2.12	2.81
4	Oudomxay	Oudomxay	1.4	1.82
5	Huaphane	Huaphane	5.8	0.87
6	Phonsavanh	Xiengkhuang	4.7	4.4
7	Luangprabang	Luangprabang	12.3	13.7
8	Xayaburi	Xayaburi	2.0	4.1
9	Another Districts of Xayaburi Province (from Thailand)	Xayaburi	2.60	5.26
10	Tha Lat	Vientiane Province	4.0	7.93
11	Phonsoung	Vientiane Province	7.8	8.2
12	Ban Don	Vientiane Province	2.3	2.7
13	Vangvieng	Vientiane Province	11.5	14.3
14	Non Hai	Vientiane Province	2.6	3
15	Nam Ngum 1	Vientiane Province	1.4	1.7
16	Nam Leuk	Vientiane Province	1.6	1.89
17	Nam Mang3	Vientiane Province	1.4	1.65
18	Phubie Minning	Vientiane Province	-	34
19	Naxaythong	Vientiane Capital	8.2	4.2
20	Phontong	Vientiane Capital	71.7	86.0
21	Tha Ngone	Vientiane Capital	14.8	12.4
22	Khoksa ad	Vientiane Capital	11.7	15
23	Thanaleng	Vientiane Capital	34.5	37.7
24	Pakxan	Bolikhamxay	9.2	9.7
25	Tha khek	Khammuane	22.8	23.9
26	Tha khek Cement Factory	Khammuane	17	14.2
27	Sepon Minning	Savannakhet	45.9	39.5
28	Pakbo	Savannakhet	20.1	26.52
29	Kengkok	Savannakhet	11.6	12.82
30	Ban Na	Champasak	3.0	4.1
31	Ban Had	Champasak	1.9	2.3
32	Bang Yo	Champasak	19.6	24.0
33	Xeset 1	Saravanh	1.39	1.8
34	Saravanh	Saravanh	7.13	6.3
35	Sekong	Sekong	1.8	1.6
36	Saphaothong	Attapeu	1.5	2
	Total		370.64	436.67

(Power demand supplied from 115/22 kV substations in the whole of Laos)

6.7.3 Power Demand Supplied from 115/22 kV Substations in the Whole of Laos

The growth rate of the residential power demand supplied from 115/22 kV substations in the whole of Laos was forecasted according to the conditions described below.

- There was an assumed correlation between residential power consumption and the population.
- The data in the Lao P.D.R census was treated as the population data for the whole of Laos up to 2020.
- The average number of household members was assumed to not change during the study period in the same manner as reflected in the JICA Master Plan in 2002.

- Electrified annual residential power consumption was assumed to be in proportion to the population and the annual electric energy consumption amount per capita. The annual electric energy consumption amount was assumed to increase by 3% per year at the same level as supposed in the JICA Master Plan in 2002.
- The power demand of newly electrified households was estimated using the electrification rates for households that were supposed to be 60% in 2007, around 90% in 2020 and 100% in 2030.

The growth rates of the commercial, industrial, irrigation and governmental power demand supplied from 115/22 kV substations in the whole of Laos were forecasted according to the conditions described below.

- The correlation between commercial and industrial power consumption and the GDP was assumed.
- The growth rate of the GDP was supposed to be 7% in the Base Case.
- The elasticity rate of the commercial and industrial power consumption to the growth of the GDP were supposed to be the same values used in the JICA Master Plan in 2002 as follows.
    - 1.8 for the industrial sector
    - 1.0 for the commercial sector (The growth rate of the commercial sector was around 6.2% and the GDP growth rate around 6.4% could calculate the elasticity of around 1.0 in the JICA Master Plan in 2002.)
- The power demand of irrigation and government power demand were assumed to be in proportion to the population.

The power demand supplied from the substations in the whole of Laos was forecasted up to 2030 by summarizing the residential, commercial and industrial power demand estimated in the abovementioned manner. Table 6.7-3 shows its results.

6.7.4 Power Demand Forecast of the Whole of Laos

The identified special consumers directly receiving electricity from the 115 kV systems were also included in the demand forecast of the whole of Laos apart from the substations described in the previous sections.

The total power demand forecast amount of the 115/22 kV substations and the special consumers identified as of July 2009 exceeded the macroeconomic demand forecast up to 2025, because the power demand of the identified special consumers became larger than the power demand that could be estimated from the GDP's 7% growth rate. On the other hand, the total power demand amount of the 115/22 kV substations and the identified special consumers became lower than the macroeconomic demand forecast after 2026, because the special consumers appearing after 2026 could not be identified and were not included in the demand forecast. Thus, the difference between the macroeconomic demand forecast and the total amount of power demand after 2026 was supposed to be the special consumers appearing after 2026. The load factor for the special consumers was assumed to be 48% in accordance with actual records.

