No.

MINISTRY OF INDUSTRY AND HANDICRAFTS

ELECTRICITE DU LAOS

THE STUDY
ON
MASTER PLAN
OF
TRANSMISSION LINE AND SUBSTATION SYSTEM
IN
LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

(SUMMARY)

SEPTEMBER 2002

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
TOKYO ELECTRIC POWER COMPANY

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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 Master Plan of Transmission and Substation System in Lao P.D.R. and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team headed by Mr. Ko NAKAJIMA of Nippon Koei Co., Ltd. organized by Nippon Koei Co., Ltd. and Tokyo Electric Power Company to Lao P.D.R. six times from March 2001 to September 2002.

The team held discussions with the officials concerned of the Government of Lao P.D.R., and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the improvement of the situation of electricity supply in Lao P.D.R. and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Lao P.D.R. for their close cooperation throughout the study.

September 2002

Takao KAWAKAMI
President
Japan International Cooperation Agency

September 2002

Mr. Takaaki Kawakami
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Kawakami,

Letter of Transmittal

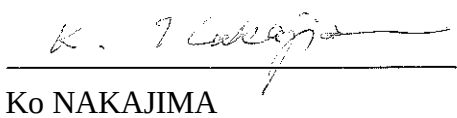
We are pleased to submit you the final report on the Study on Master Plan of Transmission and Substation System in Lao People's Democratic Republic.

This study was conducted by the joint venture of Nippon Koei Co., Ltd. and Tokyo Electric Power Company under a contract to JICA, during the period from March 2001 to September 2002. In conducting the study, we have formulated the Master Plan for the optimum transmission and substation system in Lao P.D.R. up to 2020.

We wish to take this opportunity to express our sincere gratitude to the officials concerned 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 concerned of the Ministry of Industry and Handicrafts, the Electricite du Laos and Embassy of Japan in Lao P.D.R. for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Ko NAKAJIMA
Team Leader

The Study on Master Plan of Transmission and Substation System in Lao P.D.R

Nippon Koei Co., Ltd.

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CONTENTS

ABBREVIATIONS

ACSR	:	Aluminum Conductor Steel Reinforced
ADB	:	Asian Development Bank
AFTA	:	Association of Southeast Asian Nations Free Trade Area
ASEAN	:	Association of Southeast Asian Nations
BOT	:	Build, Operate, and Transfer
BOOT	:	Build, Own, Operate, and Transfer
CA	:	Concession Agreement
CB	:	Circuit Breaker
CIF	:	Cost, Insurance, and Freight
CPC	:	Committee for Planning and Cooperation
CPI	:	Consumer Price Index
CT	:	Current Transformer
DIP	:	Department of Investment Promotion
DL	:	Distribution Line
DOE	:	Department of Electricity in MIH
DS	:	Disconnecting Switch
EDS	:	Every Day Stress
EDL	:	Electricite du Laos
EGAT	:	Electricity Generating Authority of Thailand
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EU	:	European Union
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GEF	:	Global Environment Facility
GDP	:	Gross Domestic Product
GMS	:	Greater Mekong Sub-region
HDI	:	Human Development Index
HDSS	:	Hydropower Development Strategy Study
HV	:	High Voltage (230 kV and 115 kV in Laos)
ICB	:	International Competitive Bidding
IEC	:	International Electro-technical Committee
IDA	:	International Development Association
IKL	:	Isokeraunic Level
IMF	:	International Monetary Fund
IPP	:	Independent Power Producer
IRR	:	Internal Rate of Return
ISO	:	International Standards Organization
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standard
LAO P.D.R.	:	Lao People’s Democratic Republic
LDC	:	Load Dispatching Center
LF	:	Load Factor
LNGC	:	Lao National Grid Company

LOLP	:	Loss of Load Probability
LRMC	:	Long Run Marginal Cost
LV	:	Low Voltage (380/220 V in Laos)
MIH	:	Ministry of Industry and Handicrafts
MOSES	:	Multi-Objective Scenario Evaluation System
MOU	:	Memorandum of Understanding
MV	:	Medium Voltage (34.5 kV and 22 kV in Laos)
NBCA	:	National Bio-diversity and Conservation Area
NEAP	:	National Environmental Action Plan
NETG	:	National Electricity Transmission Grid
NPV	:	Net Present Value
NTL	:	Non-Technical (Energy) Loss
OCC	:	Opportunity Cost of Capital
OH	:	Overhead (line)
OPGW	:	Optical fiber Ground-wire
O&M	:	Operation and Maintenance
PEA	:	Provincial Electricity Authority (in Thailand)
PIP	:	Public Investment Program
PLC	:	Power Line Carrier (communications)
PPA	:	Power Purchase Agreement
PS	:	Power Station
PSS/E	:	Power System Simulator for Engineering
PSSS	:	Power Sector Strategy Study (by ADB)
PT	:	Potential Transformer
RUS	:	Rated Ultimate Strength
SS	:	Substation
STEA	:	Science, Technology, and Environmental Agency
STEP	:	JICA Study Team for Electric Power Standard Establishment
SCF	:	Standard Conversion Factor
SHS	:	Solar Home System
SwS	:	Switching Station
TA	:	Technical Assistance
TL	:	Transmission Line
TOR	:	Terms of Reference
TR	:	Transformer
UNDP	:	United Nations Development Program
UNHCR	:	United Nations High Commissioner for Refugees
UXO	:	Unexploded Ordnance
WB	:	World Bank
WTO	:	World Trade Organization
WTP	:	Willingness to Pay

UNITS

LENGTH

mm	:	Millimeters
cm	:	Centimeters (10.0 mm)
m	:	Meters (100.0 cm)
km	:	Kilometers (1,000.0 m)

EXTENT

cm^2	:	Square-centimeters (1.0 cm x 1.0 cm)
m^2	:	Square-meters (1.0 m x 1.0 m)
km^2	:	Square-kilometers (1.0 km x 1.0 km)
ha	:	Hectares (10,000 m^2)

VOLUME

cm^3	:	Cubic-centimeters (1.0 cm x 1.0 cm x 1.0 cm)
m^3	:	Cubic-meters (1.0 m x 1.0 m x 1.0 m)

WEIGHT

g	:	grams
kg	:	kilograms (1,000 g)
ton	:	Metric ton (1,000 kg)

TIME

sec.	:	Seconds
min.	:	Minutes (60 sec.)
hr.	:	Hours (60 min.)

CURRENCY

KIP	:	Lao Kip
US$	:	United State Dollars
J¥	:	Japanese Yen
ECU	:	Euro Currency Unit

ELECTRIC

V	:	Volts (Joule/coulomb)
kV	:	Kilo volts (1,000 V)
A	:	Amperes (Coulomb/second)
kA	:	Kilo amperes (1,000 A)
W	:	Watts (active power) (J/s: Joule/second)
kW	:	Kilo watts (10^3 W)
MW	:	Mega watts (10^6 W)
GW	:	Giga watts (10^9 W)
Wh	:	Watt-hours (watt x hour)
kWh	:	Kilo watt-hours (10^3 Wh)
MWh	:	Mega watt-hours (10^6 Wh)
GWh	:	Giga watt-hours (10^9 Wh)
VA	:	Volt-amperes (apparent power)
kVA	:	Kilo volt-amperes (10^3 VA)
MVA	:	Mega volt-amperes (10^6 Wh)
var	:	Volt-ampere reactive (reactive power)
kvar	:	Kilo volt-ampere reactive (10^3 var)
Mvar	:	Mega volt-ampere reactive (10^6 var)

Summary

1. Conclusion and Recommendation

1.1 Optimum Transmission Line and Substation System for Domestic Supply

Major objectives of the Master Plan Study were the following, for raising electrification rate through the efficient utilization of electricity generated at the EDL's power plants for domestic supply and also delivered from IPP plants to domestic use:

(a) Formulation of the optimum transmission line and substation system for domestic supply of electricity to meet the growing demand by 2020,
(b) Selection of the highest priority project from various systems in the formulated optimum system, and
(c) Design of transmission lines and substations for the highest priority project.

The optimum system was formulated on the basis of the policy of the Government of Lao People's Democratic Republic (Lao PDR) that the current household electrification rate of 34% should be raised to 90% by the year 2020. The study has been carried out on the basis of the latest EDL's development program of power plants for domestic supply and programmed IPPs' plants.

The optimum system was formulated taking into account the commissioning years of new power stations in the country, economical delivery of electricity from those power plants to demanding areas, stability and sustainability of electricity supply, environmental considerations, and others. The optimum national transmission system for domestic electricity supply thus formulated by the Study Team is shown on Figure 1.1-1. The system was formulated for every 5 years over 2005, 2010, 2015, and 2020, coordinating with commissioning times of the power plants programmed for the domestic supply. According to the formulated system, most of the trunk power systems deem to be completed by 2020.

Through the detailed examinations, major substations are located at the provincial capitals and major demanding towns of each province. Transmission line routes are aligned avoiding or detouring the national parks, national bio-diversity and conservation area (NBCA), densely populated areas, heavy remnant areas of UXO (Unexploded Ordnance) from points of easy construction and maintenance works. The detailed examination resulted in that the optimum system voltage for domestic supply by 2020 is 115 kV and the optimum power conductors by 2020 are ACSR 240 mm^2 and 410 mm^2.

1.2 Investment Plan for the Optimum Transmission System

Total construction cost for the optimum transmission system up to the year 2020 was estimated at US$480 million including construction cost of the running “Power Transmission and Distribution Project (PTD, funded by ADB & NDF)” and “Southern Provinces Rural Electrification Project (SPRE, funded by IDA)”. Following table is summarized in the form of disbursement schedule.

The cost was estimated referring to the recent contract prices of such international competitive bidding projects as PTD and SPRE Project. Various ICB price data owned by the Team has also been referred to. It was assumed that a section of the optimum system will be completed within 24 months for normal section and 18 months for shorter sections (less than 10 km lines) taking into account work progress in the local wet season. Amounts for LC (Local Currency) in the table are those locally paid for labours, land procurement, procurement of locally available materials, inland transportation, etc.

Construction Cost & Disbursement Schedule for the Optimum System (Thousand US$)

	Transmission Line Projects			Substation Projects			Total		
Year	FC	LC	Total	FC	LC	Total	FC	LC	Total
2001	2,865.3	1,464.8	4,330.1	1,410.3	229.9	1,640.2	4,275.6	1,694.7	5,970.3
2002	15,730.1	4,305.9	20,036.0	11,698.9	1,890.0	13,588.9	27,429.0	6,195.9	33,624.9
2003	19,316.7	9,263.6	28,580.3	6,899.5	971.4	7,870.9	26,216.2	10,235.0	36,451.2
2004	54,474.0	17,107.8	71,581.9	18,090.8	2,779.2	20,870.0	72,564.8	19,887.0	92,451.8
2005	31,258.1	14,263.9	45,522.0	5,374.2	823.3	6,197.5	36,632.3	15,087.2	51,719.5
2006	8,941.5	5,540.2	14,481.6	1,438.8	288.2	1,727.0	10,380.3	5,828.4	16,208.7
2007	23,796.9	6,371.8	30,168.7	6,207.2	1,399.6	7,606.8	30,004.1	7,771.4	37,775.5
2008	10,448.1	6,322.3	16,770.4	2,294.2	372.5	2,666.7	12,742.3	6,694.8	19,437.1
2009	23,634.5	6,810.0	30,444.5	12,438.6	1,610.8	14,049.4	36,073.1	8,420.8	44,493.9
2010	15,518.1	8,987.3	24,505.4	4,430.1	546.5	4,976.6	19,948.2	9,533.8	29,482.0
2011	33,332.5	9,783.0	43,115.6	7,004.9	1,321.7	8,326.6	40,337.4	11,104.7	51,442.1
2012	8,216.7	5,755.0	13,971.6	1,329.3	215.7	1,545.0	9,546.0	5970.7	15,516.7
2013	425.2	155.1	580.3	670.4	72.9	743.3	1,095.6	228.0	1,323.6
2014	2,043.2	1,075.6	3,118.7	1,196.0	211.7	1,407.7	3,239.2	1,287.3	4,526.5
2015	11,283.8	3,353.1	14,637.0	2,785.3	334.9	3,120.2	14,069.1	3,688.0	17,757.1
2016	2,809.0	1,933.9	4,742.9	1,492.2	192.0	1,684.2	4,301.2	2,125.9	6,427.1
2017	992.2	361.9	1,354.0	414.4	81.8	496.2	1,406.6	443.7	1,850.3
2018	1,451.7	771.9	2,223.5	692.3	67.9	760.2	2,144.0	839.8	2,983.8
2019	5,478.5	1,504.0	6,982.5	1,275.9	125.4	1,401.3	6,754.4	1,629.4	8,383.8
2020	1,225.7	814.1	2,039.9	151.4	15.0	166.4	1,377.1	829.1	2,206.2
Total	**273,241.7**	**105,945.2**	**379,186.9**	**87,294.5**	**13,550.6**	**100,845.1**	**360,536.5**	**119,495.6**	**480,032.0**

1.3 Evaluation of the Optimum System

The optimum transmission system is presumed to reflect the concept of “economic efficiency” in terms of resource allocation. The “efficiency” of the optimum system would be proved by comparison of the EIRR of the system to the opportunity cost of capital (OCC). Provided that the EIRR calculated is more than the OCC, economic viability of the system is to be sustained. Though no data concerning to such an OCC in Laos is available, this is assumed to be 11% judging from the OCCs of the countries with the similar level of economic development.

Computation of the EIRR resulted in 23.9 % for the base-case. The value is higher than OCC of 11 %, and accordingly the formulated system was evaluated to be economically feasible. Following table shows the results of EIRR and the sensitivity analyses.

Results of Economic Analysis and its Sensitivity Analysis

Variables	EIRR %	NPV_{2001} million US$
Base Case	23.9	231.1
Investment Costs +15 %	20.3	192.3
Project Benefits –10 %	20.9	179.3
O&M Costs +50 %	23.2	217.3

Electricite du Laos (EDL) is a power corporation that owns every facility from generation through transmission to distribution networks, and is responsible for the entire flow from power production to retail sale to energy users. This indicates uncertainty of hand-over or wholesale price between generation outlet and transmission inlet. Furthermore, this Project is to develop the transmission and substation facilities over the country, the project system covers many remote and scattered demand points, and the power tariff includes subsidy. Under the conditions, revenue related to the transmission lines and substations is difficult to be identified. Assuming that 40 % of the current tariff regulated toward the year 2005 would be allocated for the portion of transmission lines, substations, and distribution networks, a trial calculation of FIRR for the optimum system was carried out. Results of the calculation was, however, negative.

1.4 Selection of the Highest Priority Project

Candidates systems for the highest priority project were the following 4 systems to be completed before the year 2005 excluding those systems as under construction and deemed to be implemented under assistance of IDA, ADB, or other institutions.

- Subproject of Pakxan SS ~ Thakhek SS ~ Pakbo SS,
- Subproject of Nam Theun 2 PS ~ Xaibouathong SS,
- Subproject of Kengkok SS ~ Xepon SS, and
- Subproject of Lakpet SwS ~ Ban Boun ~ Thakho SS.

The evaluated items for the candidate subprojects were discussed with EDL and are summarized below:

(a) Urgency of the subproject in the respect of the governmental development program,
(b) Impact for environmental and UXO circumstances,
(c) Saving of imported energy by a subproject,
(d) Number of beneficiaries from a subproject, and
(e) Efficiency of investment (e-1) : Energy sales per investment
(e-2) : Beneficiaries per investment

The evaluation resulted in the system of Pakxan-Thakhek-Pakbo to be the highest priority project (hereinafter referred as “the Project”).

1.5 Facility Design of the Highest Priority Project

(1) Locations of 115 kV Substations

In consideration of the EDL’s current development program, the Pakxan and Pakbo substations for the Project are selected at the existing substations by expanding the existing facilities. For the same reason, the Thakhek substation is planned in premises of the new Thakhek substation to be completed in 2004. There are no issues for land acquisition and UXO for those substations.

(2) Selection of 115 kV Transmission Line Route

The line route is selected in careful consideration of the Government’s Environmental Law, Regulation on Implementing Environmental Assessment for Electricity Projects issued by MIH, regional development plans, regional land use, remnant conditions of UXO, etc. Principally, the route is aligned along Route 13. Land for the route is almost flat, and most of trees to be cleared in the right-of-way of the line are bushes. Since soil condition along the route is quite firm, no special type foundations will be required for towers. From the facts of easy access to the route from the Road No.13 and alignment in flat land, there will be no serious sections for construction and maintenance of the line facilities, if a careful schedule in the wet season will be taken.

(3) Design of Transmission Line and Substations

Since the highest priority project is a trunk system for the domestic power supply, N-1 design criteria is applied for sustainable reliability of the system. Facility Design was achieved on the bases of results of examination on local climatic conditions, power system analyses of the Study Team, Electric Power Technical Standard established by JICA STEP team, and international technical standards currently applied for the similar projects in Lao PDR.

1.6 Cost of the Highest Priority Project

Total project cost estimated for the designed facilities was as summarized in the following table. The cost was estimated on the ICB (International Competitive Bid) base referring to the recent contract costs for similar projects in Lao PDR and trends in the world market. Total project cost is approximately US$ 27.7 million.

Total Costs of the Highest Priority Project

Items	FC (US$)	LC (US$)	Total (US$)

Transmission Lines	15,005,200	3,987,500	18,992,700
Substation Facilities	3,344,900	422,600	3,767,500
Sub-total	18,350,100	4,410,100	22,760,200
Lands & ROW Compensation	0	10,000	10,000
UXO Survey & Clearance	2,000	1,000	3,000
Consultant Fee	1,820,800	0	1,820,800
Physical Contingency	1,835,000	441,000	2,276,000
Price Contingency	550,500	352,800	903,300
Ground Total	22,558,400	5,214,900	27,773,300

The Project can be completed within 36 months including periods for the project detailed design, procurement, and construction of facilities. It is essential for the Project that MIH/EDL should, prior to the Project, acquire lands required for the Project and also environmental certificate from STEA.

1.7 Evaluation of the Highest Priority Project

Evaluation of the Project was examined in comparison of EIRR and FIRR with OCC for Lao PDR to be 11 %.

The Project will activate power interconnection between Central 1 and Central 2 regions, and in the future with Southern region. Its benefits will be the substitute for imported electricity from the EGAT system of Thailand. The Project will accrue benefits due to avoided wheeling fee assumed for the EIRR analysis. While, FIRR analysis will be based on the incremental sales revenues to EDL from the demand at Thakhek, Pakbo, and Kengkok that are immediately deliverable from the Project.

Following table shows the results of EIRR, FIRR and sensitivity analyses for the Highest Priority Project.

Results of Computation for EIRR and FIRR

	Economic IRR		Financial IRR	
	EIRR (%)	NPV_{2002}	FIRR (%)	NPV_{2002}
Base Case	23.93	31,347	14.87	52,137
Investment + 15 %	21.35	28,024	13.44	50,238
Project tariff –10 %	21.96	25,997	13.79	45,651
O & M Cost + 50 %	23.58	30,485	14.56	50,461
Energy sold –30 %	17.80	15,295	11.35	32,698

The Project in any case is higher than 11% OCC, and considered viable in both economic and financial terms.

Major effects of the Project are (i) efficient utilization of surplus electric energy through the interconnection system, (ii) saving of foreign exchange owing to reduction of imported energy: US$ 63.4 million in a period of 2005-2020, (iii) contribution to about 980,000 electrified beneficiaries, (iv) improvement of social circumstance in the related regions, (v) economic impact to the project area,

(vi) start-up of development of domestic transmission system, and others.

1.8 Recommendation

Basic laws and regulations as well as the development policy relating to the power sector and environment in the Lao P.D.R have been issued, and detailed ordinance and rules of those laws and regulations are currently examined under the assistance of international organizations. On the other hand, the international connection of the power systems in the regional countries is discussed among the countries of ASEAN and also among countries of GMS. The JICA's STEP team is establishing the technical standards for the electric facilities. The WB is assisting EDL in improving the accounting system of EDL and in formulating the new power tariff system in the country. International organizations including JICA, WB and ADB are assisting MIH/EDL in raise of electrification rate over the country including off-grid areas. Under the situations the power sector of the Lao PDR should be certainly and rapidly improved, although technical and financial assistance of the international organizations will be needed.

(1) General Recommendation on Power Sector

Through the master plan study, the team has understood the actual situations of the present power sector. On the basis of experience, the team wishes to recommend the following activities to be tackled by MIH/EDL immediately for further improvement and well maintenance of the power sector of the Lao PDR.

(a) Updating of the formulated master plan in obedience to change of the social circumstances and development program of the power sources
(b) Establishment of new organization in EDL for O & M of the transmission systems
(c) Electrification in the off-grid areas
(d) Optimum operation of the comprehensive power system
(e) Establishment of the central load dispatching center
(f) Examination on the reservoir operation
(g) Efficient utilization of taken-off energy from IPP Plants

(2) Recommendation on the Highest Priority Project

The Project is recommended for urgent implementation viewing from its effects and results of the evaluation. However, there are several particulars to clear in advance of commencement of the development. Following are proposal and/or recommendation of the study team to MIH/EDL for clearing the particulars and for the proper operation plan of the Project after its completion.

(a) Environmental Assessment

In accordance with the MIH regulation, EA (Environmental Assessment) for the Project should be immediately carried out for STEA's approval of the Project. It will take 45 days at least for obtaining the environmental certificate. Supposing additional examination or assessment to the Project is required by STEA, it will take further 147 days as ruled in the regulation. EDL is recommended to submit EA report immediately for securing the possibility of project realization. Most information necessary for preparing the EA report is available in this report.

(b) Acquisition of Land for the Project

Land issue for 3 substations will not exist, since all facilities of substations under the Project are to be installed on the premises of the existing substations. The transmission line route selected referring to information and advice of EDL branch offices is shown on the 1:100,000 maps presented by the team to EDL. Since the route is selected avoiding villages and urban districts, number of houses to be resettled is limited as of June 2002. Topographic field survey carried out during the detailed design stage will emerge final number of houses for resettlement. However, acquisition of land and right-of-way for the transmission line is possible referring to the route maps. The team proposes EDL to secure the land in cooperation with the local authorities concerned in the Project area in an adequate advance.

(c) Arrangement of the Project Finance

It is also an urgent particular that MIH/EDL should request the project finance to a certain international supporting organization. The estimated project cost is approximately US$ 27.7 Million on the basis of ICB. All information necessary for preparing the application documents for the request is available in this report.

(d) Operation Plan of the Project after Completion

i) Designation of full responsibility for operation and & maintenance system
ii) Reinforcement of TSD (Technical Service Department) in Distribution Division of EDL
iii) Arrangement of substation maintenance group to EDL branch office
iv) Increase of and education to manpower for operation and maintenance of facilities
v) Re-education of present manpower
vi) Establishment of LDC (Load Dispatching Center) for comprehensive management of power system in the country

2. Overview of Lao PDR

2.1 Geography and Population

The country is mountainous and landlocked bordering on Vietnam, Cambodia, Thailand, Myanmar, and China. The country is characterized by a tropical climate with two distinct seasons; the rainy season from the beginning of May to the end of September and the dry season from October through April. Total population of the country was 4.6 millions in 1995 census. Total work force was estimated at 2.2 million in 1995, out of which 86 % was engaged in agriculture and fishery. Thus, the present Lao PDR is a typically agricultural country. The Government intends in its 5 year socio-economic plan to develop the country's economic structure from the present agricultural activity to the industrial activity.

Country's Social Indicators

Land	Area	:	236,800 km^2
	Capital	:	Vientiane
	Climate	:	Tropical monsoon having rainy and dry seasons High temperature and wet through a year
	Boundary	:	Bordered with Vietnam, Cambodia, Thailand, Myanmar, and China
	Land Use	:	Forest (46%), Cultivation (4%), and Others (50%) (1992)
	Agricultural Land	:	Temporary crops (73%), Left fallow (11%), Permanent crops (8%), Forest (5%), and Others (2%)
Population	Total	:	5,200,000 (estimated mid-year 2001)
	Growth Rate		2.6 % per annum (estimated mid-year 2001)
Aver. Life	Expectancy	:	53.8 years old (estimated in 1999)
	Birth Rate	:	40 per 1,000 population (record in 1995)
	Infant Mortality	:	104 per 1,000 population (record in 1995)
Labour	Force	:	2,166,501 in 1995
	Growth Rate	:	3.0 % (estimate in 1995)
Religion		:	Buddhism (about 60 %)
Language	(official)	:	Lao
Net Primary Enrollment		:	77 % (1999)
Literacy		:	58 % (male : 64%, female : 42%, in 1996)
GDP	1990 Constant	:	1,065,817 million Kips (1999)
	Current Price	:	10,388,076 million Kips (1999)
	Growth Average	:	6.18% (1996-2000)
Access to Safe Water		:	39 % of population (1999)
Physicians		:	0.2 per 1,000 people (1999)
Hospital Beds		:	2.6 per 1,000 people (1999)

(Source: State Planning Committee: National Statistical Center; World Bank Indicators, 2000; Bank of Lao PDR 2000)

2.2 Energy Sector of Lao PDR

Current energy mix of the country is firewood for approximately 90 %, 5 % by electricity and 5 % by oil. Indigenous energy resources of the country are hydro, coal/lignite, firewood, and solar energy.

The country is extraordinary rich in hydraulic power. Theoretical hydropower potential in the country

is estimated at 18,000 MW to 26,000 MW excluding mainstream of the Mekong River.

Coal deposits have been confirmed in the provinces of Phongsaly, Vientiane, Xieng Khuang, Khammouan and Saravan. High quality lignite has also been found in Hongsa district of Xayabury province near the border to Thailand, and its deposits are estimated at 220 million tons. According to the ADB report for HDSS, such sufficient reserves will be utilized for power generation for about 2,000 MW installed capacity.

Production of firewood in 1994 amounted to 4.38 million m^3, and its production increased at a rate of 3 % per annum during 1991 to 1994. As preventive measures for increasing consumption of firewood, installation of mini-hydro power plants, diesel-engine/generators, and solar system generating plants are studied for mountainous and hilly areas. Annual solar radiation received in Lao PDR is about 1,800 kWh/m^2. Photovoltaic modules have been used for small-scale remote applications. MIH is expecting to develop further installation of mini-hydro and photovoltaic modules into off-grid areas under foreign assistance. While, investigations for resources of fossil oil have been carried out in the territory, but the results are not known. Potential of wind energy in the country has also not been confirmed.

3. Power Sector in Lao PDR

3.1 Overview

Present electricity supply in the country is made by main grid and off-grid. Generation of the main grid is provided from three sources:

(a) Small or medium scale power plants developed by EDL to supply electricity to the national market
(b) Domestic off-take entitlements from IPP projects
(c) Imports from Thailand and Vietnam

Generation of the off-grid is locally achieved by means of diesel-engine generators, micro/mini hydropower plants, and solar energy systems. Electrification rates of villages and households in the country were respectively 20.0 % and 34.2 % in 1999.

The Government plans the electrification rates of the country to increase to 90 % by the year 2020. In addition to the extension of transmission system and grid supply, development of such renewable energy as solar and mini-hydro is indispensable in off-grid areas for the increase of electrification rate of the country. Electrification is a high priority of the GoL, and unserved areas are to be electrified by grid extension, off-grid facilities and domestic off-take entitlements from IPP plants. Grid extension is

planned to supply electricity to main load centers and more densely populated areas with access roads. Electrification in the areas where supply from grids is not economical is to be realized by such dispersed generating facilities as mini/micro hydropower, solar modules, diesel-engine generation, or other alternatives.

Under the Electricity Law, MIH has primary responsibility for the country's power sector. Under MIH, EDL is responsible for design, construction, and operation and maintenance of generating plants, and transmission line and substation facilities including power export. EDL has branch offices in several provinces for managing and control of local power supply. Electricity supply in the provinces without EDL branch office is managed by provincial authority itself.

3.2 Existing Power Facilities

Following are the existing power facilities as of June 2002.

(1) Power Plants

Power plants in the country of more than 97 % are of hydro-power. At present IPP power plants of Theun Hinboun (210 MW completed in 1998) and Houay Ho (150 MW completed in 1999) export energy to Thailand. Existing power plants including those IPP plants in the country are as below.

Existing Power Plants

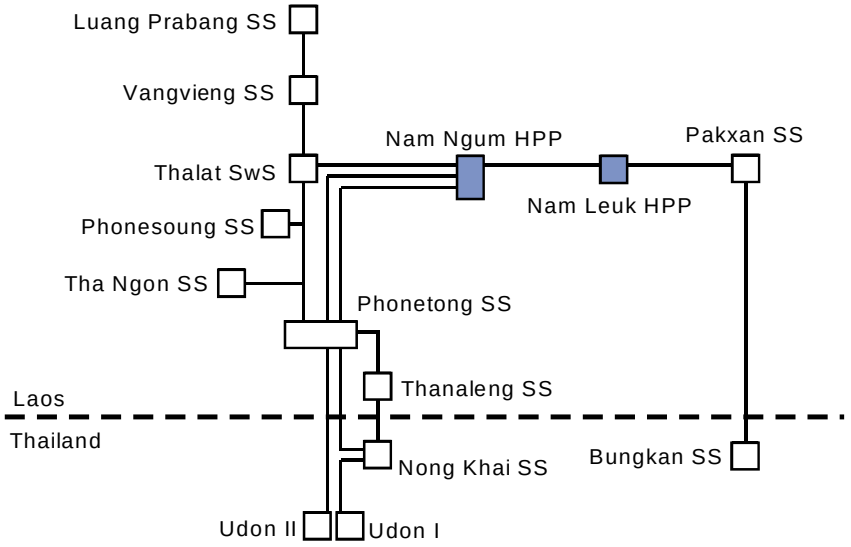
Plants (H: Hydro)	Place (Province)	Max. Output (MW)	Production GWh/year)	Owner	Completion Year
Theun Hinboun (H)	Khammouan	210	1,620	IPP	1998
Nam Ngum 1 (H)	Vientiane	150	960	EDL	1971
Houay Ho (H)	Attapeu	150	617	IPP	1999
Nam Leuk (H)	Vientiane	60	245	EDL	2000
Xeset 1 (H)	Saravan	45	181	EDL	1991
Selabam (H)	Champasak	5	34	EDL	1969
Nam Phao (H)	Bolikhamxai	1.6	7	Province	1995
Nam Ko (H)	Oudomxai	1.5	8	Province	1996
Nam Dong (H)	Luang Prabang	1	5	EDL	1970
Micro-Hydro (H)	(24 plants)	1.3	-	Province	-
Diesel	(11 plants)	15.2	-	Province	-
Total		640.6	3,677		

(2) Transmission Line Facilities

The highest system voltage for domestic supply in the country is 115 kV. Currently, there are 4 separate 115 kV transmission systems operated, which are not interconnected one another.

(a) Nam Ngum 115 kV System

This 115 kV system is the largest system in the country at present. Surplus energy is exported to Thailand.



Nam Ngum 115 kV Transmission System (as of July 2002)

(b) Thakhek 22 kV (115 kV) System

A 115 kV design transmission line with double circuits is operated as 22 kV system for energy import from Thailand to Thakhek town between EGAT's Nakhon Phanom substation and Thakhek 22 kV substation in Khammouan province.

(c) Savannakhet 115 kV System

The Savannakhet 115 kV system with 115/22 kV Pakbo substation is for importing energy from the EGAT system of Thailand through a 115 kV line to Savannakhet town because of unavailability of domestic power supply system in this area at present.

(d) Xeset 115 kV System

There are 2 power plants in the area; Xeset 1 (45 MW) and Selabam (5 MW) run-of-river type power stations. The system supplies power to rural area in Saravan province and Pakse town in Champasak province. The surplus energy of this system in the wet season is exported to Thailand. However, this area should import energy from Thailand in dry season. This 115 kV line is utilized for energy export and import.

(3) Substation Facilities

The above 4 transmission systems are operated for domestic energy supply and partially for export/ import of energy to/from Thailand. Existing 115/22 kV substations on those systems are summarized in the following table.

Existing 115/22 kV Substations (as of July 2002)

Substation	Supply Area	Number and Capacity	Total Capacity
Luang Prabang	Central 1	1 x 12.5 MVA	12.5 MVA
Vangvieng	Central 1	1 x 5 + 1 x 12.5 MVA	17.5 MVA
Phonesoung	Central 1	1 x 10 MVA	10 MVA
Tha Ngon	Central 1	1 x 22 MVA	22 MVA
Phonetong	Central 1	3 x 30 MVA	90 MVA
Thanaleng	Central 1	1 x 22 + 1 x 10 MVA	32 MVA
Pakxan	Central 1	1 x 5 MVA	5 MVA
Pakbo	Central 2	2 x 20 MVA	40 MVA
Bang Yo	Southern	1 x 16 + 2 x 8 MVA	32 MVA
Total			281 MVA

(4) Distribution Facilities

EDL's medium voltage (MV) distribution is principally 22 kV. Distribution facilities of 35 kV are partially operated for energy import from Vietnam. Those 22 kV distribution feeders are extended to urban and rural areas from 22 kV buses of 115/22 kV substations in EDL grid or diesel and small hydropower plants in provincial areas on overhead lines or underground cables. The low voltage distribution systems for supply to general consumers are 380/220 V, 3 phase and 4-wire.

3.3 Records of Electricity Demand

The average annual growth rate of peak load was 13.1% during the period from 1992 to 2000, while the rate during the recent five years (1995 to 2000) was 15.2%. Southern region showed remarkable increase of the annual energy consumption with 20.9% growth rate in the last five years. In 2000, the share of the Central 1 region was 71% of total energy consumption, followed by the Central 2 region at 18%, the Southern region at 10%, and the Northern region at 1%. In the period of 1992 to 2000, there was no drastic change in share of each region, however the Central 1 region gradually decreases its share and the Central 2 and Southern regions increase their shares.

Summary of Energy Consumption and Peak Load

										Ave. Growth Rate (%)	
	1992	1993	1994	1995	1996	1997	1998	1999	2000	92-2000	95-2000
Annual Energy Consumption (GWh)											
Northern	-	-	-	-	1.0	2.8	4.4	5.5	7.0	-	-
Central 1	204.6	200.9	213.2	258.9	287.8	323.1	375.4	402.1	462.0	10.7	12.3
Central 2	33.1	38.2	45.0	53.2	61.7	72.1	87.1	102.2	114.2	16.7	16.5
Southern	15.1	17.8	21.2	25.3	29.4	36.1	47.7	57.3	65.4	20.2	20.9
Whole country	**252.7**	**256.9**	**279.4**	**337.5**	**379.9**	**434.1**	**514.5**	**567.0**	**648.6**	**12.5**	**14.0**
Peak Load (MW)											
Northern	-	-	-	-	0.4	1.0	1.2	2.7	4.2	-	-
Central 1	51.4	50.5	55.7	64.0	70.6	77.0	90.1	102.7	119.9	11.2	13.4
Central 2	8.7	10.4	11.7	13.8	16.9	20.7	21.2	25.5	29.4	16.5	16.3
Southern	4.3	5.1	6.1	7.2	7.5	10.3	13.6	16.5	18.6	20.1	20.8
Whole country	**64.4**	**66.0**	**73.4**	**85.0**	**95.4**	**109.0**	**126.2**	**147.4**	**172.1**	**13.1**	**15.2**

3.4 Power Tariff System

(1) Domestic Power Tariff System

Energy consumption is charged according to rates in kWh, and there is no capacity charge based on the contract power. Time-of-day or seasonal differential tariffs are also not adopted. Uniform tariffs are applied throughout whole the EDL supply area and also provincial supply areas.

The Government decided to apply the following new tariff system with a rate increase of 2.3 %/month from May 2002 by the year 2005, on the basis of examination of a foreign consultant. The consultant also estimates LRMC at customers' end to be 741 Kips/kWh. The Government announced to set a subsidy to customers. However, it is expected that EDL's financial state might be improved by the new tariff system.

New Power Tariffs (Effective on May 2002)

(Tariff Unit: Kip/kWh)

Category	May 2002	Increasing Monthly Rate	Rates Forecasted		
			May 2003	May 2004	May 2005
Residence					
1 ~ 50 kWh	64	2.3 %	84	110	145
51 ~ 150 kWh	150	2.3 %	197	259	340
More than 151 kWh	433	2.3 %	569	747	982
Industry and Handicrafts	360	2.3 %	473	621	816
Commercial and Business	468	2.3 %	615	808	1,061
Entertainment	620	2.3 %	815	1,070	1,406
Irrigation	167	2.3 %	219	288	379
Governmental Agencies	400	2.3 %	525	690	907
Diplomacy & Foreigners	US$ 0.099	US$ 0.099	US$ 0.099	US$ 0.099	US$ 0.099

(Source: EDL Corporate Planning Office)

(2) Export and Import Power Tariffs of EDL

Tariffs for energy export and import have been determined through regular negotiations with the related authorities of Thailand and Vietnam. The current export rate from the Ngum/Nam Leuk and the import rate at Savannakhet and Thakhek were agreed in "Power Purchase/Sale Agreement between EGAT and EDL" on December 13, 1999 and are effective from October 1, 1999 to September 30, 2003. It is noted that no limits of peak load and energy for trading are specified in the agreement, but trading is to be achieved in the amount of as much as EDL is able to deliver and in the amount of as much as EGAT is able to import.

As seen in the table below, the import rate from EGAT is set at approximately 16 % to 17 % higher rate than that for export to EGAT. Import rates from PEA (Provincial Electricity Authority) of Thailand and that from Vietnam are set at further higher rate than that from EGAT.

