Chapter 7
Review of Power System Plans

Chapter 7 Review of Power System Plans

7.1 Power Development Plan (including IPP)

7.1.1 Power Development Plan for Domestic Supply

The actual authorized EDL Power development Plan (March 2008) is listed in the table below.

Table 7.1-1 Power Development Plan in Lao PDR (EDL PDP 2007-2016) (1/2)

	Inst. Cap (MW)	COD	Fuel Type
North&Central 1	1,825		
Nam Nhon	3	2009	Hydro
Nam Ham	4	2010	Hydro
Nam Lik 1/2	100	2010	Hydro
Nam Ngum 1 ext	40	2010	Hydro
Nam Sim	8	2010	Hydro
Nam Song	7	2010	Hydro
Nam Ngum5	120	2011	Hydro
Nam Tha1	168	2012	Hydro
Nam Lik1	60	2013	Hydro
Nam Long	5	2013	Hydro
Hongsa	100	2013	Lignite
Nam Bak2	68	2014	Hydro
Nam Mang1	60	2014	Hydro
Nam Nga	80	2014	Hydro
Nam Ngum3 (local)	115	2014	Hydro
Nam San3	48	2014	Hydro
Nam Xeuang 1	56	2014	Hydro
Nam Xeuang 2	134	2014	Hydro
Nam Beng	33	2015	Hydro
Nam feung 1	28	2015	Hydro
Nam feung 2	25	2015	Hydro
Nam feung 3	20	2015	Hydro
Nam Ngiep 1	50	2015	Hydro
Nam Ou	100	2015	Hydro
Nam Khan2	127	2016	Hydro
Nam Khan3	47	2016	Hydro
Nam Ma	120	2016	Hydro
Nam Theun1 (Local)	100	2016	Hydro

(Source: EDL Power Development Plan 2007)

Table 7.1-1 Power Development Plan in Lao PDR (EDL PDP 2007-2016) (2/2)

	Inst. Cap (MW)	COD	Fuel Type
Central 2	338		
Nam Theun2	75	2009	Hydro
Thadsalen	3	2010	Hydro
Theun Hinboun (extension)	60	2012	Hydro
Nan Mo	60	2015	Hydro
Xepon 2	30	2015	Hydro
Xepon3 (Up stream)	70	2015	Hydro
Xeneua	40	2016	Hydro
Southern	835		
Xeset 2	76	2009	Hydro
Xekaman3	25	2010	Hydro
Xelabam ext.	8	2010	Hydro
Xekaman1	32	2012	Hydro
Xekatam	61	2013	Hydro
Dark Emeun	50	2014	Hydro
Houaylamphan	68	2014	Hydro
Nam Hinboun	60	2014	Hydro
Xelanong 2	50	2014	Hydro
Xeset3-4	30	2014	Hydro
Donsahong	60	2015	Hydro
Nam Kong/Xekong	100	2015	Hydro
Tha Kho	30	2015	Hydro
Nam Phak	45	2016	Hydro
Tadsamphamit	60	2016	Hydro
Xepian/Xenamnoy (Local)	80	2016	Hydro
TOTAL	2,998		

(Source: EDL Power Development Plan 2007)

According to the power development plan, 2,998 MW of generation plants will be developed by 2016, which are nine (9) times larger than the installed capacity of 313.8 MW at present (607.8 MW including generation for power export), as of March 2009. There is electricity supply request information for new mining customers. Large -scale generation development could be required in order to be able to supply such large-scale consumers. Negotiations are supposedly required with neighboring countries' authorities such as Thailand and Vietnam if IPP projects for power export are utilized for domestic consumers.

7.1.2 Power Development Plan for Power Export

The power development plan for power export based on information from the Department of Energy (DOE), Ministry of Energy and Mines (MEM) is shown in the table below. The list describes IPP projects by stages such as the MOU of FS (plan), PDA (development agreement), CA (construction agreement) and PPA (power purchase agreement). Project locations are concentrated in the northern, suburb of Vientiane and southern area of Lao PDR. The seven projects to develop the Mekong mainstream have been in the FS stage.

Table 7.1-2 Power Development Plan for Power Export in Lao PDR

No.	Project	Capacity (MW)	COD	Location	Status	Planned Market
1	Nam Theun 2	1080	2009	Khammouan	UC	EGAT/EDL
2	Xeset 2	76	2009	Saravan	UC	EDL/EGAT
3	Xekaman 3	250	2010	Xe Kong	UC	EVN/EDL
4	Theun Hinboun Ext.	60	2012	Bolikhamxay	UC	EGAT/EDL
5	Nam Ngum 2	615	2013	Vientiane	UC	EGAT
6	Nam Koung 1	75	2012	Attapu	PDA	TBD
7	Nam Ou	1100	2013-2015	Phongsali	PDA	EGAT/EDL/CSG
8	Hongsa Lignite	1800	2013	Xaignabouli	PDA	EGAT/EDL
9	Xekaman 1	320	2013	Attapu	PDA	EVN/EDL
10	Xekong 4	300	2013	Xe Kong	PDA	TBD
11	Nam Mo	150	2014	Xieng Khouang	PDA	EVN/EDL
12	Nam Ngum 3	440	2014	Vientiane	PDA	EGAT
13	Nam Ngiep 1	278	2015	Bolikhamxay	PDA	EGAT/EDL
14	Don Sahong	360	2015	Chanpasak	PDA	EGAT/EDL
15	Xepian-Xenemnoy	390	2015	Attapu	PDA	EGAT/EDL
16	Nam Theun 1	523	2016	Bolikhamxay	PDA	EGAT/EDL
17	Xayaburi (Mekong)	1260	TBD	Xaignabouli	PDA	EGAT/EDL
18	Ban Khoum (Mekong)	2330	TBD	Chanpasak	FS	EGAT/EDL
19	Dak Emeule	130	TBD	Xe Kong	FS	EVN/EDL
20	Lat Sua (Mekong)	800	TBD	Chanpasak	FS	TBD
21	Louangprabang (Mekong)	1410	TBD	Luangprabang	FS	TBD
22	Nam Bak 1	132	TBD	Vientiane	FS	EGAT
23	Nam Khan 2	130	TBD	Luangprabang	FS	TBD
24	Nam Khan 3	95	TBD	Luangprabang	FS	TBD
25	Nam Ngiep 2	155	TBD	Vientane	FS	EGAT/EDL
26	Nam Ngum 4A&B	120	TBD	Vientane	FS	EVN/EDL
27	Nam Phoun	60	TBD	Xaignabouli	FS	TBD
28	Nam Seuang 2	220	TBD	Luangprabang	FS	TBD
29	Nam Theun 4	110	TBD	Bolikhamxay	FS	TBD
30	Pak Lay (Mekong)	1320	TBD	Xaignabouli	FS	EGAT/EDL
31	Sanakham (Mekong)	500	TBD	Xaignabouli	FS	TBD
32	Xekong 3 Upper/Lower	150	TBD	Xe Kong	FS	EVN
33	Xe Kong 5	400	TBD	Xe Kong	FS	TBD
34	Xekaman 4	220	TBD	Xe Kong	FS	EVN
35	Selanong 1	80	TBD	Savannakhet	FS	TBD
36	Xebanghieng 1	65	TBD	Savannakhet	FS	TBD
37	Xebanghieng 2	250	TBD	Khammouan	FS	TBD
38	Xe Pon 3	100	TBD	Saravan	FS	TBD
	UC	2,081				
	PDA	6,996				
	FS	8,777				
	TOTAL	17,854				

UC: Under Construction, PDA: Project Development Agreement, FS: Feasibility Study, TBD: To be decided, (Mekong): Mekong main stream project.

(出典: Documents of DOE MEM, Dec. 2008)

7.2 Methodology of Examination of Power System Plans

The power system plans based on the results of the new demand forecast discussed in the previous chapter will be examined up to 2030 in the Draft Final Report. In the following sections, the adequacies of the PDP up to 2016 formulated by EDL were confirmed from the power supply/demand simulated technical viewpoints and the power system analyses.

7.3 Basic Balancing Supply and Demand Simulation

7.3.1 Outline of Balancing Supply and Demand Simulation

The power development plan should take into consideration the minimization of cost developments and power grid constraints due to increasing demand in the Laotian system. This requires conducting a simulation that balances supply and demand in the interconnected systems. Steps requiring power development planning include 1) analysis of reserve margin reductions with system reliability improvements by interconnection, 2) analysis of economical operations in the interconnected systems in conducting a balanced supply and demand simulation so that fuel saving analyzes the utilization of surplus hydropower outputs and efficient generators through the interconnection. The latest power development plan was reviewed in the basic balancing supply and demand simulation. The series of simulation are conducted in 2016 on the most likely to be realized interconnected systems based on the latest power development plan and interconnection plan in the Indochina region. In the details of balancing supply and demand simulation, the best mix for power generation in 2030 is analyzed reflecting the results of basic simulation and based on the adopted demand forecast and scenarios.

Plans for interconnection to neighboring country projects are clarified power import projects and power export from IPP generation projects. Some projects could be suspended due to fund raising problems or PPA negotiation. The situation of each interconnection project will be examined from existing reports, interviews of counterpart personnel, private investors, the World Bank and ADB. The information for interconnection projects will be reflected in the balancing supply and demand simulation.

The reserve margin capacity can reduce demand diversity utilization through an interconnection. A presupposition of what would happen is illustrated in the figures below. Each system independently develops sufficient supply capacity without the interconnected systems.

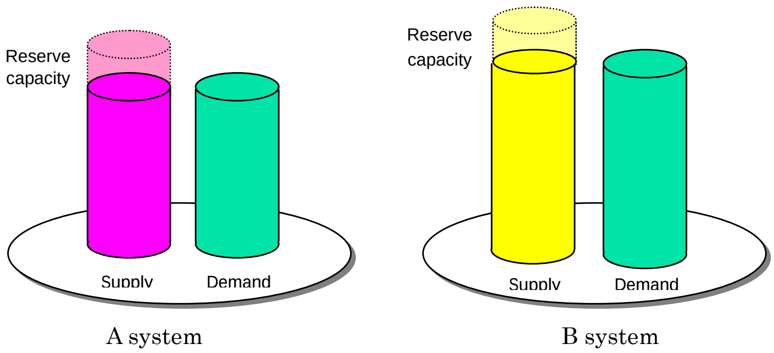

Figure 7.3-1 Without Interconnections

The appearance timing of peak demand among systems is different (demand diversity). Interconnected systems exploit demand divergence to share reserve capacity through an interconnection.

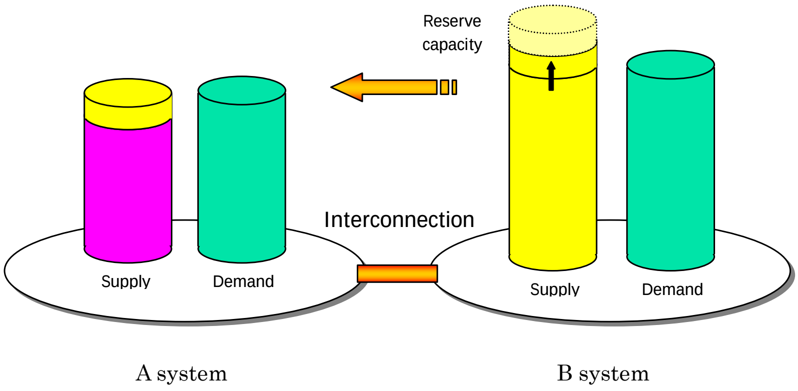

Figure 7.3-2 With Interconnections

The reserve margin to secure system reliability criterion in interconnected systems is generally less than isolated systems. The reduction amount of reserve capacity will be saturated at some capacity of interconnection. This is caused by an amount limitation utilizing mutual reserve capacity. The appropriate capacity of interconnections will be examined in comparison to annual cost savings from reserve margin reductions at each interconnection capacity.

7.3.2 Tool for Simulation of Balancing Supply and Demand

The simulation of balancing the supply and demand in Lao PDR systems should be conducted with the interconnected maximum five (5) systems in consideration of the present grid and system expansion plan constraints. Tools for the simulation and analysis of the necessary reserve margin to secure system reliability criterion should be selected from tools that possess the ability to deal with interconnected multi-system models.

The simulation tools capable of analyzing reliability and economic operation are the WASP, Strategist, PDPATII, RTICS, ESPRIT and so on. PDPATII, RETICS[1] that are able to deal with up to ten (10) interconnected systems have been adopted in this study.

Results of the simulation include the following contents.

- Economical load dispatching for generators based on hourly marginal generation costs in consideration of operational constraints ,
- Energy generation and Fuel consumption,
- Annual costs,
- Amount of power exchange necessary to improve system efficiency through interconnections,
- Potential amount of power exchange via marginal generating costs.

Economical operations are simulated on an hourly basis. This simulation is considered in the scheduled outage of the generator, the lower limitations of generator operation, Daily Start and

[1] Tokyo Electric Power Company developed the program. The program has been utilized TEPCO planning for over 25 years. The program has experiences in utilization for planning in Cambodia, Laos, Myanmar, Thailand, Vietnam, Malaysia, Indonesia, Sri Lanka, the Philippines and Bangladesh.

Stops (DSS), Weekly Start and Stops (WSS) and the reservoir operation for pumped storage hydropower. The amount of potential power exchange via marginal generation costs can be obtained because the surplus power is simulated on an hourly basis.

7.3.3 Postulation of Basic Simulation for Balancing Supply and Demand

The postulation for basic simulation of balancing supply and demand in order to review the authorized power development plan is described in the following section.

(1) Power System Configuration

The power system configuration in 2016 for basic simulation is selected as three (3) systems in Lao PDR and two (2) systems in Thailand in considering present system constraints, interconnections with the Thai system and the system expansion plan.

- Lao PDR (Three (3) systems): North + Central 1, Central 2, South
- Thailand (Two (2) systems): Northeast, Central + South

(2) Demand Forecasts

Demand forecasts by systems are listed in Table 7.3-1. The Peak demands in the Lao PDR are distributed contingent on the records in the year of 2005. Energy by systems is calculated by each peak demand and the EDL estimation of load factors. The power demand forecast of Thailand via EGAT has been used for the study.

Table 7.3-1 Demand Forecasts for Analysis (2016)

System	Peak Demand (MW)	Energy (GWh)	Load Factor (%)
Laos North+Central 1	847	4,971	67%
Laos Central 2	168	986	67%
Laos South	110	578	60%
Thai Northeast	3,468	17,547	57.8%
Thai Central+South	28,974	201,792	79.5%

(3) Power Development Plan

The power development plan to last until 2025 for the basic simulation of balancing supply and demand is shown in the table below. The consultant has prepared the power development plan based on information from the Department of Energy, Ministry of Energy and Mines (DOE, MEM). The plan's orientation is towards hydropower plant development. The Hongsa lignite thermal power plant (100 MW, Lignite) is planned in 2013. The Viengphukha thermal power plant (60 MW, Coal) is planned in 2019. The power development plan for a detailed simulation will be developed based on the results of the basic simulation, the least cost generation composition and in consideration of the primary energy potential in Lao PDR, especially coal deposits.