The load factor used for estimating the peak loads of the 115/22 kV substations was supposed to be improved from 58.2% in 2009 to 60% in 2030 according to the actual records. The inequality rate representing the summation rate of the substation peak loads to the maximum loads of the whole of Laos was supposed to be 120%.

The total loss ratio of the transmission and distribution systems as predicted in the EDL Power Development Plan was used. The loss ratio of the distribution systems was supposed to be 14.5% in 2009 according to estimates from actual records and reduced to 9.5% during the upcoming 10 years. The loss ratio of the transmission system was supposed to be 6.4% in 2009, reduced to 5.5% in 2020 and remain constant from this time.

Table 6.7-4 shows the power demand forecast of the whole of Laos and Table 6.7.5 shows the results of the power demand forecast of special consumers

6.7.5 Power Demand Forecast of 115/22 kV Substations

The total amount of the power demand of 115/22 kV substations forecasted in the previous sections was allocated for each province based on the predicted population numbers for each province. On the basis of those results, the load of each 115/22 kV substation was forecasted. The population and the power demand for each province were forecasted in the following manner.

- The preliminary population growth rate for each province was estimated based on the actual population during the 2007 and 2008 census. The population for each province up to 2030 was estimated based on the predicted population from 2009 to 2020 in the census.
- The power demand per capita for each province was calculated from the actual power demand for each province in 2008. The power demand per capita for each province for latter years was forecasted from the growth rate of power demand per capita categorized into city and rural areas.
- The power demand of the whole of Laos was allocated into each province by sharing the rate of power demand of each province calculated in the aforementioned manner.

The power demand of each substation was forecasted in accordance with the power demand forecast for each province as follows.

1) The power demand for each substation basically includes only the power demand that should be supplied the from EDL substation. The power demand of special consumers that should be supplied from the EDL 115 kV system due to its large quantity is not included in the power demand of substations. However, the power demand of special consumers that does not exceed 5 MW was included in the power demand of substations.
2) The power demand of the existing EDL substations was estimated by the annual growth rate of power demand up to 2030 for each province based on the actual peak power demand in 2008.
3) The new substation that would take a portion of the load from an existing substation was planned in case the power demand forecasted in the aforementioned manner 1) exceeded the total capacity of the substation transformers (3x30 MVA at maximum).
4) The allocation rates of the power demand to the new substations were determined in consideration of the areas to be covered and the situations or plans of the related 22kV distribution systems.

6.7.6 The Result of Power Demand Forecast for Each Substation

Table 6.7-5 to 6.7-7 show the results of the power demand forecast for each substation estimated in the previously mentioned manner. Table 6.7-8 shows the power demand forecast for special consumers. The special consumers supply are distributed from 115 kV transmission lines basically. However, they can also be supplied by 22 kV for loads under 5 MW.

Table 6.7-3 Power Demand Forecast of Substations Up to 2030

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Population		5700.4	5990.1	6110.6	6230.3	6348.8	6465.8	6580.8	6693.2	6802.0	6906.2	7005.2	7097.9	7183.6	7261.6	7329.9	7398.8	7468.3	7538.6	7609.4	7663.1	7717.2	7771.6	7826.4
GDP	7.0%																							
Electrification Ratio		60.0%	62.2%	64.4%	66.7%	68.9%	71.1%	73.3%	75.6%	77.8%	80.0%	82.2%	84.4%	86.7%	88.9%	91.1%	93.3%	95.6%	97.8%	100.0%	100.0%	100.0%	100.0%	100.0%
Population Electrified		3420.3	3727.2	3937.9	4153.5	4373.6	4597.9	4825.9	5057.1	5290.4	5525.0	5759.8	5993.8	6225.8	6454.8	6678.3	6905.5	7136.4	7371.0	7609.4	7663.1	7717.2	7771.6	7826.4

the growing ratio of power consumption per hou 3%

* Assuming the growing ratio of power consumption per house hold is 3% according to the assumption taken in 2002MP saying that the averaged number of persons per house hold would not change during the study period.