EDL/EGAT Trading Tariffs for Export and Import

Hours	Export	Import
Peak Time (18:00~21:30)	1.22 Bahts/kWh	Export Tariff plus 0.5 US Cent/kWh =1.41 Bahts/kWh
Off-Peak Time (21:30~18:00)	1.14 Bahts/kWh	Export Tariff plus 0.5 US Cent/kWh =1.33 Bahts/kWh

(Source: EDL, System Planning Office)

Note: - Tariffs of the off-peak time are applied for the whole day on Sunday.

- Payment is made in US dollar. (50% by a fixed rate of US$1=Bahts 38, 50% by an exchange rate on paying date)

3.5 Reinforcement and Extension Plans of Power System

On the basis of various studies carried out under assistance of the WB and ADB, MIH/EDL prepared their own programs for reinforcement and extension of the power system.

(1) Development Program of Power Plants

Domestic Generation Development Projects Prepared by EDL

No	Region	Project	Commissioning Year	Installed Capacity (MW)	Annual Energy Production (GWh)
1	Central	Nam Mang 3	2004	35	140
2	Southern	Xeset 2	2005	76	309
3	Central	Nam Ngum 5	2006	100	430
4	Northern	Nam Beng	2006	45	175
5	Southern	Tha Kho	2008	36	215
6	Southern	Xeset 3	2008	20	85
7	Southern	Houay Lamphan Gnai	2010	65	354
8	Central	Nam Ngum 4B	2012	54	268
9	Southern	Xepon	2012	75	338
10	Central	Nam Pot	2014	23	97
11	Southern	Nam Kong 3	2016	34	156
12	Central	Nam Bak 2B	2016	116	563
13	Central	Nam Ngum 4A	2018	54	250
14	Southern	Xexou	2020	59	277
15	Central	Nam Sane2	2020	60	279

Construction of the Nam Mang 3 power plant in the above table has started toward its completion in 2004 under the loan from Exim Bank of China.

IPP Generation Development Program Estimated by EDL

No	Region	Project	Commissioning Year	Installed Capacity (MW)	Annual Energy Production (GWh)	Allocated for Domestic Use	
						(MW)	(GWh)
1	Central 1	Nam Mo	2006	105	581	5	29
2	Central 1	Nam Ngum 2	2008	615	2,109	31	105
3	Central 1	Nam Ngum 3	2008	460	1,851	23	93
4	Central 2	Nam Theun 2	2008	1,088	5,500	75	275
5	Central 1	Hongsa Lignite	2010	720	4,265	36	213
6	Southern	Xepien-Xenamnoy	2010	390	1,995	20	100
7	Southern	Xe Kaman 1	2010	468	1,925	23	96
8	Central 1	Nam Theun 1	2012	400	1,897	20	95
9	Southern	Nam Kong 1	2012	240	802	12	40
10	Southern	Xe Kaman 3	2012	218	1,349	11	67
11	Central 1	Nam Ngiep 1	2012	240	1,429	12	71
12	Southern	Sekong 4	2014	440	1,746	22	87
13	Southern	Sekong 5	2014	253	1,183	13	59
14	Central 1	Nam Theun 3	2016	236	772	12	39
15	Central 1	Nam Ngiep 2	2016	495	2,487	25	124
16	Central 1	Nam Ou	2018	500	2,628	25	131
17	Central 1	Nam Khan 2	2018	145	724	7	36

(2) Extension Plan of Transmission Lines and Substations

The WB and ADB assist the country in the extension of transmission lines and substations for domestic power supply. The ADB concentrates on the extension program of Nam Ngum-Nam Leuk system. Construction of the export-use 230 kV and 500 kV transmission system will be mainly developed by IPP together with development of its power plant. Besides, 500 kV interconnecting transmission systems are examined by GMS (Greater Mekong Sub-region) led by the ADB and also discussed among ASEAN group for international power trade.

(3) Extension Plan of Distribution Networks

The WB and ADB continue to assist the country in the construction of new distribution networks and reinforcement of the existing facilities for the purpose of rural electrification in the areas for development of the transmission lines and substations.

3.6 Issues of the Power Sector in Lao PDR

The current issues of the sector are consolidated below.

(a) Because of no interconnecting lines in the country, surplus of indigenous electricity can not be delivered to other domestic demanding areas, and those areas are compelled to import expensive electricity from Thailand or Vietnam.

(b) Most of the power facilities rely on import due to crudity of domestic industries.

(c) EDL's serious financial state due to low power tariff restrained by the Government, hard conditions of two-step loan from the Government, various taxes, declining foreign exchange rate against US dollar, etc.

(d) Inadequacy of rules and regulations for the sector and sagging technology

4. Background and Scope of the Study

4.1 Background of the Study

Lao PDR has an estimated hydropower generation potential of more than 18,000 MW in its territory. The Government of Lao PDR has a basic policy for the power sector which aims to acquire foreign currency earnings by exporting electricity to its neighboring countries and to raise electrification rate of the country.

Export of electricity has contributed to the country in its revenue since commissioning of the Nam Ngum power station. Contribution of the energy export from Nam Ngum - Nam Leuk and Xeset systems to Thailand was US$ 22.2 million (796 GWh) in 2001. This amount was 8 % of the country's total foreign currency earnings in the year. On the other hand, due to lack of the domestic transmission facilities, some areas of the country should import electricity at higher rate than that for export, totaling US$ 6.5 million (183 GWh) in 2001.

There are no domestic interconnecting transmission lines to the areas where electricity should be imported. While, IPPs' agreements with the Government of Lao have a particular article that IPP should deliver some amount of electricity produced in the plant for domestic consumption. Adequate transmission line systems are needed for delivering energy from EDL's power plants and also such energy as taken-off from the IPP plants to domestic demanding areas.

Under the situation, GoL proposed to the Government of Japan in May 2000 a request for the Study on Master Plan of Transmission Line and Substation System in the country for the domestic supply purpose. The Government of Japan entrusted to examine the request to the Japan International Cooperation Agency (JICA). Then, JICA discussed details of the request with officials of the Lao PDR during November 2000 and decided to conduct the Study.

4.2 Objective and Scope of the Study

Specific objectives of the Study were (i) formulation of an optimum development plan of the transmission lines and substations for domestic power supply over the country up to the year 2020 taking into account the development program of EDL's power plants and efficient utilization of energy

from IPPs' power plants, (ii) selection of the highest priority project from the formulated optimum system, and (iii) facility design for the highest priority project.

The study team carried out the Study during the period of February 2001 to September 2002 in Lao PDR and Japan in three (3) stages; the investigation stage, the system planning stage, and the master plan formulation stage. Works for selection of the highest priority project and facility design for the project were achieved in the master plan formulation stage.

5. Electricity Demand Forecast

5.1 Methodology of Demand Forecast

Electricity demand was forecasted by year and by district until 2020. Both annual energy consumption in GWh and peak demand in MW were forecasted. Energy demand by each district was forecasted by four categories, residential, industrial, commercial & service and agricultural sectors. Energy demand forecast by district was obtained by summing up energy demands of these four categories plus other specific energy consumption.

The general electrification policy of the country in the Socio-Economic Development Strategy published by the Government of LAO PDR in March 2001 stipulates a rate of electrification of 90% of all households by the year 2020, which was the basis of the study team’s demand forecast for the residential sector. Energy demand forecasts in industry sector and commercial & service sector were prepared on the basis of the elasticity between growths of GDP and energy consumption in the respective sector. Energy demand for agriculture sector is considered separately. Any specific development project planned to be implemented by the Government of LAO PDR, provincial government or private sector allover the country was considered in the energy demand forecast as an additional energy demand. In addition to this base case scenario, the Team forecasted electricity demand for high and low growth scenarios. For residential demand, the average annual growth rate of energy consumption was assumed at 6% for high scenario and 4% for low scenario against 5% for the base-case scenario. While, industry and commercial demands, growth of GDP was assumed for high scenario 0.5 point higher and 0.5 point lower than the base-case scenario.

5.2 Results of Demand Forecast

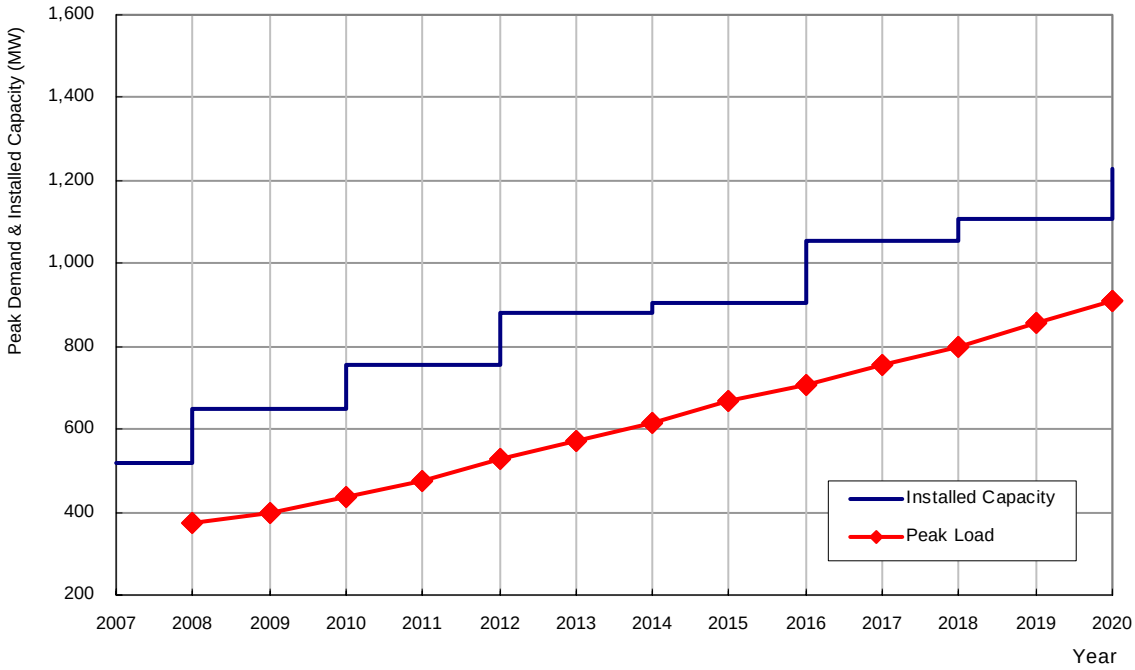
Following table summarizes the results of energy and peak load of the whole country forecasted by the study team by the year 2020.

Summary of Electricity Demand Forecast (Whole Country)

Descriptions	Unit	Scenari	2005	2010	2015	2020
Energy Demand	(GWh)	High	1,374	2,196	3,350	4,715
	(GWh)	Base	1,337	2,093	3,138	4,320
	(GWh)	Low	1,302	1,997	2,945	3,975
Losses	(GWh)	High	343	493	670	832
	(GWh)	Base	334	470	628	762
	(GWh)	Low	326	448	589	701
Total Energy Demand	(GWh)	High	1,672	2,688	4,020	5,547
	(GWh)	Base	1,672	2,563	3,765	5,082
	(GWh)	Low	1,628	2,445	3,534	4,676
Peak Demand	(MW)	High	340	512	765	1,055
	(MW)	Base	331	488	716	967
	(MW)	Low	322	465	672	890

5.3 Balance of Demand and Supply

Balance of the domestic demand forecast in the base-case of the study team and supply capability of the power plants programmed by MIH/EDL is as shown in the following chart. Supply capacity is quite sufficient to meet the growing demand till the year 2020.

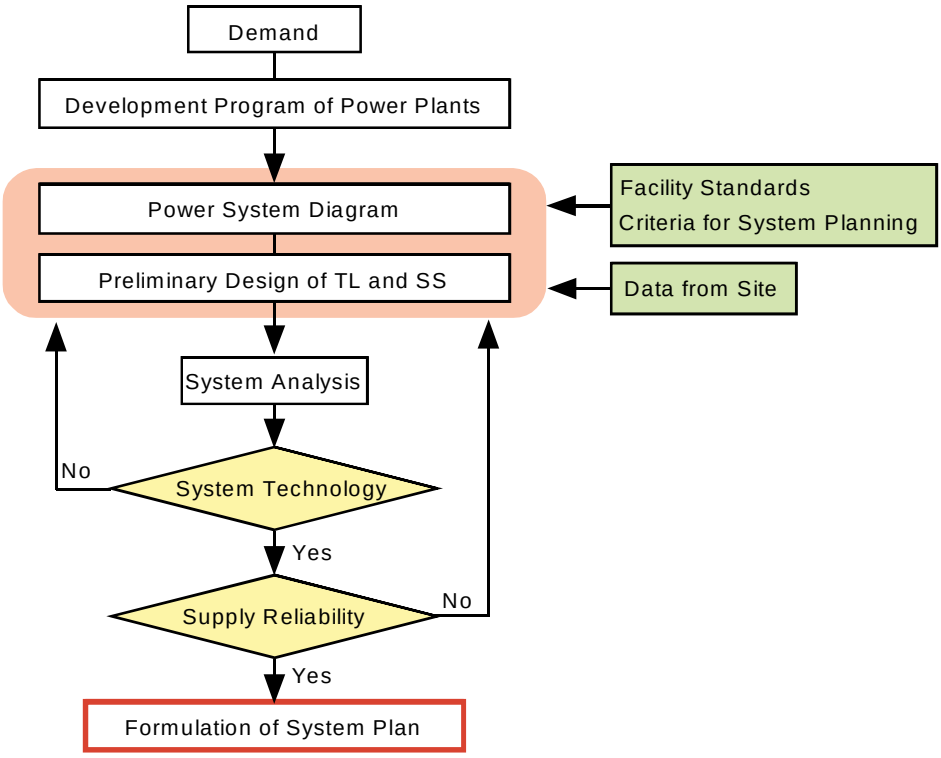


Demand – Supply Balance of EDL's National Grid

6. Formulation of Optimum Transmission System

6.1 Methodology of Formulation

Approach and methodology applied by the team for formulating the national transmission system are illustrated below. Examining the development and reinforcement program of power systems given by MIH/EDL, electricity demands forecasted by the study team, and power facilities under construction and facilities planned in the country by international organizations, the optional power system diagrams were prepared toward 2020 in every 5 years. Facility standards, system planning criteria such as supply reliability, voltage regulation, fault current, stability, and others were decided together with EDL prior to carrying out the system analysis.



Flow of System Planning

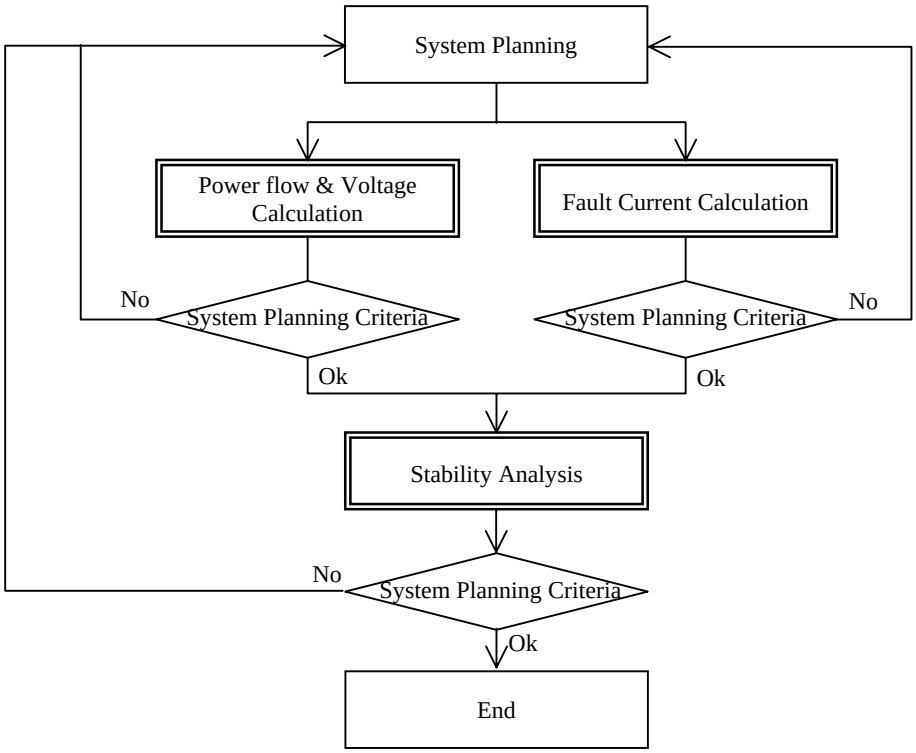
The optional system diagrams were determined taking into account various alternative interconnections between the existing and planned power plants and demanding areas. Then, the most adequate system voltage and conductors for the preliminary systems were examined and selected. Those optional systems were examined through computer analyses for confirmation of technical adequacies. The systems or system elements have been amended until results of the analysis satisfied the predetermined system criteria.

6.2 Selection Criteria of the Optimum System

The main benefits of the national transmission system are (a) to promote the national electrification rate to 90 % of all households by the year 2020 under the Government policy, (b) to facilitate adequate energy required for rural development programmed by the governmental authorities, (c) to save current import of energy by effective use of existing power stations, and (d) effectively to utilize energy taken-off from IPP plants. Following were examined in selecting the sections of the optimum transmission system.

(1) Social and environmental impacts
(2) Power flow, voltage, fault current, stability, and reliability of the transmission system
(3) Adequate and efficient energy supply to demand including rural development plans
(4) Availability of distribution network around the demand areas
(5) Degree of saving import energy
(6) Number of beneficiaries and degree of effect to Basic Human Needs by completion of the system
(7) Reducing transmission line losses
(8) Degree of UXO remnant
(9) Availability of construction and maintenance access roads
(10) Least construction and maintenance cost

6.3 Methodology of Analysis for the Optimum System



Flow of System Analysis

Based on the generation development program and the demand forecast, an appropriate system plan that satisfies the system planning criteria has been established in consideration for the EDL's international transmission system plan. Power flow, voltage regulation, fault current and stability in the system are basic technical elements that a power system will be properly and appropriately operated.

The system analyses by the Study Team were conducted in the above general flow. The supplemental system analyses have also been conducted on the cases of assumed alternation of the present generation development program for a flexible system plan. For the power system analyses, the Team has used the computer software named PSS/E that is familiar to EDL.

6.4 System Planning Criteria for System Analysis

As results of the discussions with EDL, the following system planning criteria were applied for the analysis.

(a) Classification of Power System

Power systems in this study were assumed to be two (2) kinds, "trunk" and "local", from their functional importance.

(b) Limitation of Power Flow

i) Under the normal operation condition, the load to transmission lines and transformers should be within the rated capacity.

ii) At any single contingencies, the load of transmission lines and transformers in the trunk system should be within the rated capacity without supply interruption. However, the load of 115/22 kV transformers in Vientiane municipality should be within 110% of the rated capacity after 2010 when the revised system planning criteria would be applied properly.

(c) Voltage Regulation

i) Under the normal operation condition, the voltage at any busbar in the transmission system should be maintained within 95 - 105% of the nominal voltage.

ii) At any single contingencies, the voltage at any busbar in the trunk system should be maintained within 92 - 108% of the nominal voltage without supply interruption.

iii) The power factor of each generator should be maintained within 90% (leading) - 85% (lagging).

(d) Fault Current

Three phase short circuit current and one phase to ground fault current should be less than the following limits.

Maximum Fault Current Level

Voltage class	Maximum fault current level
230 kV	40.0 kA (50.0 kA*[1])
115 kV	25.0 kA (31.5 kA*[2])
22 kV	25.0 kA (31.5 kA*[2])

(Note) *1: 50 kA should be applied when the fault current will be expected to exceed 40 kA in the future.
(Note) *2: 31.5 kA should be applied when the fault current will be expected to exceed 25 kA in the future.

(e) Stability

The power system should maintain the stability without supply interruption or limitation of power generation at main generators even under faults on transmission lines. The condition of contingencies is "a permanent three-phase fault of one circuit" with "normal fault clearing by main protection relay" and "without re-closing". The normal fault clearing time by main protective relay was assumed to be 100 ms in 230 kV system and 140 ms in 115 kV system.

6.5 Optimum System Voltage and Conductor Size

System voltages of 115 kV and/or 230 kV were examined for the domestic power supply system. The examination resulted in the optimum system voltage to be 115 kV for the domestic power supply from both economical and technical views.

Optimum conductors applied for the domestic supply system by the year 2020 in the country were selected to be ACSR 240 mm^2 and 410 mm^2.

6.6 Optimum Transmission Line and Substation System

Figure 1.1-1 shows the optimum transmission line and substation system by the year 2020 for the domestic power supply in Lao PDR, which was resulted by various examination and analyses as stated above. Suffixed figures mentioned in the Figure 1.1-1 indicate the years that the section would be commissioned. The system voltage for the domestic power supply by the year 2020 is 115 kV, and power conductors for the transmission lines are ACSR 240 mm^2 except the following sections.

Sections to be applied with ACSR 410 mm^2

From	To	Applied Conductor
Thalat SwS	Phonetong SS	ACSR 410 mm^2
Phonesoung SS	Phonetong SS	ACSR 410 mm^2
Nam Leuk PS	Nam Mang 3 PS	ACSR 410 mm^2
Lakxaosi SS	Thanaleng SS	ACSR 410 mm^2
Nam Ngum 5 PS	Phoukhoun SwS	ACSR 410 mm^2
Nam Back 2 PS	Nam Leuk PS	ACSR 410 mm^2
Ban Boun SS	Lakpet SS	ACSR 410 mm^2

6.7 Rural Electrification by Dispersed Power Supply

There are some areas that can not be covered by extensions from the optimum domestic power system formulated by the study team due to geographical, economical and/or technical difficulties.

Those isolated areas will be electrified by alternative power sources to be dispersedly provided by the related provincial or district authorities. Following are the study team's recommendations for alternative power source to those areas.

Rural Electrification by Dispersed Power Sources

Province	District	Alternatives
Phongsaly	Phonsaly, a part of Samphan & Ngot Ou, and May	Mini-hydro & diesel generator
Luang Namtha	A part of Long	Solar system
Bokeo	Houayxai, a part of Meung & Phaoudom	Mini-hydro and diesel generator
Luang Prabang	Viangkham	Mini-hydro
Houanphanh	Vienthong and Xam Tai	Mini-hydro
Xieng Khuang	Kham, Nonghed, a part of Morkmay & Phookood	Mini-hydro & solar system
Bolikhamxai	A part of Khamkheuth and Viengthong	Mini-hydro & solar system
Khammouan	A part of Boulapha	Mini-hydro & solar system
Xaisonboun	Most of districts	Solar system

7. Preliminary Design for the Facilities

7.1 Basic Design Criteria

(1) National Standards and Regulations

National technical standards, regulations or codes for electric facilities have not been issued in Lao PDR. The study team determines various criteria and design conditions of the recommended systems and facilities for the national power networks on the bases of information from the meteorological data over the Lao PDR, the JICA project "Electric Power Technical Standard Establishment (STEP)" team and EDL's practice on the system and facilities.

(2) Climatic Conditions

Climatic Conditions applied for the design were as follows;

(a)	Atmospheric Temperature	Maximum air temperature	45℃
		Minimum air temperature	0℃
		Annual mean air temperature	25℃
(b)	Air Density	0.12	
(c)	Wind Velocity	35 m/s (at 10 m height above ground)	
(d)	Wind Pressure	Conductor: 720 N/m^2	
		Insulator string: 1,010 N/m^2	
		Tower: 2,100 N/m^2 including pressure to rear structure	

(e)	Stringent Condition and EDS (Every Day Stress) Condition	Condition	Temperature	Wind
		Stringent	10 ℃	35 m/s
		EDS	25 ℃	Still air
(f)	Annual Rainfall	4,000 mm		
(g)	Isokeraunic Level （IKL）	140 days/year		
(h)	Seismic Condition	not considered		
(i)	Maximum humidity	100 %		
(j)	Pollution level	Light		

(3) Design Particulars for Transmission Lines

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

Normal condition = stringent condition: 1.5 to yield strength of materials

Broken-wire condition = normal condition + breakage of one ground-wire or one phase conductor: 1.0 to yield strength of materials

(d) Foundation

Normal condition = stringent condition: 2.0 to yield strength of foundation

Broken-wire condition = normal condition + breakage of one ground-wire or one phase conductor: 1.33 to yield strength of foundation

(4) Design Particulars for Substation Equipment

In the planning of new substations and/or reinforcement of the existing facilities for the optimum transmission system, following IEC standards were applied to the design of substation equipment. The Laotian Electric Power Technical Standard, being prepared by the JICA STEP team, was also applied to the design.

(a) Insulation Co-ordination

IEC-60071[1] and IEC-60694[2] were applied to the insulation design of the substation equipment.

(b) Standards Applied to the Design of Equipment

The latest IEC standards were applied to the design of substation equipment.

[1] IEC-60071: Insulation co-ordination

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

7.2 Preliminary Design of 115 kV Transmission Lines

(1) Selection of Conductor and Ground-wire

(a) Conductor and ground-wire

System analysis up to 2020 proved that ACSR 240 mm^2 (ASTM: Hawk) and ACSR 410 mm^2 (ASTM: Drake) are appropriate for 115 kV national transmission system. GSW 50 mm^2 (ASTM: GSW 3/8) was selected to be appropriate for the ground-wire. They are also applied for the existing and planned 115 kV lines.

(b) Standard span length

Standard span length between towers was assumed at 350 m.

(2) Insulator Design

(a) Insulator type and size

120 kN[3] (for ACSR 240 mm^2) and 160 kN[3] (for ACSR 410 mm^2) standard disc type porcelain insulators with ball and socket were applied.

(b) Number of insulator unit

Number of insulator unit per string was determined to be 10 considering pollution level, standard lightning impulse withstand voltage and the maintenance. Standard insulator sets applied for the existing and planned 115 kV lines in the Lao PDR have also 10 units per set.

(c) Number of insulator strings per set

Number of insulator string per set is applied single or double.

(3) Ground Clearance

Minimum conductor's height above ground of 115 kV level at areas where people rarely enter or will enter, such as mountains, forests, waste fields, etc. was determined as 7.0 m.

(4) Tower Configuration

(a) Insulation design

Standard gap and gap at abnormal state for 115 kV system were determined to comply with IEC60038. Those gap lengths are used for necessary clearances between conductor and tower, between conductors and between conductor and ground wire. Configurations of 8 standard types of towers were determined, accordingly.

[3] Figure is at Rated Ultimate Strength of insulator unit.

(b) Preliminary Tower Design

The conceptual design of towers was carried out. Loads from the towers to their foundations were then computed.

(c) Preliminary Design of Foundation

Preliminary concrete volumes of pad and chimney type foundations were worked out on the loads transferred from superstructure. Soil bearing capacity around foundation was assumed to be firm, because the project area is covered by such hard soil as red continental sandstone and clay spreads widely in the country

(5) Standard Quantities of 115 kV Transmission Lines

Quantities of a 115 kV transmission line per 10 km were worked out for both plain and mountainous areas for estimating average work quantities per km.

Average Quantities of 115 kV Transmission Lines per 10 km Long

		115 kV*1cct		115 kV*2cct	
		Plain	Mountain	Plain	Mountain
ACSR240 mm^2 (Hawk)	Tower	115 t	115 t	150 t	155 t
	Conductor	30 km	30km	60 km	60 km
	Ground wire	10 km	10 km	10 km	10 km
	Suspension insulator string	78 sets	69 sets	156 sets	138 sets
	Tension insulator string	18 sets	36 sets	36 sets	72 sets
	Foundation (Concrete volume)	140 m^3	170 m^3	470 m^3	540 m^3
ACSR410 mm^2 (Drake)	Tower	150 t	155 t	195 t	200 t
	Conductor	30 km	30 km	60 km	60 km
	Ground wire	10 km	10 km	10 km	10 km
	Suspension insulator string	78 sets	69 sets	156 sets	138 sets
	Tension insulator string	18 sets	36 sets	36 sets	72 sets
	Foundation (Concrete volume)	140 m^3	170 m^3	470 m^3	540 m^3

7.3 Preliminary Design of Substations

Planning and design of substations were carried out on the bases of the (i) System planning criteria, (ii) Electricity demand forecast, (iii) Power system analysis, and (iv) Optimum transmission system plan formulated by the study team.

(1) Design Concept

(a) Reliability Concept

The 'N-1' criteria were applied to 115 kV substations planned in Vientiane Municipality after the year 2011.

(b) Type of Substations

Standard substations shall be in principle of outdoor type applying the conventional equipment.

(c) Earthing System

In the switchyard of new substation, an underground earthing system should be properly laid in the form of a meshed grid. In case of extension of the existing substation, new earthing system should be connected to the existing one. All equipment installed in a substation should be connected to an earthing system effectively.

(2) Busbar Arrangement

The busbar system for 115 kV substations was selected in coordination with the related existing 115 kV and 22 kV networks in respect of supply reliability, operation and maintenance, and other factors. The 'main and transfer' busbar system was applied for 115 kV busbar system of the standard substation. While, the single busbar system was applied to such a rather small substation that provides with the limited numbers of HV feeders and/or transformers and less frequency of network switching operation.

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

(3) Main Transformers

(a) Type of Transformers

The main transformers were to be of three phase, oil immersed type with on load tap changer. ONAF (Natural oil cooling, forced air cooling) system was applied to the cooling system of a transformer. Three-winding star-star-delta (Y-Y-Δ) connection transformer was, in principle, be applied. Neutral point of primary side of transformer should be solidly grounded, while, secondary side should be grounded through a resistor.

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

The unit capacity and number of units of main transformers in a substation were determined, taking into comprehensive account demand forecast, economic feasibility, system reliability, voltage regulation, land acquisition, plan of equipment shift in the future, etc.

It is preferable to select the unit capacity and number of units of transformer so that the remaining healthy units can meet to peak load even when any one transformer is out of service ('N-1'). The N-1 criteria were applied to the existing and new substations located in the Vientiane Municipality. For the other substations, the N-1 criteria were not be applied. Also, the substation in the rural area may be provided with one unit of transformer for minimizing total construction cost if influence due to loss of unit is not so serious.

(c) Number of 22 kV Outgoing Feeders

The numbers of 22 kV outgoing feeders per transformer were, in principle, assumed to be three.

(4) Switchgear and other Equipment

(a) Circuit Breakers

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

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

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

(b) Standard Constitution of Equipment

Each line feeder, transformer feeder and bus coupler will consist of the following equipment.

Standard Constitution of Equipment

Feeders	Standard Constitution
230 kV and 115 kV line feeders	1 CB, 2 DS, 1 DS+ES, 3 CT, 2 LT, 3 VT and 3LA
230 kV and 115 kV TR feeders	1 CB, 2 DS, 1 DS+ES, 3 CT and 3 LA
230 kV and 115 kV bus coupler	1 CB and 2 DS
22 kV line feeders (outdoor)	1CB, 1 DS, 1 DS+ES, 3 CT and 3 LA
22 kV TR feeders (outdoor)	1CB, 1 DS, 3 CT and 3 LA

Note) CB: Circuit Breaker, DS: Disconnector, ES: Earthing Switch, CT: Current Transformer, LT: Line Trap, VT: Voltage Transformer and LA: Lightning Arrester

(c) Static Capacitors

In principle, installation of 22 kV static capacitors for 115/22 kV substations is planned to regulate the system voltage. Total capacity and unit capacity of capacitors required for substations were to be determined referring to the results of power system analysis. The capacitors will be connected to the 22 kV bus.

(5) Sub-projects for Substation

The reinforcement plans of substations include the following:

(a) Construction of new substations/switching stations including investigation and clearance of UXO
(b) Addition, replacement and transfer of transformers
(c) Additional transmission line bays
(d) Improvement of busbar system and switchgear
(e) Installation of static capacitors

Figures 7.3-1 to 7.3-4 shows the reinforcement plans of each station and the planned works are as follows;

(a) Construction of Substations and Switching Stations

According to the Optimum Transmission System, construction of the substations and switching stations has been planned. Number of units and unit capacity of transformers required for stations were determined in the following plans for "Addition, Replacement and Transfer of Transformers".

(b) Addition, Replacement and Transfer of Transformers

Programs for addition, replacement and transfer of 115 kV transformer have been planned in accordance with the following criteria.

i) The 'N-1' criteria will be applied to the stations sited in Vientiane Municipality after the year 2011. In that case, short duration overload of transformer would be permitted to 110% of the rating. On the other hand, the overload of transformer should not be permitted in the other substations, and the transformer should be added and/or replaced to meet the demand before the year forecasted the overload.
ii) The total capacity of transformers of each substation in each year up to the year 2020 has been estimated based on the peak MVA applying the power factor to be 0.95 for the substations in Vientiane Municipality and 0.85 for the others to the forecasted power demand of each substation.
iii) Unit capacity of newly installed transformers will be selected from 10, 20 and 30 MVA ratings.
iv) To utilize the existing transformers effectively, the shifting program of transformers among the substations was planned. The shift has been programmed in examination on the parallel operation with the existing transformers, the lifetime of transformers, timing of shift, etc. The lifetime of the existing transformers is assumed to be 40 years, and the replacement program of equipment was prepared.

(c) Additional Transmission Line Bays

The additional transmission line bays to the particular substations will be required for the construction of new transmission lines as planned in the Optimum Transmission System.

(d) Improvement of Busbar System and Switchgear

The double busbar system will be applied to the existing stations that provides the single busbar system or T-off branch. The 'N-1' criteria were applied for important substations. The double busbar system will also be provided at the stations to have additional bays mentioned above. In this relation, reinforcement of switchgear and extension of the land space was also planned.

(e) Installation of Static Capacitors

According to the results of power flow analysis, 22 kV static capacitors should be installed in several substations to maintain the system voltage within the allowable range.

8. Cost and Evaluation of the Optimum System

8.1 Construction Costs of Transmission Line and Substation Projects

The standard unit prices for the estimate have been worked out referring to the recent contract prices of such international competitive bidding projects in Lao PDR. Various ICB price data owned by the Team have also been referred to.

Costs for the UXO investigation and clearance were set for two classified areas with reference to the projects presently in progress in the country

- Heavy remnant UXO area:
  US$ 12,500/km (US$ 5,000/ha for the 25m wide ROW of 115 kV transmission lines)
- Light remnant UXO area:
  US$ 1,250/km (US$ 500/ha for the 25m wide ROW of 115 kV transmission lines)

The UXO investigation and clearance works were assumed to be carried out for most of the planned transmission lines.

(1) Construction Cost of Transmission Line Projects

Construction costs of the transmission line projects have been estimated as follows. Table 8.1-1 attached shows the detail.

Construction Costs for Transmission Line Projects

Commissioning Year	Particulars	FC (US$)	LC (US$)	Total (US$)
By 2005	Construction	93,146,200	34,586,900	127,733,100
	UXO clearance	6,248,100	3,124,000	9,372,100
	Sub-total	**99,394,300**	**37,710,900**	**137,105,200**
2006 to 2010	Construction	92,262,800	35,414,500	127,677,300
	UXO clearance	4,244,200	2,122,100	6,366,300
	Sub-total	**96,507,000**	**37,536,600**	**134,043,600**
2011 to 2015	Construction	46,392,700	18,077,100	64,469,800
	UXO clearance	5,768,600	2,884,300	8,652,900
	Sub-total	**52,161,300**	**20,961,400**	**73,122,700**
2016 to 2020	Construction	24,279,800	9,286,700	33,566,500
	UXO clearance	899,300	449,600	1,348,900
	Sub-total	**25,179,100**	**9,736,300**	**34,915,400**
	Total	**273,241,700**	**105,945,200**	**379,186,900**

(2) Construction Costs of Substation Projects

The estimated construction costs for substation projects up to the year 2020 are shown in the following table. The construction costs for each sub-project are detailed in Table 8.1-2.

Construction Costs for the Substation Projects

Commissioning Year	FC (US$)	LC (US$)	Total (US$)
～2005	43,473.700	6,693,800	50,167,500
2006～2010	26,808.800	4,217,700	31,026,500
2011～2015	12,985,800	2,157,000	15,142,800
2016～2020	4,026,200	482,100	4,508,300
Total	**87,294,500**	**13,550,600**	**100,845,100**

8.2 Project Costs and Implementation Schedule

(1) Project Costs

As shown in the following table, the total construction costs for the Optimum Transmission System up to the year 2020 is estimated at US$480 million. The costs in the table includes the construction costs of the on-going projects of ADB and IDA.