Table 7.3-2 Power Development Plan for Basic Simulation (1/2)

All plants	Inst. Cap (MW)	COD	Fuel Type
North&Central 1	2,753		
Nam Dong	1	1961	Hydro
Nam Ngum1	155	1971	Hydro
Nam Ko	2	1996	Hydro
Nam Leuk	60	2000	Hydro
Nam Mang3	40	2005	Hydro
Nam Ngay	1	2006	Hydro
Nam Nhon	3	2009	Hydro
Nam Ham	4	2010	Hydro
Nam Lik 1/2	100	2010	Hydro
Nam Ngum 1 ext	40	2010	Hydro
Nam Sim	8	2010	Hydro
Nam Song	7	2010	Hydro
Nam Ngum5	120	2011	Hydro
Nam Tha1	168	2012	Hydro
Nam Lik1	60	2013	Hydro
Nam Long	5	2013	Hydro
Hongsa	100	2013	Lignite
Nam Bak2	68	2014	Hydro
Nam Mang1	60	2014	Hydro
Nam Nga	80	2014	Hydro
Nam Ngum3 (local)	115	2014	Hydro
Nam San3	48	2014	Hydro
Nam Xeuang 1	56	2014	Hydro
Nam Xeuang 2	134	2014	Hydro
Nam Beng	33	2015	Hydro
Nam feung 1	28	2015	Hydro
Nam feung 2	25	2015	Hydro
Nam feung 3	20	2015	Hydro
Nam Ngiep 1	50	2015	Hydro
Nam Ou	100	2015	Hydro
Nam Khan2	127	2016	Hydro
Nam Khan3	47	2016	Hydro
Nam Ma	120	2016	Hydro
Nam Theun1 (Local)	100	2016	Hydro
Nam Ngiep 2	245	2017	Hydro
Nam Ngum 4	230	2019	Hydro
Viengphukha	60	2019	Coal
Nam Boun	8	2021	Hydro
Nam Hao	10	2023	Hydro
Nam Cha (local)	116	2024	Hydro
Central 2	376		
Theun HinBoun (Local)	8	1998	Hydro
Nam Theun2	75	2009	Hydro
Thadsalen	3	2010	Hydro
Theun Hinboun (extension)	60	2012	Hydro
Nan Mo	60	2015	Hydro
Xepon 2	30	2015	Hydro
Xepon3 (Up stream)	70	2015	Hydro
Xeneua	40	2016	Hydro
Xepon 3 (Down stream)	30	2021	Hydro

Table 7.3-2 Power Development Plan for Basic Simulation (2/2)

All plants	Inst. Cap (MW)	COD	Fuel Type
Southern	1,207		
Xelabam	5	1961	Hydro
Xeset1	45	1991	Hydro
Houay Ho (local)	2	1999	Hydro
Xeset 2	76	2009	Hydro
Xekaman3	25	2010	Hydro
Xelabam ext.	8	2010	Hydro
Xekaman1	32	2012	Hydro
Xekatam	61	2013	Hydro
Dark Emeun	50	2014	Hydro
Houaylamphan	68	2014	Hydro
Nam Hinboun	60	2014	Hydro
Xelanong 2	50	2014	Hydro
Xeset3-4	30	2014	Hydro
Donsahong	60	2015	Hydro
Nam Kong/Xekong	100	2015	Hydro
Tha Kho	30	2015	Hydro
Nam Phak	45	2016	Hydro
Tadsamphamit	60	2016	Hydro
Xepian/Xenamnoy (Local)	80	2016	Hydro
Xekaman 2	41	2017	Hydro
Xekaman 4	47	2017	Hydro
Xekong 3(Up/Low)	150	2017	Hydro
Xebangnuan	40	2018	Hydro
Xedon 2,3	38	2018	Hydro
Houaychampi	4	2025	Hydro
TOTAL	4,336		

(Source: DOE, EDL)

(4) System Interconnection

The Interconnected system to be reviewed will be selected in 2016 based on the latest power development plan. The capacities of interconnection are adopted from the latest power development plans of EDL and neighboring countries. The interconnection capacities for the study are described in Table 7.3-3. The configuration of the interconnected systems is illustrated in Figure 7.3-3.

Table 7.3-3 Capacities of Interconnections (2016)

System interconnection	Capacity (MW)
Lao North + Central 1 - Lao Central 2	90
Lao Central 2 - Lao South	180
Lao North + Central 1 - Thai Northeast	600
Lao Central 2 - Thai Northeast	120
Lao South - Thai Northeast	120
Thai Northeast - Thai Central + South	1,300

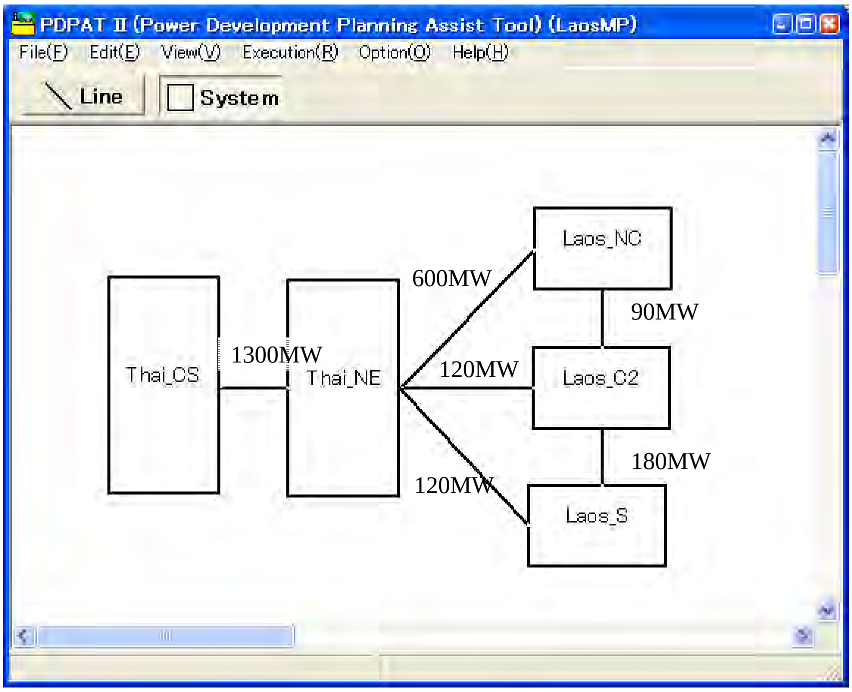

Figure 7.3-3 Interconnected System Configuration (2016)

(5) Loss of Interconnection

The loss of power transactions through interconnections is hypothesized as follows based on the results of EDL's analysis of EDL and the consultant's experiences.

- 115 kV: 4.2% = (8% x 1/2 + 4% x 1/2) x 0.7

  Rainy season: 8%

  Dry season: 4%

  Load factor: 70%

- 230 kV and 500 kV: 2 - 3%

7.3.4 Cases for the Study

In a basic simulation, the balance of supply and demand is reviewed based on the latest power development plan in 2016.

7.3.5 Results of the Basic Simulation

(1) Situations of System Reliability

The situations of system reliability for the authorized power development plan are illustrated in the Figure 7.3-4 and 7.3-5.

The reserve margin, 241 MW, is required to secure system reliability criterion (LOLE=24 hour). After interconnections, the necessary reserve margin will decrease to 88 MW.

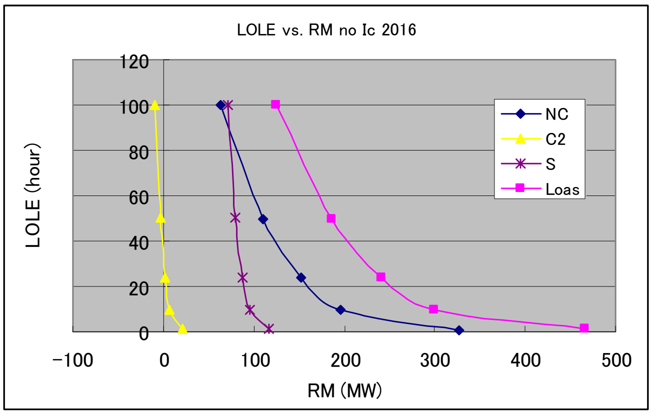

Figure 7.3-4 Relation LOLE vs. Reserve Margin in Isolated System

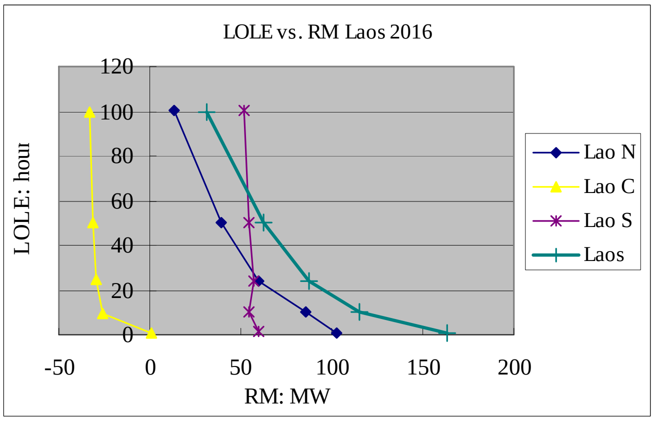

Figure 7.3-5 Relation LOLE vs. Reserve Margin in Interconnected System

(2) Balance of Supply and Demand

The monthly basis balance of supply and demand based on the latest power development plan is demonstrated in Figures 7.3-6 to 7.3-8. The black line shows the peak demand for each month. The red line shows the supply capacity for each month.

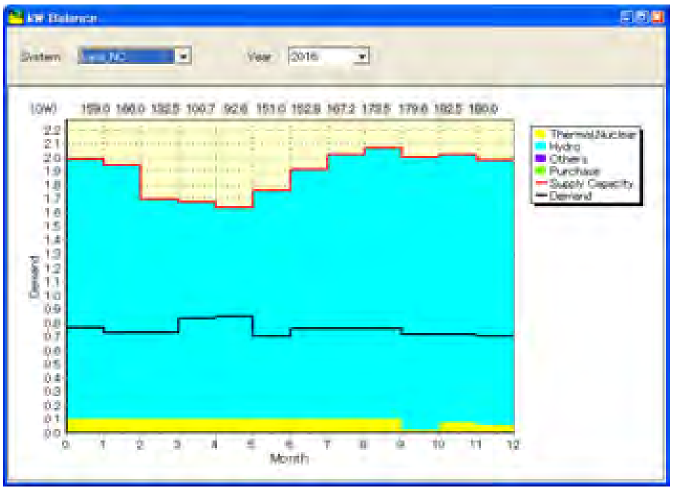

Figure 7.3-6 Monthly Balance of Supply/Demand Lao North + Central 1 System (2016)

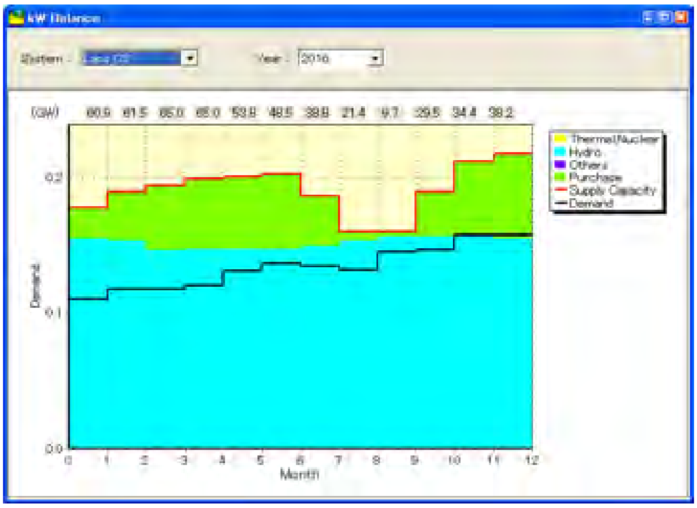

Figure 7.3-7 Monthly Balance of Supply/Demand Lao Central 2 System (2016)

The supply capacity can be secured to meet each peak demand in every system when the power plants are developed on schedule.

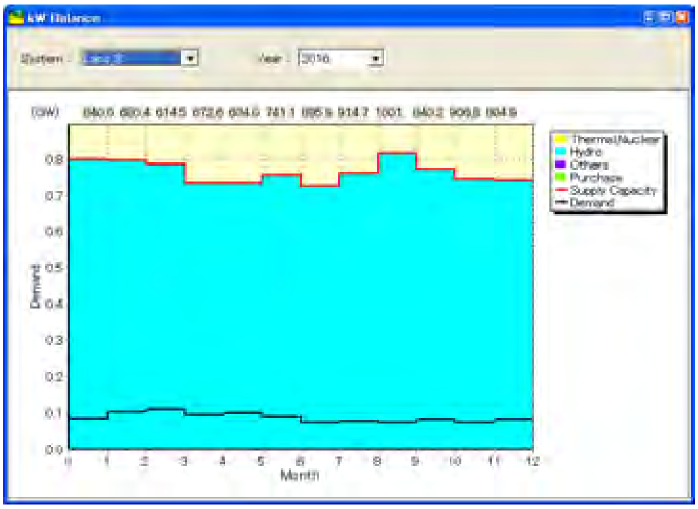

Figure 7.3-8 Monthly Balance of Supply/Demand Lao South System (2016)

The surplus energy would be concentrated in the Loa North + Central system and the South system from the monthly energy balance. The energy balance in Lao’s central2 system could be insufficient especially during the dry season when the power exchange is added through interconnections (see Figures 7.3-9 to 7.3-11. The power supply ability can be kept for the maximum power demand (MW), however, the produced power energy is not insufficient for the monthly power energy consumption (GWh). Power export to Cambodia has not been considered.

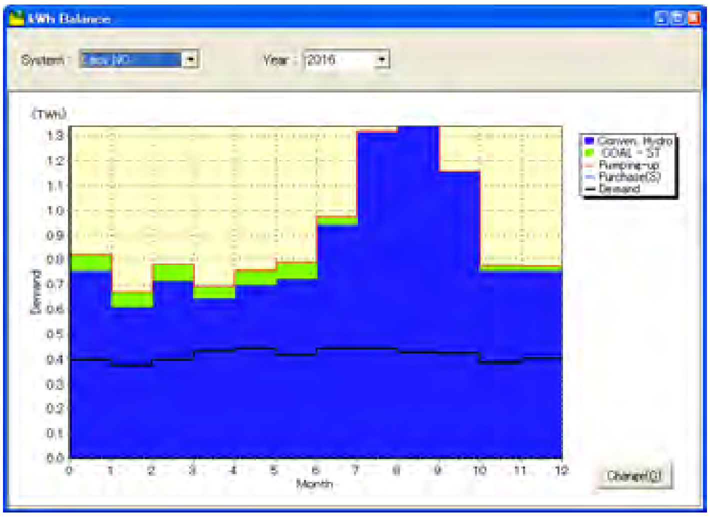

Figure 7.3-9 Monthly Energy Balance in Lao North + Central 1 System (2016)

Figure 7.3-10 Monthly Energy Balance in Lao Central 2 System (2016)

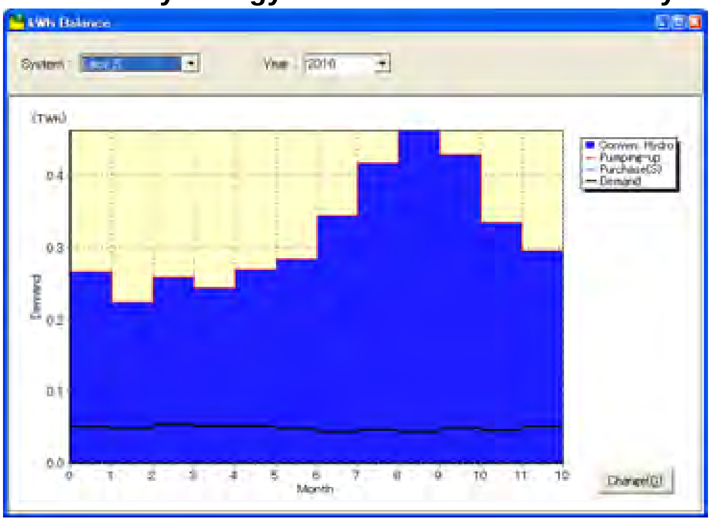

Figure 7.3-11 Monthly Energy Balance in Lao South System (2016)

7.4 Basic System Analysis

7.4.1 Overview

The power flow, voltage regulation, fault current, and stability analyses were conducted in order to confirm if the power system as of 2016, which was the last year of EDL's Power Development Plan 2007-2016, satisfied EDL's power system planning criteria. Power flow, voltage regulations, fault currents, and stability are fundamental study items for the proper functioning of the power system.

The general study flow of the system analysis is shown in Figure 7.4-1. The aforementioned study items tend to mutually affect each other and to have conflicting properties as shown in Figure 7.4-2. For instance, utilizing conductors with larger diameters, or increasing the number of circuits can resolve the overloading of transmission lines in certain sections. On the other hand, the fault current of the section increases due to reductions in the line impedance. Taking into consideration the characteristics, modification of the planned system and analyses of the fundamental study items were executed repeatedly until all of the items satisfied the system planning criteria simultaneously. Besides, the optimum conductor size was determined through the relationship analysis between power flow and the annual costs, including the cost of transmission losses.