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Residentail	GWh	642.5	722.9	772.6	824.9	880.0	937.8	998.3	1061.5	1127.0	1194.7	1264.3	1335.5	1407.9	1481.2	1554.6	1631.4	1711.7	1795.7	1883.6	1953.8	2026.6	2102.1	2180.4
	2007	642.5	695.4	730.7	767.3	805.4	844.8	885.6	927.8	971.2	1015.6	1061.1	1107.4	1154.4	1201.9	1249.6	1299.2	1350.8	1404.4	1460.1	1514.5	1570.9	1629.5	1690.2
	2008		27.5	28.9	30.4	31.9	33.5	35.1	36.7	38.5	40.2	42.0	43.9	45.7	47.6	49.5	51.5	53.5	55.6	57.8	60.0	62.2	64.5	66.9
	2009			13.0	13.6	14.3	15.0	15.7	16.5	17.3	18.1	18.9	19.7	20.5	21.4	22.2	23.1	24.0	25.0	26.0	26.9	27.9	29.0	30.0
	2010				13.6	14.3	15.0	15.7	16.4	17.2	18.0	18.8	19.6	20.4	21.3	22.1	23.0	23.9	24.9	25.9	26.8	27.8	28.9	29.9
	2011					14.2	14.9	15.6	16.3	17.1	17.9	18.7	19.5	20.3	21.1	22.0	22.8	23.8	24.7	25.7	26.6	27.6	28.7	29.7
	2012						14.7	15.4	16.2	16.9	17.7	18.5	19.3	20.1	20.9	21.8	22.6	23.5	24.4	25.4	26.4	27.3	28.4	29.4
	2013							15.2	15.9	16.7	17.4	18.2	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	26.0	27.0	28.0	29.0
	2014								15.6	16.4	17.1	17.9	18.6	19.4	20.2	21.0	21.9	22.7	23.6	24.6	25.5	26.5	27.4	28.5
	2015									15.9	16.7	17.4	18.2	18.9	19.7	20.5	21.3	22.1	23.0	23.9	24.8	25.8	26.7	27.7
	2016										16.1	16.8	17.5	18.3	19.0	19.8	20.6	21.4	22.2	23.1	24.0	24.9	25.8	26.8
	2017											16.1	16.8	17.5	18.3	19.0	19.7	20.5	21.3	22.2	23.0	23.9	24.8	25.7
	2018												16.0	16.7	17.4	18.1	18.8	19.5	20.3	21.1	21.9	22.7	23.5	24.4
	2019													15.7	16.4	17.0	17.7	18.4	19.1	19.9	20.6	21.4	22.2	23.0
	2020														15.3	15.9	16.6	17.2	17.9	18.6	19.3	20.0	20.8	21.6
	2021															14.6	15.2	15.8	16.4	17.1	17.7	18.4	19.1	19.8
	2022																15.1	15.7	16.3	17.0	17.6	18.3	18.9	19.6
	2023																	15.6	16.2	16.8	17.5	18.1	18.8	19.5
	2024																		16.1	16.7	17.4	18.0	18.7	19.4
	2025																			16.6	17.2	17.9	18.5	19.2

elasticity ratio of power consumption of a commercial sector to GDP growing ratio 1.0

* based on the fact that GDP growing ratio was 6.4 % and demand growing ratio of a commercial sector was 6.2 % during 1995-2000 described in 2002MP

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Commercial	GWh	187.97	201.1	215.2	230.3	246.4	263.6	282.1	301.8	323.0	345.6	369.8	395.7	423.4	453.0	484.7	518.6	554.9	593.8	635.3	679.8	727.4	778.3	832.8

Assuming that the power demand of irrigation is in proportion to population

Irrigation		41	43	44	45	45	46	47	48	49	49	50	51	51	52	52	53	53	54	54	55	55	56	56

Assuming that the power demand of the governmental sector is in proportion to population

Gov		112.33	118.04	120.41	122.77	125.11	127.41	129.68	131.89	134.04	136.09	138.04	139.87	141.56	143.09	144.44	145.8	147.17	148.55	149.95	151.01	152.07	153.144	154.225

elasticity ratio of power consumption of a industrial sector to GDP growing ratio 1.8

Power consumption of an industrial sector allocated to substation loads and 115 kV receiving loads was assumed to make progress at the same ratios of 2007

Industries supplied by S/S	309	348	391	441	496	559	629	709	798	898	1,012	1,139	1,283	1,444	1,626	1,831	2,062	2,321	2,614	2,943	3,314	3,732	4,202
Industries supplied by 115 kV	338	381	429	483	543	612	689	776	873	983	1,107	1,247	1,404	1,581	1,780	2,004	2,257	2,541	2,862	3,222	3,628	4,085	4,600
Total of Industries	647	728	820	923	1,040	1,171	1,318	1,484	1,671	1,882	2,119	2,386	2,687	3,025	3,406	3,835	4,319	4,863	5,476	6,166	6,942	7,817	8,802
Specific consumers foreseen		369	1,623	2,689	2,858	3,496	3,496	3,622	3,833	3,879	3,879	3,921	3,921	3,921	3,921	3,921	3,921	3,921	3,921	4,318	4,774	5,263	5,789