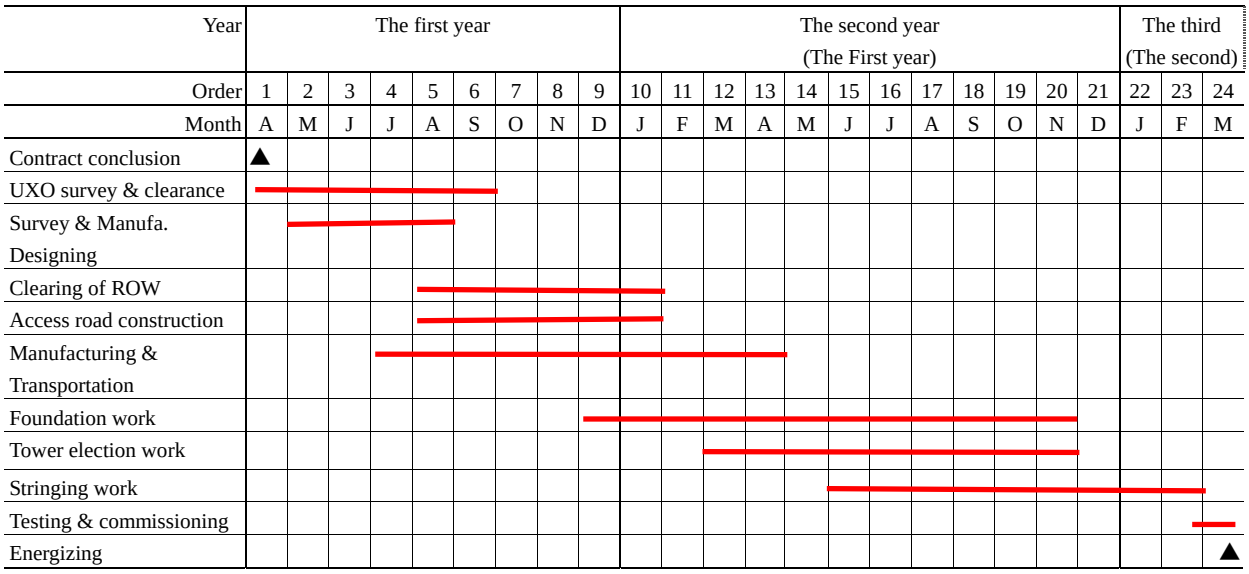
Total Construction Costs for the Optimum Transmission System

Commissioning Year	Particulars	FC (US$)	LC (US$)	Total (US$)
～2005	Transmission Lines	99,394,300	37,710,900	137,105,200
	Substations	43,473,700	6,693,800	50,167,500
	Sub-total	**142,868,000**	**44,404,700**	**187,272,700**
2006～2010	Transmission Lines	96,507,000	37,536,600	134,043,600
	Substations	26,808.800	4,217,700	31,026,500
	Sub-total	**123,315,800**	**41,754,300**	**165,070,100**
2011～2015	Transmission Lines	52,161,300	20,961,400	73,122,700
	Substations	12,985,800	2,157,000	15,142,800
	Sub-total	**65,147,100**	**23,118,400**	**88,265,500**
2016～2020	Transmission Lines	25,179,100	9,736,300	34,915,400
	Substations	4,026,200	482,100	4,508,300
	Sub-total	**29,205,300**	**10,218,400**	**39,423,700**
	Total	**360,536,200**	**119,495,800**	**480,032,000**

(2) Implementation Schedule

Construction periods required for the planned transmission sub-projects are slightly different among sub-projects due to various line lengths and terrain of the routes. It was assumed from experience of the past similar projects in the country that the construction period for the sub-projects over more than 10 km will take 24 months over 3 calendar years, commencing during April of the first year and completing in March of the third year, taking into account the efficient field works in dry season.

While, the construction period for the sub-projects of shorter than 10 km will take 18 months over 2 calendar years. The construction period of all sub-projects was, however, assumed to be 24 months irrespectively of line length and terrain.



Common Implementation Schedule for Transmission Line Projects

It was assumed that the construction period for all substation sub-projects takes 24 months over 3

calendar years same as the transmission line projects.

Year	The First Year									The Second Year												The Third		
Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Month	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Contract conclusion	▲																							
Design & manufacturing																								
Transportation																								
Civil works																								
Erection and inspection																								
Testing & commissioning																								
Energizing																								▲

Common Implementation Schedule for Substation Projects

8.3 Evaluation of the Optimum System

(1) Premises

The optimum transmission system is presumed to reflect the concept of "economic efficiency" in terms of resource allocation. The "efficiency" of the optimum system would be proved by comparison of the EIRR of the system to the opportunity cost of capital (OCC). Provided that the EIRR calculated is more than the OCC, economic viability of the system is to be sustained. Though no data is available concerning to such an OCC in Laos, this was assumed to be 11% judging from the OCCs of the countries with the similar level of economic development.

The development of the optimum transmission system consists of four (4) phases, i) up to the year 2005, ii) 2006 to 2010, iii) 2011 to 2015 and iv) 2016 to 2020. With the reasons that most of trunk transmission systems will be completed by the year 2008 and there might be some uncertainties in the development program of power stations after the year 2010, the first and second phases including the associated substations were to be taken into account for economic analysis of the project, so that both cost and benefit streams were prepared as cash flow in order to estimate the EIRR of the project.

The assumptions and conditions for the analysis are given as follows:

i) The evaluation period is 30 years from 2001 to 2030 including construction period.

ii) Both cost and benefits are expressed in real term, valued at 2001 constant price.

iii) In order to estimate the benefits comparable to project costs consisting of transmission line and substations (including MV and LV distribution facilities), the generation cost per kWh was subtracted from the willingness-to-pay (WTP) for electricity per kWh. The WTP was quoted from the relevant ADB study report and information obtained form local authorities by the Team during its site investigations.

iv) O&M costs were estimated to be 1% of investment costs for transmission line, 1.5% for substations, and 1% for distribution network.

v) Internal transfer payment such as tax and subsidy was not taken into account for economic analysis of the system.

vi) Incremental energy by the project was annually estimated in Table 4.1 in Appendix 6.2 for examination of 22 kV distribution network.

(2) Benefits

The ADB TA comprehensively studies the economic value of electricity based on the WTP for it in the report, where the demand curve expressing diminishing marginal values as electricity consumption grows, is depicted. The demand curves are prepared for new and existing customers respectively. The area under the former demand curve is calculated to be US$ 0.204 per kWh, while that under the latter demand curve is calculated to be US$ 0.193 per kWh. The weighted average of WTP of new and existing customers is estimated to be US$ 0.202 per kWh.

The ADB TA also formulated the Power Development Plan for the Domestic Consumption (2000-2010) and estimated US$ 716 million as the total project investment costs. Among the total investment, generation facility accounts for 60 %, and amounts to US$ 430 million. Accordingly, by subtracting this proportion (60 %) comprised by generation facility development from the said WTP value, the economic value of energy which corresponds to the project costs was derived in this evaluation, and calculated as US$ 0.081/kWh （US$ 0.202/kWh－US$ 0.121/kWh）.

In the master plan study, electricity consumption are disaggregated into the different sub-sectors, but consolidated and represented by general customers for domestic use of electricity.

(3) Economic Costs

The investment schedule for the project is to be converted into investment flow valued at economic price. Since the foreign currency portion is valued at border price, this portion is assumed to be equivalent to economic value of resource costs. The point is the local currency portion, often distorted by the government regulation and subsidy policies. The standard conversion factor (SCF) is employed to convert local cost at prices distorted to that at border price. SCF was presumed to be 0.9.

(4) Results of Evaluation

The cash flow is prepared to estimate EIRR of the project. The EIRR was calculated to be 23.9 %, which turns out to be higher than the said OCC (11 %) and is judged as viable in economic terms. The result is shown in the table below together with the results of sensitivity analysis of the project.

Results of Economic Analysis and its Sensitivity Analysis

Variables	EIRR %	NPV_{2001} million US$
Base Case	23.9	231.1
Investment Costs +15 %	20.3	192.3
Project Benefits –10 %	20.9	179.3
O&M Costs +50 %	23.2	217.3

(5) Financial Analysis of the Project

EDL is a power corporation, which owns every facility from generation through transmission to distribution networks, and is responsible for the entire flow from power production to retail sale to energy users. This indicates no existence of hand-over or wholesale price between generation outlet and transmission inlet. Furthermore, this Project is to develop the transmission and sub-station facilities over the country, the project system covers many remote and scattered demand points, and the power tariff includes subsidy. Under the condition, revenue related to the transmission lines and substations is difficult to be identified. Assuming that 40 % of the current tariff regulated toward the year 2005 would be allocated for the portion of transmission lines, substations and distribution networks, a trial calculation of FIRR for the Project was carried out. Result of the calculation was, however, negative.

9. Selection of Highest Priority Project

9.1 Candidate Systems

Candidate systems for the highest priority project were those systems to be completed by the year 2005 in the formulated optimum systems but excluding the systems under construction and presumed systems to be implemented under the finance of IDA, ADB, or other organizations. The candidates for the highest priority project to be examined were finally the following 4 sections.

- Subproject of Pakxan SS ~ Thakhek SS ~ Pakbo SS
- Subproject of Nam Theun 2 PS ~ Xaibouathong SS
- Subproject of Kengkok SS ~ Xepon SS
- Subproject of Lakpet SwS ~ Ban Boun ~ Thakho SS

9.2 Criteria and Methodology of Selection

The evaluation items to the candidate subprojects were discussed and agreed with EDL as summarized below:

(a) Urgency of the subproject in the respect of the governmental development program

(b) Impact for environmental and UXO circumstances

(c) Saving of imported energy by a subproject

(d) Number of beneficiaries from a subproject

(e) Efficiency of investment (e-1) : Energy sales per investment

(e-2) : Beneficiaries per investment

Four (4) candidate subprojects were evaluated on each item. For the comprehensive ranking of the candidate subprojects, the candidate subprojects were scored for each evaluation item in accordance with the definite results obtained from the master plan study.

All evaluation items except the above item (a) "Urgency" can be specifically figured. A subproject was scored at a point equivalent to percentage of its figure to the highest point among the subprojects for the evaluation item. Points for each evaluation item thus given to each subproject were summed up. The subproject given the highest point in total was ranked as the highest priority project.

As the alternative evaluation for selecting the highest priority project, the team and EDL have evaluated all candidate subprojects in accordance with the Analytic Hierarchy Process (AHP) Method. The AHP is one of the evaluation methods developed for adequate decision-making on questions. Each evaluation item to the candidates was ranked at a specific score among the subprojects based on the results of the examinations conducted during the study period in the same manner. Besides, each evaluation item was weighted among all items in accordance with the AHP. All the staffs of EDL counterparts and the study team have conducted the marking and weighting to each evaluation item. Summarizing results of those parameters in the matrix, the highest priority subproject was selected.

9.3 Results of Evaluation

Following was the result of scoring evaluation.

Scoring of Subprojects

Evaluation Item	Pakxan – Thakhek - Pakbo		Nam Theun 2 - Xaibouathong		Kengkok - Xepon		Lakpet - Ban Boun - Thakho	
	Figures	Point	Figures	Point	Figures	Point	Figures	Point
(a) Urgency	-	100	-	80	-	80	-	80
(b) Environment/UXO (US$)	1,373,000	50	688,000	100	1,705,000	40	931,000	74
(c) Saving of Import (MWh)	5,792,114	100	0	0	1,690,346	29	629,898	11
(d) No. of Beneficiaries	912,537	100	65,073	7	337,947	37	846,746	93
(e1) Energy Sales/Investment	79.40	78	83.50	82	101.64	100	44.18	43
(e2) Beneficiaries/Investment	14.19	66	4.88	23	11.28	52	21.50	100
Total Score		**494**		292		338		401

As seen in the above table, the sub-project for Pakxan ~ Thakhek ~ Pakbo system was selected to be the highest priority project. While, the AHP evaluation also resulted in the highest priority project to be Pakxan-Thakhek-Pakbo section as below.

Result of Priority Evaluation by AHP

	Pakxan ~ Thakhek ~ Pakbo	Nam Theun 2 ~ Xaibouathong	Kengkok ~ Xepon	Lakpet ~ Ban Boun ~ Thakho
Ranking	1st: 8 persons 2nd: 4 person 3rd: 1 person 4th: 0 person	1st: 0 person 2nd: 1 person 3rd: 0 persons 4th: 12 persons	1st: 0 person 2nd: 2 person 3rd: 10 persons 4th: 1 person	1st: 5 person 2nd: 7 persons 3rd: 1 person 4th: 0 person

9.4 Effects of the Highest Priority Project

Khammouan and Savannakhet provinces will not have any substantial power station until commissioning of the IPP Nam Theun 2 PS in the year 2008. These two provinces are currently relying on energy imported from EGAT of Thailand. These areas are significantly important in the national trade and industrial sectors compared with other areas, and require huge amount of electricity to realize their development plans that will contribute to improvement of the national economic development of Lao PDR.

The transmission system of Pakxan SS - Thakhek SS - Pakbo SS will primarily function to deliver domestic electric energy from Central 1 region to Central 2 region for effective utilization of surplus energy in the Central 1 region. The project should contribute the country in saving import energy from Thailand. Saving of the imported energy until the year 2020 are estimated at approximately 6,290 GWh or US$ 63 million after deduction of investment and O & M costs for the new facilities. Further, number of beneficiaries under this project will reach to 980 thousand and the regional living level would be much improved. Also, without this highest priority project, the national domestic transmission network interconnecting the Northern/Central 1 region with the Central 2/Southern regions can not be realized. This highest priority project is indispensable as the first step and the jump-start of constructing the national power network.

10. Preliminary Facility Design for the Highest Priority Project

10.1 Outline of the Design

Scope of the selected project is construction of transmission lines and substations in the section of Pakxan SS - Thakhek SS - Pakbo SS. Outline of the Project is as below:

(a) Construction of 115 kV transmission line facilities with double circuits of ACSR 240 mm^2 for the section of the existing Pakxan substation to the new Thakhek substation to be constructed under the IDA fund by the year 2004,

(b) Construction of 115 kV transmission line facilities with double circuits of ACSR 240 mm^2 for the section of the new Thakhek substation to the existing Pakbo substation,

(c) Extension of the existing 115/22 kV Pakxan substation,

(d) Extension of the newly constructed 115/22 kV Thakhek substation, and

(e) Extension of the existing 115/22 kV Pakbo substation.

Design of the project facilities was conducted principally pursuant to the standards established by the STEP team of JICA and referring to IEC standards as well as common practices adopted by international consultants to the similar facilities in Lao PDR. The applied facility standards and climate conditions for the design were as discussed in Section 7.

10.2 Transmission Line Facilities

(1) Line Route

Transmission line route has been selected based on the results of the team's examinations on Laotian environmental law, MIH's project environmental regulation, regional development program, land acquisition/compensation, existence of UXO and other factors. Considering the information and advice of the EDL branch offices and easiness of the maintenance work, the route has been selected along with the National Road No.13 avoiding the villages and NBCA (see the attached Figure 10.2-1).

Most of the route passes in flat area, and soil conditions for towers deem to be quite firm so that no special foundations will be required for the line. Therefore, the construction works and maintenance works of the transmission line facilities seem to be not difficult.

(2) Land and Environment

(a) Geology

Geological and Mineral Occurrence Map prepared by the Department of Geology and Mines is shown on the attached Figure 10.2-2.

(b) Topography and Land Items

The terrain in the entire line route is flat, open, or gently undulated.

(c) Environmental Impact

None of NBCA, national park, historic spots, cultural heritages, scenic areas or particular development area exist in the Project area, according to information from EDL branch offices. Significant influence to existing infrastructures also will not be found. Since the route is aligned at several hundred meters to 1 km apart from the Road No.13, and also bushes and trees along the Road will interfere the line facilities from passengers' vision, a visual impact of the Project facilities should be less.

Thus, synthetically environmental impact to the circumstances would be small and special mitigation measures for environmental protection will not be required.

(3) Design of Conductor and Ground-wire

ACSR 240 mm^2 (ASTM: Hawk) and GSW 50 mm^2 (ASTM: GSW 3/8) are applied for the whole line section.

(4) Insulator Design

(a) Insulator type and size

Complying with IEC 60305, 120 kN (for ACSR 240 mm^2) standard disc type porcelain insulators with ball and socket were applied.

(b) Number of insulator units

Number of insulator units per string was determined to be 10 considering pollution level, standard lightning impulse withstand voltage and the maintenance.

(c) Number of insulator strings per set

Number of standard insulator strings per set is single. However, in case transmission line of the Project crosses over such important facilities as national roads or wide rivers, the double strings of 120 kN insulator were applied to both suspension and tension insulator assemblies for two adjacent towers for safety reason.

(5) Ground Clearance

Minimum heights of conductors above the ground were determined as below.

Minimum Height of Conductor above Ground

Classification	Applied areas for the Project	Height	Reason
Areas where people rarely enter or will enter, such as mountains, forests, waste fields, etc.	Bush lands, forests, grass lands and narrow-rivers	7.0 m	5.0 m (LEPTS) +2.0 m (margin) = 7.0 m
Areas where people enter or will enter frequency	Paddy fields with mosaic of croplands, general roads and wide-rivers	8.0 m	6.0 m (LEPTS) +2.0 m (margin) = 8.0 m
Areas where distribution line exists or will be planned	National roads	9.5 m	2.36 m (LEPTS) *+5.0 m (Distribution Pole Height) +2.0 m (margin) 9.5 m

*: Clearance between 115 kV transmission line and 22 kV distribution line

(6) Tower Design

Configurations of the following 7 standard types of towers were determined.

Tower Configurations

Tower	Suspension Tower		Tension Tower				
Line Horizontal Angle	0～3°		0～15°	0～30°	0～90°		0～90° (Dead End)
Type	A1	A2	B1	C1	D1	D2	DE
Height [m]	32.9	37.9	32.8	33.3	34.0	39.0	34.0
Arm Length [m]	6.2	6.2	6.2	6.8	7.6	7.6	7.6
Width of tower [m]	6.0	7.2	7.0	7.0	7.0	8.4	7.0
Body Extension [m]	21.5	26.5	20.0	20.0	20.0	25.0	20.0
Conductor Height [m]	8.3	13.3	8.8	8.8	8.8	13.8	8.8
Applied Areas*	Ⅰ	Ⅱ	Ⅰ	Ⅰ	Ⅰ	Ⅱ	Ⅰ
Number of Figure	10.2-3	10.2-4	10.2-5	10.2-6	10.2-7	10.2-8	10.2-7

Area I: area of bush, forests, grass lands, paddy fields with mosaic of croplands, general roads and rivers

Area II: for crossing over national roads and wide rivers

Towers for the Project were provisionally designed for estimation of tower weights and foundation loads. High tensile steels were also applied to towers and bolts, and all of tower members must be galvanized.

(7) Foundation Design

Transmission lines pass over firm soil areas as seen in the attached Figure 10.2-2, and the soil boring data at the bridge sites on Route 13 also shows solid ground. Therefore, it was assumed that normal pad and chimney type foundations could be applied to all towers for the Project.

Concrete volume, weight of steel reinforcement bar, excavation volume and back-filling volume of pad and chimney type foundations were worked out to meet the loads transferred from towers.

(8) Quantities of Line Materials

Quantities of the line materials were estimated from results of the above design for the Project.

Number of Towers and the Total Weight of Towers

Type	Weight [ton]	Pakxan – Thakhek		Thakhek- Pakbo		Total Quantity	
		Towers [Units]	Total Weight [ton]	Towers [Units]	Total Weight [ton]	Towers [Units]	Total Weight [ton]
A1	5.0	490	2,450.0	275	1,375.0	765	3,825.0
A2	6.2	10	62.0	0	0.0	10	62.0
B1	6.2	21	130.2	8	49.6	29	179.8
C1	7.0	16	112.0	8	56.0	24	168.0
D1	9.2	15	138.0	7	64.4	22	202.4
D2	11.0	2	22.0	0	0.0	2	22.0
DE	9.4	4	37.6	2	18.8	6	56.4
Ga	1.5	4	6.0	0	0.0	4	6.0
Total		562	2,957.8	300	1,563.8	862	4,521.6

Quantities of Conductor and Ground-wire

Type	Number [Units]	Pakxan – Thakhek		Thakhek- Pakbo		Total Quantity [km]
		Route Length [km]	Quantity [km]	Route Length [km]	Quantity [km]	
ACSR 240 mm^2	6	194.6	1,226.0	105.2	662.8	1,888.8
GSW 50 mm^2	1	194.6	204.3	105.2	110.5	314.8

10.3 Substation Facilities

(1) Design Concept

In addition to the general concept of the preliminary design described in Section 7, the design concept focusing on the Project is stated below:

(a) Utilization of the existing substations

Construction of new substations is not necessary for the Project, because the effective utilization of the existing substations is possible.

(b) Coordination to the existing substation facilities

The specifications and layout of the facilities for the Project were determined in considering of the coordination with the existing facilities in each substation.

(c) Busbar system

Pakxan SS and the planned Thakhek SS are equipped with the double busbar (main and transfer) system. The single busbar system of Pakbo SS should be upgraded to the double busbar system.

(d) Main transformer and 22 kV facilities

The replacement and/or reinforcement of transformers and 22 kV facilities are not considered in the Project.

(2) Substation Site

(a) Pakxan Substation

In 1999, the existing Pakxan SS was commenced the operation to distribute electrical energy from Nam Ngum 1 and Nam Leuk PS to Pakxan area, and to export the surplus energy to Thailand. Pakxan SS is located in 2 km east of Pakxan City in Bolikhamxai Province along the Road No. 13.

Two bays for the Pakxan - Thakhek 2 cct transmission line are to be installed at Pakxan SS under the Project. There are now four 115 kV switchgear bays in Pakxan SS, i.e. one each TL bay for Nam Leuk PS and Bungkhan SS (EGAT), one TR bay and one bus-tie bay. The land space for installation of two additional line bays under the Project is still available in the existing 115 kV switchyard.

Since no habitation exists surrounding Pakxan SS, there is no anxiety for social environment

influence such as the noise/vibration from the construction works.

(b) Thakhek Substation

There is no 115 kV substation available in Thakhek City to which the new transmission line under the Project can be connected. A 22 kV substation is currently in operation to distribute the import energy from Thailand to the city. However, a new 115 kV Thakhek Substation is planned to be constructed as part of the SPRE project funded by IDA. The status of the new Thakhek SS project is under tender evaluation by EDL as of July 2002, and its comissioning is expected to be within 2004. A 115 kV transmission line from this substation to Nam Theun 2 IPP project will be constructed to deliver electricity for construction use of the Nam Theun 2 project.

EDL has secured a sufficient land space in the new 115 kV substation for 4 115 kV TL bays to connect the transmission lines to Pakxan SS and Pakbo SS under the Project. Accordingly, the 115 kV switchgear under the Project can be installed in the new 115 kV Thakhek SS.

The planned site for new 115 kV Thakhek SS is located in 3 km south of Thakhek City in Khammouan Province. Since the planned site is on the slightly elevated hill and no habitation exists surrounding there, there is no anxiety for social environment influence by the construction works.

(c) Pakbo Substation

The existing Pakbo SS was commenced the operation in 1996 to import electrical energy from Thailand and to distribute it to Savannakhet town. The Pakbo SS is located in approximately 7 km north of Savannakhet City in Savannakhet Province. The SPRE project is on-going under the IDA fund in Pakbo SS for replacement of transformers, installation of a new TL bay for Kengkok SS, and reinforcement of 22 kV facilities.

The Project plans to install two TL bays in the Thakhek SS and to upgrade the existing single busbar system to double busbar in the substation. However, the present land space of the substation is insufficient for those plans. Expansion of the land of the Pakbo SS is necessary. The adjacent land to be expanded is available and owned by EDL, and there is no inhabitation around Pakbo SS.

(3) Design of Pakxan Substation

The replacement of transformers and reinforcement of 22 kV facilities are planned as a part of the SPRE project in Pakxan SS. The status of the project is under tender evaluation stage and the project is scheduled to be completed within the year 2004. Therefore, the design for Pakxan SS under the Project should be focused on the substation facilities and layout after completion of the SPRE project.

Figure 10.3-1 and Figures 10.3-2 (1) & (2) show respectively the single line diagram and the layout

plans of Pakxan SS for the Project.

The Scope of Works for Pakxan SS under the Project is as follows;

(a) Shift of bus-tie bay
(b) Installation of TL bays for 2 circuits of transmission line
(c) Extension of gantries
(d) Civil and erection works
(e) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance
(f) Procurement of spare parts

(4) Design of Thakhek Substation

The new 115 kV Thakhek substation is also planned to be constructed as a part of the SPRE project funded by IDA, and to be commissioned within the year 2004.

The plan for the new Thakhek SS has already included the land space for installation of 4 transmission line bays to connect the transmission lines with Pakxan SS and Pakbo SS under the Project. Accordingly, substantial modification of the switchyard in the new Thakhek SS will not be necessary under the Project.

Four transmission line bays connecting to Pakxan SS and Pakbo SS are to be installed to Thakhek SS under the Project. Figure 10.3-3 and Figures 10.3-4 (1) & (2) show respectively the single line diagram and the layout plans of Thakhek SS for the Project. But, the specifications and layout of the planned 115 kV facilities of Thakhek SS might be altered, because the layout of the SPRE project for the construction of Thakhek SS is under tender evaluation stage as of July 2002.

The Scope of Works for Thakhek SS under the Project is as follows;

(a) Installation of TL bays for 4 circuits of transmission line
(b) Civil and erection works
(c) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance
(d) Procurement of spare parts

(5) Design of Pakbo Substation

The replacement of transformers, installation of TL bay, and reinforcement of 22 kV facilities are on-going at Pakbo SS as a part of the SPRE project, and the works will be completed within the year 2003. Therefore, the design for Pakbo SS under the Project should be focused on the substation

facilities after the SPRE project.

Figure 10.3-5 and Figures 10.3-6 (1) & (2) show respectively the single line diagram and the layout plans of Pakbo SS for the Project.

The Scope of Works for Pakbo SS under the Project is as follows;

(a) Upgrading the single busbar to double busbar
(b) Installation of TL bays for 2 circuits of transmission line
(c) Extension of gantries
(d) Installation of a voltage transformer to the main bus
(e) Extension of the substation control room
(f) Civil and erection works
(g) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance
(h) Procurement of spare parts

(6) Main facilities

Quantity of the main facilities of each substation required for the Project is shown below;

Quantity of the Main Facilities

	Main facilities	Pakxan SS	Thakhek SS	Pakbo SS
(a)	Circuit Breaker (3 phase)	2 units	4 units	3 units
(b)	Disconnection Switch (3 phase)	4 units	-	9 units
(c)	Disconnection Switch with Earthing Switch (3 phase)	2 units	4 units	2 units
(d)	Disconnection Switch (single phase – pantograph type)	-	8 sets	-
(e)	Current Transformer	6 units	12 units	6 units
(f)	Voltage Transformer	6 units	12 units	9 units
(g)	Lightning Arrester	6 units	12 units	6 units
(h)	Line Trap	4 units	8 units	4 units

10.4 Implementation Plan

(1) Implementation Policy

Preparatory works e.g. acquisition of the environment certificate for the Project from STEA, arrangement of fund for the Project, employment of project consultants, etc. should be done by EDL to accelerate the Project.

(2) Procurement of Facilities

The Project comprises of two components: transmission line and substation. Although it depends on the source of the project fund, the Project will be in principle executed under separate contracts of transmission line and substation, and the contractors will be selected through ICB (International Competitive Bidding) mode for full-turn-key basis.

The contractors for each contract lot should be carefully selected taking into account their qualifications for quality control of goods, production capacities, experience in similar projects, remedial claims of their previous contracts, financial status of the contractor and their major subcontractors, and others. Bid documents prepared by the consultants will specify bidder's qualification and its evaluation criteria.

It will be specified in the contract documents that the contractors should guarantee all functions of the facilities provided under the Project for a certain period after commissioning. Besides, it is recommended that the contractors will train EDL's operators and maintenance staffs on the job site during the construction period and a certain period after commencement of operation of the substations.

(3) Scope of Works

Equipment/materials for the Project and construction works at site will be procured in the ICB full turn-key base. EDL will be responsible for special particulars required for the project execution. Following table shows major works allotted for the contractors and EDL. EDL should arrange its staffs and budget to execute the allotted works.

Scope of Works

	Contractors	EDL
Procurement of Goods	- Design and manufacture of goods - Factory tests of goods - Packing for export & transportation - Storage of goods at site	- Examination on drawings & documents from contractors - Pre-arrangement for customs clearance of imported goods - Issue of payment certificates
Construction	- Civil & building works for the Project - UXO survey - Overall construction of line facilities - Overall construction of substations - Commissioning test	- Securing of land for the Project - Acquisition of right for tree clearing - UXO clearance, if any - De-energizing schedule - Dispatch of inspectors - Issue of payment certificate - Acceptance of completion

(4) Plan of Supervision

Procurement, management and supervision of the Project will be performed by the following staffs from EDL and the project consultants, after the contracts between EDL and the contractors would have been concluded.

(a) EDL Staffs

i) Project manager in the EDL's project office should be on duty throughout the project period.

ii) Staffs of the EDL's environment office for monitoring the environmental measures taken by the contractors should be timely dispatched to the sites. Persons from the related province and/or district may also monitor the situation.

iii) Transmission line inspectors including persons from EDL branch offices should be assigned for each working section of the contractor. : at least 1 civil inspectors throughout the contractors' civil works, at least 2 inspectors for tower erection and stringing operation. Those inspectors should be responsible not only for supervision of the contractors' work but also for communication with local authorities on the matters for which EDL has responsibility.

iv) EDL's inspectors will be lined up with 1 person for civil/building works and 1 person for electrical works per each substation.

(b) Consultants

i) Detailed design and preparation of bidding documents

ii) Public bid and contract

iii) Procurement management including approval of contractors' designs and drawings, inspections and tests of equipment and materials in the factories.

iv) Supervision of contractors' field works

v) Commissioning test and inspection for defect liability period

(5) Implementation Schedule

Figure 10.4-1 shows the overall implementation time schedule of the Project.

The period from appointment of the project consultants to the conclusion of the turn-key contracts for both transmission line and substations was assumed to be 13 months. The period from the conclusion of the contracts to the taking-over of the facilities was assumed to be 23 months making total implementation period to be 36 months after appointment of the project consultants.

10.5 Project Operation Plan

(1) Organization

Technical Service Department (TSD) in the Distribution Division of EDL head office manages and controls all the works for operation and maintenance works of all branch offices except 115 kV transmission lines. EDL Branch Offices carry out actual operation and maintenance works of all 115 kV facilities together with MV and LV networks in their territory.

While, responsible territory for maintenance of the existing 115 kV transmission lines are at the

boundary of the provinces where the line runs. Transmission line maintenance group of each branch office has its full responsibility for the facilities existing in its territory.

EDL does not find any serious issues in such present organization and procedures for operation and maintenance of transmission lines and substations in the current system.

(2) Reinforcement of Operation and Maintenance of 115 kV Systems

There seems no serious issues in the current EDL's operation and maintenance system of 115 kV transmission lines and substations except a heavy duty to TSD, as far as the works are carried out strictly following the EDL's operation and maintenance manuals and the present scale of power system.

Before this Project, the running rural electrification projects of ADB in the northern and Central 1 regions (PTD) and of IDA in the Central 1 and Central 2 regions (SPRE) will be commissioned. The 115 kV power systems and MV/LV networks in the country will be broadly extended. Before the year 2005, new seven (7) 115 kV substations and 115 kV transmission line over 1,100 cct-km are scheduled to be commissioned. In addition, development of a huge number of MV and LV distribution networks are in progress. Total quantities of 115 kV substations and transmission lines after the commission of those projects will increase to about double the existing facilities.

Before commissioning of the current rural electrification projects, following measures will be required for stable and sustainable operation of the facilities.

(a) Establishment of specific duty of EDL Head Office for O & M of 115 kV transmission lines
(b) Reinforcement of Distribution Division in EDL's head office
(c) Education to persons for O & M of 115 kV transmission lines and substations
(d) OJT of EDL's staffs during project implementation
(e) Procurement of measuring instrument, spare parts and tools i sufficient quantities
(f) Standardization of recording format of operation data
(g) Enrichment of EDL's repair shop
(h) Development of communications among power systems
(i) Reinforcement of substation maintenance group
(j) Aggressive utilization of EDL's Training Center for education of the present and future O & M staffs.

(3) O & M Manuals and Education

EDL provides the standard O & M manuals (Lao version) for 115 kV transmission lines and substations. The manuals have been revised as needed referring to experience in faults occurred and measures taken

for restoration of the faults. The present O & M manuals are prepared on the bases of the manuals submitted by the related consultants and suppliers to the projects. Both contracts of the consultants and contractors for the Project should also include a term for duty of submission of the O & M manuals.

The present EDL's standard manuals seem adequate. However, in implementing the Project, review of the standard manuals is recommended taking into account the O & M organization and particular circumstances around the Project.

Generally, O & M manuals for a completed substation are to be prepared and submitted to EDL by the related consultants and contractor before commissioning of the substation. Manuals submitted by the contractor should cover technical specifications, characteristics, composition of components, dismantling and inspection procedures, adequate frequencies of parts replacement, etc. of all equipment and materials the substations in detail. The contract for the Project should also include contractor's duty for execution of OJT to EDL's operators during installation of equipment, tests of various facilities and initial operation of the substation under the supervision of the contractor. Manuals prepared by the consultants should be comprehensive by covering proper attentions to O & M works of the substation taking into account compliance between the EDL's standard manuals and the contractor's manuals.

Participation to the project construction sites of EDL' employees who are anticipated to be operators and maintenance crew of the facilities after commissioning of the Project is an effective training program. Another program for training of operation and maintenance of substations is that experts of the contractor will jointly operate and maintain the substation for a certain period at the initial stage of operation.

11. Estimate of the Project Costs

11.1 Land and UXO

(1) Compensation for Land and Right of Way (ROW)

At present, EDL acts itself all negotiations for land procurement and resettlement required for the constructions of transmission lines and substations in Laos PDR.

According to the information of EDL, there are no EDL's standards for compensation of lands and ROW, and they are under preparation at present. EDL has taken the individual ways of land negotiation and compensation in each project. But a standard procedure is now under preparation. In case of the transmission line project of Nam Leuk PS - Pakxan SS, EDL compensated landowner of

paddy field occupied by towers for the 5 years rice harvests from the occupied area. EDL also compensated growers and house-owners for cutting their valuable trees and resettlement from the ROW through individual negotiations with them. The compensation costs varied case-by-case, accordingly. The cost for paddy field compensation per tower paid under the above mentioned project was around US$20.

As the Project is considered to be extension of the Nam Leuk PS - Pakxan SS line, compensation costs for the Project were estimated in the similar way. Since 150 towers will be constructed in paddy fields over the whole sections of transmission lines under the Project, compensation costs for the harvest are roughly estimated at US$3,000. The total amount of compensation costs for the Project is thus assumed to be US$10,000 including compensation cost for trees and resettlement.

(2) Costs for UXO Investigation and Clearance

Since a large quantity of UXO still remains in the country, investigation and clearance works should be necessary prior to the construction works. Under the ongoing PTD project (ADB), the local consultant for UXO employed by the contractor carried out UXO investigation and clearance works at each tower site. The cost for UXO investigation and clearance for the Project will be estimated at the same manner, accordingly.

(a) Particular areas for UXO Investigation and Clearance

UXO scarcely remains on the some areas of the selected transmission line route for the Project. The areas where the map suggests the remanence of UXO are the following sections.

i) Pakxan SS～Thakhek SS section; Nam Kading River～Naliang Village: about 35 km
ii) Thakhek SS～Pakbo SS section; Thakhek SS～Xe Bang Fai River: around 44 km

It was assumed that UXO investigation and clearance would be carried out at all of tower sites (256 m^2／tower) constructed in these areas prior to their excavation work for tower foundations.

(b) Costs for UXO Investigation and Clearance

The unit price of “US$ 500/ha in Light remnant UXO area” was applied with reference to the PTD project and information given by a firm for UXO investigation and clearance in Vientiane. The cost of UXO investigation and clearance for the Project (226 towers in UXO areas noted above) was roughly estimated at US$3,000.

11.2 Construction Costs of Transmission Lines

The table below shows the construction costs of transmission lines for the Project, and Tables 11.2-1～11.2-2 also show the details.

Construction Cost of Transmission Lines

Sections	Items	FC (US$)	LC (US$)	Total (US$)
Pakxan SS～Thakhek SS (194.6 km)	Plant & Equipment	8,233,500	0	8,233,500
	Civil & Erection	1,594,900	2,617,200	4,212,100
	Sub-total	9,828,400	2,617,200	12,445,600 ($63,955/km)
Thakhek SS ～ Pakbo SS (105.2 km)	Plant & Equipment	4,359,200	0	4,359,200
	Civil & Erection	817,600	1,370,300	2,187,900
	Sub-total	5,176,800	1,370,300	6,547,100 ($62,235/km)
Total (299.8 km)	Plant & Equipment	12,592,700	0	12,592,700
	Civil & Erection	2,412,500	3,987,500	6,400,000
	Total	15,005,200	3,987,500	18,992,700 ($62,351/km)

11.3 Construction Costs of Substation Facilities

The table below summarizes the construction costs of substation facilities for the Project, and attached Table 11.3-1 also shows the details.

Construction Cost of Substation Facilities

Substations	Items	FC (US$)	LC (US$)	Total (US$)
Pakxan SS	Plant & Equipment	619,400	0	619,400
	Civil & Erection	24,100	87,900	112,000
	Miscellaneous Costs	73,100		73,100
	Sub-total	716,600	87,900	804,500
Thakhek SS	Plant & Equipment	1,173,300	0	1,173,300
	Civil & Erection	48,200	170,500	218,700
	Miscellaneous Costs	139,200		139,200
	Sub-total	1,360,700	170,500	1,531,200
Pakbo SS	Plant & Equipment	1,093,300	0	1,093,300
	Civil & Erection	44,100	164,200	208,300
	Miscellaneous Costs	130,200		130,200
	Sub-total	1,267,600	164,200	1,431,800
	Total	3,344,900	422,600	3,767,500

11.4 Total Project Costs

The conditions for the estimate of the total Project costs are as follows;

(a) Compensation cost for lands and ROW and cost for UXO investigation and clearance are included.