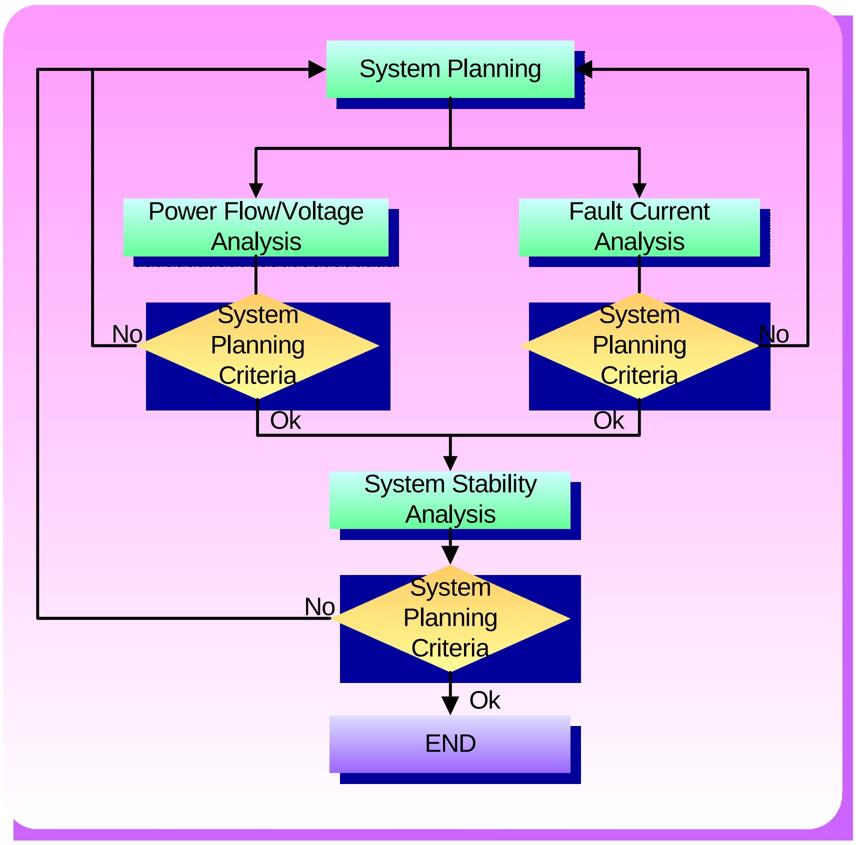

Figure 7.4-1 System Analysis Study Flow

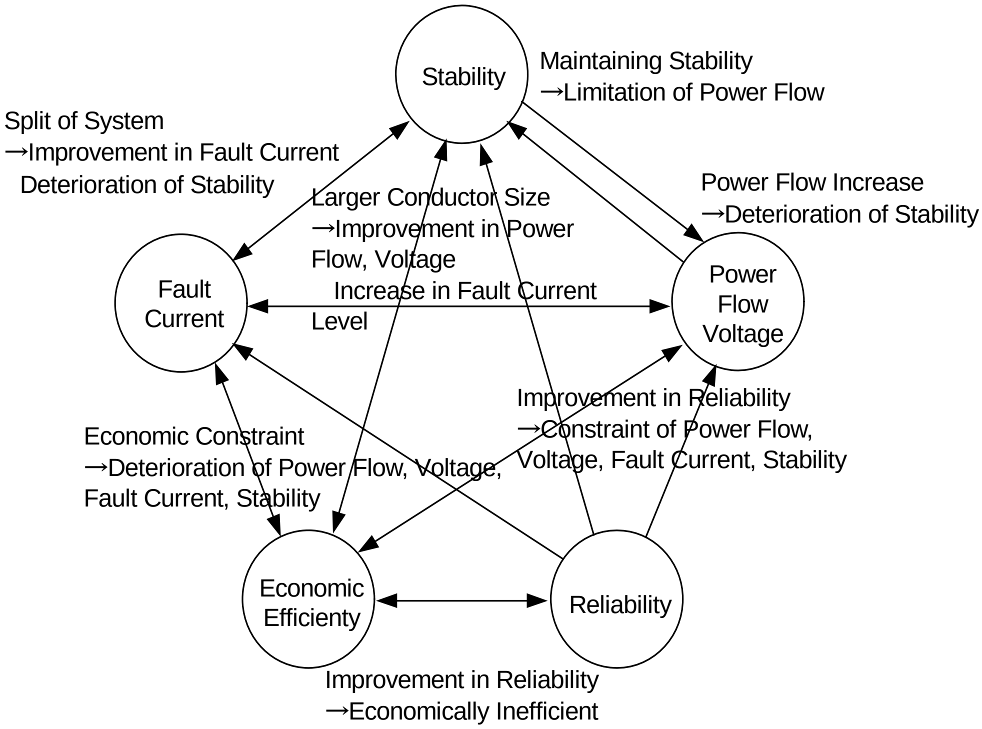

Figure 7.4-2 Interrelationships among System Analysis Study Items

7.4.2 Analysis Tools

PSS/E (Power System Simulator for Engineering) Ver.31, which EDL also owns, was used for the series of system analysis works.

PSS/E is the system analysis software developed by Siemens Power Technologies International (Siemens PTI) in the USA. This software has been used by a wide variety of entities, such as electricity utilities, engineering firms, educational institutions, etc. in more than 115 countries and can be regarded as borderless and universal software. PSS/E has various analysis functions such as power flow calculation, voltage analysis, fault current analysis, stability analysis, etc. It's analytical precision and results are highly reliable.

7.4.3 Fundamental Technical Criteria and Study Conditions

Basically, EDL's power system is to be planned so as to maintain an appropriate system voltage and fault current level without causing power outages for Laos' domestic power demand. EDL's technical criteria for power system planning are described below.

(1) Power Flow

- Under normal operation, loads of transmission lines and transformers must be within their rated capacities.
- In case of a single circuit fault for the section with more than double circuits, the power flow of remaining facilities must be within the rated capacities.
- Power transmission from the generators with single circuit transmission lines is allowed when the generator rejection is not significant in the event of a single circuit fault.

- In case of a single fault of an 115/22 kV transformer, the loads of the remaining transformers must be within 110% of the rated capacities.
- In the event of a single fault of a 230/115 kV transformer, the loads of the remaining transformers must be within the rated capacities after reducing power export to Thailand by restricting the specified power outputs of generators.

(2) System Voltage

- Under normal operating conditions, bus voltages in the transmission system must be within the range from 95% to 105% of the nominal voltage. In the case of a single contingency, bus voltages must be within the range from 92% to 108% of the nominal voltage.
- The power factors of generators must be within the range from 90% (leading) to 85% (lagging).

(3) Fault Current

- The fault currents of the transmission system must not exceed the maximum fault currents shown in the Table 7.4-1.

Table 7.4-1 Maximum Fault Current

Voltage Level	Maximum Fault Current
230 kV	40～50 kA
115 kV	25～31.5 kA
22 kV	25～31.5 kA

(4) Stability

- Power system stability must be maintained without restricting the generation output of principal power plants or interrupting the power supply to the demand in case of a permanent three-phase short circuit fault, after clearing the fault by main protection relays, not considering any reclosing operations.
- Fault clearing times by main protection relays are shown in Table 7.4-2

Table 7.4-2 Fault Clearing Times by Main Protection Relays

Voltage Level	Fault Clearing Time
230 kV	100 ms
115 kV	140 ms

(5) System Voltage Level

Either 230 kV or 115 kV is applied to the transmission system for domestic power supply. Particularly, application of 230 kV is considered for the following cases:

- Application of 230 kV can be considered economical including transmission line losses.
- Application of 115 kV may have possibility of leading to environmental and social problems due to increase in the number of circuits in the same section.
- Only applying 115 kV cannot maintain the fault currents within allowable levels.
- Only applying 115 kV cannot maintain the system stability.

(6) Transmission Line

Conductors were selected among the standardized conductors used by EDL and EGAT. The rated capacities of the conductors are shown in Table 7.4-3.

Table 7.4-3 Standard Conductors

		MW	A	MVA
115 kV	477 MCM ACSR	100	600	120
	795 MCM ACSR	140	818	163
	2 x 795 MCM ACSR	280	1636	326
230 kV	1272 MCM ACSR	365	1,078	429
	2 x 1272 MCM ACSR	730	2,156	859
	4 x 1272 MCM ACSR	1,460	4,312	1,718
500 kV	4 x 795 MCM ACSR	2,300	3,272	2,834
	4 x 1272 MCM ACSR	3,200	4,312	3,734

477 MCM ACSR is equivalent to240mm^2 (Hawk).
795 MCM ACSR is equivalent to 410mm^2 (Drake).

PSS/E data of the power system as of 2008 to 2016 were provided by EDL and the line constants in the data were basically applied. Line constants shown in Table7.4-4 were applied when new circuits, which were not considered in the PSS/E data, were added.

Table 7.4-4 Line Constants

Type	Positive-phase-sequence Impedance（pu/km）		
	R	X	B
115 kV 477 MCM ACSR	0.00091	0.003	0.00038
115 kV 795 MCM ACSR	0.00055	0.00287	0.0004
230 kV 1272 MCM ACSR	0.0001	0.00072	0.0016

(7) Substation

PSS/E data of the power system as of 2008 to 2016 were provided by EDL. For newly planned substations, which were not considered in the PDP 2007-2016, the following conditions are assumed.

- As a 230 kV bus configuration, a one-and-a-half (1+1/2) method is basically applied. The application of a double bus arrangement is also considered if higher supply reliability is required.
- 115/22 kV Transformers
  - 30 MVA, 3 banks in maximum in a substation
  - Maximum load target is 60 MVA
- 230/115 kV Transformers
  - The capacities of primary and secondary sides are determined with predicted power flow.
  - The voltage of the 22 kV and the delta winding are applied to the tertiary sides. The capacity of the tertiary side is basically 30% of that of primary and secondary sides.
  - On-load tap changers are applied.
- Standard Impedance

  The impedances of power supply transformers are as shown in Table 7.4-5.

Table 7.4-5 Standard Impedance of Power Supply Transformer

Voltage	Impedance between Primary and Secondary Sides
230/115 kV	12.5%
115/22 kV	8.5%

7.4.4 Power Flow and Voltage Analysis

Power flow calculation and voltage analysis for both the dry and wet seasons were conducted for the power system as of 2016, the final year of the PDP 2007-16. The assumptions of the analysis are as follows:

- The power system model for the analysis does not take into account distribution lines. Therefore, interconnecting lines between Vietnam (connected by 35 kV distribution system) were not modeled. Interconnecting line to Cambodia is planned from Ban Hat substation (Laos) to Stung Treng substation (Cambodia, marked as EDC on the power flow diagram) by 115 kV transmission line and refrected to the model. (Same condition was applied to the power system in 2020 and 2030)
- Up to the year 2012, power supply is planned to the area that is north of Luangprabang by interconnecting transmission line between Laos and China Yunnan Province, however, the situation after 2012 is unknown. In order to evaluate the severer system condition, the power system up to the northernmost part of Laos was modeled. (Same condition was applied to the power system in 2020 and 2030.)
- For both the dry and wet seasons, peak loads are applied for substation loads
- The dry season outputs in Annex D: Estimated Generation in Dry Season/Year, ADB “Preparing the Greater Mekong Subregion Northern Power Transmission Project”, October 2008, for dry season generator outputs. As for generator outputs in the dry season, 70% of the installed capacities are applied for the generators those firm capacities are unknown.
- In wet season, the power outputs of the generators in the southern area are restricted to 80% of the installed capacities to maintain system stability under normal operating conditions.
- In wet season, stability calculations cannot be converged even under normal operating conditions due to overloading of an 115 kV 2 cct transmission line between Sirindhom and Ubon on Thailand’s side. In this simulation, it is necessary for the EGAT system to be sound whatever the condition inside Laos system since the EGAT system cannot be modified under the control of system planning by EDL. Therefore, two more circuits were added to form 4 cct in the section between Sirindhom and Ubon to make calculation converged.
- Under normal operating conditions, the 500/115 kV transformers in the Hongsa Lignite thermal power station are opened to avoid the overloading of the transformers due to huge increases (119 MW) in power flow towards Thailand’s side in wet season.

7.4.5 Analysis Results

(1) Dry Season (PF-D1)

The power flow and bus voltage analyses results under normal operating conditions and at any single contingency are shown in Figure 7.4-3 and Table 7.4-6, respectively. Under normal operating conditions, no overloading of transmission lines or abnormal voltage at substation buses occurs. Under single contingency conditions, over voltages occur at the Xieng Nguen and

Boun Neua substations and voltage drops occur at the Thongkhoun and Phubia substaions. Switching operations and/or installation of shunt capacitors can solve these voltage violation problems.

Table 7.4-6 Power Flow and Voltage Analysis Results at any Single Contingency (Dry Season)

Fault Location					Analysis Result	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

(2) Wet Season (PF-W1-80)

The power flow and bus voltage analysis results under normal operating conditions and at any single contingency are shown in Figure 7.4-4 and Table 7.4-7, respectively. Under normal operating conditions, no overloading of transmission lines or abnormal voltage at substation buses occurs. Under the following single contingency cases, an overload occurs to the remaining circuits of the same sections.

- 115 kV Saravan SS – Sekong SS (1 cct Open)

This situation is due to the calculation conditions that all of the generation outputs of the generators in Southern Area are restricted to 80% of their installed capacity, and that the remaining generators in the system are operated at their rated capacity, in other words, 100% of their installed capacities. This condition is severer than actual generator operating conditions because, in reality, some of the genetors will be out of service due to periodical inspection. Therefore, total generator output can be considered smaller than that of this analysis and the solving of such overloads are to be expected.

Overloading occurs to the section between the Xieng Nguen and Luangprabang 1 substations in the event of a single fault at the 115/22 kV transformer in Boun Neua substation. Therefore, further study on the operations of the northern system is considered necessary. Besides, the appropriate switching operations of existing static condensers and/or installation of additional or new static condensers to their buses is expected to resolve the abnormal voltages at the Xieng Nguen, Thongkhoun, Phubia, and Boun Neua substations.

Table 7.4-7 Power Flow and Voltage Analysis at Any Single Contingency (Wet Season)

Fault Location					Analysis Results	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Saravan	115	Sekong	115	1	Overload	From Saravan 115kV To Sekong 115kV cct 2
Saravan	115	Sekong	115	2	Overload	From Saravan 115kV To Sekong 115kV cct 1
Boun Neua	115	Boun Neua	22	1	Overload	From Xieng Nguen 115kV To Luangprabang 1 115kV cct 1
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

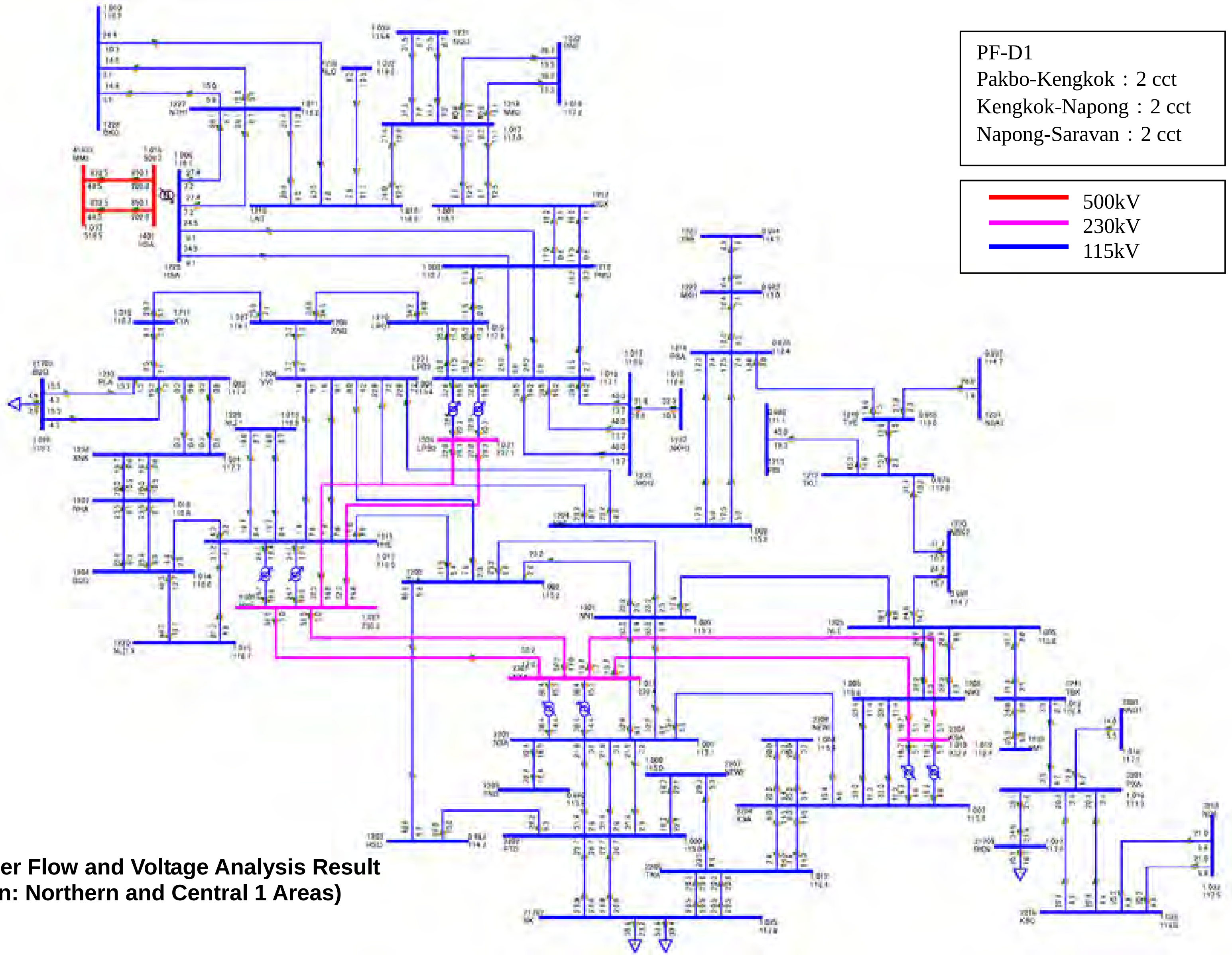

Figure 7.4-3(a) Power Flow and Voltage Analysis Result (Yr 2016 Dry Season: Northern and Central 1 Areas)