Power consumpiton supplied from SS

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Residentail		642	723	773	825	880	938	998	1,061	1,127	1,195	1,264	1,335	1,408	1,481	1,555	1,631	1,712	1,796	1,884	1,954	2,027	2,102	2,180
Commercial		188	201	215	230	246	264	282	302	323	346	370	396	423	453	485	519	555	594	635	680	727	778	833
Gov		112	118	120	123	125	127	130	132	134	136	138	140	142	143	144	146	147	149	150	151	152	153	154
Irrigation		41	43	44	45	45	46	47	48	49	49	50	51	51	52	52	53	53	54	54	55	55	56	56
Industries		309	348	391	441	496	559	629	709	798	898	1,012	1,139	1,283	1,444	1,626	1,831	2,062	2,321	2,614	2,943	3,314	3,732	4,202
S/S		**1,292**	**1,433**	**1,543**	**1,663**	**1,793**	**1,934**	**2,086**	**2,252**	**2,431**	**2,624**	**2,834**	**3,061**	**3,307**	**3,573**	**3,862**	**4,180**	**4,529**	**4,913**	**5,337**	**5,783**	**6,275**	**6,821**	**7,425**

Table 6.7-4 Power Demand Forecast of the Whole of Laos Up to 2030

year		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Specific Demand	MW	386.1	639.6	679.6	831.5	831.5	861.5	911.5	922.5	922.5	932.5	932.5	932.5
Specific Demand	GWh	1,623	2,689	2,858	3,496	3,496	3,622	3,833	3,879	3,879	3,921	3,921	3,921
S/S Load at Consumer Side	GWh	1,543	1,663	1,793	1,934	2,086	2,252	2,431	2,624	2,834	3,061	3,307	3,573
Distribution Loss Ratio		14.5%	14.0%	13.5%	13.0%	12.5%	12.0%	11.5%	11.0%	10.5%	10.0%	9.5%	9.5%
S/S Load at Substation Bus Bars	GWh	1,767	1,896	2,035	2,185	2,347	2,522	2,710	2,913	3,131	3,367	3,621	3,913
Load Factor for Substation		58.2%	58.4%	58.5%	58.7%	58.9%	59.1%	59.3%	59.5%	59.6%	59.8%	60.0%	60.9%
Peak Load of Substations	MW	347	371	397	425	455	487	522	559	599	643	689	733
Nonuniform Factor for S/S		120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%
Summation of Peak Loads S/S	MW	416	445	476	510	546	585	626	671	719	771	827	880
Power Demand 115 Receiving End	GWh	3,391	4,586	4,893	5,682	5,844	6,144	6,543	6,792	7,010	7,288	7,542	7,834
Transmission Line Loss Ratio		6.4%	6.4%	6.3%	6.3%	6.2%	6.2%	6.2%	6.1%	6.1%	6.1%	6.0%	5.5%
Power Demand at Gen. Terminal	GWh	3,607	4,877	5,202	6,039	6,209	6,526	6,947	7,209	7,438	7,730	7,997	8,265
Demand at Consumer Side	GWh	3,167	4,353	4,651	5,430	5,583	5,874	6,263	6,503	6,713	6,982	7,228	7,494

year		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Specific Demand	MW	932.5	932.5	932.5	932.5	932.5	1,026.9	1,135.3	1,251.7	1,376.7	1,510.5
Specific Demand	GWh	3,921	3,921	3,921	3,921	3,921	4,318	4,774	5,263	5,789	6,351
S/S Load at Consumer Side	GWh	3,862	4,180	4,529	4,913	5,337	5,783	6,275	6,821	7,425	8,096
Distribution Loss Ratio		9.5%	9.5%	9.5%	9.5%	9.5%	9.5%	9.5%	9.5%	9.5%	9.5%
S/S Load at Substation Bus Bars	GWh	4,229	4,577	4,959	5,380	5,844	6,332	6,872	7,469	8,131	8,865
Load Factor for Substation		61.8%	62.7%	63.6%	64.5%	65.5%	66.4%	67.3%	68.2%	69.1%	70.0%
Peak Load of Substations	MW	781	833	890	952	1,019	1,089	1,166	1,251	1,343	1,446
Nonuniform Factor for S/S		120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%	120.0%
Summation of Peak Loads S/S	MW	937	999	1,068	1,142	1,223	1,307	1,399	1,501	1,612	1,735
Power Demand 115 Receiving End	GWh	8,150	8,498	8,880	9,301	9,765	10,650	11,645	12,732	13,920	15,216
Transmission Line Loss Ratio		5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%
Power Demand at Gen. Terminal	GWh	8,598	8,965	9,369	9,813	10,302	11,236	12,286	13,433	14,685	16,053
Demand at Consumer Side	GWh	7,783	8,101	8,450	8,834	9,258	10,101	11,049	12,084	13,214	14,447