(b) Consultant service fee is included in FC portion and estimated at 8 % of total construction cost of transmission lines and substations including the field topographical survey of transmission line and substations.

(c) Physical contingencies for both FC and LC portions are estimated at 10 % of each portion of total construction costs.

(d) Price contingencies for FC and LC portion are respectively estimated at 3%/year[4] of FC portion and 8%/year[5] of LC portion of total construction cost.

The table below shows the total costs for the Project.

Total Project Costs

Items	FC (US$)	LC (US$)	Total (US$)
Transmission Lines	15,005,200	3,987,500	18,992,700
Substation Facilities	3,344,900	422,600	3,767,500
Sub-total	18,350,100	4,410,100	22,760,200
Lands & ROW Compensation	0	10,000	10,000
UXO Survey & Clearance	2,000	1,000	3,000
Consultant Fee	1,820,800	0	1,820,800
Physical Contingency	1,835,000	441,000	2,276,000
Price Contingency	550,500	352,800	903,300
Ground Total	22,558,400	5,214,900	27,773,300

11.5 Disbursement Schedule of the Costs

Conditions for preparing the disbursement schedule of the investment for the Project were assumed as follows;

(a) The construction costs for transmission lines and substation facilities for the Project would be disbursed in second and third years equally, after conclusion of the contracts with contractors.
(b) Compensation cost for lands and ROW would be disbursed in the first year.
(c) UXO investigation and clearance would be carried out before excavation work of foundation for steel towers, and its cost would be equally disbursed in the second and third years.
(d) The consultant fee will be disbursed equally over three years.
(e) Both physical and price contingencies would be disbursed in the second and third years equally.

The table below shows the disbursement schedule for the Project costs for three years.

4 Inflation rate in foreign currency portion is estimated at 3% as same figure to have been applied by WB. (SPRE project Aide Memoire of the Midterm Review Mission, WB, dated April 25, 2002)

5 Estimated from the past record of inflation in Lao PDR (Bank of Lao PDR)

Disbursement Schedule

Months	Items	FC (US$)	LC (US$)	Total (US$)
1～12 Months (Design Stage)	Transmission Lines	0	0	0
	Substation Facilities	0	0	0
	Lands & ROW Compensation	0	10,000	10,000
	UXO Survey & Clearance	0	0	0
	Consultant Fee	607,000	0	607,000
	Physical Contingency	0	0	0
	Price Contingency	0	0	0
	Sub-total	607,000	10,000	617,000
13～24 Months (Construction Stage)	Transmission Lines	7,502,600	1,993,750	9,496,350
	Substation Facilities	1,672,450	211,300	1,883,750
	Lands & ROW Compensation	0	0	0
	UXO Survey & Clearance	1,000	500	1,500
	Consultant Fee	606,900	0	606,900
	Physical Contingency	917,500	220,500	1,138,000
	Price Contingency	275,250	176,400	451,650
	Sub-total	10,975,700	2,602,450	13,578,150
25～36 Months (Construction Stage)	Transmission Lines	7,502,600	1,993,750	9,496,350
	Substation Facilities	1,672,450	211,300	1,883,750
	Lands & ROW Compensation	0	0	0
	UXO Survey & Clearance	1,000	500	1,500
	Consultant Fee	606,900	0	606,900
	Physical Contingency	917,500	220,500	1,138,000
	Price Contingency	275,250	176,400	451,650
	Sub-total	10,975,700	2,602,450	13,578,150
	Ground Total	22,558,400	5,214,900	27,773,300

12. Project Evaluation

12.1 Evaluation Criteria

The Project was evaluated in the modes of Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR) of the Project. Following were the assumptions to estimate IRRs of the Project.

(a) Both cost and benefits were expressed in real terms, valued at 2002 constant prices. They were discounted to the beginning of 2003.

(b) The evaluations were carried out for thirty years in economic terms of the Project facilities.

(c) Following costs were taken into account:

- Costs for facilities, consulting fees, investigation and clearance charges of UXO, and physical and price contingencies.
- O & M costs of the facilities; 1 % per annum of investment for transmission line and 1.5 % per annum of investment for substations.

- For EIRR evaluation, local currency portion was converted into investment flow valued at economic prices with Standard Conversion Factor of 0.9.
- Depreciation, interest charges, other taxes and duties were excluded.
- For FIRR, costs for MV and LV distribution networks related the project substations were added.

12.2 Benefit of EIRR

(a) The Project will activate power interconnection between Central 1 and Central 2 regions, and in the future with Southern region. Its benefits will be the substitute for imported electricity from the EGAT system of Thailand.

(b) The Project will accrue benefits due to avoided wheeling fee assumed for the EIRR analysis to be US cent 1.0 per kWh after 2005, as advised by EDL.

(c) Electricity demand at Xepon mines during the period from 2005 to 2012 is also met by imported electricity without the project case. It was assumed that after 2013 the electricity supply to the mine would be from different domestic source like Xepon PS and/or Nam Theun 2 IPP. Therefore, avoided wheeling fee as US cent 1.0 per kWh is applied to estimate the project benefit.

12.3 Benefit of FIRR

(a) FIRR analysis will be based on the incremental sales revenues to EDL from the demand at Thakhek, Savannakhet, and Kengkok that are immediately deliverable from the Project.

(b) Energy sales revenue corresponding to the Project FIRR's benefit stream were estimated at 40% of the total sales revenues, since investment share of transmission and distribution system is around 40% of total system investment.

(c) The tariff applied for all category of demand in 2005 were 2.068 US cent/kWh (40 % of 5.17 US cents per kWh, average selling price for all customers).

12.4 Results of IRRs and Sensitivity Analyses

EIRR and FIRR of the Project were computed under the criteria set in the above. Sensitivity of IRRs was analyzed for the following scenarios.

(a) 15 % higher Investment Cost
(b) 10 % lower Tariffs
(c) 50 % higher O & M Cost
(d) 30 % lower forecasted demand

Following are the computed results of EIRR, FIRR and Sensitivities.

Results of Computation

Base Case & Sensitivities	Economic IRR		Financial IRR	
	EIRR (%)	NPV_{2002}	FIRR (%)	NPV_{2002}
Base Case	23.93	31,347	14.87	52,137
Investment + 15 %	21.35	28,024	13.44	50,238
Project tariff –10 %	21.96	25,997	13.79	45,651
O & M Cost + 50 %	23.58	30,485	14.56	50,461
Energy sold –30 %	17.80	15,295	11.35	32,698

The Project in any scenarios is higher than 11% OCC and considered economically feasible and financially viable.

In addition, it is understood that the emerging national grid will have high long term financial benefits by bringing cheaper hydropower to load centers in Central 2 region and further all over the country.

TABLES

Table 7.2-1(1) Commissioning Year and Disbursement Schedule of Transmission Line Projects (Including UXO Clearance)

Year	from	to	cct	Conductor [mm^2]	Length [km]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total [1,000US$]
	Construction: 2001-2003																									**29,695**
2003	Xieng Nguen SwS	Xayabury	1	240	76.0	507	2,730	881																		4,118
	Thalat	Ban Don	1	240	45.8																					
	Ban Don	Non Hai	1	240	54.0	658	3,547	1,145																		5,350
	Nam Leuk	Phonsavan	1	240	164.0	1,242	6,695	2,161																		10,098
	Pakbo	Kengkok	1	240	52.0	229	1,236	399																		1,864
	Thakek	Nam Theun 2	2	240	68.0	1,694	5,051	1,520																		8,265
					Total	4,330	19,259	6,106																		29,695
					FC	2,865	15,174	3,613																		21,651
					LC	1,465	4,086	2,493																		8,044
	Construction: 2002-2004																									**6,867**
2004	Nam Mang 3	Laxaosi	2	410	28.0		426	2,661	683																	3,770
	Laxaosi	Thanaleng	2	410	23.0		350	2,186	561																	3,097
					Total		777	4,847	1,244																	6,867
					FC		557	3,958	782																	5,297
					LC		220	889	462																	1,571
	Construction: 2003-2005																									**100,543**
2005	Thalat	Vangvieng	2	240	64.0			1,099	6,190	1,874																9,164
	Luang Prabang	Oudomxai	2	240	164.0			4,644	15,862	5,006																25,511
	Xeset 2	Paksong	2	240	39.0			972	2,897	871																4,740
	Xeset 1	Xeset 2	2	240	2.0			50	149	45																243
	Paxan	Thakek	2	240	185.0			3,106	13,742	3,967																20,815
	Thakek	Pakbo	2	240	93.0			1,615	6,908	2,000																10,524
	Nam Theun 2	Xaibouathong	1	240	50.0			1,020	2,104	695																3,818
	Kengkok	Xepon	1	240	124.0			2,529	5,217	1,723																9,470
	Lakpet	Ban Boun	2	410	61.0			1,684	5,798	1,572																9,053
	Ban Boun	Thakho	2	240	66.0			909	4,903	1,393																7,205
					Total			17,628	63,768	19,147																100,543
					FC			11,746	49,340	11,360																72,446
					LC			5,881	14,429	7,786																28,096
	Construction: 2004-2006																									**40,898**
2006	Nam Beng	Oudomxai	2	240	122.0				1,592	9,062	2,565															13,219
	Nam Ngum 5	Phoukhoun	2	410	26.0				810	3,076	895															4,781
	Vangvieng	Phoukhoun	2	240	72.2				2,044	6,983	2,204															11,231
	Phoukhoun	Luang Prabang	2	240	75.0				2,124	7,254	2,289															11,667
					Total				6,570	26,375	7,953															40,898
					FC				4,352	19,898	4,645															28,895
					LC				2,217	6,478	3,309															12,004
	Construction: 2006-2008																									**45,827**
2008	Oudomxai	Namo SwS	1	240	43.0						462	2,210	719													3,391
	Namo	Luang Nam Tha	1	240	43.0						462	2,210	719													3,391
	Namo	Boun Neua	1	240	96.0						1,032	4,935	1,604													7,571
	Xayabury	Paklay	1	240	124.0						995	5,217	1,553													7,765
	Pakbo	Kengkok	1	240	52.0						417	2,188	651													3,256
	Kengkok	Lakpet	2	240	180.0						3,148	13,371	3,874													20,393
	Xeset 3	π connection	2	240	0.5						12	37	11													61
					Total						6,528	30,169	9,130													45,827
					FC						4,297	23,797	5,379													33,472
					LC						2,232	6,372	3,752													12,355

Table 7.2-1(1) Commissioning Year and Disbursement Schedule of Transmission Line Projects (Including UXO Clearance)

Year	from	to	cct	Conductor [mm^2]	Length [km]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total [1,000US$]
	Construction: 2001-2003																									**29,695**
	Construction: 2008-2010																									**47,318**
	Hongsa Lignite	Hongsa	2	240	1.0								13	74	21											108
2010	Nam Beng	Hongsa	1	240	37.0								398	1,902	618											2,918
	Hongsa	Xayabury	1	240	64.0								688	3,290	1,070											5,047
	Lakpet	Xeset 1	2	240	76.0								1,893	5,645	1,698											9,237
	Xeset 1	Saravan	2	240	32.0								797	2,377	715											3,889
	Saravan	Sekong	2	240	58.0								1,445	4,308	1,296											7,049
	Sekong	Houay Lamphan Gnai	2	240	18.0								448	1,337	402											2,188
	Naxaythong	Tha Ngon	1	240	12.0								96	505	150											751
	Nam Leuk	Nam Mang 3	2	410	56.0								1,051	6,626	1,851											9,527
	Nam Leuk	Pakxan	1	240	85.2								810	4,380	1,412											6,602
					Total								7,640	30,444	9,233											47,318
					FC								5,069	23,634	5,436											34,140
					LC								2,571	6,810	3,797											13,178
	Construction: 2011-2012																									**72,189**
2012	Nam Beng	Huayxai	1	240	103.0										1,552	5,295	1,771									8,618
	Phoukhoun	Nam Ngum 4B	2	240	59.0										1,671	5,706	1,801									9,178
	Nam Ngum 4B	Phonesavan	2	240	35.0										991	3,385	1,068									5,444
	Phonesavan	Xam Nua	1	240	152.0										3,326	7,814	2,728									13,868
	Xepon P/S	Xepon S/S	2	240	94.0										2,342	6,983	2,100									11,425
	Xepon S/S	Xaibouthong	1	240	114.0										2,325	4,796	1,584									8,706
	Ban Boun	Attapeu	2	240	123.0										3,064	9,137	2,749									14,950
					Total										15,272	43,116	13,802									72,189
					FC										10,082	33,333	8,105									51,520
					LC										5,190	9,783	5,696									20,670
	Construction: 2013-2014																									**933**
2014	Nam Pot	π connection	2	240	6.0												170	580	183							933
					Total												170	580	183							933
					FC												111	425	105							642
					LC												59	155	78							292
	Construction: 2014-2016																									**21,919**
2016	Nam Bak 2B	Nam Leuk	2	410	42.0														840	4,969	1,394					7,203
	Nam Kong 3	Attapeu	2	240	30.0														747	2,228	670					3,646
	Thalat	Phonetong	2	410	68.4														1,348	7,439	2,282					11,069
					Total														2,936	14,637	4,347					21,919
					FC														1,938	11,284	2,549					15,771
					LC														997	3,353	1,797					6,148
	Construction: 2017-2018																									**2,178**
2018	Nam Ngum 4A	Nam Ngum 4B	2	240	14.0																396	1,354	427			2,178
					Total																396	1,354	427			2,178
					FC																260	992	245			1,497
					LC																137	362	182			681
	Construction: 2018-2020																									**10,819**
2020	Nam Xan 2	Pakxan	2	240	49.0																		675	3,640	1,034	5,349
	Xexou	Attapeu	2	240	45.0																		1,121	3,343	1,006	5,469
					Total																		1,796	6,983	2,040	10,819
					FC																		1,207	5,479	1,226	7,911
					LC																		590	1,504	814	2,908
					Total	4,330	20,036	28,580	71,582	45,522	14,482	30,169	16,770	30,444	24,505	43,116	13,972	580	3,119	14,637	4,743	1,354	2,224	6,983	2,040	**379,187**
Total [1,000US$]					FC	2,865	15,730	19,317	54,474	31,258	8,941	23,797	10,448	23,634	15,518	33,333	8,217	425	2,043	11,284	2,809	992	1,452	5,479	1,226	**273,242**
					LC	1,465	4,306	9,264	17,108	14,264	5,540	6,372	6,322	6,810	8,987	9,783	5,755	155	1,076	3,353	1,934	362	772	1,504	814	**105,945**

Table 7.2-1(2) Commissioning Year and Disbursement Schedule of Transmission Line Projects (Not Including UXO Clearance)

Year	from	to	cct	Conductor [mm^2]	Length [km]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total [1,000US$]
	Construction: 2001-2003																									27,924
2003	Xieng Nguen SwS	Xayabury	1	240	76.0	487	2,625	847																		3,960
	Thalat	Ban Don	1	240	45.8																					
	Ban Don	Non Hai	1	240	54.0	627	3,381	1,091																		5,099
	Nam Leuk	Phonsavan	1	240	164.0	1,190	6,412	2,070																		9,672
	Pakbo	Kengkok	1	240	52.0	229	1,236	399																		1,864
	Thakek	Nam Theun 2	2	240	68.0	853	5,051	1,426																		7,330
					Total	3,386	18,705	5,833																		27,924
					FC	2,237	14,736	3,445																		20,418
					LC	1,149	3,969	2,388																		7,506
	Construction: 2002-2004																									6,867
2004	Nam Mang 3	Laxaosi	2	410	28.0		426	2,661	683																	3,770
	Laxaosi	Thanaleng	2	410	23.0		350	2,186	561																	3,097
					Total		777	4,847	1,244																	6,867
					FC		557	3,958	782																	5,297
					LC		220	889	462																	1,571
	Construction: 2003-2005																									92,942
2005	Thalat	Vangvieng	2	240	64.0			1,020	6,190	1,866																9,076
	Luang Prabang	Oudomxai	2	240	164.0			2,614	15,862	4,780																23,256
	Xeset 2	Paksong	2	240	39.0			489	2,897	818																4,204
	Xeset 1	Xeset 2	2	240	2.0			25	149	42																216
	Paxan	Thakek	2	240	185.0			2,320	13,742	3,880																19,942
	Thakek	Pakbo	2	240	93.0			1,166	6,908	1,950																10,025
	Nam Theun 2	Xaibouathong	1	240	50.0			401	2,104	626																3,131
	Kengkok	Xepon	1	240	124.0			995	5,217	1,553																7,765
	Lakpet	Ban Boun	2	410	61.0			929	5,798	1,488																8,214
	Ban Boun	Thakho	2	240	66.0			828	4,903	1,384																7,114
					Total			10,787	63,768	18,387																92,942
					FC			7,186	49,340	10,854																67,379
					LC			3,601	14,429	7,533																25,563
	Construction: 2004-2006																									38,448
2006	Nam Beng	Oudomxai	2	240	122.0				1,530	9,062	2,558															13,151
	Nam Ngum 5	Phoukhoun	2	410	26.0				488	3,076	859															4,423
	Vangvieng	Phoukhoun	2	240	72.2				1,151	6,983	2,105															10,238
	Phoukhoun	Luang Prabang	2	240	75.0				1,196	7,254	2,186															10,636
					Total				4,364	26,375	7,708															38,448
					FC				2,882	19,898	4,481															27,261
					LC				1,482	6,478	3,227															11,187
	Construction: 2006-2008																									44,580
2008	Oudomxai	Namo SwS	1	240	43.0						409	2,210	713													3,332
	Namo	Luang Nam Tha	1	240	43.0						409	2,210	713													3,332
	Namo	Boun Neua	1	240	96.0						913	4,935	1,591													7,439
	Xayabury	Paklay	1	240	124.0						995	5,217	1,553													7,765
	Pakbo	Kengkok	1	240	52.0						417	2,188	651													3,256
	Kengkok	Lakpet	2	240	180.0						2,257	13,371	3,775													19,403
	Xeset 3	π connection	2	240	0.5						6	37	10													54
					Total						5,406	30,169	9,006													44,580
					FC						3,548	23,797	5,296													32,641
					LC						1,857	6,372	3,710													11,939

Table 7.2-1(2) Commissioning Year and Disbursement Schedule of Transmission Line Projects (Not Including UXO Clearance)

Year	from	to	cct	Conductor [mm^2]	Length [km]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total [1,000US$]
	Construction: 2008-2010																									44,649
	Hongsa Lignite	Hongsa	2	240	1.0								13	74	21											108
2010	Nam Beng	Hongsa	1	240	37.0								352	1,902	613											2,867
	Hongsa	Xayabury	1	240	64.0								609	3,290	1,061											4,959
	Lakpet	Xeset 1	2	240	76.0								953	5,645	1,594											8,192
	Xeset 1	Saravan	2	240	32.0								401	2,377	671											3,449
	Saravan	Sekong	2	240	58.0								727	4,308	1,216											6,252
	Sekong	Houay Lamphan Gnai	2	240	18.0								226	1,337	377											1,940
	Naxaythong	Tha Ngon	1	240	12.0								96	505	150											751
	Nam Leuk	Nam Mang 3	2	410	56.0								1,051	6,626	1,851											9,527
	Nam Leuk	Pakxan	1	240	85.2								810	4,380	1,412											6,602
					Total								5,238	30,444	8,967											44,649
					FC								3,468	23,634	5,258											32,361
					LC								1,770	6,810	3,708											12,288
	Construction: 2011-2012																									63,619
2012	Nam Beng	Huayxai	1	240	103.0										979	5,295	1,707									7,981
	Phoukhoun	Nam Ngum 4B	2	240	59.0										941	5,706	1,720									8,367
	Nam Ngum 4B	Phonesavan	2	240	35.0										558	3,385	1,020									4,963
	Phonesavan	Xam Nua	1	240	152.0										1,445	7,814	2,519									11,778
	Xepon P/S	Xepon S/S	2	240	94.0										1,179	6,983	1,971									10,132
	Xepon S/S	Xaibouthong	1	240	114.0										914	4,796	1,428									7,139
	Ban Boun	Attapeu	2	240	123.0										1,542	9,137	2,579									13,258
					Total										7,559	43,116	12,945									63,619
					FC										4,940	33,333	7,534									45,806
					LC										2,619	9,783	5,411									17,813
	Construction: 2013-2014																									851
2014	Nam Pot	π connection	2	240	6.0												96	580	175							851
					Total												96	580	175							851
					FC												62	425	99							587
					LC												34	155	75							264
	Construction: 2014-2016																									21,449
2016	Nam Bak 2B	Nam Leuk	2	410	42.0														788	4,969	1,388					7,146
	Nam Kong 3	Attapeu	2	240	30.0														376	2,228	629					3,234
	Thalat	Phonetong	2	410	68.4														1,348	7,439	2,282					11,069
					Total														2,512	14,637	4,299					21,449
					FC														1,656	11,284	2,518					15,458
					LC														856	3,353	1,782					5,991
	Construction: 2017-2018																									1,985
2018	Nam Ngum 4A	Nam Ngum 4B	2	240	14.0																223	1,354	408			1,985
					Total																223	1,354	408			1,985
					FC																144	992	232			1,369
					LC																79	362	176			617
	Construction: 2018-2020																									10,132
2020	Nam Xan 2	Pakxan	2	240	49.0																		614	3,640	1,028	5,282
	Xexou	Attapeu	2	240	45.0																		564	3,343	944	4,851
					Total																		1,179	6,983	1,971	10,132
					FC																		795	5,479	1,180	7,453
					LC																		384	1,504	791	2,679
					Total	3,386	19,482	21,467	69,377	44,762	13,114	30,169	14,244	30,444	16,525	43,116	13,040	580	2,687	14,637	4,523	1,354	1,587	6,983	1,971	353,447
	Total [1,000US$]				FC	2,237	15,293	14,589	53,004	30,751	8,030	23,797	8,764	23,634	10,198	33,333	7,596	425	1,756	11,284	2,662	992	1,027	5,479	1,180	256,029
					LC	1,149	4,189	6,878	16,373	14,011	5,084	6,372	5,480	6,810	6,327	9,783	5,445	155	932	3,353	1,860	362	560	1,504	791	97,418

Table 7.3-1 Construction and Disbursement Schedule of Substation Projects

items	Commissioning Year	Total Cost		FC&LC 1,000$	Construction and Disbursement Schedule (US$1,000) 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Northern Area																								
Oudomxai SS																								
(ADB) New Construction, 4 TL, 1x20 MVA TR	2005	$2,456,000	FC	2074.3			207.4	1,659.4	207.4															
			LC	381.7			38.2	305.4	38.2															
(ADB) additional 1 TL bay to Namo SwS (ADB)	2008	$273,000	FC	246.1						24.6	196.9	24.6												
			LC	26.9						2.7	21.5	2.7												
- additional new 1x20 MVA TR	2015	$532,000	FC	471.5													47.2	377.2	47.2					
			LC	60.5													6.0	48.4	6.0					
Boun Neua SS																								
(ADB) New Construction, 1 TL, 1x10 MVA TR	2008	$1,492,000	FC	1139.0						113.9	911.2	113.9												
			LC	353.0						35.3	282.4	35.3												
Luang Namtha SS																								
- New Construction, 1 TL, 1x20 MVA TR	2008	$1,576,000	FC	1220.1						122.0	976.1	122.0												
			LC	355.9						35.6	284.7	35.6												
Namo SwS																								
(ADB) New Construction, 3 TL	2008	$1,469,000	FC	1219.4						121.9	975.5	121.9												
			LC	249.6						25.0	199.7	25.0												
Xam Nua SS																								
- New Construction, 1 TL, 1x20 MVA TR	2012	$1,556,000	FC	1200.1										120.0	960.1	120.0								
			LC	355.9										35.6	284.7	35.6								
Huayxai SS																								
- New Construction, 1 TL, 1x20 MVA TR	2012	$1,550,000	FC	1196.9										119.7	957.5	119.7								
			LC	353.1										35.3	282.5	35.3								
Nam Beng HPS																								
- additional 1 TL bay to Hongsa SS	2010	$295,000	FC	262.0								26.2	209.6	26.2										
			LC	33.0								3.3	26.4	3.3										
- additional 1 TL bay to Huayxai SS	2012	$295,000	FC	262.0										26.2	209.6	26.2								
			LC	33.0										3.3	26.4	3.3								
Total of Northern Area		**$11,494,000**	FC	9,291.5	0.0	0.0	207.4	1,659.4	207.4	382.5	3,059.7	408.7	209.6	292.1	2,127.2	265.9	47.2	377.2	47.2	0.0	0.0	0.0	0.0	0.0
			LC	2,202.5	0.0	0.0	38.2	305.4	38.2	98.5	788.3	101.8	26.4	77.5	593.6	74.2	6.0	48.4	6.0	0.0	0.0	0.0	0.0	0.0
Central 1 Area																								
Ban Don SS																								
(ADB) New Construction (U/C), 2 TL, 1x16 MVA TR	2003	ADB (U/C)																						
Non Hai SS																								
(ADB) New Construction (U/C), 1 TL, 1x16 MVA TR	2003	ADB (U/C)																						
Phonsavan SS																								
(ADB) New Construction (U/C), 1 TL, 1x16 MVA TR	2003	ADB (U/C)																						
- additional 1 TL bay to Xam Nua & 2 TL bays to Phoukhoun	2012	$899,000	FC	814.4										81.4	651.5	81.4								
			LC	84.6										8.5	67.7	8.5								
- additional new 1x10 MVA TR	2020	$543,000	FC	482.4																		48.2	386.0	48.2
			LC	60.6																		6.1	48.4	6.1
Xayabury SS																								
(ADB) New Construction (U/C), 1 TL, 1x16 MVA TR	2003	ADB (U/C)																						
- additional 1 TL bay to Paklay SS, 10 Mvar capacitor	2008	$305,000	FC	277.5						27.8	222.0	27.8												
			LC	27.5						2.7	22.0	2.7												
- additional 1 TL bay to Hongsa SS	2010	$286,000	FC	258.5								25.9	206.8	25.9										
			LC	27.5								2.7	22.0	2.7										
Xieng Nguen SwS																								
(ADB) New Construction (T-off) (U/C)	2003	ADB (U/C)																						
- Connection to new LP-VV line, 2 TL, with Double busbar	2006	$968,000	FC	832.2				83.2	665.8	83.2														
			LC	135.8				13.6	108.6	13.6														

Table 7.3-1 Construction and Disbursement Schedule of Substation Projects

items	Commissioning Year	Total Cost		FC&LC 1,000$	Construction and Disbursement Schedule (US$1,000) 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Phounkhoun SwS																								
(ADB) New Construction, 6 TL	2006	$2,374,000	FC	2040.9				204.1	1,632.7	204.1														
			LC	333.1				33.3	266.5	33.3														
- additional 2 TL bays to Phonsavan SS	2012	$591,000	FC	513.5										51.4	410.8	51.4								
			LC	77.5										7.7	62.0	7.7								
Paklay SS																								
(ADB) New Construction, 1 TL, 1x10 MVA TR	2008	$1,258,000	FC	893.5						89.4	714.8	89.4												
			LC	364.5						36.4	291.6	36.4												
- additional 1x10 MVA TR from Kengkok SS	2018	$330,000	FC	258.0																25.8	206.4	25.8		
			LC	72.0																7.2	57.6	7.2		
Hongsa SS																								
- New Construction, 4 TL, 1x20 MVA TR	2010	$2,439,000	FC	2063.0								206.3	1,650.4	206.3										
			LC	376.0								37.6	300.8	37.6										
Thalat SwS																								
(ADB) additional 1 TL bay to Ban Don SS (U/C)	2003	ADB (UC)																						
- additional 2 TL bays to Vangvieng SS	2005	$685,000	FC	601.4			60.1	481.1	60.1															
			LC	83.6			8.4	66.9	8.4															
- additional 1 TL to Phonetong, and 2 CB	2016	$412,000	FC	354.8														35.5	283.9	35.5				
			LC	57.2														5.7	45.7	5.7				
Nam Leuk HPS																								
(ADB) additional 1 TL bay to Phonsavan SS (U/C)	2003	ADB																						
- additional 1 TL to Pakxan 2nd cct & 2 TL to Nam Mang 3	2010	$1,186,000	FC	1043.8								104.4	835.1	104.4										
			LC	142.2								14.2	113.7	14.2										
- additional 2 TL bays to Nam Bak 2B HPS	2016	$583,000	FC	531.1														53.1	424.9	53.1				
			LC	51.9														5.2	41.5	5.2				
Luang Prabang SS																								
(ADB) additional 2 TL bays to Oudomxai SS	2005	$777,000	FC	675.1			67.5	540.1	67.5															
			LC	101.9			10.2	81.5	10.2															
(ADB) additional 2 TL to Phoukhoun, 1 CB to existing Vangvieng line	2006	$671,000	FC	588.5				58.8	470.8	58.8														
			LC	82.5				8.3	66.0	8.3														
- replacement of TR, 12.5 to 20 MVA	2007	$404,000	FC	336.9					33.7	269.5	33.7													
			LC	67.1					6.7	53.7	6.7													
- additional new 1x20 MVA TR	2013	$596,000	FC	535.5											53.5	428.4	53.5							
			LC	60.5											6.1	48.4	6.1							
Vangvieng SS																								
(ADB) additional 2 TL to Thalat SwS, 1 CB to existing Thalat line	2005	$815,000	FC	719.4			71.9	575.5	71.9															
			LC	95.6			9.6	76.5	9.6															
(ADB) additional 2 TL bays to Phoukhoun SwS	2006	$567,000	FC	514.5				51.5	411.6	51.5														
			LC	52.5				5.2	42.0	5.2														
- additional 1x12.5 MVA TR from Luang Prabang SS	2008	$337,000	FC	267.9						26.8	214.3	26.8												
			LC	69.1						6.9	55.3	6.9												
Phonesoung SS																								
- replacement of TR, 10 to 30 MVA, add 10 Mvar capacitor	2003	$513,000	FC	439.3	43.9	351.4	43.9																	
			LC	73.7	7.4	59.0	7.4																	
- connection to new Thalat-PT line, 2 TL	2016	$926,000	FC	797.9														79.8	638.4	79.8				
			LC	128.1														12.8	102.4	12.8				

Table 7.3-1 Construction and Disbursement Schedule of Substation Projects

items	Commissioning Year	Total Cost		FC&LC 1,000$	Construction and Disbursement Schedule (US$1,000) 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pakxan SS																								
- replacement of TR, 5 to 20 MVA	2003	$404,000	FC	336.9	33.7	269.6	33.7																	
			LC	67.1	6.7	53.6	6.7																	
- additional 2 TL bays to Thakhek SS	2005	$756,000	FC	659.5			65.9	527.6	65.9															
			LC	96.5			9.7	77.2	9.7															
- additional 1 TL bay to Nam Leuk HPS	2010	$294,000	FC	266.5								26.6	213.2	26.6										
			LC	27.5								2.8	22.0	2.8										
- additional 2 TL bays to Nam Xan2 HPS	2020	$569,000	FC	518.4																		51.8	414.7	51.8
			LC	50.6																		5.1	40.5	5.1
Nam Mang 3																								
- additional 2 TL bays to Nam Leuk HPS	2010	$563,000	FC	502.5								50.3	402.0	50.3										
			LC	60.5								6.0	48.4	6.0										
Naxaithong SwS																								
- upgrading SwS to SS, 6 TL, 2x30 MVA TR	2010	$3,748,000	FC	3412.2								341.2	2,729.7	341.2										
			LC	335.8								33.6	268.7	33.6										
Phonetong SS																								
- additional new 1x30 MVA TR	2011	$745,000	FC	684.5									68.4	547.6	68.4									
			LC	60.5									6.1	48.4	6.1									
- additional 1 TL bay to Thalat SwS	2016	$318,000	FC	285.0														28.5	228.0	28.5				
			LC	33.0														3.3	26.4	3.3				
- replacement of TR, 30 to 30 MVA	2017	$496,000	FC	445.4															44.5	356.3	44.5			
			LC	50.6															5.1	40.5	5.1			
Tha Ngon SS																								
- replacement of TR, 22 to 30 MVA, 10 Mvar capacitor	2008	$488,000	FC	426.4						42.6	341.1	42.6												
			LC	61.6						6.2	49.3	6.2												
- additional 1 TL bay to Naxaythong SS	2010	$618,000	FC	559.2								55.9	447.4	55.9										
			LC	58.8								5.9	47.0	5.9										
- additional new 1x30 MVA TR, 10 Mvar capacitor	2011	$706,000	FC	645.5									64.6	516.4	64.6									
			LC	60.5									6.0	48.4	6.0									
Laxsaosi SS																								
- New Construction, 4 TL, 2x30 MVA TR	2004	$3,229,000	FC	2921.9		292.2	2,337.6	292.2																
			LC	307.1		30.7	245.6	30.7																
- additional new 1 x 30 MVR TR	2010	$701,000	FC	643.8								64.4	515.0	64.4										
			LC	57.2								5.7	45.8	5.7										
- additional new 1 x 30 MVR TR	2012	$701,000	FC	643.8										64.4	515.0	64.4								
			LC	57.2										5.7	45.8	5.7								
Tanaleng SS																								
- additional 2 TL bays to Lakxaosi SS	2004	$1,443,000	FC	1240.0		124.0	992.0	124.0																
			LC	203.0		20.3	162.4	20.3																
- replacement of TR, 22 to 30 MVA, 10 Mvar capacitor	2008	$527,000	FC	444.6						44.5	355.7	44.5												
			LC	82.4						8.2	65.9	8.2												
- additional new 1x30 MVA TR, 10 Mvar capacitor	2011	$714,000	FC	653.5									65.4	522.8	65.4									
			LC	60.5									6.0	48.4	6.0									
- replacement of TR, 10 to 20 MVA, 10 Mvar capacitor	2017	$481,000	FC	398.4															39.8	318.8	39.8			
			LC	82.6															8.3	66.0	8.3			
Total of Cemtral 1 Area		**$35,966,000**	FC	31,528.1	77.6	1,037.2	3,672.7	2,938.1	3,480.1	898.1	1,881.6	1,105.9	7,198.0	2,658.9	1,829.2	625.6	53.5	196.9	1,659.4	897.8	290.8	125.9	800.7	100.1
			LC	4,437.9	14.1	163.6	459.9	413.5	527.6	174.6	490.8	169.1	886.5	275.7	199.7	70.3	6.1	27.0	229.5	140.7	70.9	18.3	88.9	11.1

Table 7.3-1 Construction and Disbursement Schedule of Substation Projects

items	Commissioning Year	Total Cost		FC&LC 1,000$	Construction and Disbursement Schedule (US$1,000) 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Central 2 Area																								
Thakhek SS																								
- New Construction, 4 TL, 2x30 MVA TR	2003	$3,337,000	FC	2943.3	294.3	2,354.7	294.3																	
			LC	393.7	39.4	314.9	39.4																	
- additional 4 TL bays to Pakxan SS & Pakbo SS	2005	$1,067,000	FC	995.5			99.6	796.4	99.6															
			LC	71.5			7.1	57.2	7.1															
- additional new 1x30 MVA TR, 10 Mvar capacitor	2014	$701,000	FC	643.8												64.4	515.0	64.4						
			LC	57.2												5.7	45.8	5.7						
- additional new 1x30 MVA TR, 10 Mvar capacitor	2019	$701,000	FC	643.8																	64.4	515.0	64.4	
			LC	57.2																	5.7	45.8	5.7	
Pakbo SS																								
(WB) replacement of TR, 2x10 to 2x20 MVA (U/C)	2002	WB																						
(WB) additional 1 TL bay to Kengkok SS (U/C)	2003	WB																						
- additional 2 TL bays to Thakhek SS, 20 Mvar capacitor	2005	$911,000	FC	805.8			80.6	644.6	80.6															
			LC	105.2			10.5	84.2	10.5															
- additional 1 TL bay to Kengkok SS 2nd cct	2008	$298,000	FC	270.5						27.0	216.4	27.0												
			LC	27.5						2.8	22.0	2.8												
- replacement of TR, 20 to 30 MVA, 10 Mvar capacitor	2012	$499,000	FC	430.9										43.1	344.7	43.1								
			LC	68.1										6.8	54.5	6.8								
- replacement of TR, 20 to 30 MVA, 10 Mvar capacitor	2015	$499,000	FC	430.9													43.1	344.7	43.1					
			LC	68.1													6.8	54.5	6.8					
- additional new 1x30 MVA TR, 10 Mvar capacitor	2016	$753,000	FC	692.5														69.2	554.0	69.2				
			LC	60.5														6.1	48.4	6.1				
Kengkok SS																								
(WB) New Construction (U/C), 1 TL, 2x10 MVA TR	2003	WB																						
(WB) additional 1 TL bay to Xepon SS, double bus system	2005	$854,000	FC	758.6			75.9	606.9	75.9															
			LC	95.4			9.5	76.3	9.5															
- additional 1 TL to Pakbo and 2 TL to Lakpet	2008	$883,000	FC	798.3						79.8	638.7	79.8												
			LC	84.7						8.5	67.7	8.5												
- replacement of TR, 10 to 20 MVA from Pakbo	2012	$198,000	FC	115.3										11.5	92.3	11.5								
			LC	82.7										8.3	66.1	8.3								
- replacement of TR, 10 to 20 MVA from Pakbo	2015	$198,000	FC	115.3													11.5	92.3	11.5					
			LC	82.7													8.3	66.1	8.3					
Xepon SS																								
- New Construction. 1TL, 1x20 MVA	2005	$1,740,000	FC	1372.6			137.3	1,098.1	137.3															
			LC	367.4			36.7	293.9	36.7															
- additional new 1x30 MVA TR	2011	$657,000	FC	605.3									60.5	484.2	60.5									
			LC	51.7									5.2	41.4	5.2									
- additional 2 TL to Xepon HPS & 1 TL to Xaibouathong	2012	$911,000	FC	830.8										83.1	664.6	83.1								
			LC	80.2										8.0	64.2	8.0								
Xaibouathong SS																								
- New Construction, 1 TL, 1x30 MVA TR	2005	$1,801,000	FC	1450.8			145.1	1,160.6	145.1															
			LC	350.2			35.0	280.2	35.0															
- additional 1 TL bay to Xepon SS	2012	$294,000	FC	266.5										26.6	213.2	26.6								
			LC	27.5										2.8	22.0	2.8								
Nam Theun 2 HPS (IPP)																								
- additional 1 TL bay to Xaibouathong SS	2005	$290,000	FC	257.0			25.7	205.6	25.7															
			LC	33.0			3.3	26.4	3.3															
Total of Cemtral 2 Area		**$16,592,000**	FC	14,427.4	294.3	2,354.7	858.4	4,512.3	564.0	106.9	855.0	106.9	60.5	648.6	1,375.3	228.7	569.7	570.6	608.6	69.2	64.4	515.0	64.4	0.0
			LC	2,164.6	39.4	314.9	141.6	818.1	102.3	11.2	89.8	11.2	5.2	67.2	212.0	31.6	60.8	132.4	63.5	6.1	5.7	45.8	5.7	0.0