PF-D1
Pakbo-Kengkok : 2 cct
Kengkok-Napong : 2 cct
Napong-Saravan : 2 cct

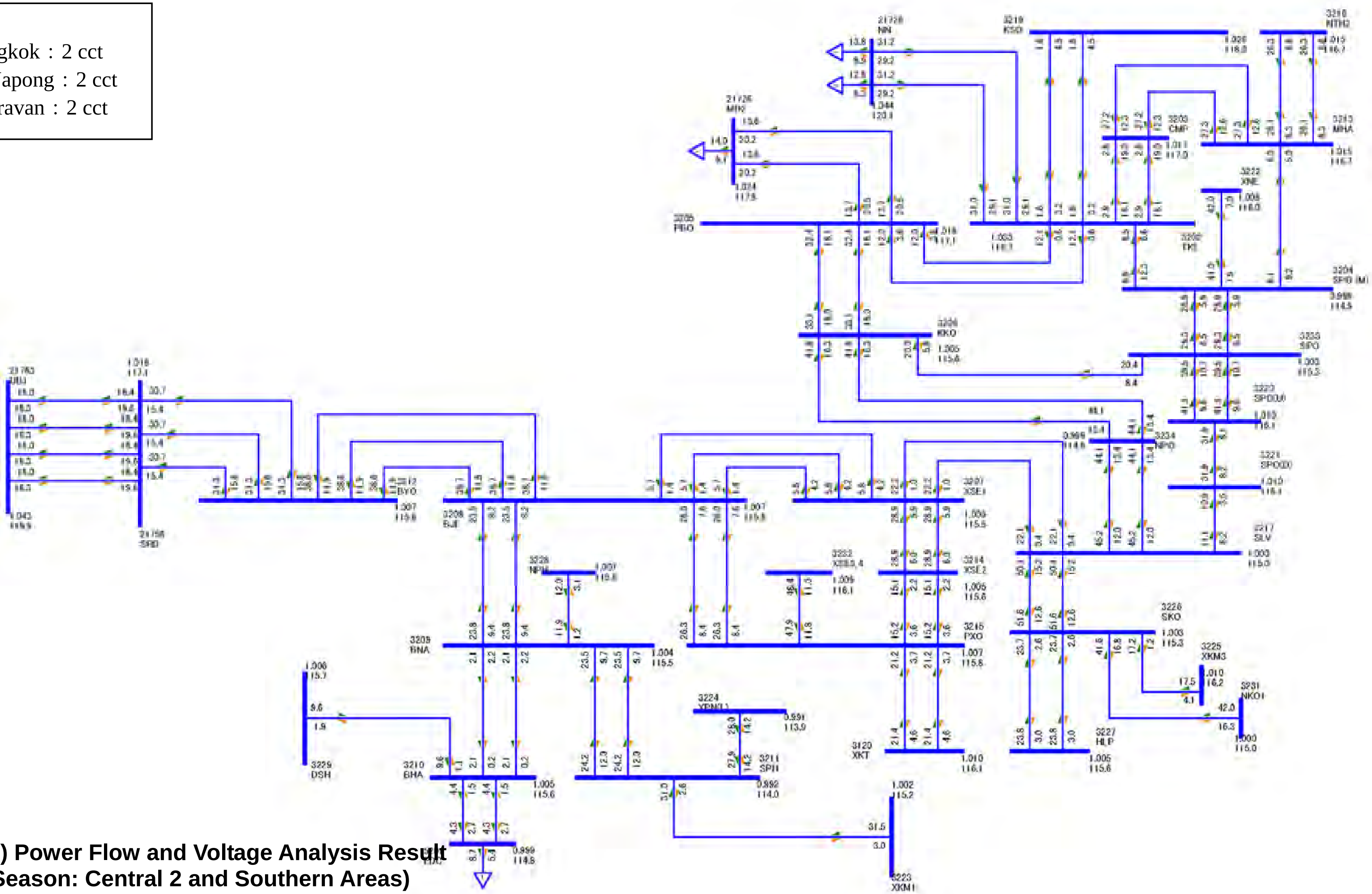

Figure 7.4-3(b) Power Flow and Voltage Analysis Result (Yr 2016 Dry Season: Central 2 and Southern Areas)

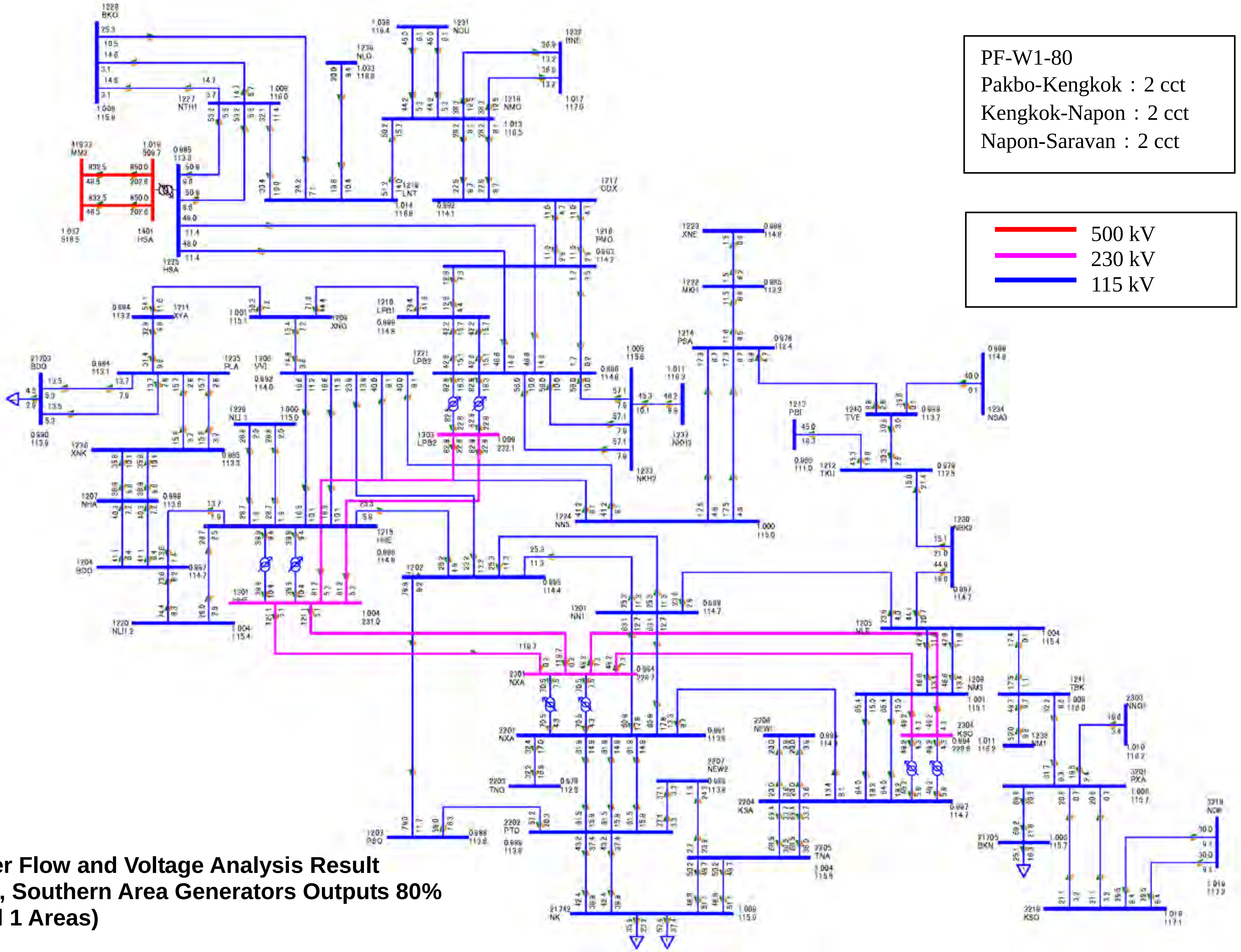

Figure 7.4-4 (a) Power Flow and Voltage Analysis Result (Yr 2016 Wet Season, Southern Area Generators Outputs 80% Northern and Central 1 Areas)

PF-W1-80
Pakbo-Kengkok : 2 cct
Kengkok-Napon : 2 cct
Napon-Saravan : 2 cct

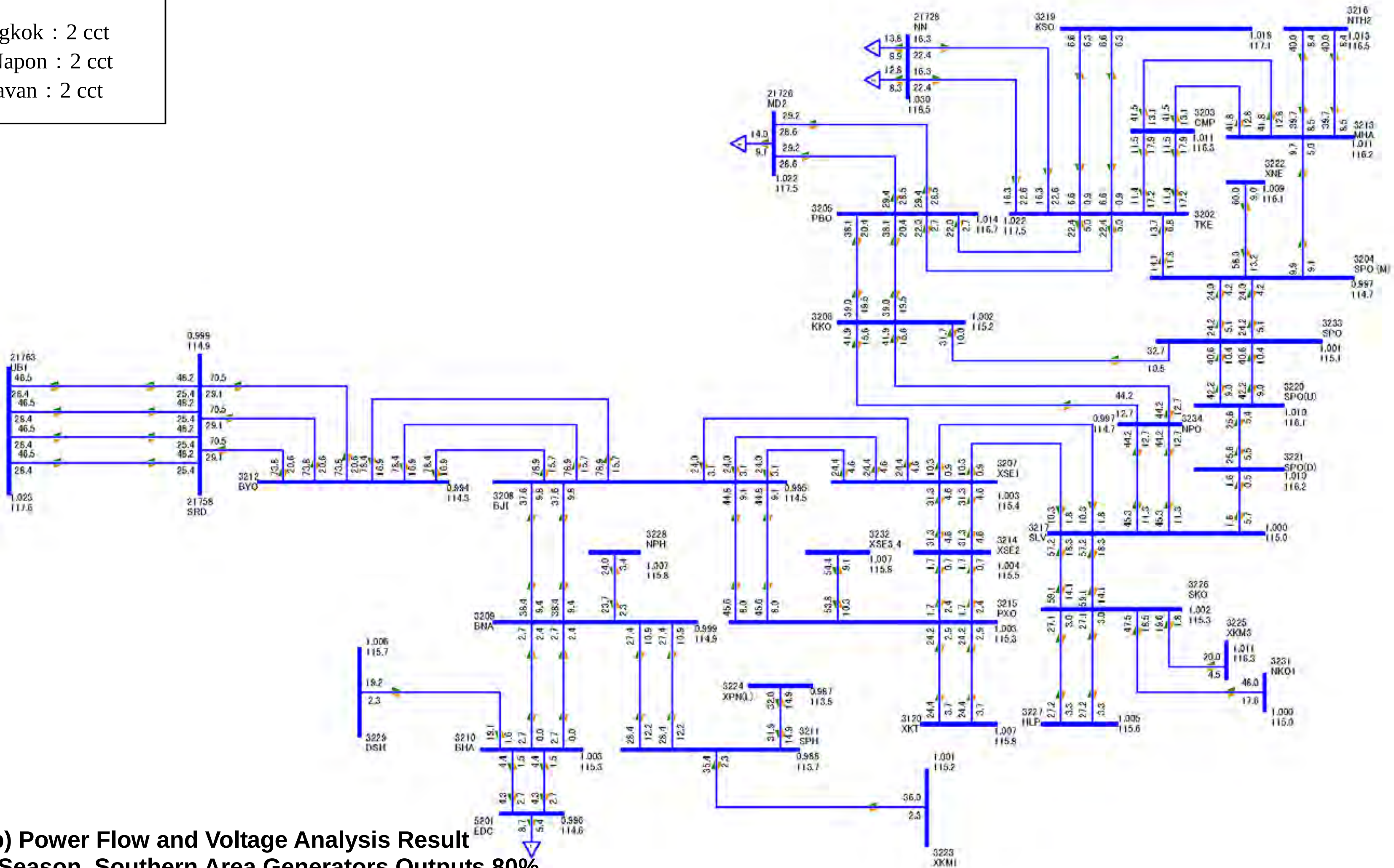

Figure 7.4-4(b) Power Flow and Voltage Analysis Result (Yr 2016 Wet Season, Southern Area Generators Outputs 80% Central 2 and Southern Areas)

7.5 Environmental and Social Consideration on Power Network System Plan

In this section, the Long Term Power Network System Plan (the Plan) is examined from an environmental and social perspective. First, the environmental and social conditions in Lao PDR must be relevant to the transmission line project described. Next, the environmental and social issues need to be considered in the Plan addressed.

7.5.1 Natural Environment

Lao PDR is a landlocked country with a total area of 236,800 km^2. It borders Vietnam, Cambodia, Thailand, Myanmar and China. The country is divided into 16 provinces and the Capital City is Vientiane.

The arable land consists mainly of narrow valleys and productive, silt rich flood plains of the Mekong River and its tributaries. The arable land under cultivation is estimated to be 800,000 ha. This comprises 43% of the intensive agricultural land, or only 3.4% of the total land area. Rice is grown on 78% of this land.

Forest resources are rich. A mixed deciduous forest is the predominant forest type, which consists of dry dipterocarp, dry evergreen and coniferous forests. The forest accounts for 41.5% or approximately 10.2 million hectares as of 2002. Deforestation and forest degradation are significant environmental problems in Lao PDR. Deforestation rates in certain districts have exceeded 20% between 1993 and 1997. Other blocks of forest are becoming increasingly fragmented and disturbed, resulting in decreasing degrees of tree covering and crown density. In order to conserve its forest resources and biodiversity, the government of Lao PDR established the National Protected Area (NPA) system through a Prime Ministerial Decree in 1993. The decree states that the National Protected Areas (NPAs), formerly known as National Biodiversity Conservation areas (NBCAs), are managed as resource areas. They are designed to (a) preserve natural resources, (b) protect the abundance of nature and (c) preserve the beauty of natural scenery for leisure resorts, study and research. In total, 20 NPAs and two Corridors cover almost 3.4 million hectares, or more than 14% of the country. Moreover, large areas have been designated as protected areas (protection forest) and conservation areas at Provincial and District levels. All these classes of protected areas cover over 5.3 million ha or more than 22% of the total land. The number of NPA, Provincial conservation and protection forest areas and District conservation and protection forest areas is shown in the Table 7.5-1. Figure 7.5--1 shows the location of NPAs (NBCA) and Protected Forests in Lao PDR. Appndix 7.5 shows the location of NBCAs and Protected Forests in each province.

Table 7.5-1 Conservation and Protection Forest Areas in Lao PDR

Level	Number	Total Area (ha)	Shares in Total Land Area (%)
National	20 NPAs	3,310,200	13.98
	2 Corridors	77,170	0.33
Provincial	57 Conservation Areas	931,969	3.94
	23 Protection Forest	461,410	1.95
District	144 Conservation Areas	503,733	2.12
	52 Protection Forests	55,713	0.23
Total		5,340,195	22.55

(Source: Lao PDR Environmental Monitor 2007. World Bank)

Logging, collecting forest products, excavation or mining, expansion of shifting cultivation on land designated as Conservation and Protection Forest areas is strictly prohibited unless specific exceptions are made by the Government[2].