Table 6.7-5 Power Demand Forecast for Each Substation (Central 1 Area)

[Unit: MW]

Province	Station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
VIENTIANE Capital		176.4	186.3	196.9	208.1	219.9	232.5	245.9	260.0	274.9	290.7	307.4	322.7	338.8	356.2	375.0	395.2	417.1
		6.0%	5.8%	5.8%	5.8%	5.8%	5.9%	5.9%	5.9%	5.9%	5.8%	5.8%	5.1%	5.1%	5.2%	5.3%	5.5%	5.6%
1	Phonetong SS	91.1	96.4	76.5	81.0	68.6	72.6	76.8	81.3	86.1	91.1	96.5	76.0	79.9	84.0	88.5	70.0	74.0
2	Tanaleng SS	40.0	42.3	44.7	47.3	50.1	53.0	56.1	59.4	62.9	66.6	70.5	74.1	77.8	81.9	51.8	54.6	57.6
	Naxaithong SS+VC	13.7	14.2	14.7	15.3	15.9	16.5	17.2	17.9	18.7	19.4	20.3	21.1	21.9	22.8	23.7	24.7	25.8
4	Khoksaat SS	15.9	16.8	17.8	18.8	19.9	21.1	22.3	23.6	25.0	26.5	28.0	29.5	31.0	32.6	34.3	36.2	38.2
5	Thangone SS	15.7	16.6	17.6	18.6	19.7	20.9	22.1	23.4	24.8	26.2	27.8	29.2	30.7	32.3	34.0	35.8	37.8
6	New 1 SS			25.5	27.0	28.6	30.2	32.0	33.9	35.9	38.0	40.2	42.2	44.4	46.7	49.2	51.9	54.8
7	New 2 SS					17.1	18.1	19.2	20.3	21.5	22.8	24.1	25.3	26.6	28.0	29.5	31.1	32.9
8	New 3 SS												25.3	26.6	28.0	29.5	31.1	32.9
9	ew 4 SS for Tanaleng															34.5	36.4	38.4
10	New 5 SS																23.3	24.7
VIETIANE		52.0	56.4	61.2	66.4	72.0	78.1	84.8	92.0	99.8	108.3	117.5	126.6	136.4	147.1	158.8	171.7	185.9
		25.7%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	7.7%	7.7%	7.9%	8.0%	8.1%	8.2%
1	Phonsoung SS	10.3	11.2	12.1	13.2	14.3	15.5	16.8	18.2	19.8	21.5	23.3	25.1	27.0	29.2	31.5	34.0	36.8
2	Vangvieng SS	18.0	19.5	21.1	22.9	24.9	27.0	29.3	31.8	34.5	37.4	40.6	43.8	47.1	50.8	54.9	29.7	32.1
3	Thalat SS	10.0	10.8	11.7	12.7	13.8	15.0	16.3	17.6	19.1	20.8	22.5	24.3	26.1	28.2	30.4	32.9	35.6
4	Nam Ngum1	2.1	2.3	2.5	2.7	3.0	3.2	3.5	3.8	4.1	4.5	4.8	5.2	5.6	6.0	6.5	7.1	7.6
5	Nam Leuk PS	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.2	4.6	4.9	5.4	5.8	6.2	6.7	7.3	7.8	8.5
6	Ban Don SS	3.4	3.7	4.0	3.2	3.5	3.8	4.2	4.5	4.9	5.3	5.8	6.2	6.7	7.2	7.8	8.4	9.1
7	Hin Heup SS				1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0
8	Non Hai SS	3.8	4.1	4.4	4.8	5.2	5.7	6.1	6.7	7.2	7.9	8.5	9.2	9.9	10.7	11.5	12.5	13.5
9	Nam Mang 3 PS	2.1	2.2	2.4	2.6	2.9	3.1	3.4	3.7	4.0	4.3	4.7	5.0	5.4	5.9	6.3	6.8	7.4
10	lew SS for Vangvieng																29.7	32.1
CENTRAL 1		**408.5**	**581.8**	**597.2**	**681.4**	**699.0**	**717.7**	**737.6**	**759.0**	**781.7**	**806.0**	**831.9**	**856.3**	**882.2**	**910.3**	**940.8**	**974.0**	**1,010.0**