Table 7.3-1 Construction and Disbursement Schedule of Substation Projects

items	Commissioning Year	Total Cost		FC&LC 1,000$	Construction and Disbursement Schedule (US$1,000) 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Southern																								
Lakpet SS																								
- New Construction, 4 TL	2005	$1,972,000	FC	1661.2			166.1	1,329.0	166.1															
			LC	310.8			31.1	248.6	31.1															
- additional 2 TL bays to Kengkok SS	2008	$552,000	FC	513.5						51.4	410.8	51.4												
			LC	38.5						3.8	30.8	3.8												
- Upgrading SwS to SS, 2 TL to Xeset 1, 20 MV TR	2010	$1,136,000	FC	1048.0								104.8	838.4	104.8										
			LC	88.0								8.8	70.4	8.8										
- additional new 1x20 MVA TR	2017	$644,000	FC	592.3															59.2	473.9	59.2			
			LC	51.7															5.2	41.3	5.2			
Thakho SS																								
- New Construction, 4 TL, 1x20 MVA TR	2005	$2,422,000	FC	2066.1			206.6	1,652.9	206.6															
			LC	355.9			35.6	284.7	35.6															
Ban Boun SS				0.0																				
- New Construction, 4 TL, 1x20 MVA TR	2005	$2,404,000	FC	2106.9			210.7	1,685.5	210.7															
			LC	297.1			29.7	237.7	29.7															
- additional 2 TL bays to Attapeu SS	2012	$552,000	FC	513.5										51.4	410.8	51.4								
			LC	38.5										3.8	30.8	3.8								
Saravan SS																								
- New Construction, 4 TL, 1x20 MVA TR	2010	$2,327,000	FC	2057.3								205.7	1,645.9	205.7										
			LC	269.7								27.0	215.7	27.0										
Sekong SS				0.0																				
- New Construction, 4 TL, 1x5 MVA TR	2010	$2,152,000	FC	1778.9								177.9	1,423.1	177.9										
			LC	373.1								37.3	298.5	37.3										
Attapeu SS				0.0																				
- New Construction, 2 TL, 1x10 MVA TR	2012	$1,935,000	FC	1578.0										157.8	1,262.4	157.8								
			LC	357.0										35.7	285.6	35.7								
- additional 2 TL bays to Nam Kong 3 HPS	2016	$552,000	FC	513.5														51.4	410.8	51.4				
			LC	38.5														3.8	30.8	3.8				
- additional 2 TL bays to Xexou HPS	2020	$552,000	FC	513.5																	51.4	410.8	51.4	
			LC	38.5																	3.8	30.8	3.8	
Xeset 1				0.0																				
- dditional 2 TL bays to Xeset 2 and double busbar system	2005	$902,000	FC	788.5			78.8	630.8	78.8															
			LC	113.5			11.4	90.8	11.4															
- additional 4 TL bays to Saravan SS & Lakpet SS	2010	$1,314,000	FC	1192.2								119.2	953.7	119.2										
			LC	121.8								12.2	97.5	12.2										
Bang Yo SS																								
- additional 30 Mvar static capacitor	2010	$150,000	FC	136.8								13.7	109.4	13.7										
			LC	13.2								1.3	10.6	1.3										
Pakson 230/115/22 kV SS																								
- New Construction, 2x230 kV TL, 2x 115 kV TL, 1 TR	2005	$5,079,000	FC	4603.5			460.3	3,682.8	460.3															
			LC	475.5			47.6	380.4	47.6															
Total of Cemtral 2 Area		**$24,645,000**	FC	21,663.7	0.0	0.0	1,122.6	8,981.0	1,122.6	51.4	410.8	672.7	4,970.5	830.5	1,673.2	209.1	0.0	51.4	470.1	525.2	59.2	51.4	410.8	51.4
			LC	2,981.3	0.0	0.0	155.3	1,242.2	155.3	3.8	30.8	90.4	692.7	126.1	316.4	39.6	0.0	3.8	35.9	45.2	5.2	3.8	30.8	3.8
Overall Total		**88,697,000.0**	FC	76,910.7	372.0	3,391.8	5,861.1	18,090.8	5,374.2	1,438.8	6,207.2	2,294.2	12,438.6	4,430.1	7,004.9	1,329.3	670.4	1,196.0	2,785.3	1,492.2	414.4	692.3	1,275.9	151.4
			LC	11,786.3	53.4	478.6	795.0	2,779.2	823.3	288.2	1,399.6	372.5	1,610.8	546.5	1,321.7	215.7	72.9	211.7	334.9	192.0	81.8	67.9	125.4	15.0

Table 11.2-1 Total Construction Cost of Transmission Lines for the Project

Item		Paxan - Thakhek					Thakhek - Pakbo					Total			
	Unit Wt[t]	No. of Tower	Tot. Wt[t]	FC [USD] 1,100	LC [USD]	Total [USD]	No. of Tower	Tot. Wt[t]	FC [USD] 1,100	LC [USD]	Total [USD]	Qty	FC [USD]	LC [USD]	Total [USD]
Towers															
A1: Suspention Type 1	5.0	490	2,450.0	2,695,000		2,695,000	275	1,375.0	1,512,500		1,512,500	3,825.0	4,207,500		4,207,500
A2: Suspension Type 2	6.2	10	62.0	68,200		68,200	0	0.0	0		0	62.0	68,200		68,200
B1: Tension 0-15	6.2	21	130.2	143,220		143,220	8	49.6	54,560		54,560	179.8	197,780		197,780
C1: Tension 0-30	7.0	16	112.0	123,200		123,200	8	56.0	61,600		61,600	168.0	184,800		184,800
D1: Tension 0-90 Type 1	9.2	15	138.0	151,800		151,800	7	64.4	70,840		70,840	202.4	222,640		222,640
D2: Tension 0-90 Type 2	11.0	2	22.0	24,200		24,200	0	0.0	0		0	22.0	24,200		24,200
DE: Dead End	9.4	4	37.6	41,360		41,360	2	18.8	20,680		20,680	56.4	62,040		62,040
Ga: Gantry	1.5	4	6.0	6,600		6,600	0	0.0	0		0	6.0	6,600		6,600
Total Tower		562	2,957.8	3,253,580		3,253,580	300	1,563.8	1,720,180		1,720,180	4,521.6	4,973,760		4,973,760
	[Unit]	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]				
Conductors	[km]	1,226.0	2,600	3,187,600		3,187,600	662.8	2,600	1,723,280		1,723,280	1,888.8	4,910,880		4,910,880
Ground Wires	[km]	204.3	600	122,580		122,580	110.5	600	66,300		66,300	314.8	188,880		188,880
Insulators															
Sus. Strings	[Units]	30,840	18	555,120		555,120	16,620	18	299,160		299,160	47,460	854,280		854,280
Ten Strings	[Units]	7,680	18	138,240		138,240	3,000	18	54,000		54,000	10,680	192,240		192,240
Jumper Supporting (for Ga)	[Units]	240	18	4,320		4,320	0	18	0		0	240	4,320		4,320
Total Insulators		38,760		697,680		697,680	19,620		353,160		353,160	58,380	1,050,840		1,050,840
Strings Conductor															
Single Suspension	[Units]	2,916	50	145,800		145,800	1,638	50	81,900		81,900	4,554	227,700		227,700
Double Suspension	[Units]	84	75	6,300		6,300	12	75	900		900	96	7,200		7,200
Single Tension	[Units]	672	100	67,200		67,200	300	100	30,000		30,000	972	97,200		97,200
Double Tension	[Units]	48	100	4,800		4,800	0	100	0		0	48	4,800		4,800
V Structure (for Ga)	[Units]	12	150	1,800		1,800	0	150	0		0	12	1,800		1,800
Total Strings Conductor		3,732		225,900		225,900	1,950		112,800		112,800	5,682	332,100		338,700
Fittings															
Dampers Conductor	[Units]	6,720	20	134,400		134,400	3,600	20	72,000		72,000	10,320	206,400		206,400
Dampers GW	[Units]	1,120	10	11,200		11,200	600	10	6,000		6,000	1,720	17,200		17,200
Compresure Joints Conductor	[Units]	817	20	16,347		16,347	442	20	8,837		8,837	1,259	25,184		25,184
Compresure Joints GW	[Units]	68	10	681		681	37	10	368		368	105	1,049		1,049
GW Suspension Fittings	[Units]	500	25	12,500		12,500	275	25	6,875		6,875	775	19,375		19,375
GW Tension Fittings	[Units]	62	50	3,100		3,100	25	50	1,250		1,250	87	4,350		4,350
Total Fittings				178,228		178,228			95,331		95,331		273,558		273,558
Tower Earthing	[Units]	562	100	56,200		56,200	302	100	30,200		30,200	864	86,400		86,400
Tower Tests	[Units]	5	20,000	100,000		100,000	2	20,000	40,000		40,000		140,000		140,000
Spare Parts and Tools	[Lots]	1		411,700		411,700	1		218,000		218,000		629,700		629,700
Total Supply				**8,233,468**	**0**	**8,233,468**			**4,359,251**	**0**	**4,359,251**		**12,592,718**	**0**	**12,592,718**
Construction Works															
	Unit	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]		Unit Price	FC [USD]	LC [USD]	Total [USD]	Qty	FC [USD]	LC [USD]	Total [USD]
Preliminary Work															
Survey, Profile Drawing	[km]	194.6	1,200	70,056	163,464	233,520	105.2	1,200	37,872	88,368	126,240	299.8	107,928	251,832	359,760
Design & Engineering	[km]	194.6	1,200	70,056	163,464	233,520	105.2	1,200	37,872	88,368	126,240	299.8	107,928	251,832	359,760
Bush Clearing	[km]	159.6	1,000	47,872	111,700	159,572	78.9	1,000	23,670	55,230	78,900	238.5	71,542	166,930	238,472
Access Roads Construction	[km]	94.5	1,000	28,356	66,164	94,520	75.1	1,000	22,543	52,600	75,143	169.7	50,899	118,764	169,663
Soil Investigation	[Units]	558	100	16,740	39,060	55,800	300	100	9,000	21,000	30,000	858	25,740	60,060	85,800
Total Preliminaly				233,080	543,852	776,932			130,957	305,566	436,523		364,036	849,418	1,213,455
Foundation Work															
Pad-1 (A1, A2 Tower, Soil- 1)	[Units]	115	2,200	126,500	126,500	253,000	0	2,200	0	0	0	115	126,500	126,500	253,000
Pad-2 (B1, C1 Tower, Soil-1)	[Units]	8	3,800	15,200	15,200	30,400	0	3,800	0	0	0	8	15,200	15,200	30,400
Pad-3 (D1, D2, DE Tower, Soil-	[Units]	6	7,000	21,000	21,000	42,000	0	7,000	0	0	0	6	21,000	21,000	42,000
Pad-4 (A1, A2 Tower, Soil- 2)	[Units]	234	2,600	304,200	304,200	608,400	261	2,600	339,300	339,300	678,600	495	643,500	643,500	1,287,000
Pad-5 (B1, C1 Tower, Soil-2)	[Units]	17	5,300	45,050	45,050	90,100	16	5,300	42,400	42,400	84,800	33	87,450	87,450	174,900
Pad-6 (D1, D2, DE Tower, Soil-2	[Units]	12	10,300	61,800	61,800	123,600	8	10,300	41,200	41,200	82,400	20	103,000	103,000	206,000
Pad-7 (A1, A2 Tower, Soil- 3)	[Units]	151	3,700	279,350	279,350	558,700	14	3,700	25,900	25,900	51,800	165	305,250	305,250	610,500
Pad-8 (B1, C1 Tower, Soil-3)	[Units]	12	8,800	52,800	52,800	105,600	0	8,800	0	0	0	12	52,800	52,800	105,600
Pad-9 (D1, D2, DE Tower, Soil-	[Units]	3	17,400	26,100	26,100	52,200	1	17,400	8,700	8,700	17,400	4	34,800	34,800	69,600
Pad-10: (Ga: Gantry Structure)	[Units]	4	1,000	2,000	2,000	4,000	0	1,000	0	0	0	4	2,000	2,000	4,000
Total Foundation Work		562		934,000	934,000	1,868,000	300		457,500	457,500	915,000	862	1,391,500	1,391,500	2,783,000
Tower Erection															
A1: Suspention Type 1	[ton]	2,450.0	150	147,000	220,500	367,500	1,375.0	150	82,500	123,750	206,250	3,825	229,500	344,250	573,750
A2: Suspension Type 2	[ton]	62.0	150	3,720	5,580	9,300	0.0	150	0	0	0	62	3,720	5,580	9,300
B1: Tension 0-15	[ton]	130.2	150	7,812	11,718	19,530	49.6	150	2,976	4,464	7,440	180	10,788	16,182	26,970
C1: Tension 0-30	[ton]	112.0	150	6,720	10,080	16,800	56.0	150	3,360	5,040	8,400	168	10,080	15,120	25,200
D1: Tension 0-90 Type 1	[ton]	138.0	150	8,280	12,420	20,700	64.4	150	3,864	5,796	9,660	202	12,144	18,216	30,360
D2: Tension 0-90 Type 2	[ton]	22.0	150	1,320	1,980	3,300	0.0	150	0	0	0	22	1,320	1,980	3,300
DE: Dead End	[ton]	37.6	150	2,256	3,384	5,640	18.8	150	1,128	1,692	2,820	56	3,384	5,076	8,460
Ga: Gantry	[ton]	6.0	150	360	540	900	0.0	150	0	0	0	6	360	540	900
Total Tower Erection		2,957.8		177,468	266,202	443,670	1,563.8		93,828	140,742	234,570	4,522	271,296	406,944	678,240
Stringing and Sagging															
6 Conductors	[km]	194.6	2,500	194,600	291,900	486,500	105.2	2,500	105,200	157,800	263,000	299.8	299,800	449,700	749,500
1 Ground Wire	[km]	194.6	500	38,920	58,380	97,300	105.2	500	21,040	31,560	52,600	299.8	59,960	89,940	149,900
Total Stringing and Sagging				233,520	350,280	583,800			126,240	189,360	315,600		359,760	539,640	899,400
Earthing Work	[Units]	562	100	16,860	39,340	56,200	302	100	9,060	21,140	30,200	864	25,920	60,480	86,400
Inland Transportation															
Tower	[ton]	2,957.8	100	0	295,780	295,780	1,563.8	100	0	156,380	156,380	4,521.6	0	452,160	452,160
Conductors	[ton]	1,197.2	100	0	119,720	119,720	647.2	100	0	64,720	64,720	1,844.4	0	184,440	184,440
Ground Wires	[ton]	82.9	100	0	8,290	8,290	44.9	100	0	4,490	4,490	127.8	0	12,780	12,780
Insulators	[ton]	224.8	100	0	22,480	22,480	113.8	100	0	11,380	11,380	338.6	0	33,860	33,860
Strings Conductors	[ton]	74.6	100	0	7,460	7,460	39.0	100	0	3,900	3,900	113.6	0	11,360	11,360
Fittings	[ton]	84.1	100	0	8,410	8,410	45.0	100	0	4,500	4,500	129.1	0	12,910	12,910
Tower Earthings	[ton]	11.2	100	0	1,120	1,120	6.0	100	0	600	600	17.2	0	1,720	1,720
Spare Parts	[ton]	203.0	100	0	20,300	20,300	100.2	100	0	10,020	10,020	303.2	0	30,320	30,320
Total Inland Transportation		4,835.7		0	483,560	483,560	2,559.9		0	255,990	255,990	7,092.4	0	739,550	739,550
Total Construction Works				**1,594,928**	**2,617,234**	**4,212,162**			**817,585**	**1,370,298**	**2,187,883**		**2,412,512**	**3,987,532**	**6,400,045**
Total Construction Cost				***9,828,395***	***2,617,234***	***12,445,630***			***5,176,836***	***1,370,298***	***6,547,134***		***15,005,231***	***3,987,532***	***18,992,763***

Table 11.2-2 Cost of Foundation Work for the Project

Soil Type	Foundation Type	Compression and Uplift Loads [kN]	Concrete Volume [m3]	Excavation Volume [m3]	Foundation Work	UNIT	Quantity /Tower	Unit Price [USD]	Total [USD]
Soil -I	Pad-1	～200	0.6	3.4	Excavation	m3	13.6	5	68
					Reinforcement	ton	0.2	700	168
					Concrete	m3	2.4	80	192
					Backfilling	m3	11.2	20	224
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**2,200**
	Pad-2	200～400	2.0	12.1	Excavation	m3	48.4	5	242
					Reinforcement	ton	0.8	700	560
					Concrete	m3	8.0	80	640
					Backfilling	m3	40.4	20	808
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**3,800**
	Pad-3	400～600	5.1	28.2	Excavation	m3	112.8	5	564
					Reinforcement	ton	2.0	700	1,428
					Concrete	m3	20.4	80	1,632
					Backfilling	m3	92.4	20	1,848
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**7,000**
Soil -II	Pad-4	～200	0.9	6.3	Excavation	m3	25.2	5	126
					Reinforcement	ton	0.4	700	252
					Concrete	m3	3.6	80	288
					Backfilling	m3	21.6	20	432
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**2,600**
	Pad-5	200～400	3.5	19.8	Excavation	m3	79.2	5	396
					Reinforcement	ton	1.4	700	980
					Concrete	m3	14.0	80	1,120
					Backfilling	m3	65.2	20	1,304
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**5,300**
	Pad-6	400～600	8.8	41.9	Excavation	m3	167.6	5	838
					Reinforcement	ton	3.5	700	2,464
					Concrete	m3	35.2	80	2,816
					Backfilling	m3	132.4	20	2,648
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**10,300**
Soil -III	Pad-7	～200	1.5	14.2	Excavation	m3	56.8	5	284
					Reinforcement	ton	0.6	700	420
					Concrete	m3	6.0	80	480
					Backfilling	m3	50.8	20	1,016
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**3,700**
	Pad-8	200～400	6.3	40.7	Excavation	m3	162.8	5	814
					Reinforcement	ton	2.5	700	1,764
					Concrete	m3	25.2	80	2,016
					Backfilling	m3	137.6	20	2,752
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**8,800**
	Pad-9	400～600	15.6	77.7	Excavation	m3	310.8	5	1,554
					Reinforcement	ton	6.2	700	4,368
					Concrete	m3	62.4	80	4,992
					Backfilling	m3	248.4	20	4,968
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**17,400**

Table 11.3-1 Construction Cost of Substation Facilities

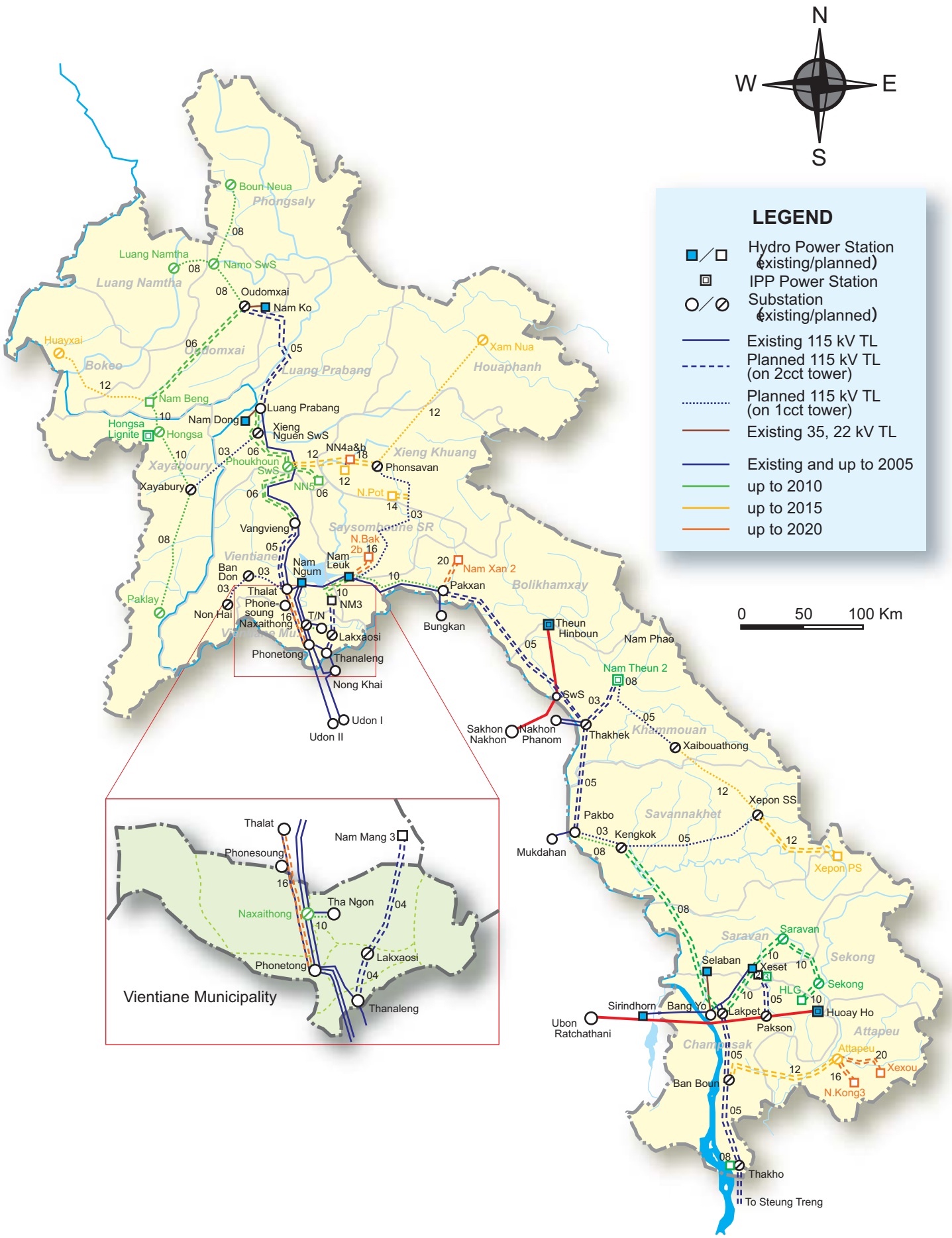
1. Plant and equipment including inland transportation

	Items	unit	CIF ($)	Pakxan SS		Thakhek SS		Pakbo SS	
				Q'ty	Total Price	Q'ty	Total Price	Q'ty	Total Price
1.1	**115 kV outdoor switchyard**								
1	Circuit breaker	pcs	61,653.00	2	123,306.00	4	246,612.00	3	184,959.00
2	Isolator	pcs	10,302.00	4	41,208.00	8	82,416.00	9	92,718.00
3	Isolator with earthing switch	pcs	12,240.00	2	24,480.00	4	48,960.00	2	24,480.00
4	Current transformer	pcs	6,069.00	6	36,414.00	12	72,828.00	6	36,414.00
5	Capacitive voltage transformer	pcs	4,488.00	6	26,928.00	12	53,856.00	9	40,392.00
6	Lightning arrester	pcs	2,193.00	6	13,158.00	12	26,316.00	6	13,158.00
7	Line trap	pcs	6,834.00	4	27,336.00	8	54,672.00	4	27,336.00
8	Steel structure	lot	20,000.00	1	20,000.00	1.5	30,000.00	3	60,000.00
9	Accessories, insulators, buswork	lot	40,000.00	1	40,000.00	1.5	60,000.00	3	120,000.00
1.2	**Control and Monitoring Equipment**								
1	Local control, bay unit	lot	106,080.00	1	106,080.00	2	212,160.00	2	212,160.00
1.3	**Protection 115 kV**								
1	Line feeder	pcs	43,110.00	1	43,110.00	2	86,220.00	2	86,220.00
2	Bus bar protection (integration in the existing system)	pcs	12,699.00	1	12,699.00	1	12,699.00	1	12,699.00
1.4	**Communication and SCADA**								
1	Extension of ex. SCADA/PLC system	lot	46,410.00	1	46,410.00	1	46,410.00	1	46,410.00
1.5	**MV, LV cables**								
1	Control cables and LV power cables	lot	25,000.00	1	25,000.00	2	50,000.00	2	50,000.00
2	Cable supporting structures	lot	1,000.00	1	1,000.00	2	2,000.00	2	2,000.00
1.6	**0.4 kV AC installations**								
1	Integration into the existing AC system	lot	4,947.00	1	4,947.00	1	4,947.00	1	4,947.00
1.7	**Earthing, Lighting, Lightning**								
1	Earthing system (integration in the existing system)	lot	17,750.00	1	17,750.00	1	17,750.00	1	17,750.00
2	Lightning system (integration in the existing system)	lot	6,612.00	1	6,612.00	1	6,612.00	1	6,612.00
3	Lighting and socket system (integration in the existing system)	lot	2,958.00	1	2,958.00	1	2,958.00	1	2,958.00
1.8	**Spare Parts**								
	5% of Total above	lot			31,000.00		55,900.00		52,100.00
					650,396.00		1,173,316.00		1,093,313.00

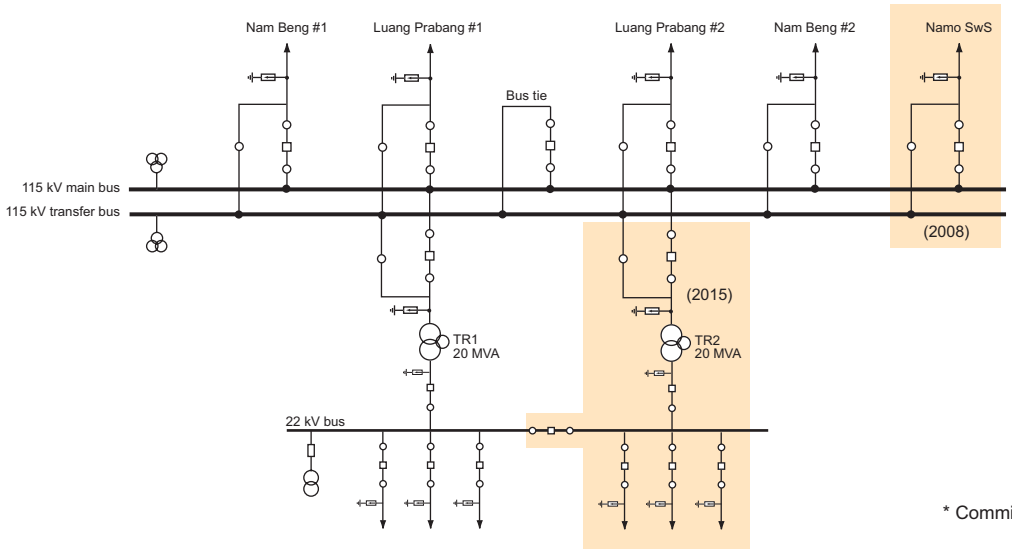
2. Civil and erection works

	Items		FC (US$)	LC (US$)	Total (US$)
2.1	Civil works				
	Pakxan SS	lot	9,100.00	33,000.00	42,100.00
	Thakhek SS	lot	18,200.00	66,000.00	84,200.00
	Pakbo SS	lot	14,100.00	71,800.00	85,900.00
2.2	Erection works				
	Pakxan SS	lot	15,000.00	54,900.00	69,900.00
	Thakhek SS	lot	30,000.00	104,500.00	134,500.00
	Pakbo SS	lot	30,000.00	92,400.00	122,400.00

FIGURES

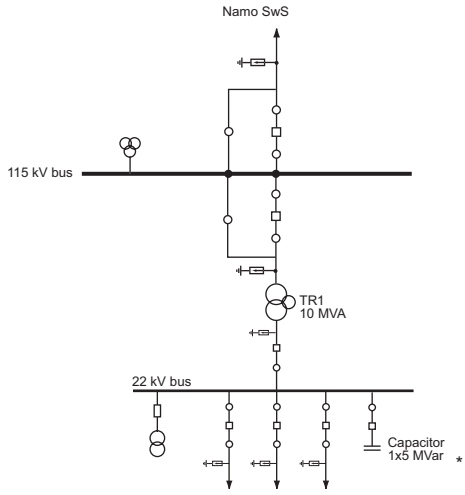


Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 1.1-1 Title The Optimum Transmission System for Domestic Supply in 2020



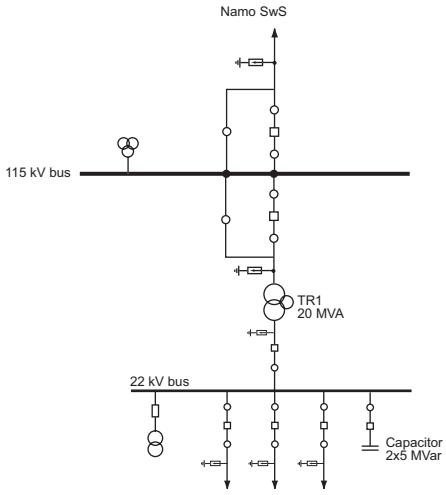
* Commissioning Year: 2005

(1) Oudomxai SS



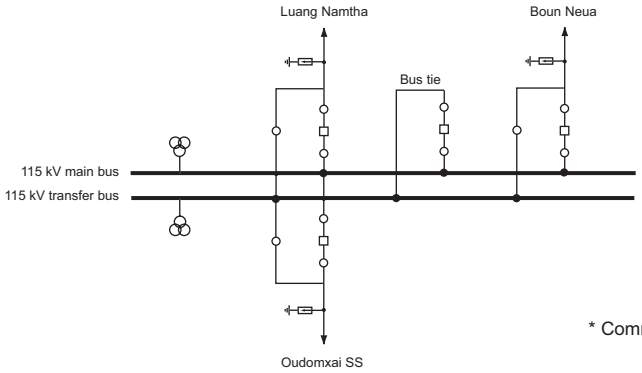
* Commissioning Year: 2008

(2) Boun Neua SS



* Commissioning Year: 2008

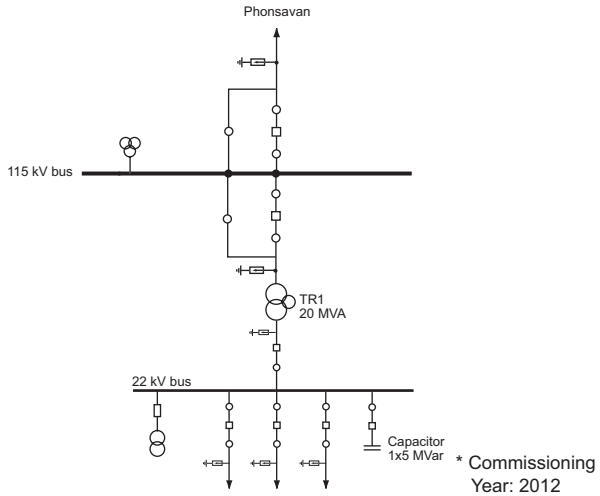
(3) Luang Namtha SS



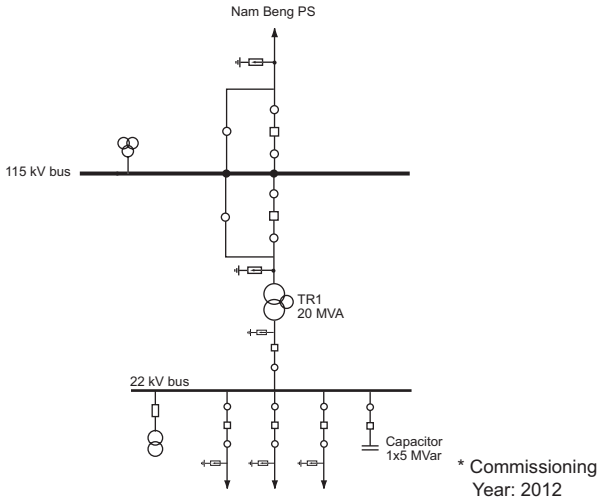
* Commissioning Year: 2008

(4) Namo SwS

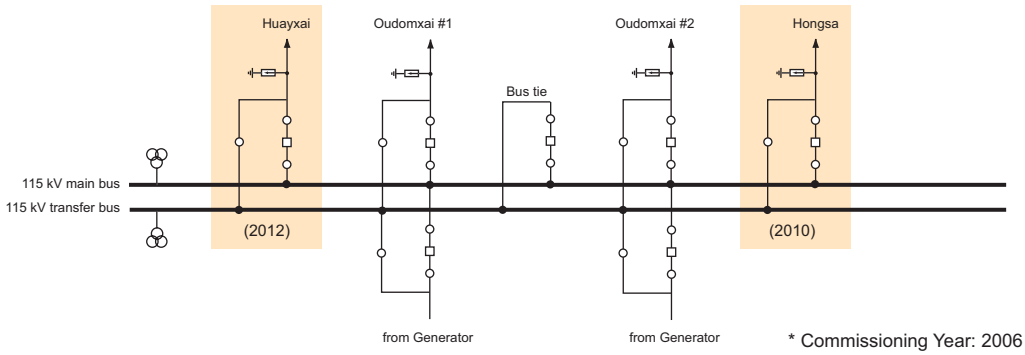
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-1 (1) to (4) **Title** Single Line Diagram of Substation /Switching Station in Northern Region



(5) Xam Nua SS

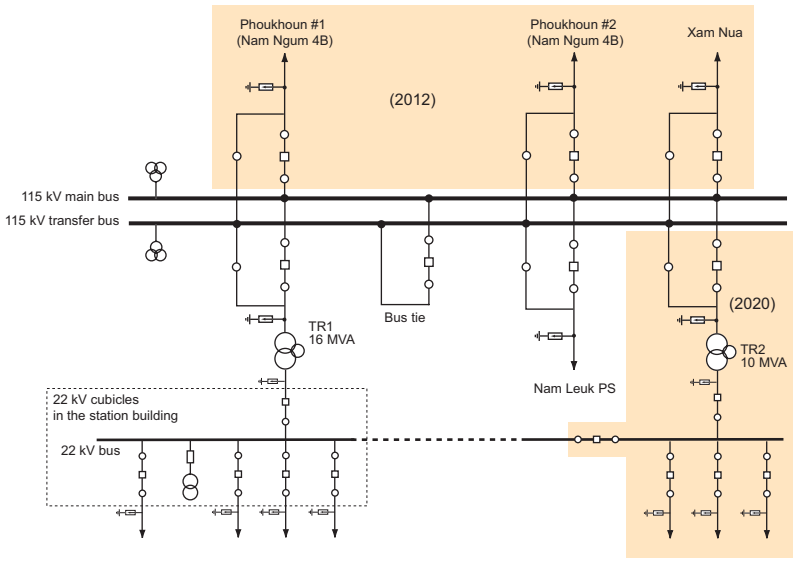


(6) Huayxai SS



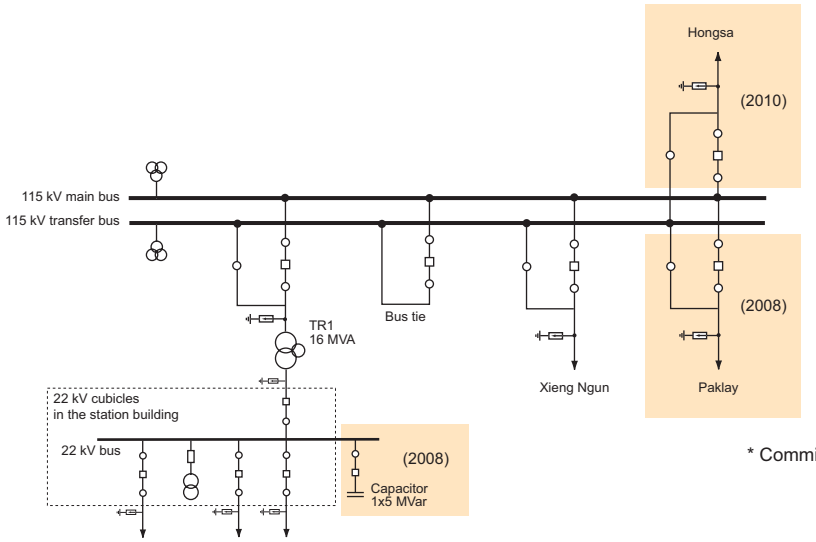
(7) Nam Beng PS Switchyard

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-1 (5) to (7) **Title** Single Line Diagram of Substation /Switching Station in Northern Region