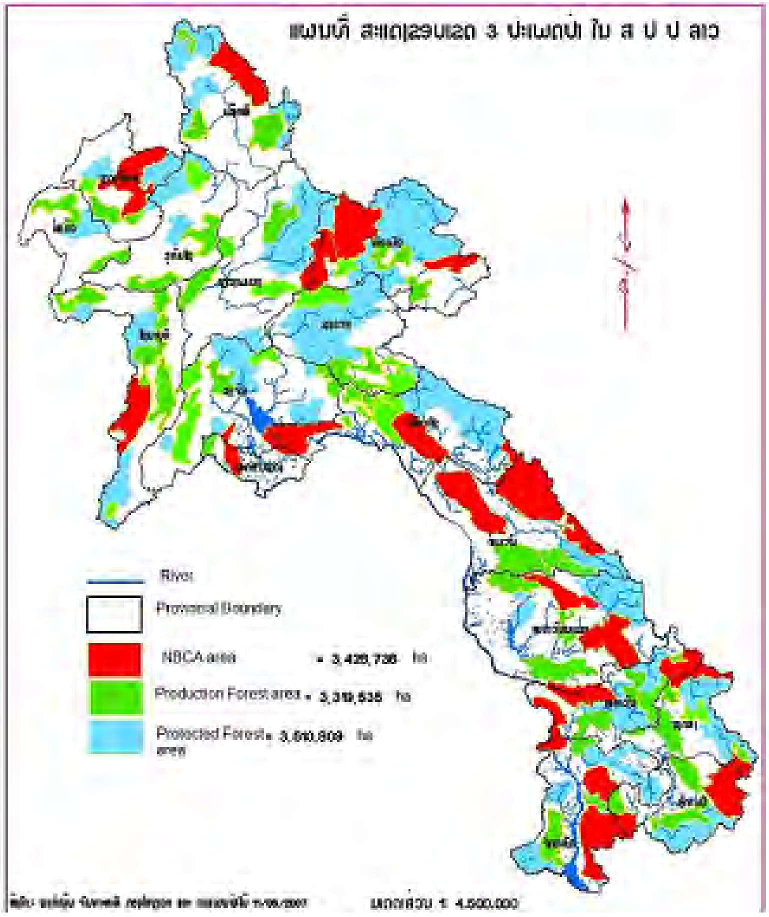

Figure 7.5-1 NBCA and Protection Forest Map in Lao PDR

(Source: Department of Forestry, Ministry of Agriculture and Forestry)

The country has rich biodiversity. There are at least 8,100 different species of flora and fauna including reptiles, amphibians (160 species), 700 different bird species and 11 unique mammal species. 87 of the variety of fish species in Indochina are mainly to be found in Lao. 1300 species have natural habitats along the banks of the Mekong and its tributaries. In order to protect and manage this biodiversity, the law on Wildlife and Aquatic Animals was enacted in 1997 and amended in 2004. The endangered species were examined and classified into three categories; critically endangered species fall under Category 1., endangered species fall under Category 2, and vulnerable species fall under Category 3. Table 7.5-2 shows the number of species in each category. The law stipulates that these species need to be constantly surveyed

[2]. In 2007, the Forestry Law was revised and all forests in Lao PDR were divided into three categories; Protected forests, Conservation forests and Production forests. According to the law, all activities are strictly prohibited in Protection and Conservation forest areas. However, such areas can be utilized for national projects if proper procedures are undertaken to receive government approval.

and recorded for proper protection. The Ministry of Agriculture & Forestry annually reviews the list in cooperation with the International Union of Conservation of Nature (IUCN) in every year.

Table 7.5-2 Number of Species in Category

	Number of Species					
	Mammals	Birds	Reptiles	Amphibians	Insects	Fishes
Category 1 Prohibition Category	44	36	9	1		
Category 2 Management and control category	15	22	13		7	9
Category 3 General category	6		8	3	5	18

(Source: IUCN Red List 2008)

The Mekong River flows about 1,860 km throughout the country and its basin covers nearly 90% of the country's total land mass. In addition to the Mekong, several smaller river basins drain out from Lao PDR towards Vietnam. The rivers' discharge follows the pattern of rainfall: about 80% during the rainy season (May-October) and 20% during the dry season (November -April). The water level in the Mekong River may experience up to a 20m fluctuation depending on whether or not it is the wet or dry season. Lao's own watersheds generate a significant portion of the nation's water resources. Average annual rainfall ranges from 1,300 mm per year in the northern valleys to 3,700 mm per year at higher elevations in the South.

7.5.2 Social Environment

The population is about 5.8 million[3] and the population density is 24 persons per 1km^2 in 2007. Figure 7.5-2 shows the distribution of population density in Lao PDR. The urban population is estimated to comprise 20% of the total population. The majority of the population is engaged in agriculture and the country's economy depends on rich natural resources, including forest and water resources.

Public health services are quite basic and 35% of urban population has no access to a communal water supply. There is a limited drainage and sewage system, insufficient wastewater treatment, insufficient solid waste disposal sites both for household and hazardous waste. In addition, there is a lack of ambient quality and emission standards for noise, air and odorous pollution.

(1) Unexploded Ordinances (UXO)

Lao PDR suffers from UXO remaining over from the first Indochina War (1946-1954) and following the second Indochina War (1960-1975), which was the heaviest aerial bombardment in history. The United States dropped more than two million tons of bombs between 1964 and 1973. Figure 7.5-3 shows the locations containing UXO contamination. Among the 16 provinces including Vientiane Capital City, 15 have been significantly affected by UXO. It is estimated that UXOs are still present in nearly 50% of the total arable land area. In 2007, 100 casualties from UXO including 31 people killed were reported. The total amount of land cleared in 2007 was 42 km^2.[4] The National Regulatory Authority (NRA) is the national clearance agency responsible for clearance, coordinating and regulating all UXO action.

[3] Statistical Year Book 2007, Vientiane June 2008, Department of Statistics, Ministry of Planning and Investment
[4] Landmine Monitor Report 2008, Mines Action Canada.

Figure 7.5-2 Population Density in Lao PDR

(Source: United Nations Institute of Training and Research)

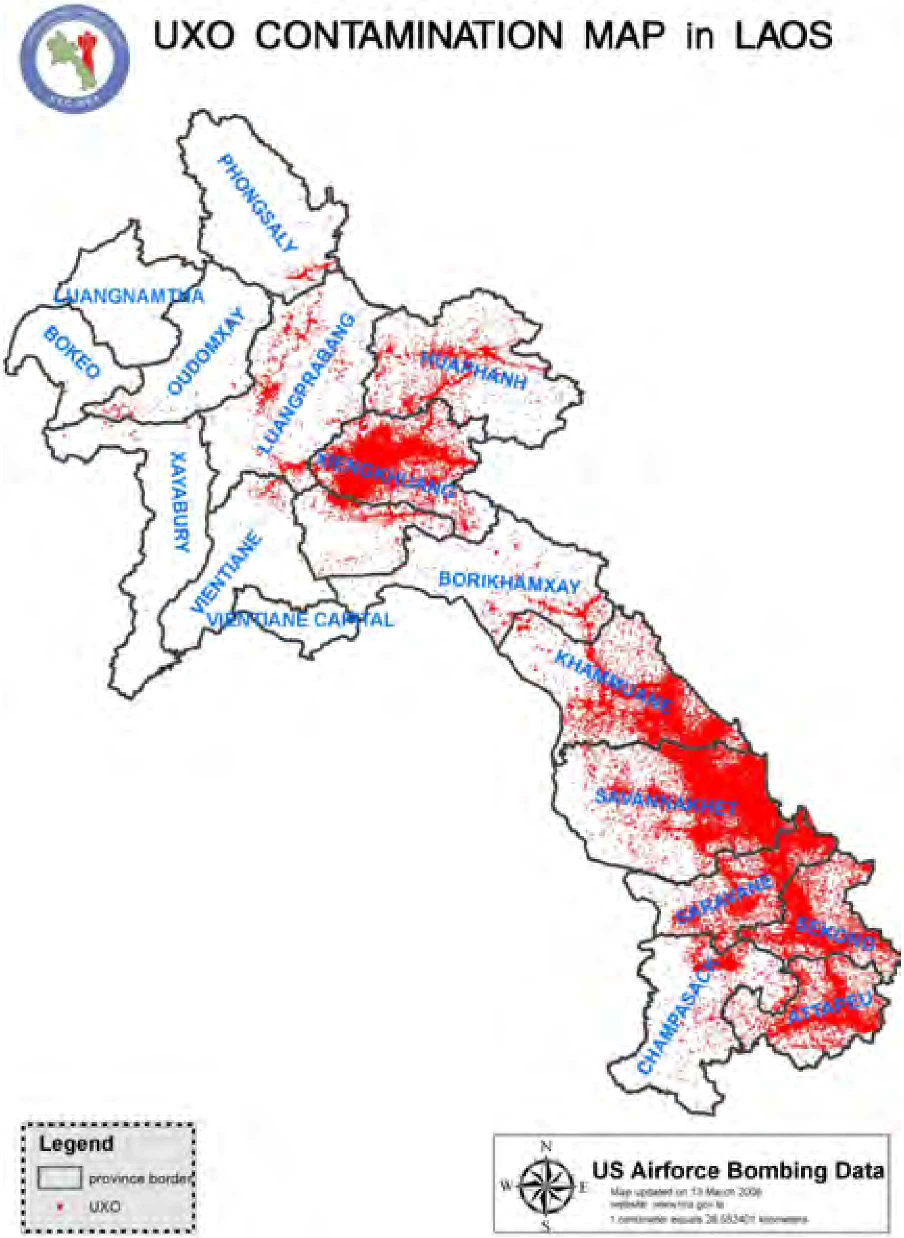

Figure 7.5-3 UXO Contamination Map In Lao PDR

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

(2) Ethnicity

In the Lao PDR there are 49 official ethnic groups[5] comprising some 200 ethnic subgroups. The population can be grouped into four broad ethnic categories: Lao-Tai, Mon-Khmer, Hmong-Iu Mien and Sino-Tibet. While the variety of languages spoken by the different ethnic groups contributes to the rich linguistic diversity in Lao PDR, it also makes the task of

[5] Revision of the number of ethnic groups from 49 to 47 has been discussed in the National Assembly. (as of November 2008.)

including these groups in national development more complex. While most of the non-Lao-Tai live in upland areas, there is a wide disparity in geographic, economic and social living conditions, and cultural diversity that provide additional dimensions to the already challenging task of reducing poverty. The Distribution Map of Ethnic People is shown in Figure 7.5-4.

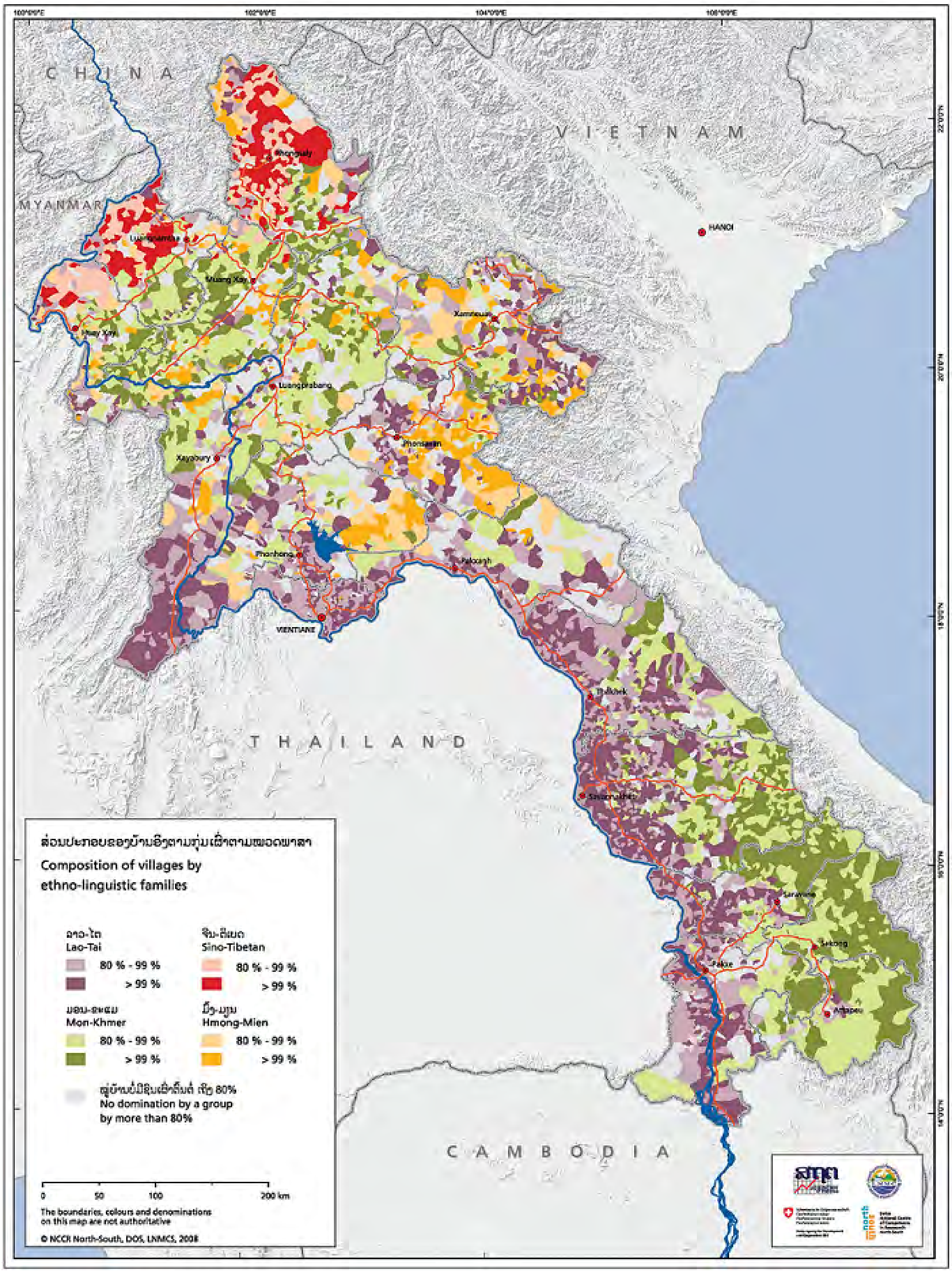

Figure 7.5-4 Distribution Map of Ethnic People in Lao PDR

(Source: "Socio-Economic Atlas of the Lao PDR" Swiss National Center of Competence North-South, Department of Statistics, Ministry of Planning and Investment)

7.5.3 Environmental and Social Issues in the Project of the Plan

In order to implement the transmission line project (including substation construction) while duly considering the natural environment and society, the following steps are to be taken.

- At the project planning and design phase, the natural environmental and societal situation in the project area is to be examined in order to predict potential negative impacts (discussed in 3.8.4 (1) Environmental screening), then those impacts are to be assessed by conducting an IEE and minimized by developing mitigation measures.
- At the operations phase, those impacts are monitored and appropriate action taken if deemed necessary.

Considering the environmental and social situation in Lao PDR addressed in Section 7.5.1 as well as the predicted negative impacts listed in Section 3.8.4, minimizing resettlement, reducing disturbance to the natural environment, lowering the risk of UXO and remedying the disadvantage of ethnic minority people are the key elements in the context of environmental and social considerations of transmission line projects. Based on the information collected at the site survey from the northern and southern provinces during the second site study as well as the information contained in the map of population distribution (Figure 7.5-2), the map of protection and conservation area (Figure 7.5-2-Figure 7.5-18), the UXO contamination map (Figure 7.5-3), the distribution map of ethnic people (Figure 7.5-4), the issues in each element are to be discussed for developing transmission line networks taking into account environmental and social considerations.

Minimize resettlement

The population density in the northern part of the country is relatively lower than the central and southern part. The population is concentrated in the Vientiane capital and in the western to central part of the Savannakhet Province. The population is also concentrated along the National Road 13 from the Bolikhamxay Province to the Champasack Province. There has not been a high degree of resettlement in past transmission line projects. Given the country's low population density, the installation of transmission lines in regions other than residential areas was considered to be a feasible proposition. However, the population increase coupled with upgraded road conditions has led to encroaching migration towards main roads in recent years. In particular, the population near the National Road 13, the main road that passes through the southern provinces, has been skyrocketing yearly. Further, as a result of increasing urbanization, the population density has also been intensifing in the Vientiane Capital as well as the capital city of the Khammouan Province, Savannakhet Province and Champasack Province. Given that it is a common practice to construct transmission lines alongside roads, it is predicted that land acquisition for transmission line routes will become increasingly more difficult in the near future. Accordingly, much more consideration in favor of transmission line alignment should be made in order to minimize future resettlement.

Reduce disturbance to natural environment

The NBCA are placed in all provinces except the Bokeo Province and the Oudomxay Province. Nearly 30% of the total areas in the Luang Namtha Province, the Khammouan Province and the Champassack Province are NBCA areas. Protected forests (watershed areas, areas for preventing soil erosion and protecting soil quality, strategic areas for national defense and so on) and conservation areas such as conservation forest areas are located at national, provincial and district levels[6] in all provinces. In the past, special attention was paid to avoid installing transmission lines in these areas. However, in light of the fact that EIA implementation is being imposed on NBCA projects under the revised Regulation on Environmental Assessment

[6] At this stage, detail location of those areas needs to inquire at the Forestry Office where the area placed.

(Regulation)[7], it can only be assumed that increased Government concern and and conservation efforts towards the environment will lead to stricter measures governing areas that are targeted as potential transmission line routes during selection.

During the operations phase, the periodical monitoring of habitats near designated conservation areas that crisscross with transmission line routes has been made an obligatory part of the Environmental Management Plan (EMP), the responsibility of which is to be undertaken by the project owner. However, since it appears that this monitoring is not being carried out properly[8], the WREA in the revised Regulations have added a clause emphasing proper implementation of the monitoring. Accordingly, the present monitoring plan needs to be reviewed and re-designed to be more practical and effective.