Table 6.7-6 Power Demand Forecast for Each Substation (Central 2 Area and South Area)

[Unit: MW]

Province	Station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BOLIKHAMXAY		10.6	11.5	12.5	15.8	17.2	18.8	20.4	22.3	24.2	26.4	28.8	31.1	33.6	36.4	39.5	42.9	46.6
	rate of increase	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.1%	8.1%	8.3%	8.4%	8.5%	8.7%
1	Pakxan SS	10.6	11.5	12.5	13.6	14.9	16.2	17.6	19.2	20.9	22.8	24.8	26.9	29.0	31.4	34.1	37.0	40.2
2	Khonsoung SS				2.2	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.9	6.4
KHAMMOUAN		30.0	32.6	35.4	38.4	41.7	45.3	49.1	53.3	57.9	62.8	68.2	73.5	79.2	85.5	92.3	99.9	108.1
	rate of increase	8.5%	8.5%	8.5%	8.5%	8.5%	8.6%	8.6%	8.6%	8.6%	8.6%	8.5%	7.7%	7.8%	7.9%	8.0%	8.2%	8.3%
1	Thakhek SS	25.9	28.1	30.5	33.1	36.0	39.1	42.4	46.0	50.0	54.2	29.4	31.7	34.2	36.9	39.8	43.1	46.7
2	Mahaxai SS	4.1	4.5	4.8	5.3	5.7	6.2	6.7	7.3	7.9	8.6	9.3	10.1	10.9	11.7	12.6	13.7	14.8
3	New SS for TKK											29.4	31.7	34.2	36.9	39.8	43.1	46.7
SAVANNAKHET		41.8	44.4	47.2	50.2	53.4	65.8	69.9	74.3	79.0	84.0	89.3	94.3	99.5	105.2	111.3	117.9	125.1
	rate of increase	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	5.5%	5.6%	5.7%	5.8%	5.9%	6.1%
1	Pakbo SS	28.2	30.0	31.8	33.9	36.0	38.3	40.7	43.3	46.0	48.9	52.0	54.9	29.0	30.6	32.4	34.3	36.4
2	SS 1 at Savannakhet													29.0	30.6	32.4	34.3	36.4
3	Kengkok SS	13.6	14.5	15.4	16.4	17.4	18.5	19.7	20.9	22.2	23.6	25.1	26.5	28.0	29.6	31.3	33.2	35.2
4	Sepon SS						9.0	9.6	10.2	10.8	11.5	12.2	12.9	13.6	14.4	15.2	16.1	17.1
CENTRAL 2		**275.4**	**341.5**	**348.1**	**357.4**	**365.3**	**382.8**	**392.5**	**402.9**	**414.2**	**426.3**	**439.3**	**451.9**	**465.4**	**480.1**	**496.1**	**513.6**	**532.8**
Province	**Station**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
SARAVAN	residencial demand	10.8	11.7	12.7	13.8	15.0	16.2	17.6	19.1	20.7	22.5	24.4	26.3	28.3	30.5	33.0	35.6	38.6
	rate of increase		8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%	7.7%	7.7%	7.8%	8.0%	8.1%	8.2%
1	Saravan SS		10.0	10.8	9.0	9.7	10.5	11.4	12.4	13.5	14.6	15.9	17.1	18.4	19.8	21.4	23.2	25.1
2	Xeset 1 PS	1.8	1.8	1.9	2.1	2.2	2.4	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.6	4.9	5.3	5.8
3	(New) Nongsano SS				2.8	3.0	3.2	3.5	3.8	4.1	4.5	4.9	5.3	5.7	6.1	6.6	7.1	7.7
XEKONG	residencial demand	2.2	2.4	2.6	2.8	3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.9	8.7
	rate of increase		9.3%	9.3%	9.3%	9.3%	9.3%	9.3%	9.3%	9.3%	9.3%	9.3%	8.5%	8.5%	8.6%	8.8%	8.9%	9.0%
1	Xekong SS					3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.9	8.7
ATTAPEU	residencial demand	2.7	2.9	3.1	3.3	3.6	3.9	4.2	4.5	4.9	5.3	5.7	6.1	6.5	7.0	7.5	8.1	8.7
	rate of increase		7.8%	7.9%	7.9%	7.9%	7.9%	7.9%	7.9%	7.9%	7.9%	7.9%	7.1%	7.1%	7.2%	7.4%	7.5%	7.6%
1	Saphaothong SS	2.7	2.9	3.1	3.3	3.6	3.9	4.2	4.5	4.9	5.3	5.7	6.1	6.5	7.0	7.5	8.1	8.7
CHAMPASA	residencial demand	37.5	39.9	42.4	45.1	48.0	51.0	54.3	57.7	61.4	65.3	69.5	73.4	77.5	82.0	86.8	92.0	97.6
	rate of increase	23.2%	6.3%	6.3%	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	5.6%	5.6%	5.7%	5.9%	6.0%	6.1%
	Bang Yo SS	25.1	14.1	15.0	16.0	17.0	18.1	19.3	20.5	21.8	23.2	24.7	26.0	27.5	29.1	30.8	32.6	34.6
	Jianxai SS		12.6	13.4	14.2	15.1	16.1	17.1	18.2	19.4	20.6	21.9	23.1	24.4	25.8	27.4	29.0	30.8
	Pakson SS	4.4	4.7	5.0	5.3	5.7	6.0	6.4	6.8	7.3	7.7	8.2	8.7	9.2	9.7	10.3	10.9	11.5
	Ban Na SS	5.1	5.4	5.8	6.1	6.5	6.9	7.4	7.9	8.4	8.9	9.5	10.0	10.5	11.2	11.8	12.5	13.3
	Ban Hat SS	2.8	3.0	3.2	3.4	3.6	3.9	4.1	4.4	4.6	4.9	5.3	5.5	5.9	6.2	6.6	7.0	7.4
SOUTHERN		**107.0**	**119.4**	**123.2**	**155.2**	**162.6**	**167.5**	**222.8**	**228.4**	**234.4**	**240.9**	**247.8**	**254.5**	**261.5**	**269.2**	**277.5**	**286.6**	**296.5**