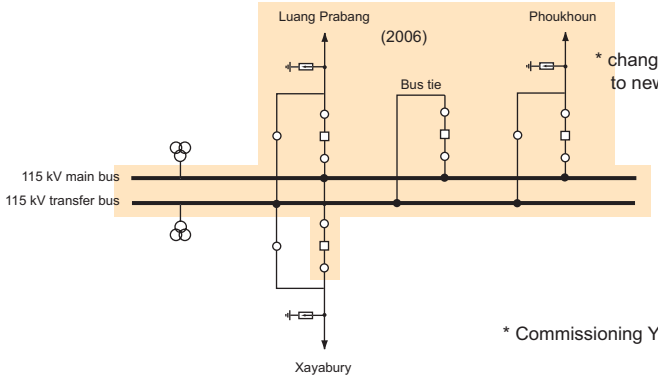
* Commissioning Year: 2003

(1) Phonsavan SS



* Commissioning Year: 2003

(2) Xayabuly SS

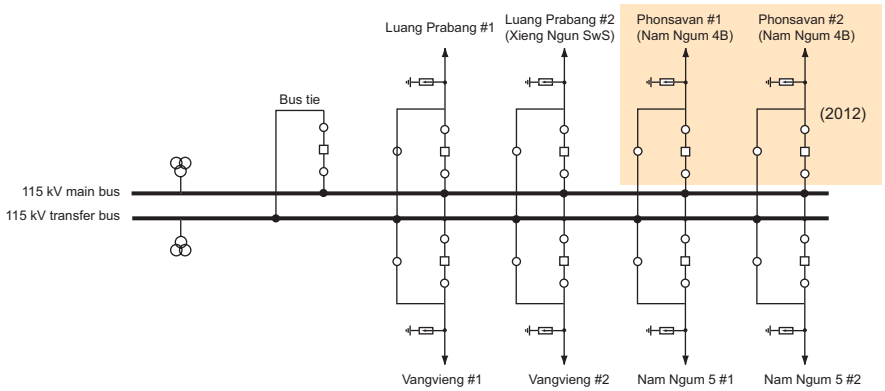


* changing the tap-off connection to pi-connection to new Luang Prabang - Phoukhoun line

* Commissioning Year: 2003

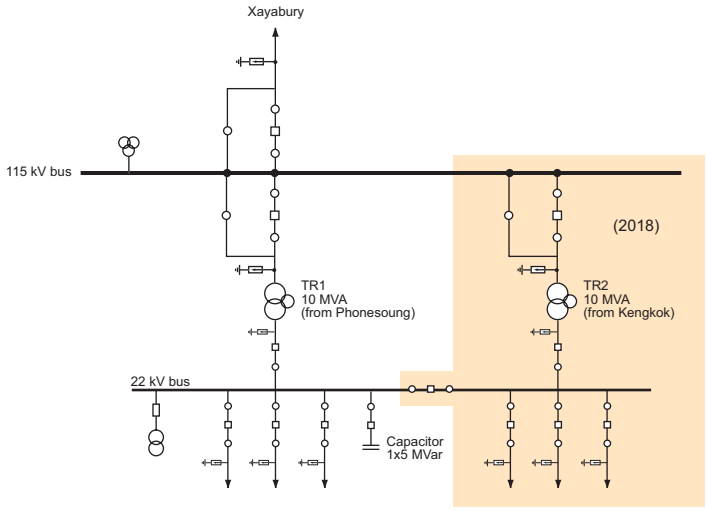
(3) Xieng Ngun SwS

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-2 (1) to (3) **Title** Single Line Diagram of Substation /Switching Station in Central 1 Region



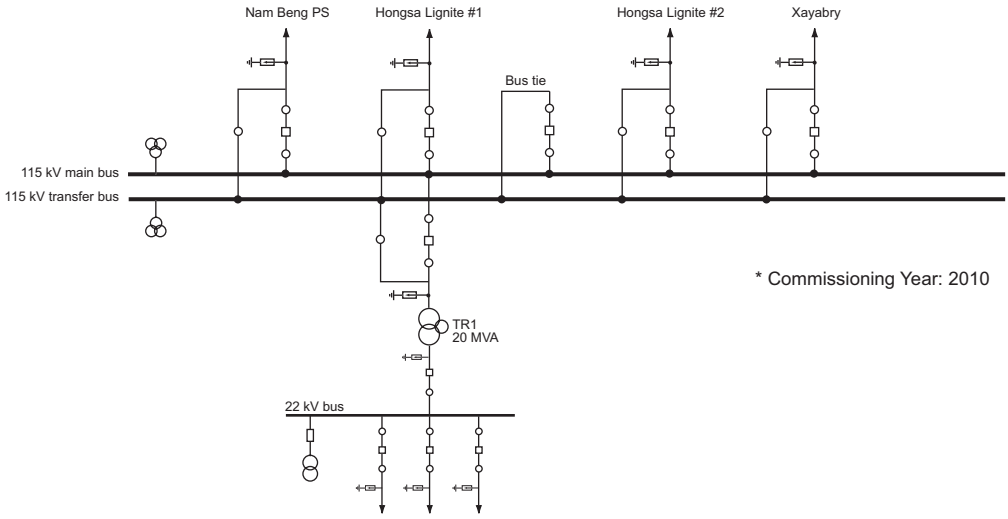
* Commissioning Year: 2006

(4) Phoukhoun SwS



* Commissioning Year: 2008

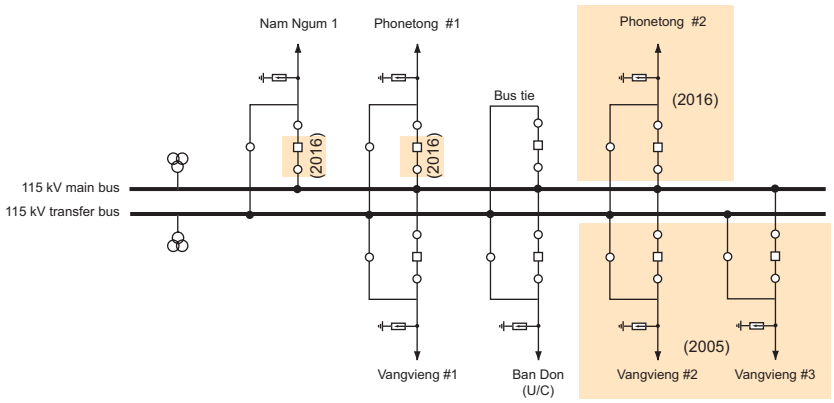
(5) Paklay SS



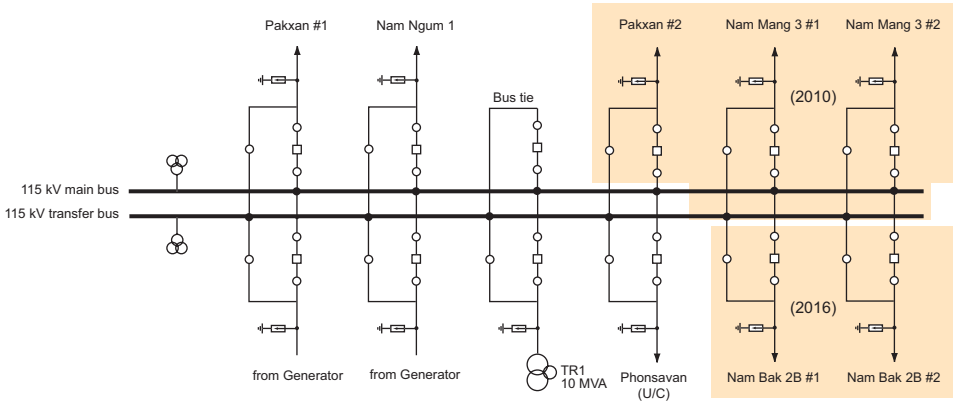
* Commissioning Year: 2010

(6) Hongsa SS

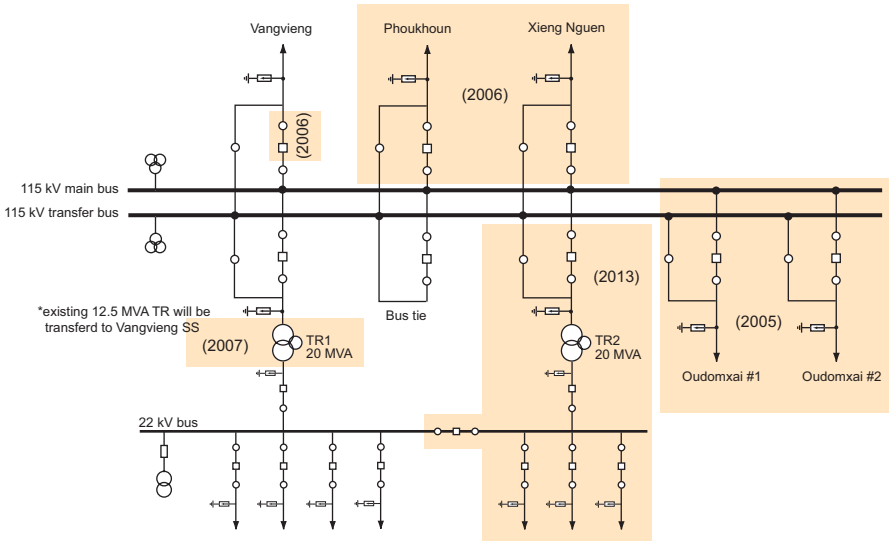
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-2 (4) to (6) **Title** Single Line Diagram of Substation /Switching Station in Central 1 Region



(7) Thatat SwS

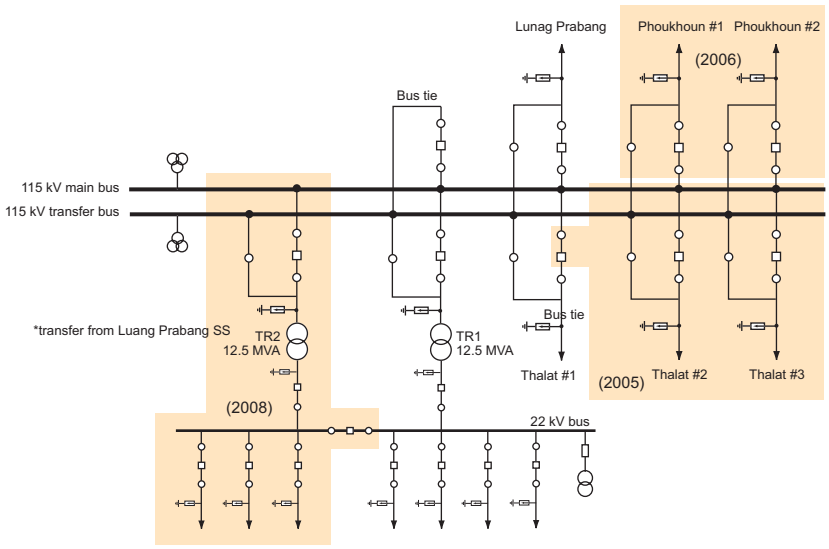


(8) Nam Leuk PS Switchyard

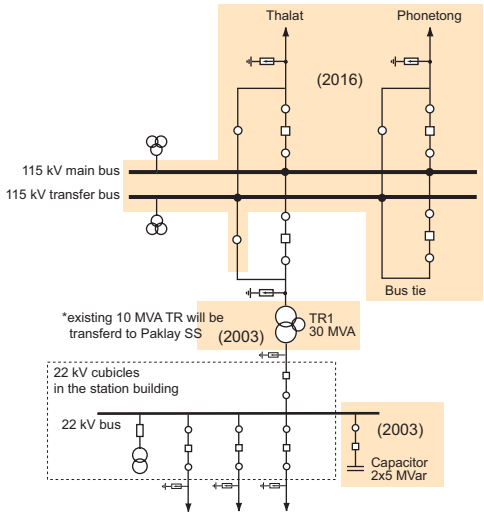


(9) Luang Prabang SS

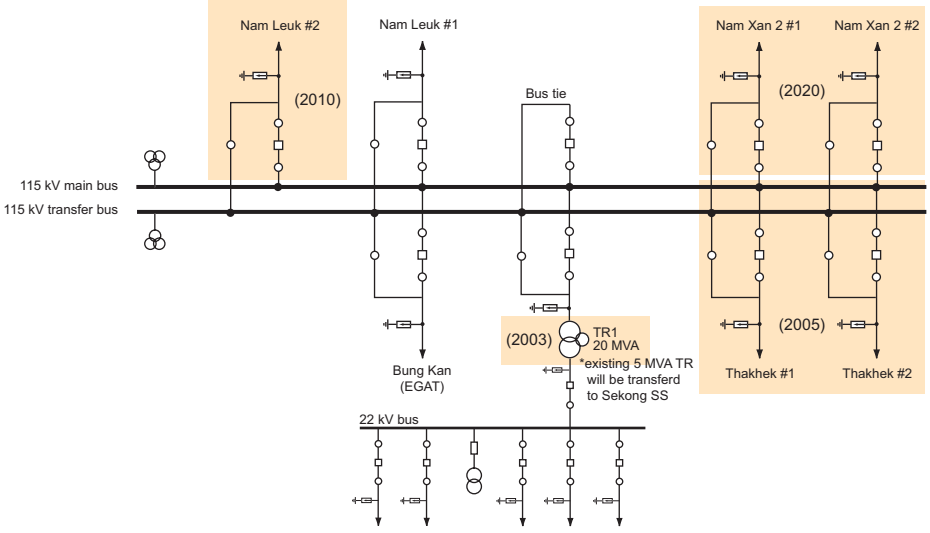
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-2 (7) to (9) **Title** Single Line Diagram of Substation /Switching Station in Central 1 Region



(10) Vangvieng SS

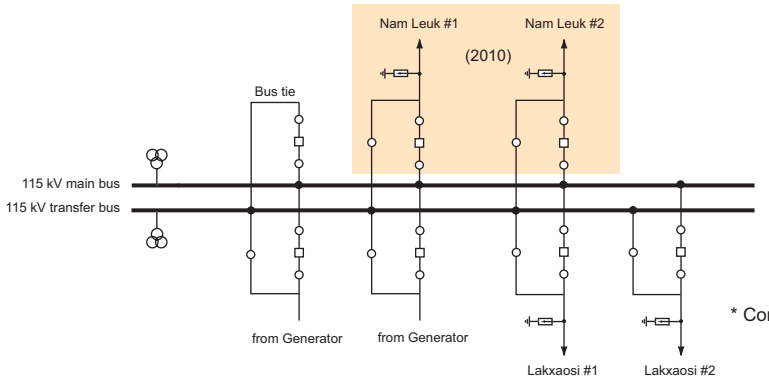


(11) Phonesoung SS



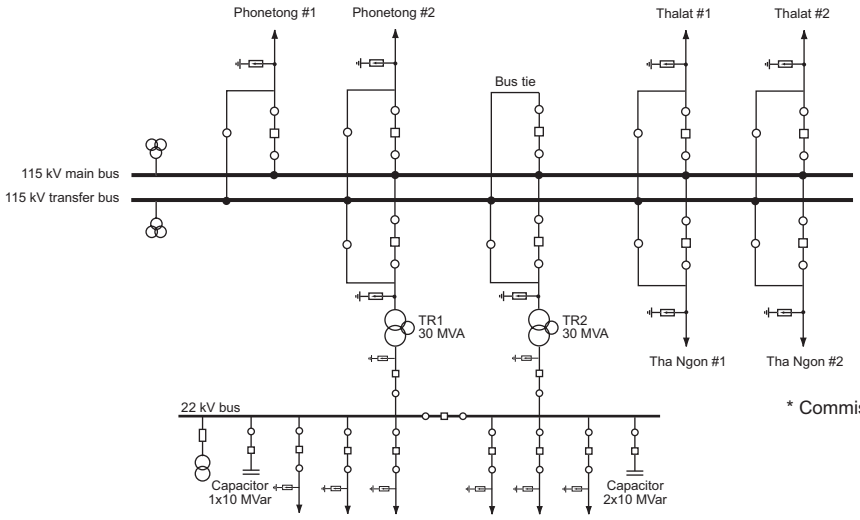
(12) Pakxan SS

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-2 (10) to (12) **Title** Single Line Diagram of Substation /Switching Station in Central 1 Region



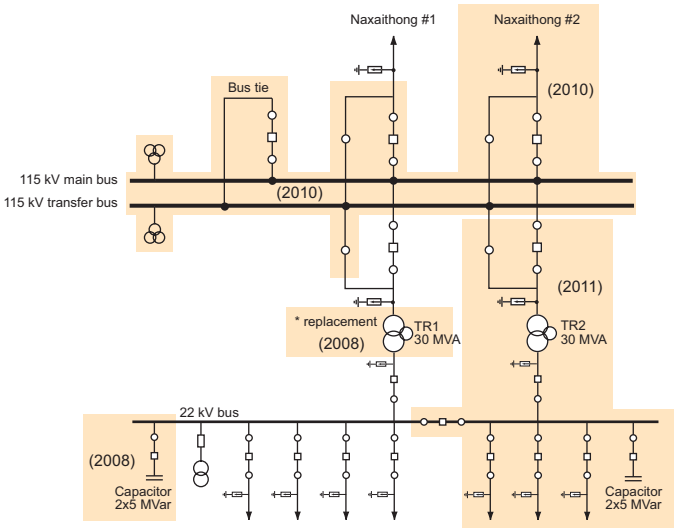
* Commissioning Year: 2004

(13) Nam Mang 3 PS Switchyard



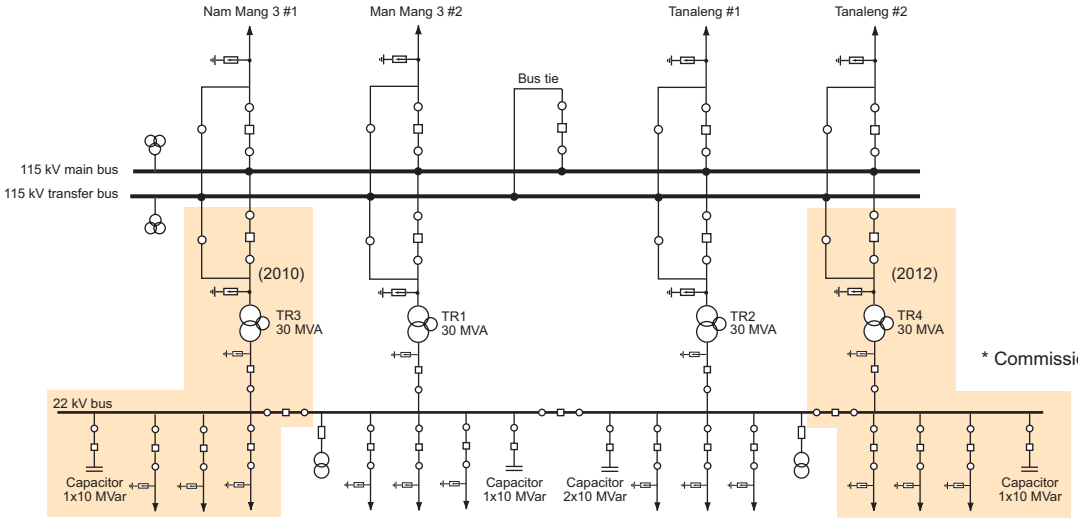
* Commissioning Year: 2010

(14) Naxithong SS (upgrading from SwS)



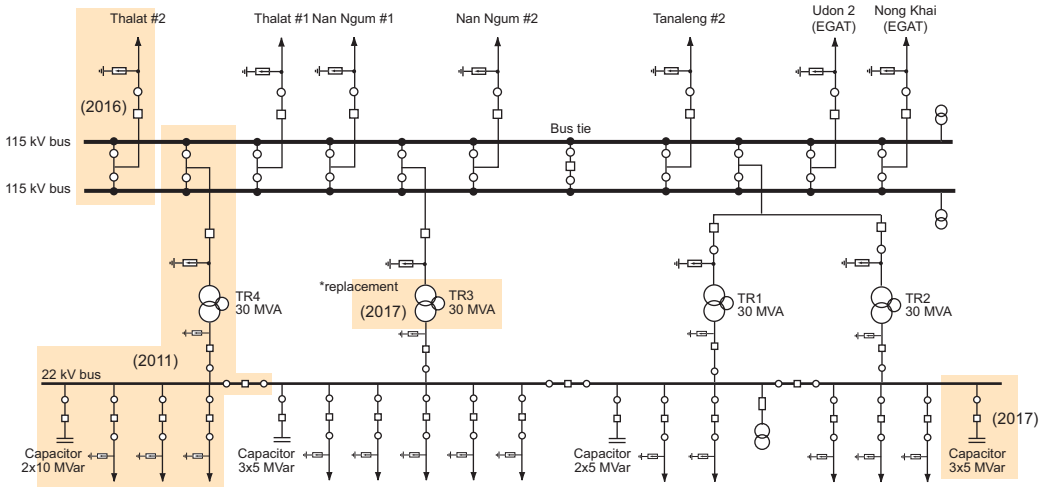
(15) Tha Ngon SS

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 7.3-2 (13) to (15) Title Single Line Diagram of Substation /Switching Station in Central 1 Region

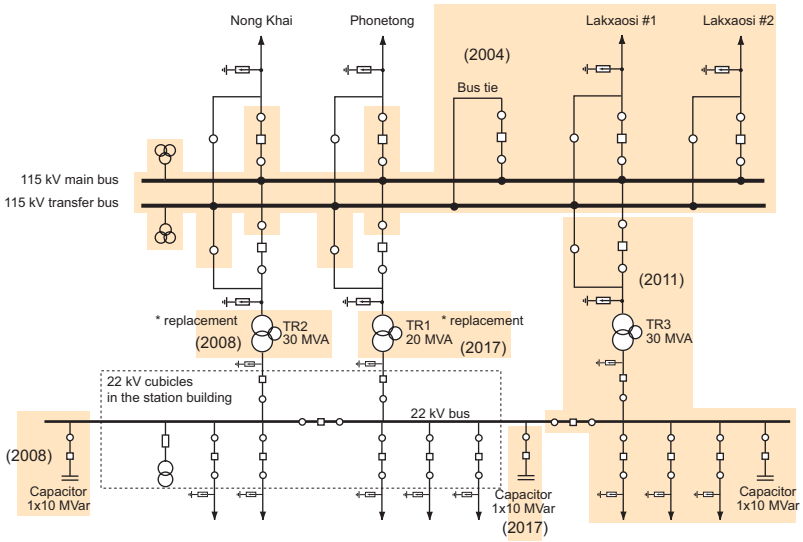


* Commissioning Year: 2004

(16) Lakxaosi SS

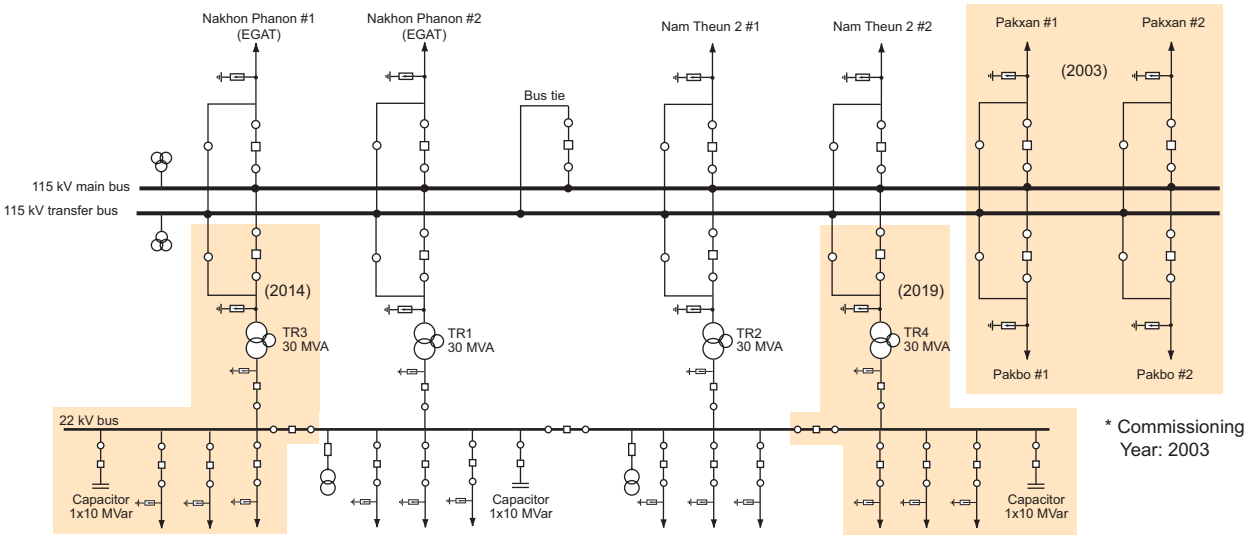


(17) Phonetong SS



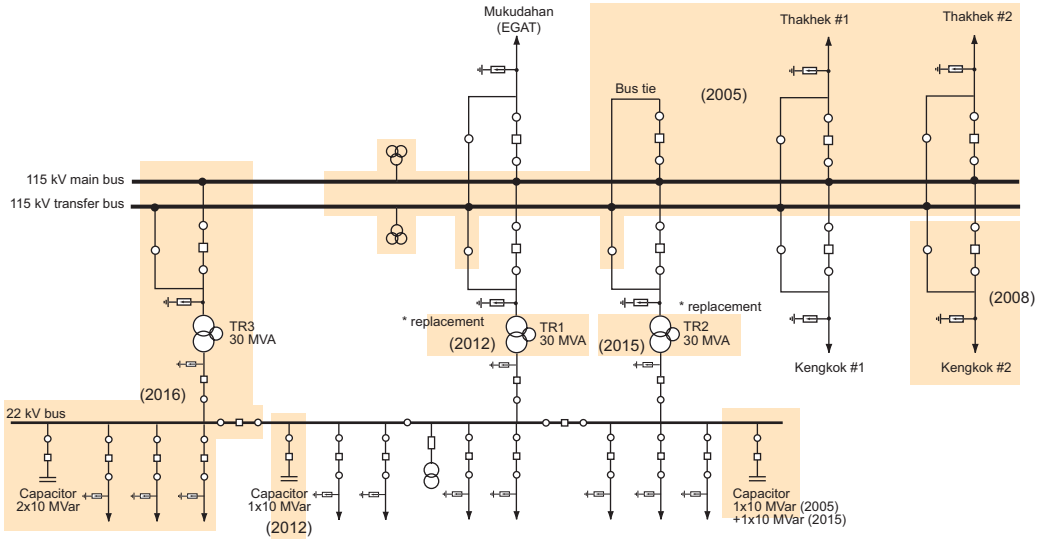
(18) Tanaleng SS

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-2 (16) to (18) **Title** Single Line Diagram of Substation /Switching Station in Central 1 Region

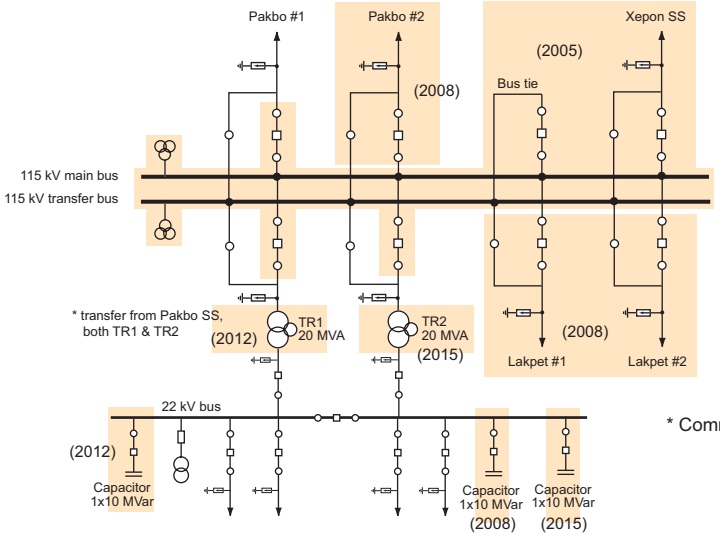


* Commissioning Year: 2003

(1) Thakhek SS



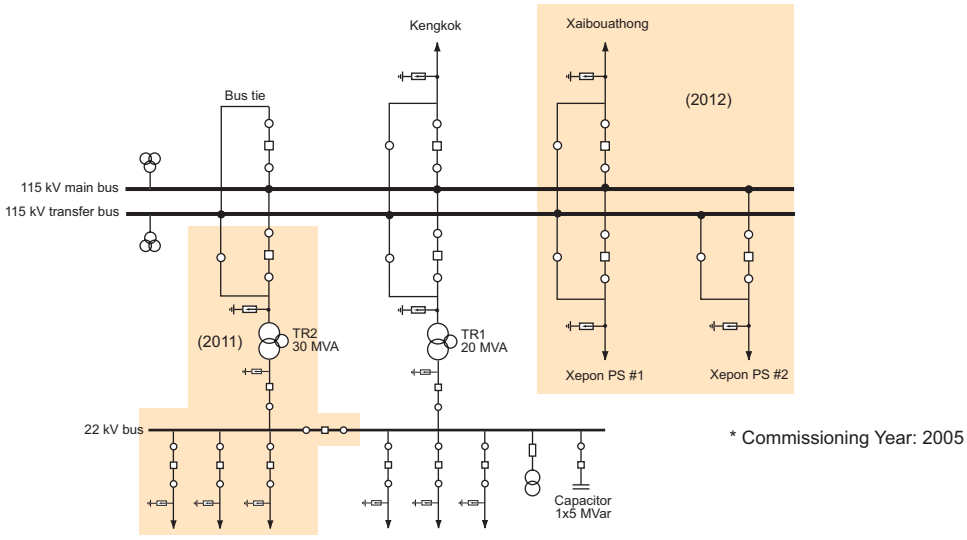
(2) Pakbo SS



* Commissioning Year: 2003

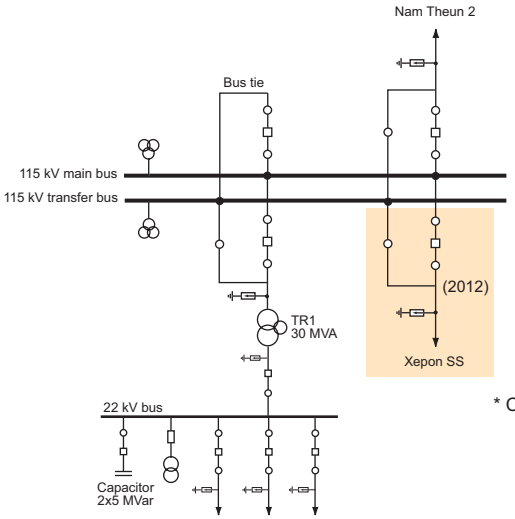
(3) Kengkok SS

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-3 (1) to (3) **Title** Single Line Diagram of Substation /Switching Station in Central 2 Region



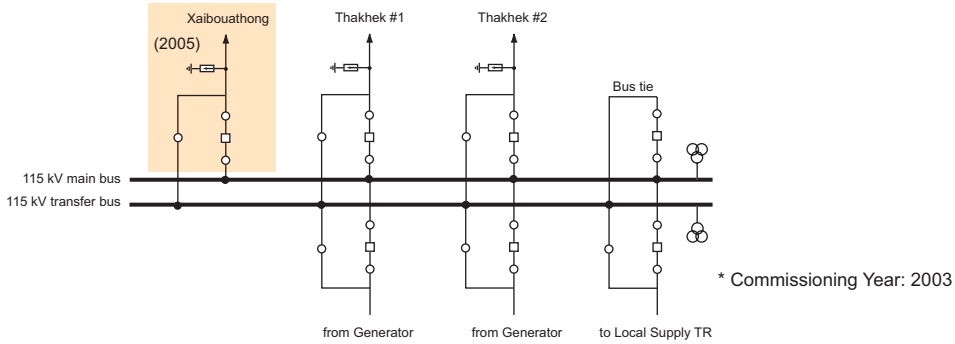
* Commissioning Year: 2005

(4) Xepon SS



* Commissioning Year: 2005

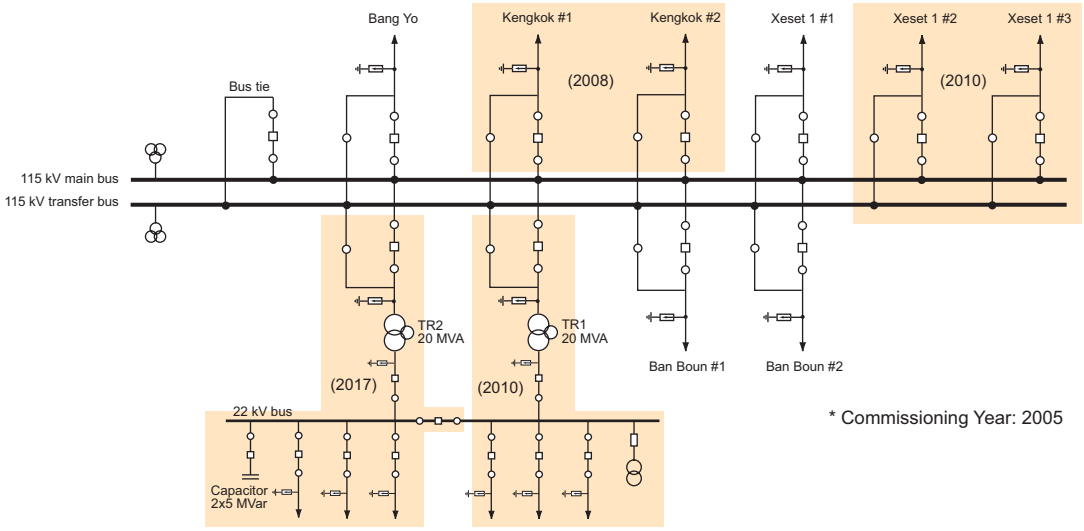
(5) Xaibouathong SS



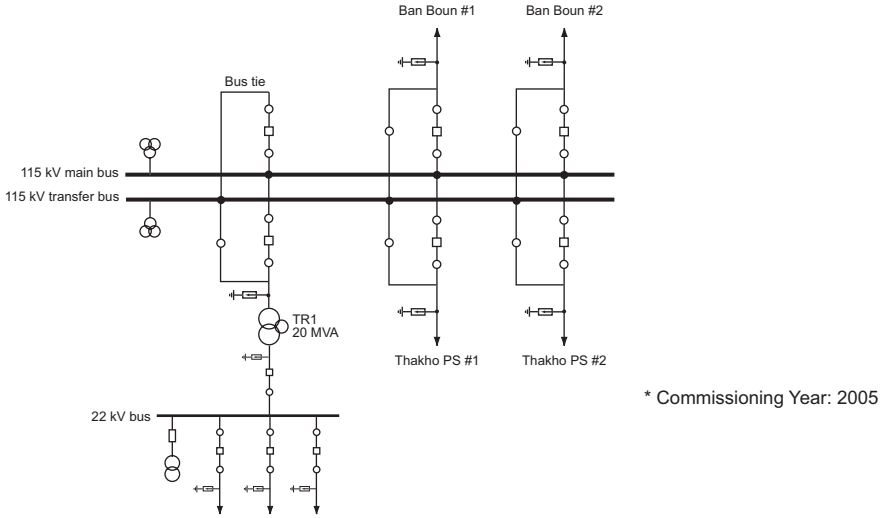
* Commissioning Year: 2003

(6) Nam Theun 2 PS Switchyard

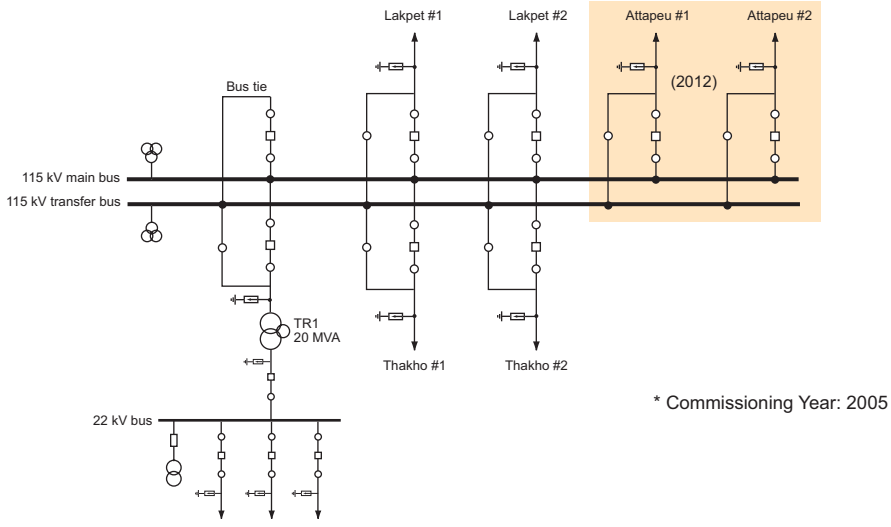
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-3 (4) to (6) **Title** Single Line Diagram of Substation /Switching Station in Central 2 Region



(1) Lakpet SS (upgrading from SwS)