Lower the risk of UXO accident

UXO contamination is concentrated in the area near the Vietnam border from the central province of Khammouan throughout all the southern provinces. In addition, all areas of the Xieng Khuang Province have been severely contaminated by UXO due to the fact that the area housed the headquarters of the Lao Revolution Army during second Indo-China War. In order to avoid any UXO accidents, a survey including holding hearings with the local people at the project site is being practiced as part of the IEE. In the event that UXO are found in project areas, it will be cleaned up prior to any transmission line construction.

Surveys concerning the location and clean up of UXO is under way by the Government. Consequently, it is being assumed that the number of UXO will decrease in the future. However, given the tremendous number of UXO remaining, it is predicted that the cleaning operation will take some time. Accordingly the practices of taking site surveys and cleaning up the UXO in project areas needs to be done continuously.

Remedy the disadvantage of ethnic minority people

In all northern provinces as well as the Xieng Khuang Province, the Luang Prabang Province, northern part of the Vientiane Province, the majority of the ethnic minority people belongs to the linguistic family of the Sino-Tibetan, Mon-Khmer and Hmong-Mien and is larger than people who belong to the Lao-Tai linguistic family whose mother tongue is the official language, Lao. On the east side of the Khammouan Province through the central and eastern side of the Savannakhet Province, the population of the Mon-Khmer is large. In the southern provinces, the central and eastern parts of the Saravan Province and most of the parts of the Sekong and Attapeu Province, the Mon-Khmer population is a majority.

In order to remedy the disadvantageus position of ethnic minority people, measures such as preparing translators for those who can not speak the official language or hearings with those people on their land have been practiced for past transmission line projects. Considering the following two facts that 1) the number of ethnic people who understand the official language has been increasing and that 2) gathering the information on land use for those people by the Ministry of Agriculture and Forest are under way, the needs of special consideration for those people will decrease in the future. However, taking into account the fact that the ethnic minority amounts to nearly 40% of the total population, special attention such as collecting information on the distribution spread of ethnic minorities and their situation in project areas through conducting IEE needs to continue.

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[7] Working Draft 18 Regulation on Environmental and Social Assessment: There is no clear stipulation for NBCA in conventional Regulation on Environmental Assessment.

[8] According to the briefing at the Environment Office in EdL.

7.6 Operational Consideration for Power Systems

7.6.1 Situations of Power System Operation in 2011 and 2012

The rehabilitation or the construction of power transmission and substation systems can solve the power network system issues in the long or middle term range. However, the operational countermeasures utilizing the existing or commissioning facilities should be taken for the issues on the system within 2 or 3 years because the large-scale construction of power system facilities cannot be completed in time as the countermeasures.

In this section, the operational situations of Laos's power system in 2011 and in 2012 (two or three years from now) were studied. The following information as of August 2009 was reflected in the study.

- All the power plants that were under construction and expected firmly operated such as the Xeset 2, Nam Thuen 2 or Nam Lik 1/2 were included in the system models.
- Nam Ngum 5 and Nam Lik 1 were not included in the system in 2011 because they would be delayed one year with operations scheduled to commence in 2012.
- The Nam Tha1 was not included in the system models of 2011 and 2012 because it would be delayed two years and expected operations were in 2014.
- The maximum load of the Steel Making Plant for special consumers appearing in Vientiane City in 2011, was changed to 79.5 MW.
- The actual peak demands of the Khoksaad substation and Tangong substation had exceeded the peak demand forecast. Thus the demand forecasts of those two substations for 2011 and 2012 were changed.
- Special consumers in the event that the completion of the nearest substations or the transmission lines were expected delayed were excluded from the demand forecast because their power transmission could be difficult.
- The power supply from China to Nam Mo through a single circuit of 115 kV lines was considered.
- The interconnection from China to Nam Mo through a single circuit of 115 kV is scheduled to start operations from around 2009 to 2010. The EDL 115 kV system supplied from China has to be separated from the system supplied from Thailand to avoid direct connections between China and Thailand because it becomes difficult to control the excessive power flow for the capacity of the EDL 115 kV system even when the small perturbation of the system frequency occurs due to the large scales of the systems of Thailand and China around 30,000 to 70,000 MW. According to the information from South China Grid Co. and EDL, the power was supposed to be supplied from China to the Pakmong substation in the north of Luang Prabang and the transmission line between Luang Prabang and Pakmong was opened.

The power system analyses were carried out for the systems in 2011 and 2012 under the aforementioned conditions. The peak power demand, power generation capacity and the power flow of interconnections to neighboring countries are shown in Table 7.6-1.

Table 7.6-1 The Situations of EDL Power Systems in 2011 and 2012

[Unit: MW]

	2011	2012
Summation of peak power demand of 115/22 kV substations	461	510
Summation of Special Power Demand	518	536
Summation of Peak Power Demand	979	1046
Generation Capacity for Domestic Power Supply	706	849
China -> North Area	40	55
EGAT->Central 1 Area	152 *1)	71
EGAT->Pakxan in Central 2 Area	-10	-26
EGAT->Thakhek in Central 2 Area	181 *2)	158 *2)
EGAT->Pakbo in Central 2 Area	18	13
EGAT->Bang Yo in South Area	-36	-51

*1) Udon-Nonkai Transmission line in Thailand suffering the overloaded

*2) A remaining circuit in the event of a single circuit fault suffering the overloaded

7.6.2 Situations of the System in 2011

The summation of the peak power demand of 115/22 kV substations in 2011 is 461 MW, the summation of the peak power demand of special consumers is 518 MW and the summation of the peak power demand of the whole of Laos is 979 MW. On the other hand, the summation of the generation capacities in 2011 is 706 MW reflecting the delay in the completion of Nam Ngum 5 and Nam Lik 1 aforementioned. Thus, the summation of the peak power demand exceeds the total generation capacity and a shortage of generation capacity causes the power export from EGAT system and the system of China. The results of the power system analysis revealed the following issues.

- A single circuit among 115 kV transmission lines between Udon 1-Nongkhai of the EGAT system will suffer the overloaded conditions due to the large amount of imported energy from EGAT to Central 1.
- A remaining single circuit among the 115 kV transmission lines between Thakhek- Nakhon Phanom (EGAT) in the event of a single circuit fault will suffer overloaded conditions due to the large amount of imported energy from EGAT to Central 2.
- There will be no significant problems regarding the power flow conditions apart from the aforementioned matters. However, the installation of some capacitors will be required for the areas assumed to be suffering from low voltage conditions.

7.6.3 Situations of the System in 2012

The power import from China will be still continued through the interconnection to Nam Mo similar to the 2011 power supply to the North area. However, the capacity restriction of the interconnection and the construction delay in the of Nam Tha1 power station will make the power supply to the entire expected load of special consumers impossible and the completion delay of some transmission lines will make it difficult to fulfil supply requirements to some special consumers. Apart from those special consumers, the total maximum power demand of 115/22 kV substations will be 510 MW, the total maximum power demand of special consumers will be 536 MW and the total maximum power demand of the whole of Laos will be 1,046 MW. On the other hand, the summation of the generation capacity in 2012 will be 849 MW reflecting the delay in Nam Tha1. Thus, the summation of the peak power demand exceeds the total generation capacity and a shortage of the generation capacity causes the power export from EGAT system and the system of China, as is the case with 2011.

The results of the power system analysis revealed the fact that the remaining single circuit would suffer the overloaded conditions in the event of a single circuit fault between Thakhek-Nakhon Phanom (EGAT), as is the case with 2011, even though the overloaded conditions of the interconnections between Central 1 and EGAT would be mitigated.

There will be no significant problems with regards to the power flow conditions apart from the aforementioned matters. However, the installation of some capacitors will be required for those areas expected to suffer from low voltage conditions, as is the case with 2011.

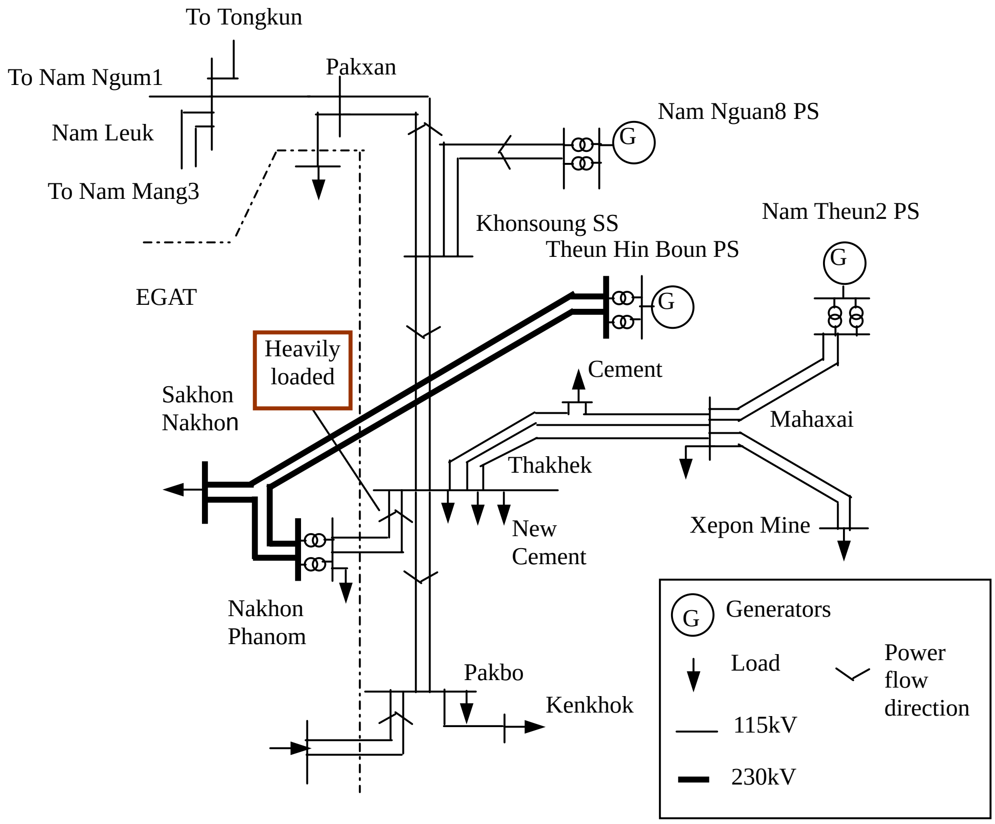

Figure 7.6-1 Situations of the System of Central 2 in 2012

7.6.4 Countermeasures against the Issues on the System in 2011 and 2012

The countermeasures against operational problems on the system in 2011 and 2012 can be listed as follows.

1) The special consumers have a large effect on the system due to its large load. The actual demand of the special consumers will often become smaller than expected because the peak demand of the special consumers are forecasted as the maximum expected load of the special consumer when applied to EDL. The start of power consumption for special consumers is often delayed. Thus, EDL should always follow the latest information pertaining to special consumers.

2) The remaining circuit in the event of a single circuit fault will suffer overloaded conditions between the Thakhek substation in the Central 2 area and the Nakhon Phanom (EGAT) due to its large power flow. It will be caused by the power flow in the EGAT over the Mekong

River from the Thuen Hin Boun power station imported through Thakhek because of insufficient power in around the Thakhek substation even though Nam Theun 2 in 2009 and Nam Nguang 8 in 2012 will be commissioned. Overload conditions will occur and cascading large blackouts may be occur even in the event of a single circuit fault because the maximum value of this power flow will be over 150 MW. Countermeasures to level the load distribution in this area by utilizing the transmission lines coming from Pakbo and Pakxan now under construction to split the load distribution around the Thekhek substation are to be considered. For example, the power transmitted from Pakbo to Thakhek in the opposite direction will switch a portion of the load around the Thakhek substation to a portion of the load supplied from EGAT through Pakbo or opening the Pakxan terminal of the transmission line between Pakxan and Thakhek will switch over the entire power from Nam Nguang8 to the power supplied to Central 2. EDL should start the study of countermeasures including changing the system configuration as soon as possible.

3) Shunt capacitors and shunt reactors can play an effective role in improving the operational system voltage because their installation work takes about one year. Importance should be placed on the works of measuring the reactive power loads as well as the active power loads for the study of the adequate amount of installed capacitors or reactors. EDL should make annual plans of the shunt capacitors and reactors based on the correct data about the power system and its loads.

The aforementioned situations in 2) will be improved after 2014 upon completion of the transmission line from Saravan-Pakbo, which is a highest prioritized project in this study, and the Xepon hydropower station is able to transmit the surplus power from the South to the Central 2 area.

7.6.5 Central Load Dispatching Center

The construction of the Central Load Dispatching Center has been scheduled to start supported by China through the F/S and the consultant works for the construction supported by the World Bank. The Central Load Dispatching Center will be required up to 2011 or 2012 when the three regions, North, Central 1 and Central 2, will be connected each other. It is recommended that the Central Load Dispatching Center should be equipped with the following supervising and controlling functions.

Supervising functions

- Supervising the power flow in the interconnections between the neighboring countries and EDL system
- Supervising the power flow in the 115 kV (230 kV) transmission line
- Supervising the voltage of 115/22 kV substations
- Supervising the loads of 115/22 kV substations
- Supervising the tap positions of the transformers in 115/22 kV substations
- Supervising the power outputs of 115 kV power stations
- Supervising the status of open or close of switches in 115/22 kV substations
- Supervising the working of the protection system in 115/22 kV substations
- Supervising the dam water levels of the reservoir in the reservoir type power stations

Controlling functions

- Controlling the power flow of interconnections between the neighboring countries and EDL system (For example, TBC frequency control[9])

[9] TBC frequency control: the controlling scheme of the frequency deviations by controlling the generator power

- Designating the power output adjustment of the 115 kV power stations

To fulfill the aforementioned functions requires the communication systems among the 115/22 kV substations, 115 kV power stations and the Central Load Dispatching Centers.

The aforementioned functions are prepared when full specifications are required. The alternated minimum functions can be considered that the supervising functions are placed in the main portion and the controlling functions are just composed of the manual functions to be designated by the Central Dispatching Center by telephone. However, it is recommendable to centralize and automate the controlling functions to a certain degree in case a more reliable and quick response power system operation is required.

EDL has to consult with neighboring power operators such as the EGAT regarding the adoption of controlling the power flow of interconnections although the TBC frequency-controlling scheme has been recommended in the aforementioned manner.

The hierarchy of the power dispatching centers can be considered to consist of multiple centers when the transmission lines and the substations or the power demand in the system will be expanded. However, it will suffice to assign only the Central Load Dispatching Center to take a role in supervising and designating its controlling at the initial stages for a power system the scale of Laos’s.

The EDL power system operation department that may be established at the same time of the Central Load Dispatching Center will likely take the following tasks.

- Annual and daily power demand forecast
- Confirmation of the patterns of outputs of power stations responding to the situations of the power system
- Making plans for power system operations
- Scheduled outages such as for facility inspections
- Restoring operations of the system in the event of faults
- Making installation plans of the “protection relay systems”
- Turning of the protection relay systems
- Functions to train the staff of the dispatching center and the power system operations

The works in the power system operation area of EDL will likely escalate in importance in correlation with the future expansion of the transmission and the substation system. Further, EDL staffs are required to further enhance their technical skills regarding power system operations.

It is expected that the data and information collection for the power system operation and the management of the quality of electric power such as system reliability and voltage will become more difficult because the IPPs or the large scale power consumers connected to the EDL system will increase. Thus, the common rule (Grid Code) that determines the requirements for connecting the EDL power systems and the types of the information that will be applied for all the power network users and will be provided to the system operator should be urgently established

For example, apart from the technical specification requirements such as the stipulations pertaining to the IPP power generator control system to be connected, the types of required power system protection relays, the types of information to be sent to the EDL central dispatching center, the agreement of the actions to take in response to emergency cases, the rules of voltage maintenance on the consumer side in the event of large-scale consumer

outputs in the inner power system just by the amount of power already determined while keeping the power flow of the interconnections within the reference values. The amount of power to be controlled is determined according to the scale of the system and the sensitivity to the frequency deviations.

connections, the procedures and the information to be disclosed to all EDL users, power system operators are also included in the common rule items.

7.7 Rural Electrification Plan

The electrification rate for households exceeded 50% in 2016 and the government of Laos has targeted the electrification rate for households improved to 90% up to 2020. Around 80% of the villages has been planned to be electrified up to 2020 in PDP 2007-2016. Table 7.1-1 shows the target of the numbers of the electrified households.

The projects for the rural electrification in Laos is composed of the Rural Electrification Project (REP) financed by the World Bank and the Northern Area Rural Electrification Projects (NARP) by ADB. Table 7.7-2 shows the target of the electrification rate for households up to 2016 by EDL.