Table 6.7-7 Power Demand Forecast for Each Substation (North Area)

[Unit: MW]

Province		Station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
LUANPRAB/		residencial demand	16.8	17.7	18.7	19.8	20.9	22.1	23.4	24.7	26.1	27.6	29.2	30.6	32.1	33.8	35.5	37.4	39.5
		rate of increase	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	4.9%	4.9%	5.1%	5.2%	5.3%	5.5%
	1	Luangpraban 1 SS	14.5	15.3	16.2	17.1	7.2	7.6	8.1	8.5	9.0	9.5	10.1	10.6	11.1	11.7	12.3	12.9	13.6
	2	P-3 (Xieng Nguen) SS					10.8	11.5	12.1	12.8	13.5	14.3	15.1	15.9	16.7	17.5	18.4	19.4	20.4
	3	LP-2 (Pakmong) SS	2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.9	5.1	5.4
XAYABULY		residencial demand	12.7	13.9	15.2	16.6	18.2	20.0	21.9	24.0	26.3	28.8	31.5	34.3	37.3	40.7	44.3	48.4	52.9
		rate of increase	35.2%	9.5%	9.5%	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	8.8%	8.8%	8.9%	9.0%	9.2%	9.3%
	1	Xayabuly SS	5.5	6.1	6.6	7.3	8.0	8.7	9.6	10.5	11.5	12.6	13.8	15.0	16.3	17.8	19.4	21.2	23.2
	2	Paklay SS						5.2	5.7	6.3	6.9	7.5	8.3	9.0	9.8	10.6	11.6	12.7	13.9
	3	Hongsa SS					5.5	6.0	6.6	7.2	7.9	8.6	9.5	10.3	11.2	12.2	13.3	14.5	15.9
XIENGKHOU		residencial demand	6.0	6.7	7.5	8.3	9.3	10.3	11.5	12.8	14.2	15.8	17.6	19.4	21.5	23.7	26.3	29.2	32.4
		rate of increase	9.5%	11.2%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	10.5%	10.5%	10.6%	10.8%	10.9%	11.0%
	1	Phonsavan SS	4.8	5.4	6.0	6.6	7.4	8.2	9.1	10.2	11.3	12.6	14.0	15.5	17.1	18.9	21.0	23.3	25.8
	2	Moung Kham SS			1.5	1.7	1.9	2.1	2.3	2.6	2.9	3.2	3.6	3.9	4.3	4.8	5.3	5.9	6.6
HUAPHANH		residencial demand	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.5	2.8	3.0	3.3	3.6	4.0	4.3	4.8	5.2
		rate of increase		9.9%	9.9%	9.9%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	9.1%	9.2%	9.3%	9.4%	9.6%	9.7%
	1	Xam Neua SS			1.4	1.6	1.7	1.9	2.1	2.3	2.5	2.8	3.0	3.3	3.6	4.0	4.3	4.8	5.2
PHONGSAL		residencial demand	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7
		rate of increase		7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	6.2%	6.2%	6.4%	6.5%	6.6%	6.7%
			0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7
	1	Boun Neua SS				0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7
LUANGNAM		residencial demand	3.9	4.3	4.8	5.3	5.9	6.6	7.4	8.2	9.2	10.2	11.4	12.6	13.9	15.4	17.1	19.0	21.1
		rate of increase	37.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	11.4%	10.6%	10.6%	10.7%	10.9%	11.0%	11.1%
	1	Luangnamtha SS	3.9	4.3	4.8	5.3	5.9	6.6	7.4	8.2	9.2	10.2	11.4	12.6	13.9	15.4	17.1	19.0	21.1
OUDOMXAY		residencial demand	2.5	2.7	2.9	3.2	3.5	3.8	4.2	4.6	5.0	5.5	6.0	6.5	7.1	7.7	8.4	9.1	10.0
		rate of increase	34.9%	9.3%	9.3%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	8.6%	8.6%	8.7%	8.9%	9.0%	9.1%
	1	Oudomxai SS	2.5	2.7	2.9	2.6	2.8	3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	8.0
	2	Namo SS				5.6	5.7	5.8	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.7	6.8	7.0
BOKEO		residencial demand	5.3	5.9	6.6	7.3	8.2	9.1	10.1	11.3	12.6	14.1	15.7	17.3	19.2	21.3	23.6	26.2	29.1
		rate of increase	37.5%	11.4%	11.4%	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%	10.6%	10.7%	10.8%	10.9%	11.1%	11.2%
	1	Houayxai SS				7.3	8.2	9.1	10.1	11.3	12.6	14.1	15.7	17.3	19.2	21.3	23.6	26.2	29.1