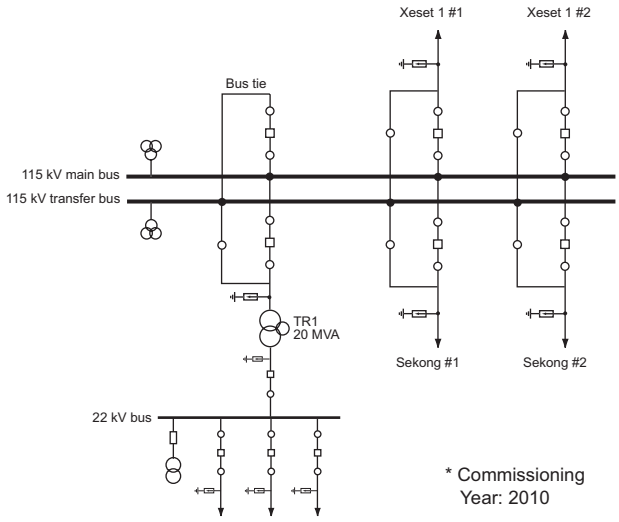


(2) Thakho SS

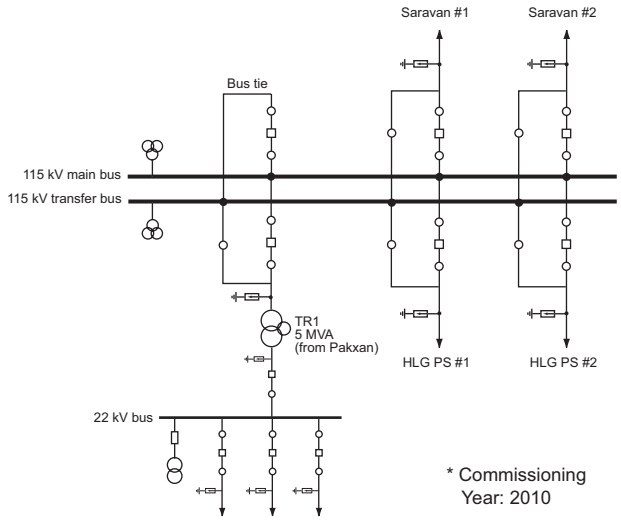


(3) Ban Boun SS

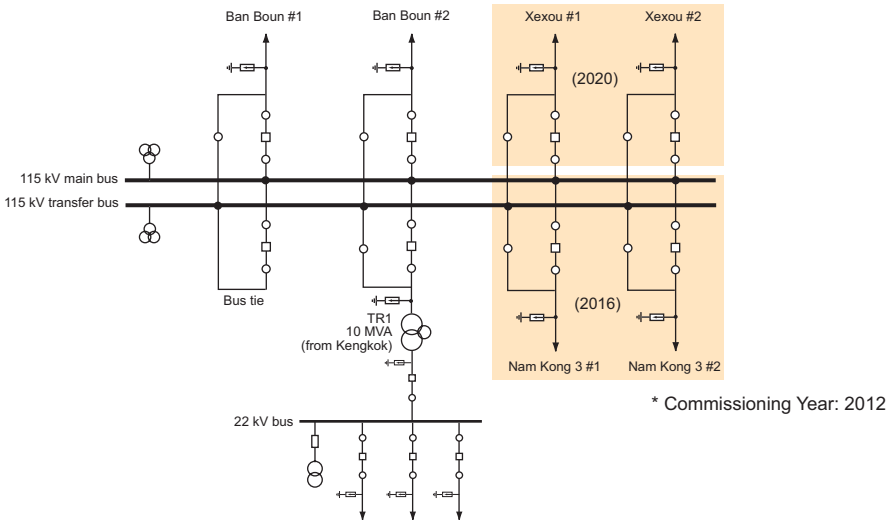
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-4 (1) to (3) **Title** Single Line Diagram of Substation /Switching Station in Southern Region



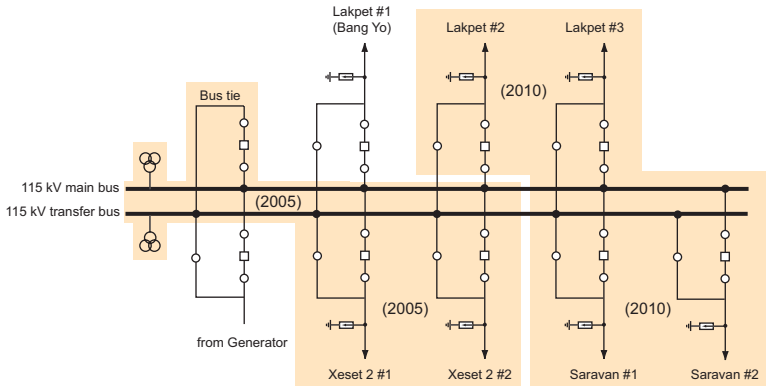
(4) Saravan SS



(5) Sekong SS

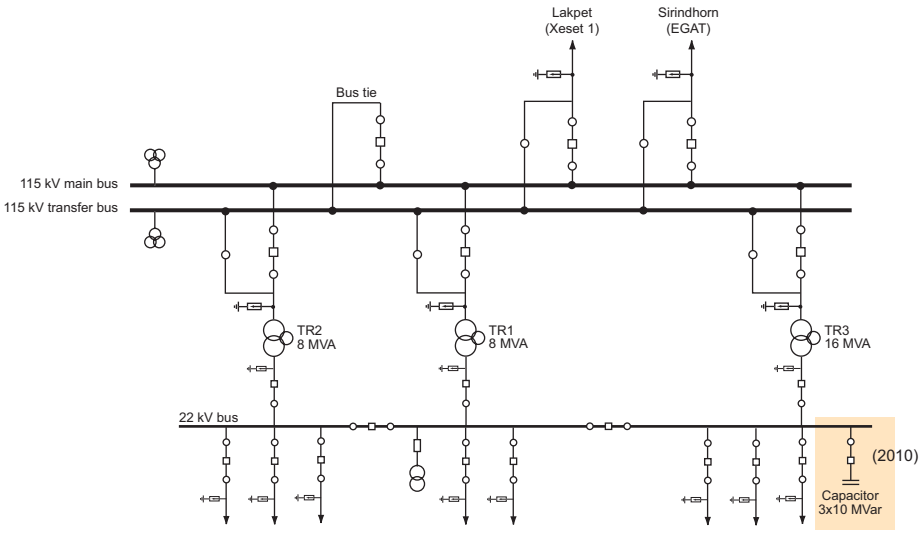


(6) Attapeu SS

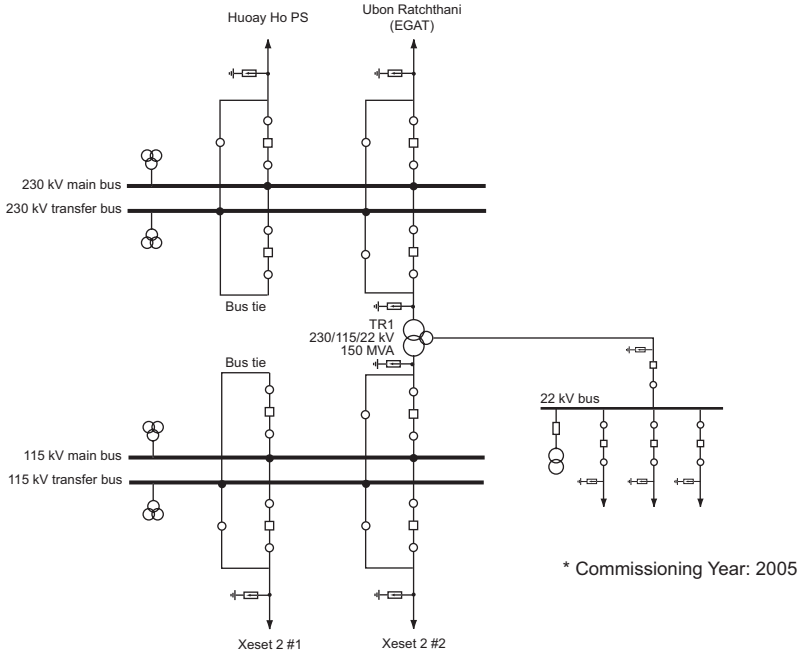


(7) Xeset 1 PS Switchyard

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-4 (4) to (7) **Title** Single Line Diagram of Substation /Switching Station in Southern Region



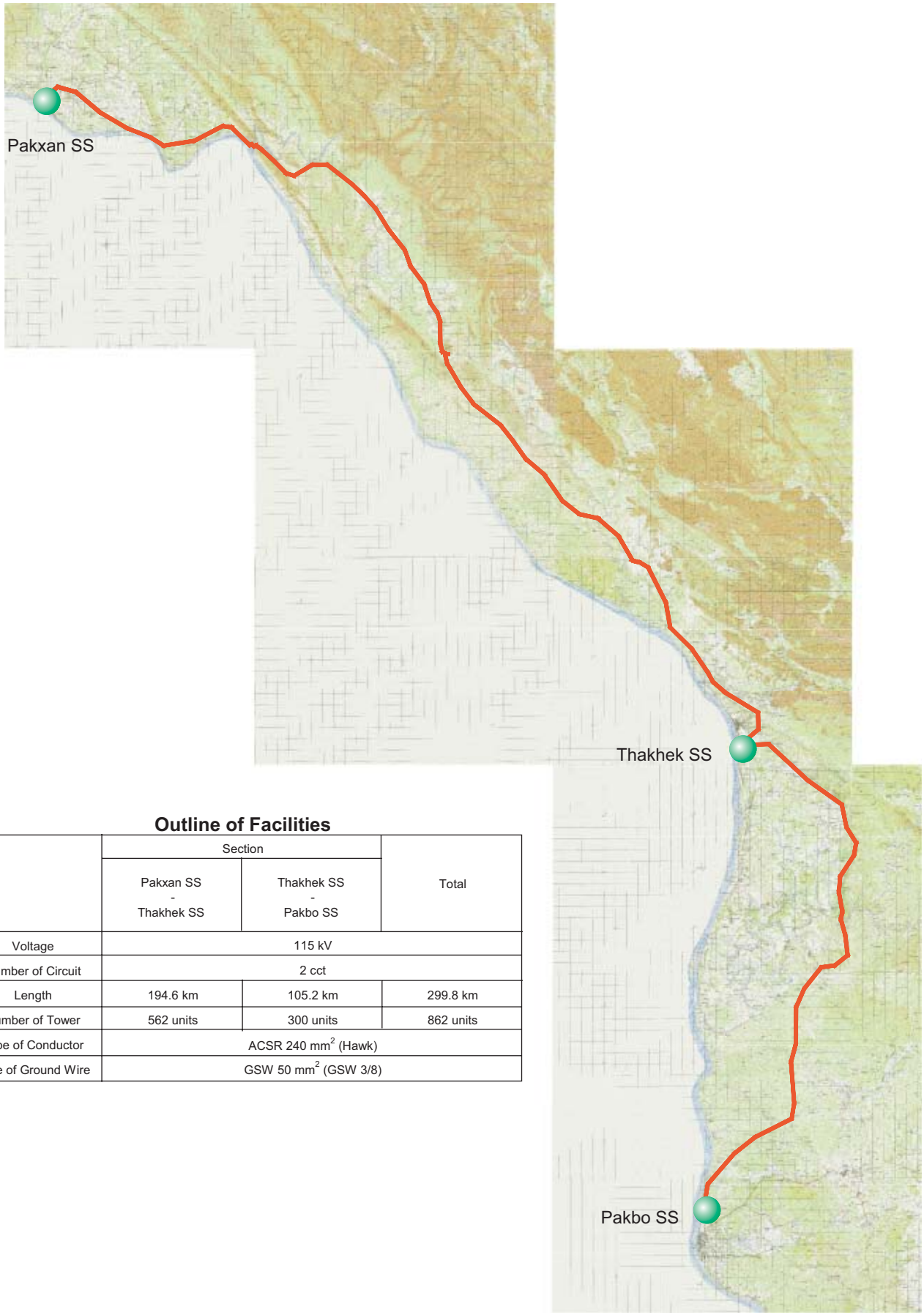
(8) Bang Yo SS



* Commissioning Year: 2005

(9) Pakson 230 kV SS

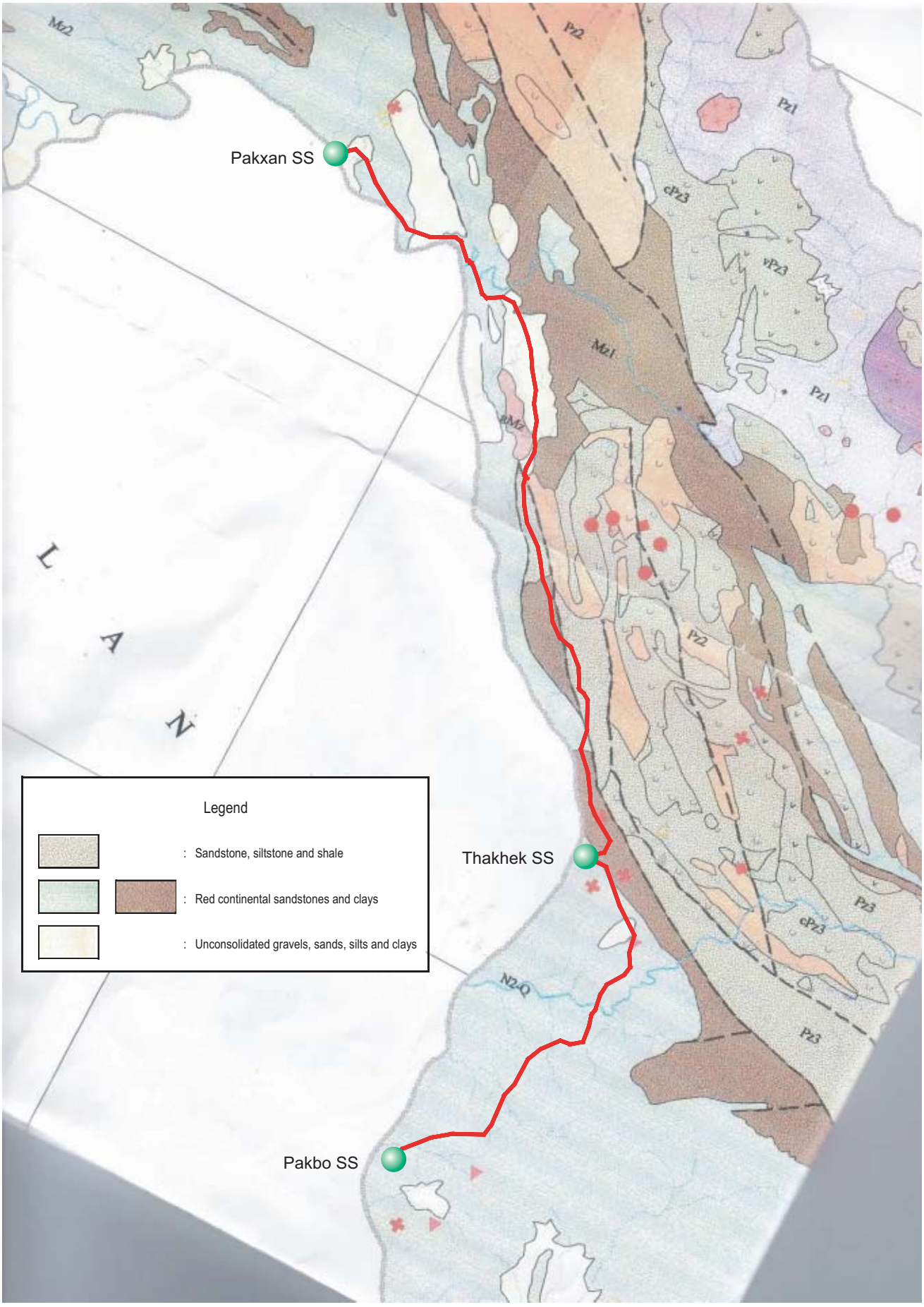
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 7.3-4 (8) and (9) **Title** Single Line Diagram of Substation /Switching Station in Southern Region



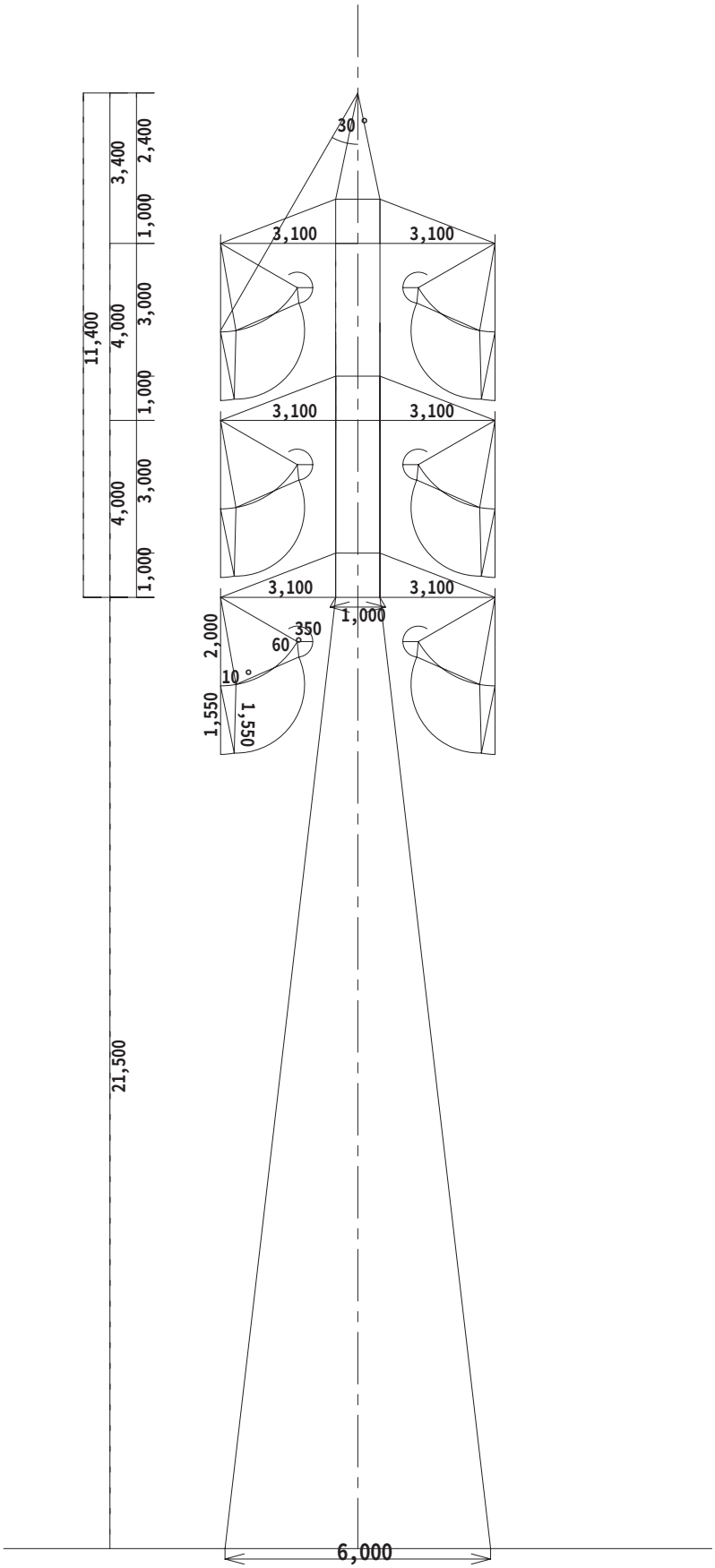
Outline of Facilities

	Section		Total
	Pakxan SS - Thakhek SS	Thakhek SS - Pakbo SS	
Voltage	115 kV		
Number of Circuit	2 cct		
Length	194.6 km	105.2 km	299.8 km
Number of Tower	562 units	300 units	862 units
Type of Conductor	ACSR 240 mm^2 (Hawk)		
Type of Ground Wire	GSW 50 mm^2 (GSW 3/8)		

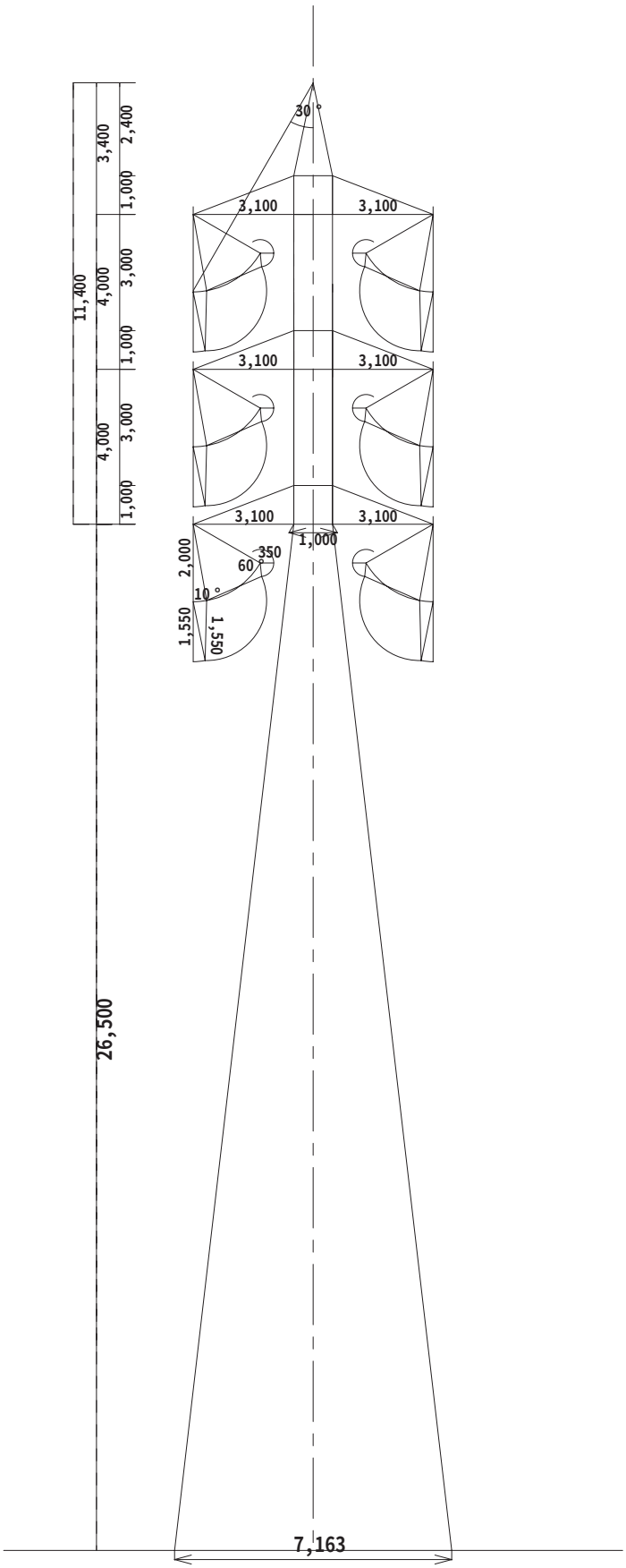
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-1 **Title** Selected Transmission Line Route from Pakxan SS to Pakbo SS



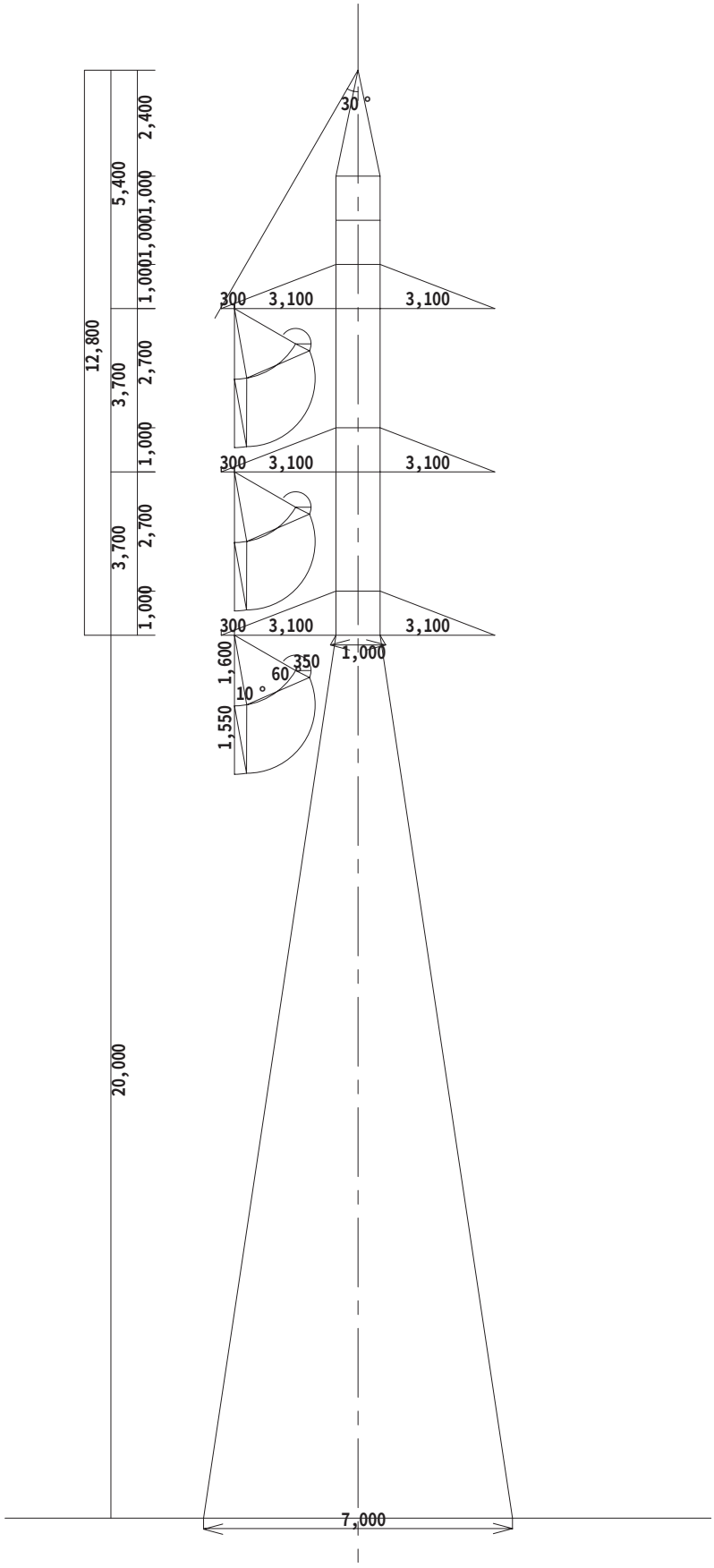
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.2-2 Title Geological Features Map



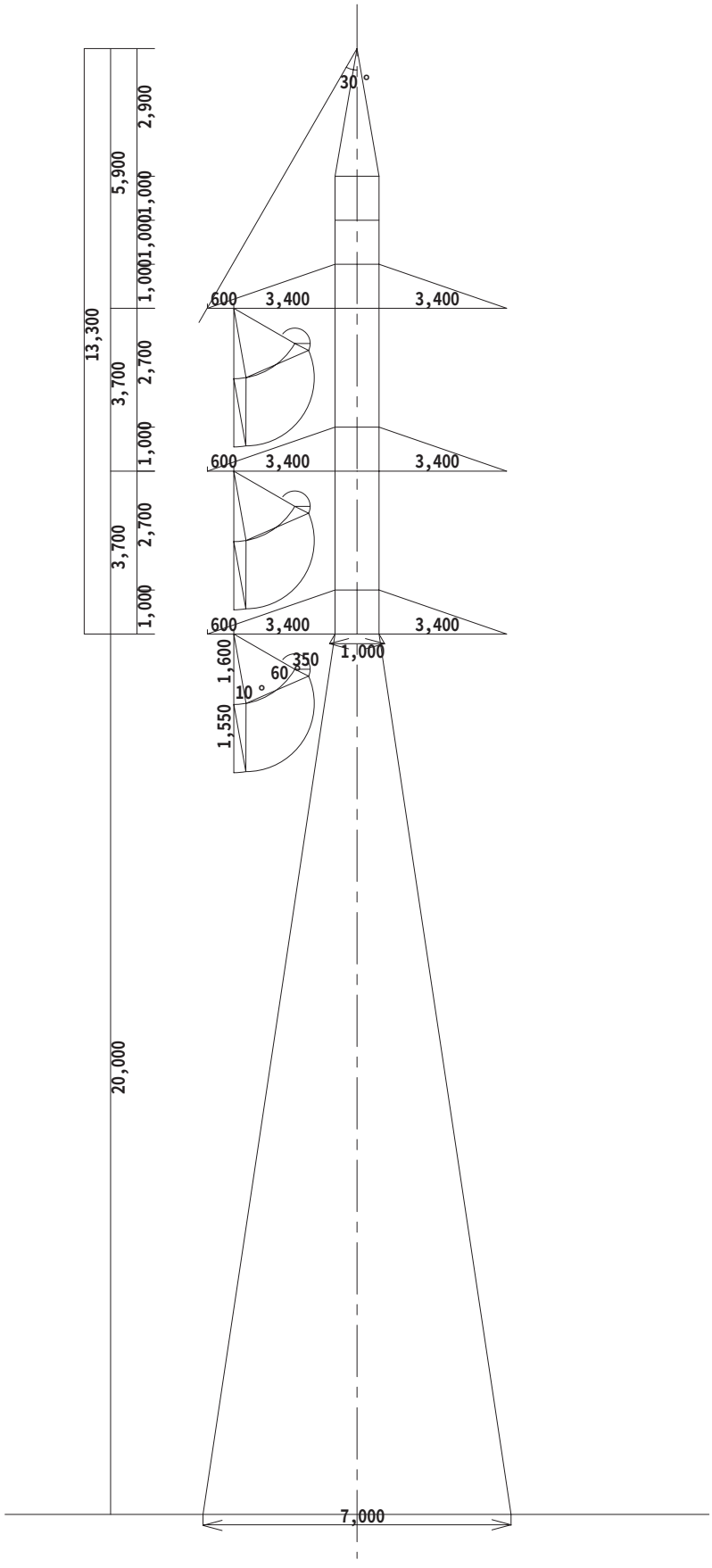
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-3 **Title** Suspension Tower : A1 Type (Line Horizontal Angle : 0 - 3 deg.)



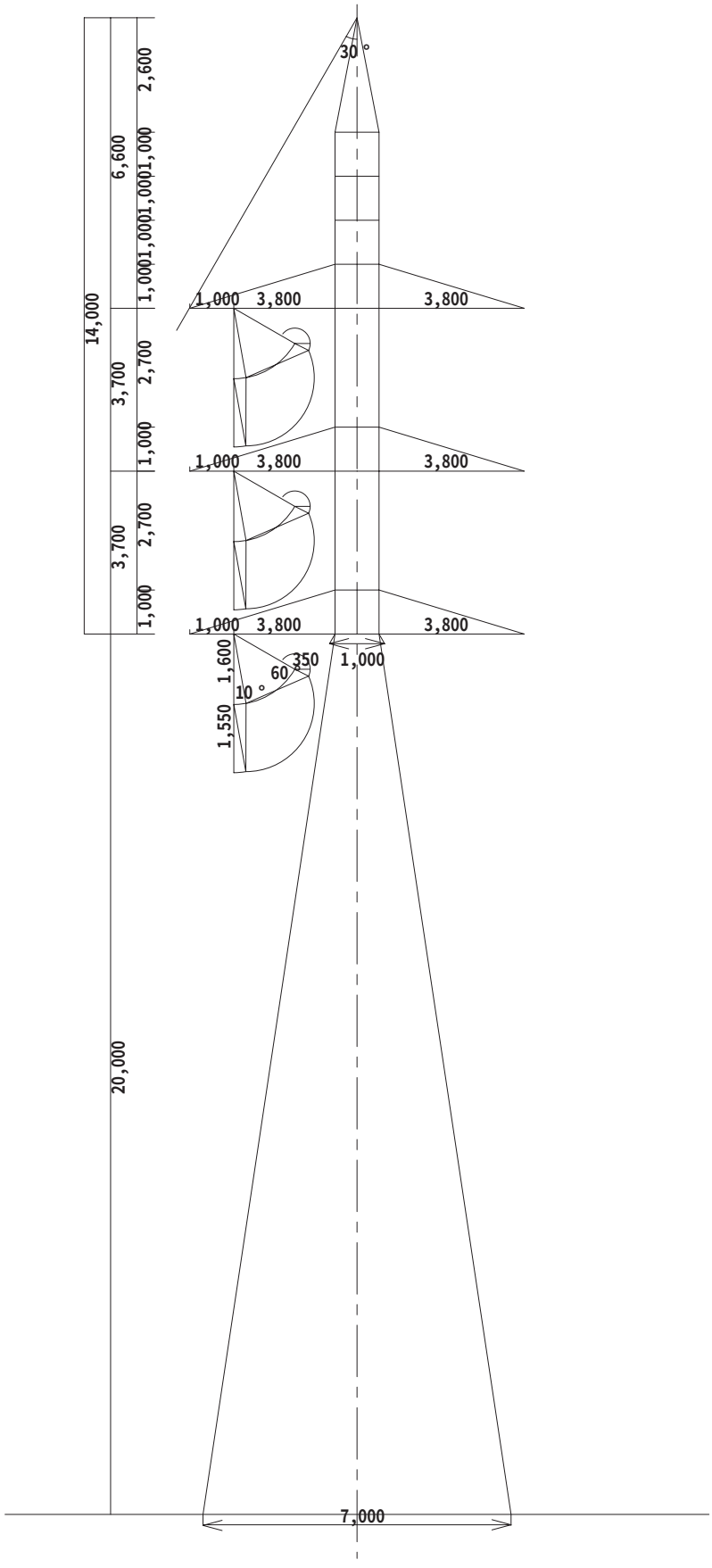
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-4 **Title** Suspension Tower : A2 Type (Line Horizontal Angle : 0 - 3 deg.)



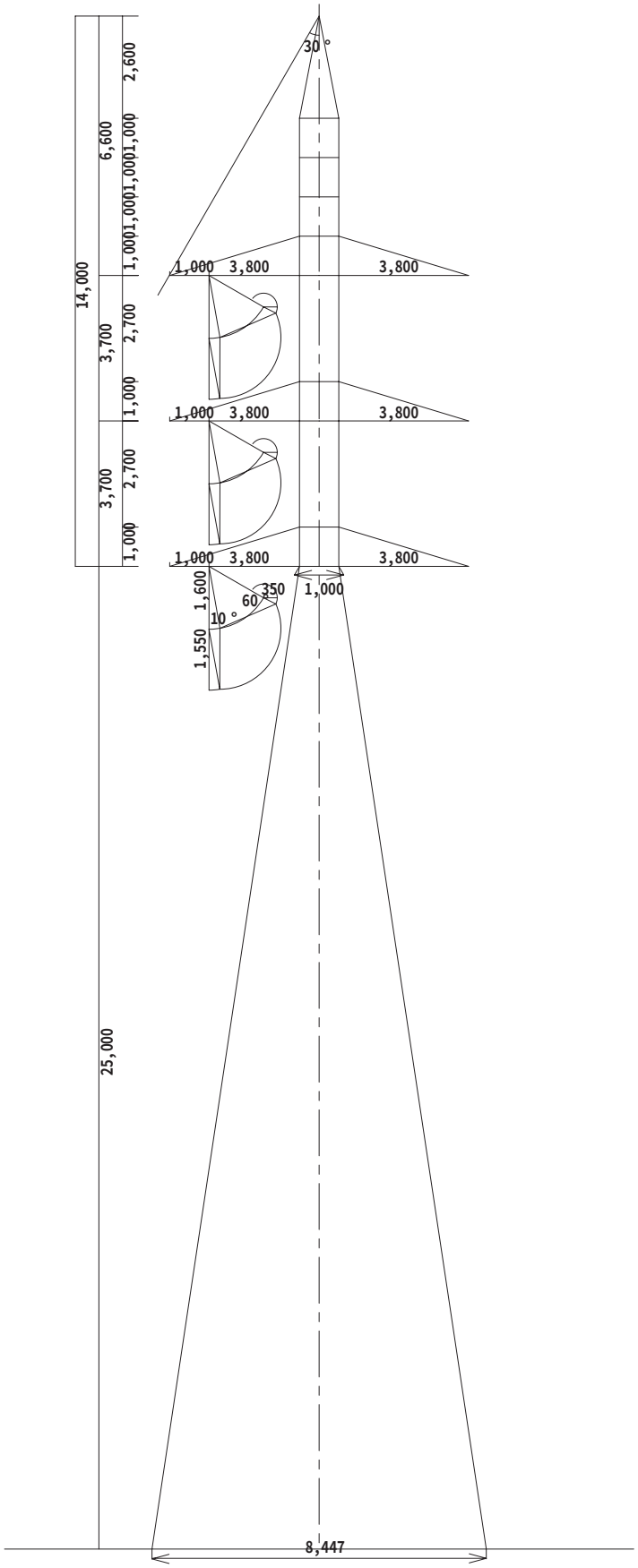
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-5 **Title** Tension Tower : B1 Type (Line Horizontal Angle : 0 - 15 deg.)