Table 7.7-1 Target of the Number of Electrified Households

	2006	2016	2020
Total households	935,019	1,147,033	1,231,788
Target of the Number of Electrified Households by Government	504,000	950,737	1,108,609
Target of the Number of Electrified Households by EDL	465,988	879,032	1,024,997
Target of the Number of Electrified Households by other contributions	38,012	71,705	83,612

(Source: PDP 2007-2016 (EDL))

Table 7.7-2 Target of Electrification Rate for Households up to 2016 by EDL

Projects	Number of Households
Existing	465,988
REP1	42,295
NARP1	30,567
REP2	63,443
NARP2	45,851
REP3	57098
NARP3	41,265
Consumer expansion	132,526
Total	879,033

(Source: PDP 2007-2016 (EDL))

Chapter 8
Selection of Highest Prioritized Project

Chapter 8 Selection of Highest Prioritized Project

8.1 Criteria for Selection of Prioritized Project

Before selecting the prioritized projects, the selction criteria were established based on the discussion with the counterparts as shown in the followings.

1. Select the projects among all the projects of the transmission lines and substations up to 2016 listed in the Power Development Plan 2007-16 made by EDL in 2008
2. Exclusion of projects under construction or have firm fund source expectations
3. Excluding the projects that play a role in power transmission from a specified IPP because the projects have a strong possibility of gaining promotion mainly by that IPP and have no priority in being examined in this study
4. Excluding projects whose power supply role is restricted to only one specified power consumer such as a large-scaled mine or factory

On the basis of the aforementioned criteria, projects that can bring wide benefits through domestic power supply in Laos were selected as the prioritized projects in this study.

8.2 Selection of Prioritized Project

All the projects up to 2016 listed by the EDL in 2008 are as shown in Tables 8.2-1 to 8.2.3. According to the selection criteria 1 “Select the projects among all the projects of the transmission lines and substations up to 2016 listed by EDL in 2008”, the prioritized projects are selected from those lists.

Table 8.2-1 The List of Transmission Line Projects in EDL PDP (2008-2011)

	Projects	Length (km)	Voltage (kV)	No. of cct.	Comm. years	Source of fund
1	Luanprabang2 - Pakmong	86.9	115	2*	2008	ADB,NDF, EDL
2	Pakmong - Oudomxay	51.8	115	2*	2008	ADB,NDF, EDL
3	Oudomxay - Na Moh	41	115	2*	2008	ADB,NDF, EDL
4	Na Moh - Luangnamtha	42.7	115	1	2008	ADB,NDF, EDL
5	Hin Heup - Vangvieng	40.8	115	2*	2008	ADB,NDF, EDL
6	Nam Ngum1 -Thalat	5.1	115	1	2008	ADB,NDF, EDL
7	Pakxan - Thakhek	198	115	2	2009	JBIC
8	Thakhek -Pakbo	87	115	2	2009	JBIC
9	Xeset1 - Xeset2 - Pakxong	45.5	115	2	2009	NORINCO, EDL
10	Nam Theun2 - Mahaxay	18	115	2	2009	Nam Theun2
11	Mahaxay - Cement factory	20	115	2*	2009	Sepon (mime)
12	Luangnamtha - Border (China)	33	115	2*	2009	?
13	Mahaxay - Sepon (mine)	117	115	2	2009	Sepon (mime)
14	Ban Hat - Border (Cambodia)	26	115	1	2010	World Bank
15	Xeset1 - Saravan	26	115	2	2010	?
16	Khok Saat - New1	10	115	2	2010	?
17	Nam Lik1.2 - Hin Heup	13	115	1	2010	Nam Lik1/2
18	Nam Lik1/2 - Ban Don	33	115	1	2010	Nam Lik1/2
19	Hin Heup - Naxaythong	83.2	230	2	2010	China?
20	Upgrade T/L (Phonsoung-Phontong Line No.1) to be D/C line, section of Phontong-Naxaythong by using the existing ROW	12	115	2	2010	China?
21	Nam Ngum5 - Phonsavan	66.9	115	2	2011	China
22	Nam Ngum5 - Vangvieng	74.8	115	2	2011	China
23	Luangprabang1 - Luangprabang2	22	115	2	2011	China
24	Luangprabang2 - Hin Heup	210	230	2	2011	China
25	Hongsa - Luangprabang2	100	115	2	2011	Ban Pu
26	Luangprabang1 - Pakmong (Install an add.cct.)	86.9	115	1	2011	?
27	Pakmong - Oudomxay (Install an add.cct.)	51.8	115	1	2011	?
28	Oudomxay - Namoh (Install an add.cct.)	41	115	1	2011	?
29	Nam Mang3 - Khoksaat (Install an add.cct.)	35	115	1	2011	?
30	Hin Heup - Vang Vieng (Install an add.cct.)	40.8	115	1	2011	?
31	Khoksaat - Thanaleng (Construct an add.cct.)	17	115	1	2011	?
32	Thanaleng - Border (Upgrade)	2.0	115	2	2011	?
33	Phonsavan - Muongkham	56.2	115	2*	2011	China
34	Muongkham - Xam Neua	146	115	1	2011	China
35	Phontong - Thanaleng (Upgrade)	18	115	1	2011	?
36	Non Hai - Paklay	105	115	2	2011	ADB
37	Paklay-Khanthao	68	115	2	2011	ADB

* Towers will have been designed as double circuit towers only with one side stringing.

Table 8.2-2 The List of Transmission Line Projects in EDL PDP (2012-2016)

	Projects	Length (km)	Voltage (kV)	No. of cct.	Comm. years	Source of fund
38	Luangnamtha - Bokeo	170	115	2	2012	?
39	Nam Tha1 - Bokeo	82	115	2	2012	ADB
40	Nam Tha1 - Connection point	40	116	1	2012	ADB
41	Bokeo - Border	8	115	2	2012	ADB?
42	Hongsa-Nam Tha1	93	115	1	2012	China
43	Nam Gnuang8 - Khonsong	60	115	2	2012	THPC?
44	Nam Lik1 - Hin Heup	10	115	2	2012	?
45	Ban Jiangxay - Xeset1 (New Construction)	76	115	2	2012	India
46	Ban Jiangxay - Pakxong	40	115	2	2012	India
47	Ban Jiangxay - Bang Yo (New Construction.)	8	115	2	2012	India
48	Bang Yo - Border (New Construction)	41	115	2	2012	?
49	Xekatam - Pakxong	35	115	2	2012	?
50	Sepon3 (U) - Sepon (mine)	136.4	115	2	2013	?
51	Sepon3 (U) - Sepon (D)	6	115	1	2013	?
52	Sepon3 (D) - Saravan	135.6	115	1	2013	?
53	Nam Bak2 - Conn. Point	1	115	2	2013	Nam Bak2
54	Kengkok - Sepon	140	115	1	2014	?
55	Namoh - Boun Neua	96	115	2	2014	ADB?
56	Nam Ou (local) - Namoh	45	115	2	2014	Nam Ou
57	Xayabuly - Paklay	134	115	1	2014	ADB?
58	Non Hai - Ban Don (New construction)	54	115	1	2014	?
59	Nam Ngiep (R) - Pakxan	40	115	1	2014	?
60	Kengkok - Saravan	185	115	2	2014	?
61	Sekong - Houaylamphan	18	115	2	2014	?
62	Saravan - Sekong	58	115	2	2014	?
63	Xekaman3 - Sekong	100	115	1	2014	?
64	Luangprabang2 - Nam Khan2	35	115	3	2014	?
65	Nam Leuk - Nam Mang3	56	115	2	2014	?
66	Xekaman1 - Saphaothong	51	115	1	2014	?
67	Xepian/Xenamnoy - Saphaothong	6	115	1	2014	?
68	Xe Neua - Sepon (mine)	50	115	1	2014	Xe Neua
69	Nam Sane3 - Thavieng	28	115	2	2014	Nam Sane3
70	Naxaythong - Khoksaat	18	230	2	2014	?
71	Nam Khan2 - Nam Khan3	50	115	1	2015	?
72	Nam Mang1 - Thabok	10	115	1	2015	?
73	Sekong 4- Sekong	23	115	1	2015	?
74	Nam Phak- Ban Na	56	115	1	2015	?
75	Donsahong- Ban Had	25	115	1	2015	?
76	Xeset3&4 - Pakxong	23	115	1	2016	?
77	Nam Long - Luangnamtha	40	115	1	2016	?

* Towers will have been designed as double circuit towers only with one side stringing.

Table 8.2-3 The List of Substation Projects in EDL PDP(2008-2016)

	Name of substation	Location (province)	Voltage level	Comm. years	Sources of fund	Ownerships
1	Oudomxay	Oudomxay	115 /22kV	2008	ADB, NDF, EDL	EDL
2	Luangnamtha	Luangnamtha	115 /22kV	2008	ADB, NDF, EDL	EDL
3	Xam Neua	Huaphan	115 /22kV	2011	CERIECO, China?	EDL
4	Houayxay	Bokeo	115 /22kV	2012	ADB, NDF, EDL?	EDL
5	Namoh SWS	Luangnamtha	115/115kV	2014	ADB, NDF, EDL?	EDL
6	Boun Neua	Phongsaly	115 /22kV	2014	?	EDL
7	Thongkhoun	Vientiane	115/115kV	2007	Phubia mining	Phubia mining
8	Hin Heup SWS	Vientiane	115/115 kV	2008	ADB, NDF, EDL	EDL
9	Hin Heup SS	Vientiane	230/115kV	2010	China?	EDL
10	Pak Mong	Luangprabang	115/22kV	2008	ADB, NDF, EDL?	EDL
11	New1	Vientiane Capital	115/22kV	2010	?	EDL
12	Naxaythong	Vientiane Capital	230/115kV	2010	China?	EDL
13	New2	Vientiane Capital	115/22 kV	2011	EDL?	EDL
14	Hongsa	Xayabury	115/22 kV	2011	Ban Pu	Ban Pu
15	Muong Kham	Xiengkhuang	115/22 kV	2011	China?	EDL
16	Luangprabang2	Luangprabang	115/22 kV	2011	China?	EDL
17	Luangprabang2	Luangprabang	230/115 kV	2011	China?	EDL
18	Khonsong	Bolikhamxay	115/22kV	2012	THPC	THPC
19	Paklay	Xayabury	115/22 kV	2013	ADB, NDF, EDL?	EDL
20	Xanakham	Vientiane	115/22 kV	2014	Mining?	
21	Khok Saat	Vientiane Capital	230/115kV	2014	EDL?	EDL
22	New3	Vientiane Capital	115/22 kV	2015	EDL?	EDL
23	Mahaxay	Khammouan	115/22 kV	2009	NTEC	EDL
24	Sepon	Savannakhet	115 /22kV	2014	China?	EDL
25	Pakxong	Champasak	115/22 kV	2009	NORINCO, EDL	EDL
26	Saravan	Saravan	115 /22kV	2010	World Bank, EDL?	EDL
27	Sekong	Sekong	115 /22kV	2014	Vietnam?	EDL

8.3 Short List of Prioritized Projects

According to the selction criteria 2 “Excluding the projects that are under construction or have firm expectations of fund sources”, the seclection criteria 3 “Excluding the projects whose power transmission role is restricted to a specified IPP and the selection criteria 4 “Excluding the projects that play a power supply role restricted to one specified power consumer such as a large-scaled mine or factory”, projects possessing surefire fund sources as listed below were excluded.

(i) Transmission line project No. 12: Luangnamtha - Border (China)

This project is one that mainly aims at domestic power supply to Laos. However, the interconnection to China enhances greatly the possibility of Chinese investors being introduced. In the selection criteria 2, this project is excluded from the prioritized projects. The connecting point of this project may be changed to the substation neighbour to the Luangnamntha substation.

(ii) Transmission line project No. 15: Xeset1 – Saravan

This project has already begun receiving funding from the World Bank meeting the selection criteria 3 and hence is not recognized as a prioritized project.

(iii) Transmission line project No. 38: Luangnamtha – Bokeo

This project had been studied by ADB's masterplan meeting the criteria 3 and hence is not recognized as a prioritized project.

(iv) Transmission line project No. 50, 51, 52: Sepon3 – Sepon(Mine)、Sepon3 (U) - Sepon (D), Sepon3 (D) – Saravan

This project is a transmission line project used for transmitting power generated from the Sepon hydropower station to the EDL grid. Sepon hydropower station is expected to be an IPP that will possibly funded by China. Thus, this project meets the criteria 3 and hence is not recognized as a prioritized project.

(v) Transmission line project No. 62: Saravan – Sekong

This project has the strong possibility of being funded by India coming under the criteria 2 and hence will not be recognized as a prioritized project.

(vi) Substation project No.6: Boun Neua substation

The main portion of the load of this substation, 60 MW with a total load of 80 MW, will be consumed by a mining company invested in by China, thus meeting the criteria 4 and hence will not be recognized as a prioritized project..

(vii) Transmission line projects No. 44, 49, 59, 61, 63, 64, 66, 67, 71, 72, 73, 74, 75, 76 and 77

All of those projects are transmission line projects to be used for power transmission from a single IPP power station to the EDL grid thus meeting the criteria 3 and hence will not be recognized as prioritized projects. From the aforementioned examinations, the prioritized projects were selected among all the projects as listed in Table 8.3-1.

Table 8.3-1 Prioritized Projects

No.	Project No.	Projects
1	Substation 11	Installation of New 1 substation
2	Substation 12, 22	Installaiton of New 2 substaiton and Installation of New 3 substation
3	Transmission 26, 27	Construciton of another circuit in Luangprabang 1 - Pakmong - Oudomxay
4	Transmission 29, 65	Construciton of another circuit in Nam Mang 3 - Khoksaad Construciton of Nam Leuk - Nam Mang 3
5	Transmission 31, 32, 35, 70	Construciton of another circuit in Khoksaad – Thanaleng Reinforcement of Thanaleng - Thai Reinforcement of Phontong - Thanaleng Construction of 230 kV Naxaythong - Khoksaad
6	Transmission 5	Construciton of another circuit in Hin Heup - Vang Vieng
7	Transmission 54	Construciton of Kengkok – Sepon
8	Transmission 58	Construciton of another circuit in Non Hai - Ban Don
9	Transmission 60	Construciton of Kengkok – Saravan
10	Transmission 48	Reinforcement and construction of another circuit in Bang Yo - Border

8.4 Selection Criteria for Highest Prioritized Project

The following points of the prioritized projects were evaluated from the perspectives of urgency, effectiveness, costs and social/environmental considerations.

(1) Urgency

The candidates were evaluated from the required commissioning year and for the reason of necessity.

(2) Effectiveness

Evaluations were carried out from the following perspectives.

- The degree of project priorities for domestic power supply is increased and the degree of project priorities mainly for power export of domestic surplus power is lower
- Projects are prioritized if without them in the near future, a high possibility of causing power supply interruptions exists.
- Projects expected to have a large power flow, calculated as a 2016 power system simiulation, are prioritized.
- Projects that have a large power flow per unit cost are prioritized.

(3) Screening for Short-listed Projects from the Points of Environmental and Social Consideration

10 short-listed projects that were prioritized project candidates were screened from the points of environmental and social consideration. Considering its importance at the early stages of project design, the possible negative impacts regarding transmission route selection were examined in each short-listed project. Measures for evaluating the impacts were chosen from "Table 3.8-1 Possible impacts in design and construction phases" in the Section 3.9.4. Those measures are as follows, 1) resettlement and loss of agricultural lands, 2) deterioration of the local economy, 3) disturbance to social infrastructures and services, 6) loss of historical, cultural and archeological properties and heritages, 7) ethnic people, 8) disturbance to wild life or in protected areas, 9) cleaning of forests or bushes interfering with a transmission lines right of way, 10) destruction of landscape, 11) soil erosion and 18) accidents caused by UXO. In reviewing the information gathered at the site survey in the North and the South provinces as well as reliable secondhand information resources collected during the second site study, four measures, 1) resettlement and loss of agricultural lands, 7) ethnic people, 8) disturbance to wild life or in protected areas and 18) accidents caused by the UXO were considered to be applicable to impact evaluations. Measures other than these four were omitted because there was limited information available at this stage. As for measure 9) the cleaning of forest or bushes interfering with the transmission line's right of way, the impact was not appropriately evaluated because the reliable land uses a map that was not available. However, the impact of the measure was taken into account in case the transmission line route was aligned in the NBCA and/or protection forest and the result was reflected on the impact measured by 8) disturbance to wild life or in protected areas. The following are evaluation criteria applied for and second resources referred to at the screening process. The maps used here are shown in the Section 7.5 Environmental and Social consideration on long-term power network plan.