NORTHERN			**59.0**	**91.3**	**137.2**	**198.8**	**209.0**	**240.0**	**246.8**	**254.3**	**262.5**	**271.4**	**281.3**	**291.1**	**301.9**	**313.8**	**327.0**	**341.7**	**358.0**
TOTAL			**849.9**	**1,134.1**	**1,205.7**	**1,392.9**	**1,435.9**	**1,508.0**	**1,599.7**	**1,644.6**	**1,692.8**	**1,744.6**	**1,800.3**	**1,853.7**	**1,911.0**	**1,973.4**	**2,041.5**	**2,115.9**	**2,197.3**

Table 6.7-8 Power Demand Forecast for Special Consumers

[Unit: MW]

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VIENTIANE CITY	Vinetiane Commerce(new)		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Iron/coal Mine(new)	12	13.5	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
VIETIANE PROVINCE	Phubia mine	49.1	49.1	49.1	49.1	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	Kaly Factory (Sinno Lao)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Sanakham mining (Dow Lao)					40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Iron processing factory					25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Vang Vient Mining Co.(new)		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Steal making plant	64.5	85.5	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224
LUANPRABANG	Cement factory (Pakmong SS)			9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
	United			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
XAYABULY	Cu Mining (Pakday) (Deuktian)				40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
XIENGKHOUANG	Fe Mining (Muong Kham)		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Fe mining (Phonsavan)					10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
KHAMMOUAN	Cement Factory(Lao Cement)		17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	Many Companies(new)		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Lao Cement Industry			60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
SAVANNAKHET	Xepon Mine		74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
	Savan Park			5	5	11	11	21	21	32	32	42	42	42	42	42	42	42	42	42	42	42	42	42
SARAVAN	Cement factory (Chaugyang)		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
XEKONG	Lao Aluminium Industry		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
ATTAPEU	Sinoma					20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Army Mining Company								50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
CHAMPASAK	Sinoma					8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
PHONGSALY	Cu Mining			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Cu Mining							20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
LUANGNAMTHA	Cu Mining		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
OUDOMXAY	Cu Mining, (Sanmou)					20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Cement factory					10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Lao Younesin Mining Development	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Toun Haung Lao-China Mining					10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Specific Demand appering later																			94.43	202.8	319.2	444.2	578
		150.6	386.1	639.6	679.6	831.5	831.5	861.5	911.5	922.5	922.5	932.5	932.5	932.5	932.5	932.5	932.5	932.5	932.5	1026.9	1135.3	1251.7	1376.7	1510.5