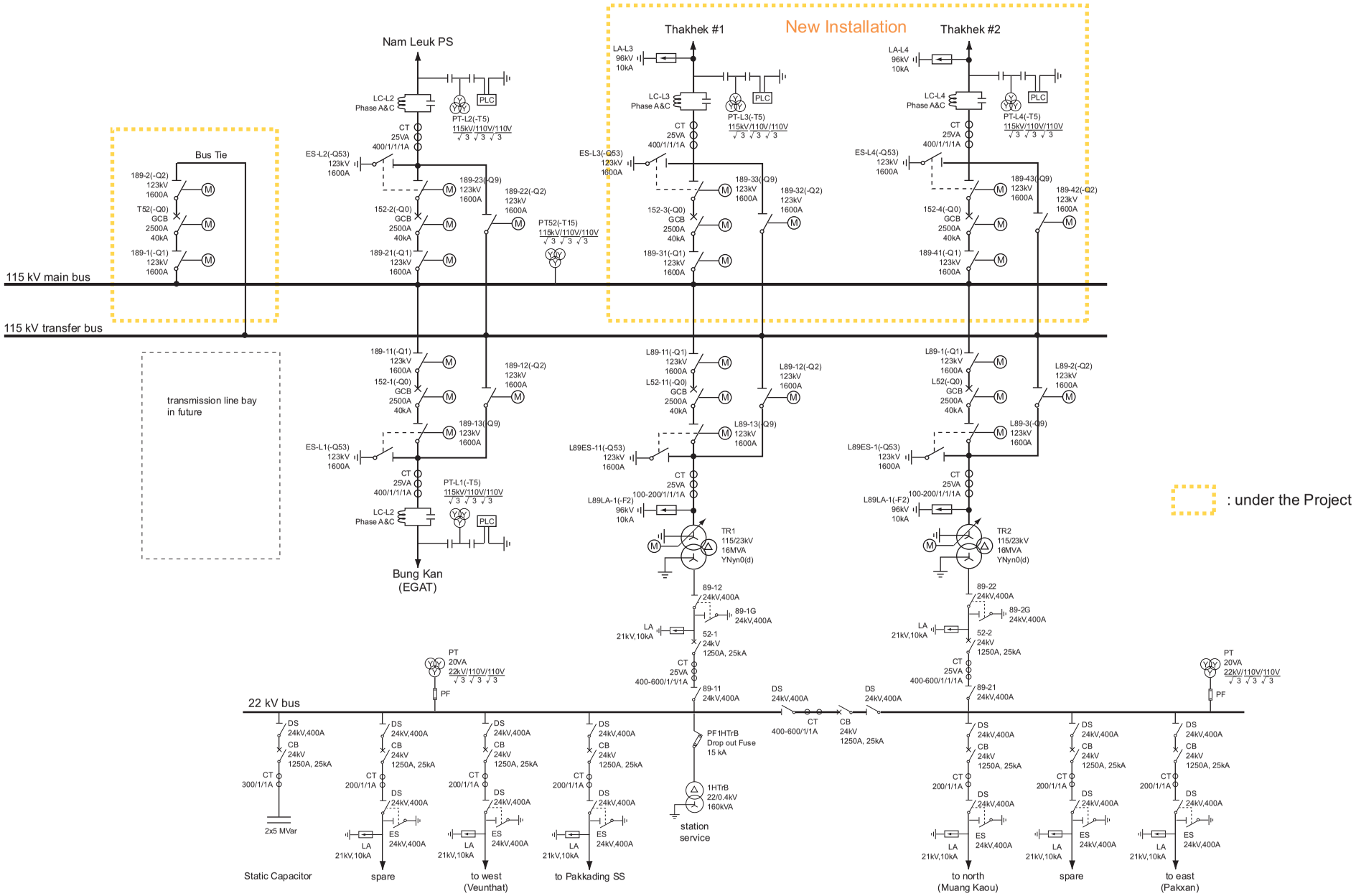
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-6 **Title** Tension Tower : C1 Type (Line Horizontal Angle : 0 - 30 deg.)



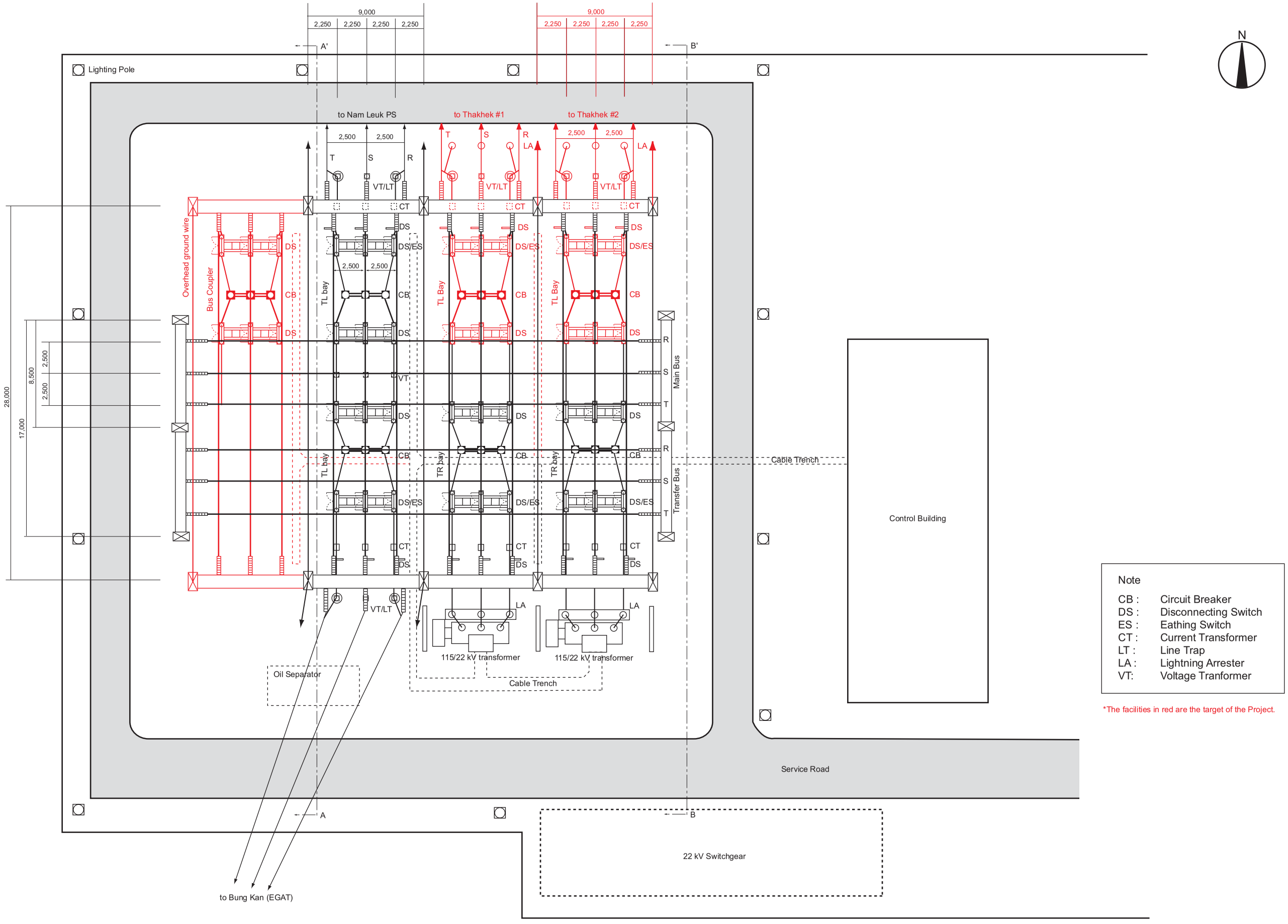
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-7 **Title** Tension Tower : D1, DE Type (Line Horizontal Angle : 0 - 90 deg.)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.2-8 **Title** Tension Tower : D2 Type (Line Horizontal Angle : 0 - 90 deg.)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.3-1 Title: Pakxan Substation Single Line Diagram (after the Project)



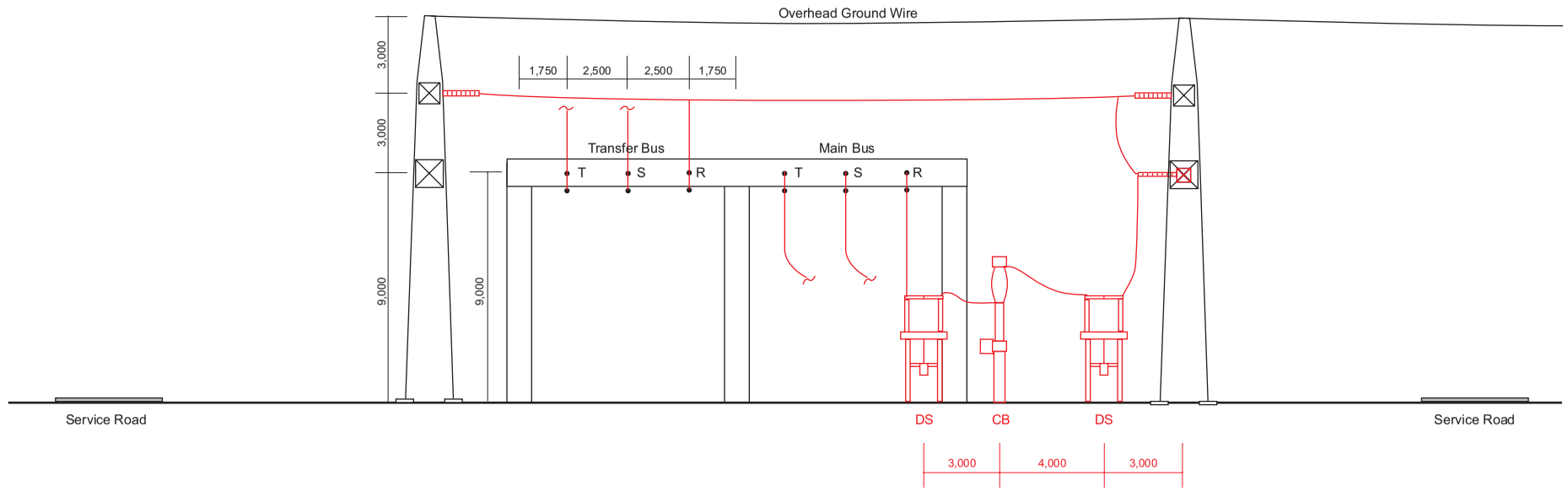
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

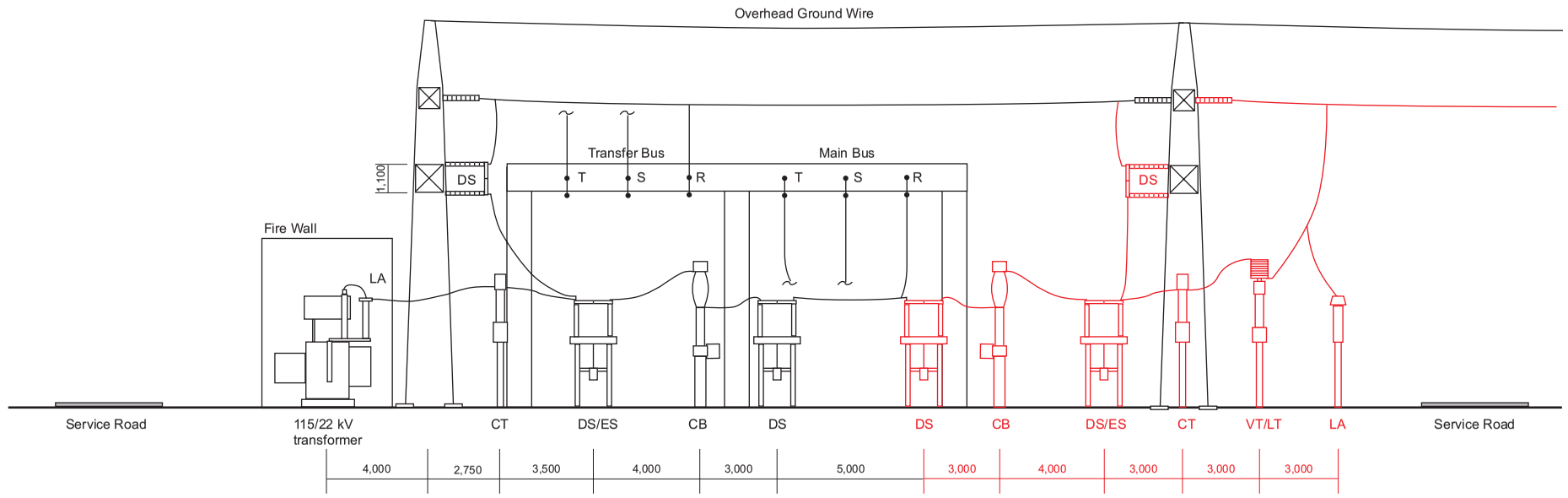
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.3-2 (1) Title Pakxan Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

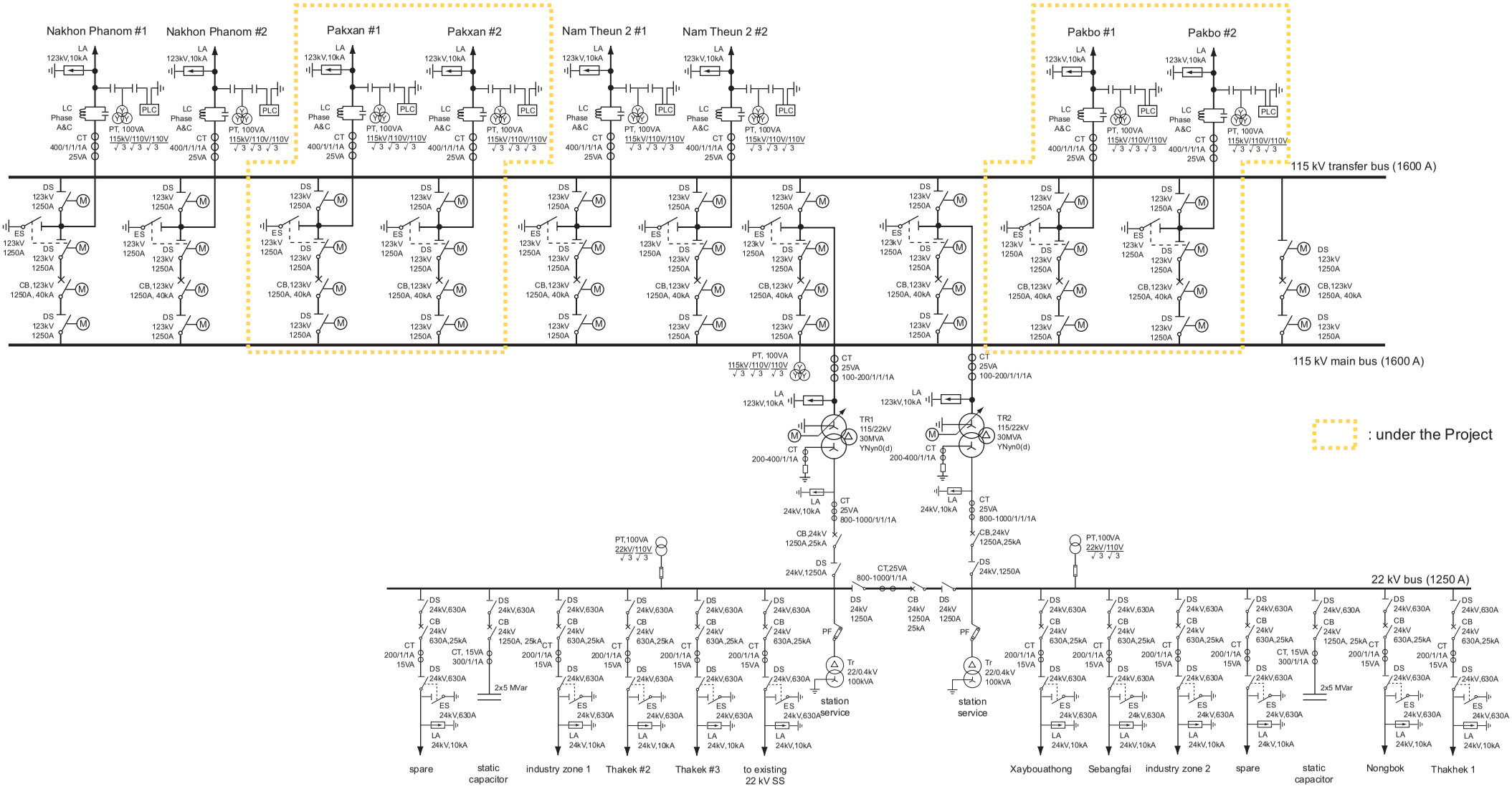
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

*The facilities in red are the target of the Project.

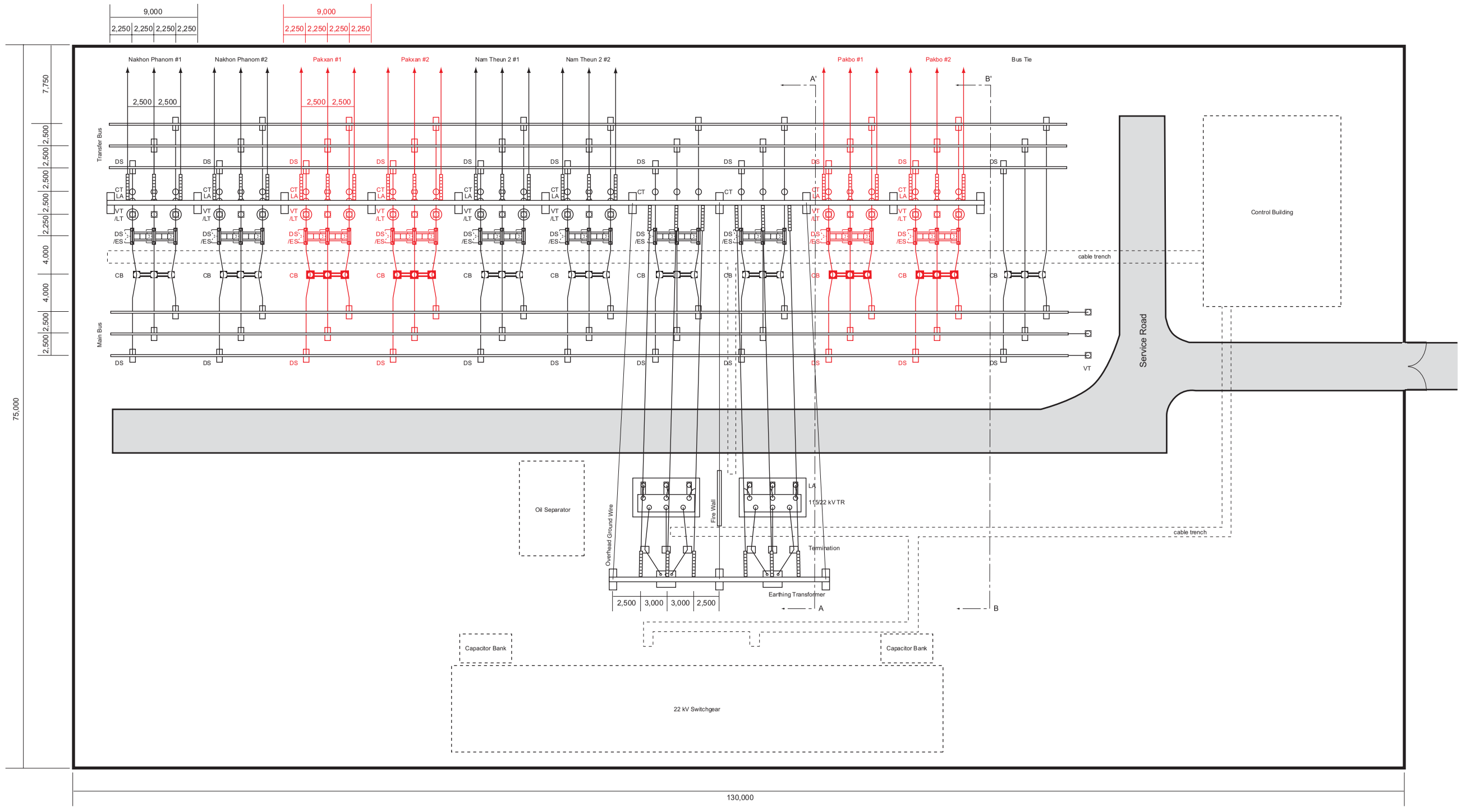
* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.3-2 (2) **Title** Pakxan Substation 115 kV Switchyard Layout Plan (Side View)



as of June 22, 2001

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.3-3 Title: Thakhek Substation Single Line Diagram



Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

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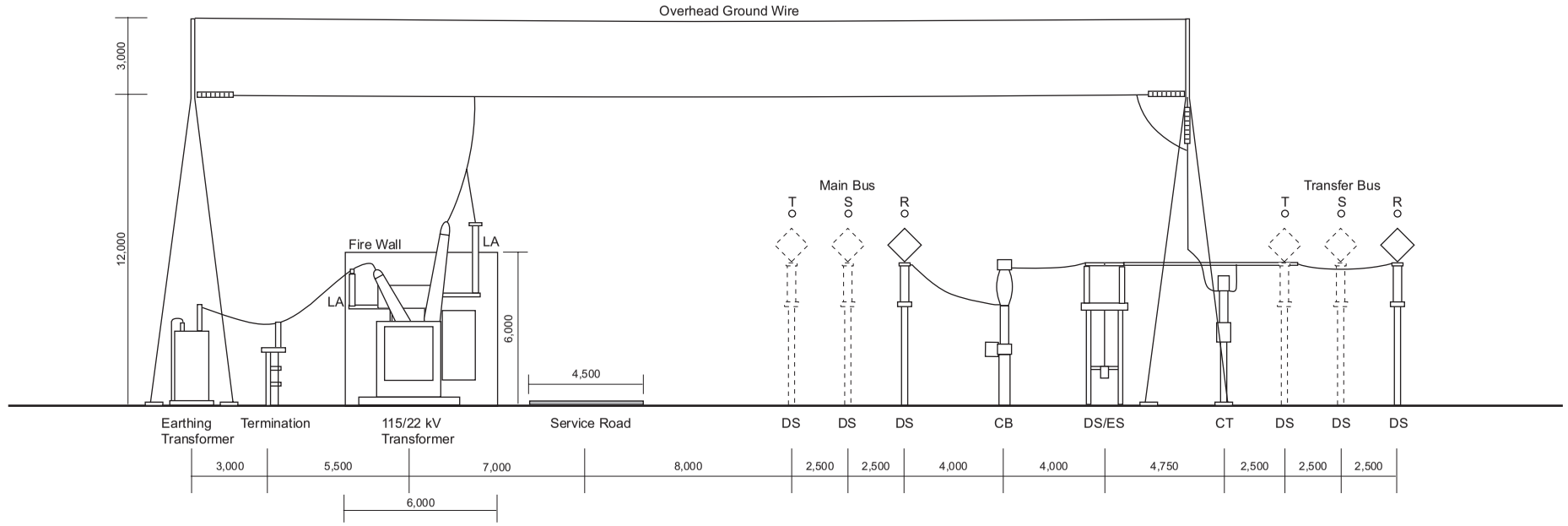
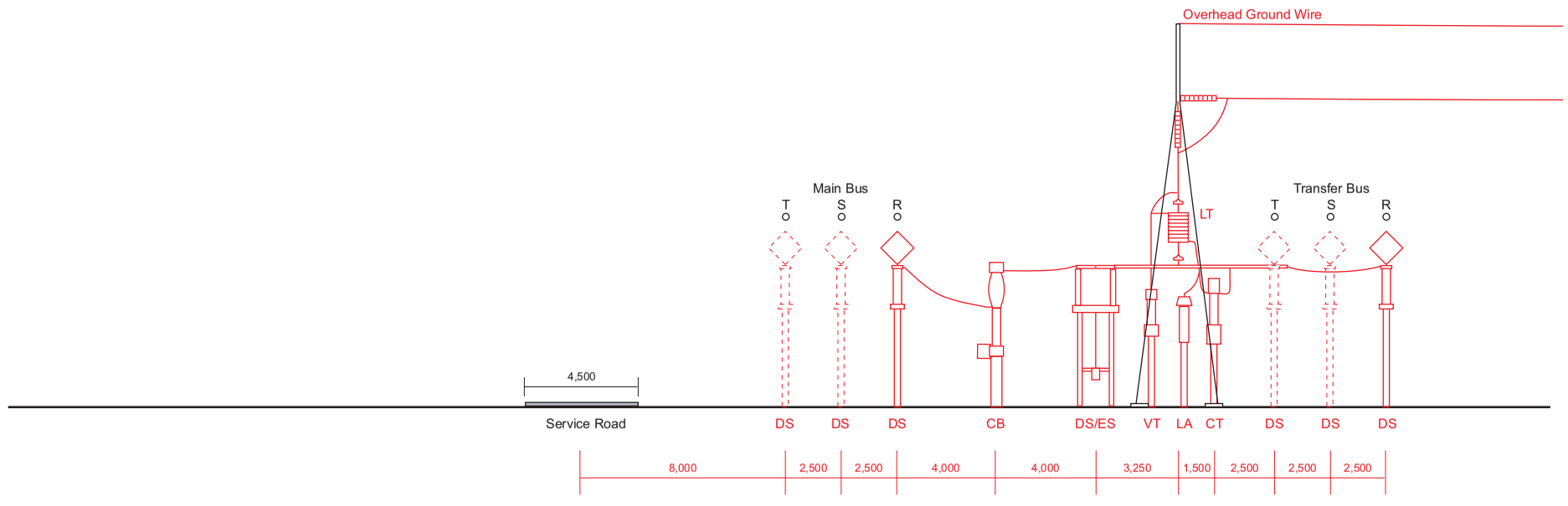
* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.3-4 (1) Title Thakhek Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

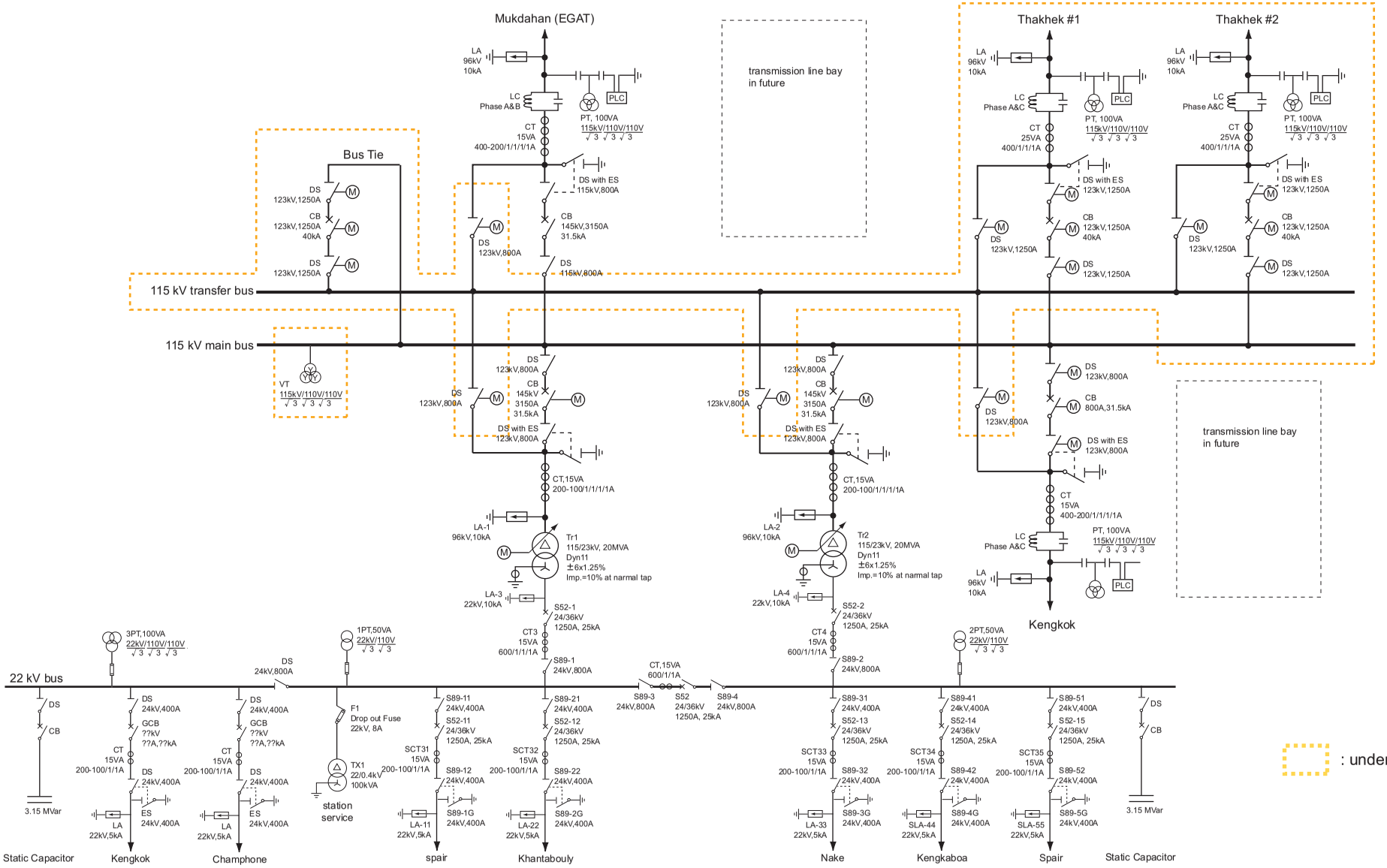
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

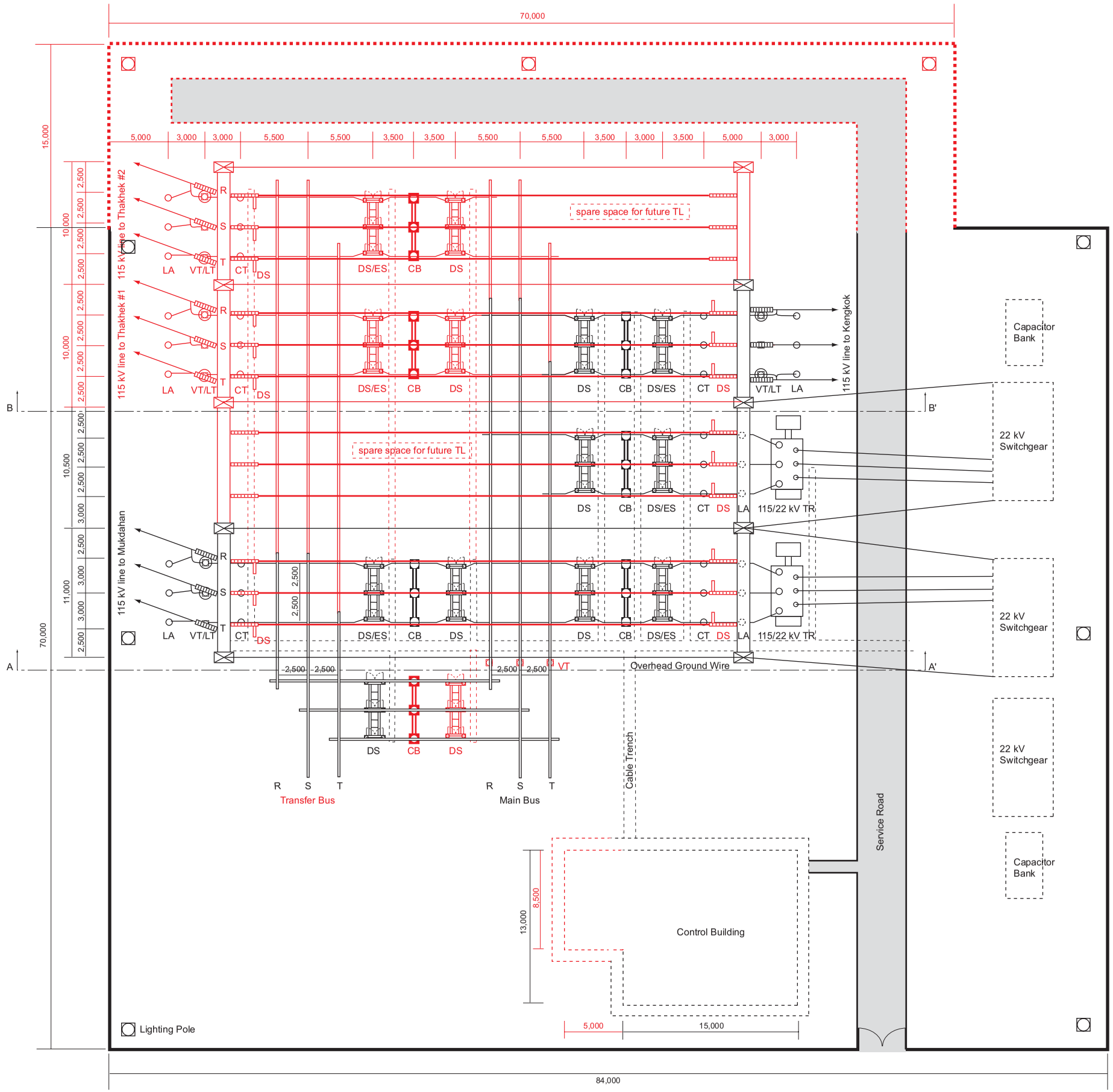
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.3-4 (2) **Title** Thakhek Substation 115 kV Switchyard Layout Plan (Side View)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 10.3-5 Title: Pakbo Substation Single Line Diagram (after the Project)



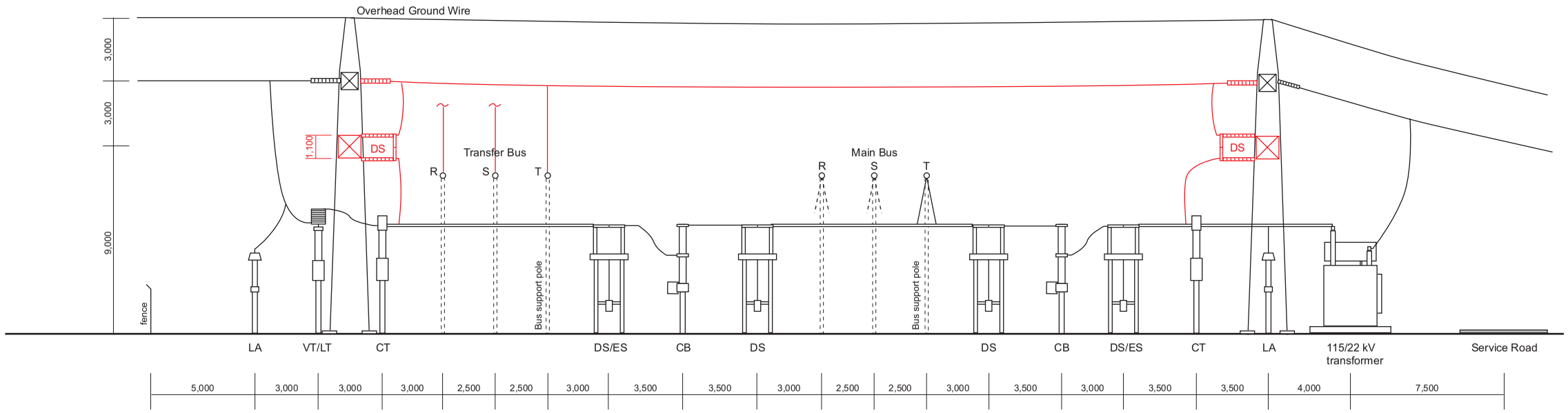
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

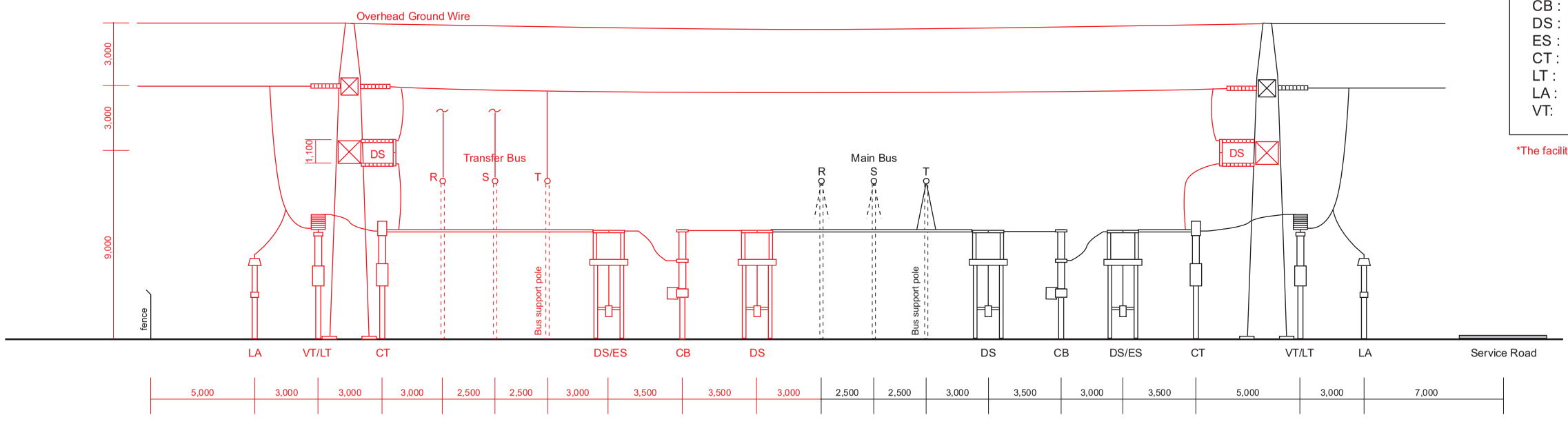
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.3-6 (1) **Title** Pakbo Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 10.3-6 (2) **Title** Pakbo Substation 115 kV Switchyard Layout Plan (Side View)

Figure 10.4-1 Implementation Schedule