1) Resettlement and loss of agricultural lands

Evaluation criteria: The population densities in project areas were taken into account. With regards to the loss of agricultural lands, it is not discussed here because there was no reliable land usage map available to pinpoint specific locations of agricultural lands. In considering the standards on resettlement[1], it was stipulated that projects that affect over 200 people or if the number of an ethnic minority exceeds 100 persons, development of a mitigation plan, or formulation of evaluation criteria is required.

A: Severe impact is predicted: a project where the transmission line route is aligned with the area where the population density is more than 100 persons per square km

B: Some impact is predicted: a project where transmission line route is aligned in an area where the population density is from three to 100 persons per square km

[1] Environmental Management Standard for Electricity Project, No.0366/MIH.DOE

C: Extent of impact is unknown (Examination is needed): A project where the transmission line route is aligned with an area where the population density is from 0 to 2 persons per square Km

No mark: No impact is predicted: A project where the transmission line route is aligned with an area where the population density is 0 persons per square km

Reference: Population Density in Lao PDR (Figure 7.5-19)

7) Ethnic people

Evaluation criteria: Distribution of ethnic people in project areas was taken into account.

A: Severe impact is predicted: A project where the entire transmission line route is aligned with an area where the composition of villages by ethnic minority people is more than 99%

B: Some impact is predicted: A project where some part of the transmission line route is aligned with an area where the composition of villages by ethnic minority people is exceeds 99% and/or the entire transmission line route is aligned with an area where the village composition of ethnic people comprises from 80% to 99%

C: Extent of impact is unknown (Examination is needed): a project where some part of the transmission line route is aligned with an area where the composition of villages by ethnic minority people comprises 80% to 99%

No mark: No impact is predicted: the project where the entire transmission line route is aligned with an area where the composition of villages by Lao-Tai ethno-linguistic families (ethnic majority people) comprises more than 99%

Reference: Distribution Map of Ethnic People in Lao PDR (Figure 7.5-21)

8) Disturbance to wild life or protected areas

Evaluation criteria: Protected areas (NBCA and protection forest) within project areas were taken into account.

A: Severe impact is predicted: a project where the transmission line route is aligned with an protected area

B: Some impact is predicted: a project where the transmission line route is aligned adjacent to a protected area

C: Extent of impact is unknown (Examination is needed): a project where the transmission line route is aligned near a projected area

No mark: No impact is predicted: a project where there is no protection area near the transmission line route

Reference: The NBCA and Protection Forest Map in Lao PDR (Figure 7.5-1) and NBCA and Protection Forest Map in each province (Figure 7.5-2～Figure 7.5-18)

18) Accidents caused by UXO

Evaluation criteria: UXO contamination in project areas was taken into account.

A: Severe impact is predicted: a project where the entire route of the transmission line is aligned with a contaminated area of UXO

B: Some impact is predicted: a project where some part of the transmission line route is aligned with a contaminated area of UXO

C: Extent of impact is unknown (Examination is needed): a project where less than 10% of the transmission line route is aligned with a contaminated area of UXO

No mark: No impact is predicted: a project where there is no area of UXO contamination near the transmission line route

Reference: UXO Contamination Map in Lao PDR (Figure 7.5-20)

8.5 Selection of Highest Prioritized Project

The ten prioritized projects listed in Table 8.3-1were evaluated according to designated criteria for the highest prioritized project. Potential negative impacts were predicted for each candidate project, however, the degree of impact is considered to be not severe and minimizing negative impact is attainable by taking appropriate mitigation measures during the project design phase.

Table 8.5-1 shows the contents of the evaluation results including the result of environmental screening. The outlines of the evaluation were as follows.

<u>Prioritized project 1: installation New1 Substaiton</u>

Recently, the Phonetong Substation has been operating under almost overloaded conditions. In the near future, the power flow is expected to reach its limit. Thus, the installation of a New 1 substation is required for a rapid load increase in the Vientiane Capital. Wthout this project, large power blackouts are to be expected. This situation is urgent. With regards to environmental and social considerations, special attention needs to be paid to minimizing resettlements at the sub-station site.

<u>Prioritized project 2: installation of New 2, New3</u>

As is the case with New1, installation of New 2 and New 3 will be required successively during the years from 2012 to 2015. The reason for the requirements is similar to the case with New1. However, because the required commissioning years are later than New1, the urgency of this project is weak. With regards to environmental and social considerations, special attention needs to be paid to minimizing resettlement at the sub-station site.

<u>Prioritized project 3: adding a new circuit in Luangprabang1 – Pakmong – Oudomxay</u>

This project is to add a single circuit to the transmission lines supported by ADB fund sources yielding relatively not so high impacts. With regards to environmental and social considerations, special attention needs to be paid to the distribution spread of ethnic people in project areas where a high rate of ethnic minorities are expected. Mitigation measures need to be taken as required.

<u>Prioritized project4: construction of Nam Leuk - Nam Mang3, adding a new circuit in Nam Mang3 - Khoksaad</u>

After 2011, when hydropower stations such as the Nam Lik1, Nam Ngum 5, Nam Lik 1/2 will start operations. The Central 1 grid will have the surplus power during wet seasons and the capability of being able to export power to Thailand. Those projects will be required for the power export of such surplus power. (As described in the Section 9.10) Thus, the ranking of priorities considered from the viewpoints of urgency and effectiveness is low according to the criteria that the high priority should be put on those projects realizing a sufficient amount of domestic power supply during the dry seasons. With regards to environmental and social considerations, an alignment of transmission line needs to avoid NBCA between Nam Leuk and Nam Mang 3. Considering the high rate of ethnic minorities living in the northern part of the

Vientiane province, special attention needs to be paid to the distribution spread of ethnic people. Mitigation measures need to be taken as deemed necessary.

Prioritized project 5: reinforcement of Khoksaad-Thanaleng, Phontong - Thanaleng and Thanaleng-Thai and Construction of 230 kV Naxaythong - Khoksaad

The reason is identical to the case of the Prioritized project 4. With regards to environmental and social considerations, special attention needs to be paid to minimizing resettlement near the Thanaleng area between the Khoksaad-Thanalleng transmission line route and near the Nasaythong area between the Naxaythong-Khoksaad transmission line route. The negative impacts regarding screening measures discussed here are not predicted between the Phontong-Thanaleng transmission line routes because the transmission line is to be reconstructed on an existing route.

Prioritized project 6: adding a circuit of Hin Heup - Vang Vieng

The reason is identical to the case of Prioritized Project 4. The project has two options for selecting transmission line routes at this stage. Option 1) a transmission line is to be aligned in parallel with an existing transmission line. In this case, the alignment of the transmission line needs to bypass protected forest areas near Vang Vieng. Further, special attention needs to be paid to the distribution spread of ethnic people in project areas where high numbers of ethnic people are expected to reside. Mitigation measures need to be taken as deemed necessary. Option 2) a transmission line is to be aligned on the existing route. In this case, negative impact regarding the screening measures discussed here are not expected.

Prioritized project 7: construciton of Kengkok - Sepon

This project is to transmit power from the Xepon hydropower station to Kengkok supporting the transmission line route from Xepon to Kengkok through Mahaxai and Thakhek. The power flow and the priority of this project are lower than Kengkok-Saravan that will take a similar role of power transmission from the South region to the Central 2 to this project. With regards to environmental and social considerations, special attention needs to be paid to the area near Sepon in the Savannakhet province where a high risk of UXO contamination is expected. A site investigation and cleaning of UXO needs to be implemented prior to construction. Considering the high rate of ethnic minorities living around the Sepon area, special attention needs to be paid to the distribution spread of ethnic people.

Prioritized project 8: construciton of Non Hai - Ban Don

This project is to add a single circuit of the existing line route causing limited impact. With regards to environmental and social considerations, special attention needs to be paid to the distribution of ethnic people in the project area where a high number of ethnic minorities are expected to reside. Mitigation measures need to be taken as appropriate.

Prioritzed project 9: construciton of Kengkok - Saravan

This project will be required when the Houaylamphan (68 MW; 2014) will be commissioned in the South region. After that, when the hydropower stations will be operated successively, this project will take on the role of supplying to the C2 region where power shortage is to be expected during the dry seasons utilizing the surplus power in South region. The power flow in this project is the largest (100 MW at maximum) and can much reduce power imports from Thailand. With regards to environmental and social considerations, special attention needs to be paid to the area near area near the Vietnam border in the Saravan province where a high risk of UXO contamination is expected. The site investigation and cleaning of UXO needs to be implemented prior to construction. In addition, in considering the high number of ethnic minorities residing in the area, special attention needs to be paid to the distribution spread of ethnic people in the project area.

Prioritized project 10: reinforcement and adding a single circuit of Bang Yo - Border

This project will be required for the power export of surplus power in the South region to Thailand. Thus, the degree of the priority considered from the perspective of urgency and effectiveness is low according to the criteria that high priority should be placed on projects realizing a sufficient amount of domestic power supply during the dry seasons. With regards to environmental and social considerations, special attention needs to be paid to minimizing resettlement in Pakse City, Champasack Province.

As stated above, the following two projects are selected as the higher prioritized projects taking on a relatively high importance.

- **Installation of New 1**
- **Construction of Kengkok-Saravan**

The installation of the New 1 substation will avoid the power supply interruption of around 20 MW for the important customers such as government offices, commercial activities and factories in the Vientiane capital and will be able to reduce the loss of power over the distribution systems. Although the New 1 substation has a high degree of both importance and urgency, the construction of the Kengkok-Saravan was selected based on counterpart discussions regarding the highest prioritized project for this study that can carry on wide power trade and much reduce power imports from Thailand.

The project of Kengkok-Saravan can also contribute to the improvement of the rural electrification rate by the installation of the substation that has been described in Chapter 11 at the middle of the line as well as power transmission to the Central area.

Reviewing of the power system plans describe in Chapter 7 and this 8 also clarify the degree of the priority of this project.

Figure 8.5-1 shows the route map of Kengkok-Saravan. The blue coloured line on the map indicates the route of the transmission line. As mentioned later, it would be beneficial if the starting point is changed from Kengkok to Pakbo, therefore, in the following sections in this report, the highest prioritized project is named “Construction of the transmission line from Pakbo to Saravan”.

Table 8.5-1(a) Comparison among Prioritized Projects

	Projects	Urgency			Efficiencies	
		Reason for Requirements	Requiring year		Power flow in 2016	Cost
1	New 1 Substation	Increase in power consumption in Vientiane Capital causes the overloaded condition of Phonetong substation. To avoid it, a new substation is installed.	2010	Required when the existing capcity of Phonetong substation will not be enough for power supply to Vientinane Capital.	20MW	10 million US$
2	New 2, New 3 Substation	Ditto.	New2 : 2011 New3: 2015	Required when after New1 commissioned and the capacities of the existing substations become insufficient.	New2: 37 MW New3:	New2: 8 million US$ New3: 25 million US$
3	Luangprabang 1 – Pakmong – Oudomxay(add.cct.)	To enhance the system reliability in case of missing of a single circuit of Luangprabang -Pakmong-Oudomxay constructed by ADB fund.	2011		0-13 MW	3.94 million US$
4	Nam Mang 3 - Khoksaad (Install an add.cct.) Nam Leuk - Nam Mang3	C1 grid will have the surplus power in wet season in the future. To utilize the power, the projects will be required for power export to Thailand.	2011-2014	Required when hydropower stations commissioned such as Nam Lik1、Nam Ngum5、Nam Lik1/2	29-48 MW	18 million US$
5	Khoksaad-Thanaleng (Construct an add.cct.) Thanaleng-Border (Upgrade) Phontong-Thanaleng (Upgrade) Naxaythong – Khoksaad	ditto	2011-2014	ditto	8-70 MW	14.5 million US$
6	Hin Heup - Vang Vieng (Install an add.cct.)	ditto	2011	ditto	2-17 MW	2.07 million US$
7	Kengkok- Sepon	Increase in the power consumption in Savannakhet Provinse will cause the heavily loaded condition from Pakbo to Kengkok. The transmission line has to be constructed from Sepon to Kengkok.	2014	Required when the heavy load expected in Pakbo-Kengkok due to increase in the load of Savannakhet	32-43 MW	13 million US$
8	Non Hai - Ban Don (New construction)	Increase in the power consumption in Non Hai will cause the heavily loaded condition from Ban Don – Non Hai. A circuit has to be added.	2014	Required when the heavy load expected in Ban Don –Non Hai due to increase in the load in the direction to Non Hai	24-41 MW	6.17 million US$
9	Kengkok – Saravan	Increase in the power consumption in Central 2 will causes the power shortage in the Central 2. The surplus power in the South will be supplied to the Central 2.	2014	Required when Houaylanphan (68 MW, 2014) commissioned	86-88 MW	33 million US$
10	Bang Yo – Border (New Construction)	To utilize the surplus power in the South region after hydropower stations commissioned.	2012	Required when Xekatam (60 MW, 2012) commissioned	39-79 MW	6.7 million US$

Table 8.5-1(b) Comparison among Prioritized Projects

	Projects	Efficiencies		Social/Environmental Considerations	Evaluation
		Effects	Impact		
1	New 1 Substation	• Secure power supply ability for Vientiane Capital • Enhance power system supply reliability • Covering industrial zone plans • Distribution loss reduction in Vientiane Capital	Without this project, the large power supply interruption expected making large impact.	Special attention needs to be paid for minimizing resettlement in sub-station site in Vientiane Capital	Strong candidate for the highse prioritized project
2	New 2, New 3 Substation	• ditto	ditto	ditto	Required after New 1 substation
3	Luangprabang 1 – Pakmong – Oudomxay(add.cct.)	• Enhancement of supply reliability • Transmission loss reduction	The project just with adding a circuit to the existing transmission line making a small impact.	Special attention needs to be paid for the distribution of ethnic people in the project area where high rate of ethnic minority is expected.	The degree of the priority is low
4	Nam Mang 3 - Khoksaad (Install an add.cct.) Nam Leuk - Nam Mang3	• Increase in revenue by power export to Thailand • Secure the power supply ability to Vientiane Capital in case of emergency	This project can reduce the power import from Thailand making a smaller impact.	An alignment of transmission line needs to avoid NBCA between Nam Leuk and Nam Mang3. Special attention needs to be paid for the distribution of ethnic people.	Required for the power export of surplus power. The degree of the priority is lower comaring the projects realizing the enough domestic power supply in dry seasons.
5	Khoksaad-Thanaleng (Construct an add.cct.) Thanaleng-Border (Upgrade) Phontong-Thanaleng (Upgrade) Naxaythong – Khoksaad	• ditto	ditto	Special attention needs to be paid for minimizing resettlement between Khoksaad-Thanalleng transmission line route and between Naxaythong-Khoksaad transmission line route.	ditto
6	Hin Heup - Vang Vieng (Install an add.cct.)	• Increase in the revenue by power export to Thailand • Secure the power supply ability to Vientiane Capital in case of emergency and unil 230 kV Luangprabang - Hin Heup commissioned	ditto	The alignment of transmission line needs to avoid protection forest area near Vang Vieng. Also, special attention needs to be paid for the distribution of ethnic people.	ditto
7	Kengkok- Sepon	• Enhancement of supply reliability • Suppoting the other transmission line route from Sepon hydropower station to Kengkok through Mahaxay andThakhek • Transmission loss reduction	Even without this project, the altebative can be place such as an increase in the number of circuit in Pakbo-Kengkok	Special attention needs to be paid in the area near Sepon in Savannakhet province where the high risk of UXO contamination is expected. The special attention needs to be paid for the distribution of ethnic people	One of the strong candidates, however, The power flow and the priority of this project are lower than Kengkok-Saravan that will take a similar role of power transmission from the South to the Central 2
8	Non Hai - Ban Don (New construction)	• Enhancement of supply reliability • Transmission loss reduction	The project just with adding a circuit to the existing transmission line making a small impact.	Special attention needs to be paid for the distribution of ethnic people in the project area where high rate of ethnic minority is expected.	With not so large power flow and not so high cost performance
9	Kengkok – Saravan	• Enhancement of supply reliability to C2 region • This project can reduce much power import from Thailand.	Without this project, the large power supply interrputoion would be expected in C2 making large impact.	Special attention needs to be paid near Vietnam border in Saravan province where the high risk of UXO contamination is expected. The special attention needs to be paid for the distribution of ethnic people in the project area.	The power flow in this project is large with high operational factor. The efficency of the cost is higher than other projects.
10	Bang Yo – Border (New Construction)	• Increase in revenue by power export to Thailand • Secure the power supply ability to the South region in case of emergency	This project can reduce the power import from Thailand making a small impact.	Special attention needs to be paid for minimizing resettlement in Pakse City , Champasack Province	Required for the power export of surplus power. The degree of the priority is lower comparing the projects realizing the enough domestic power supply in dry seasons.

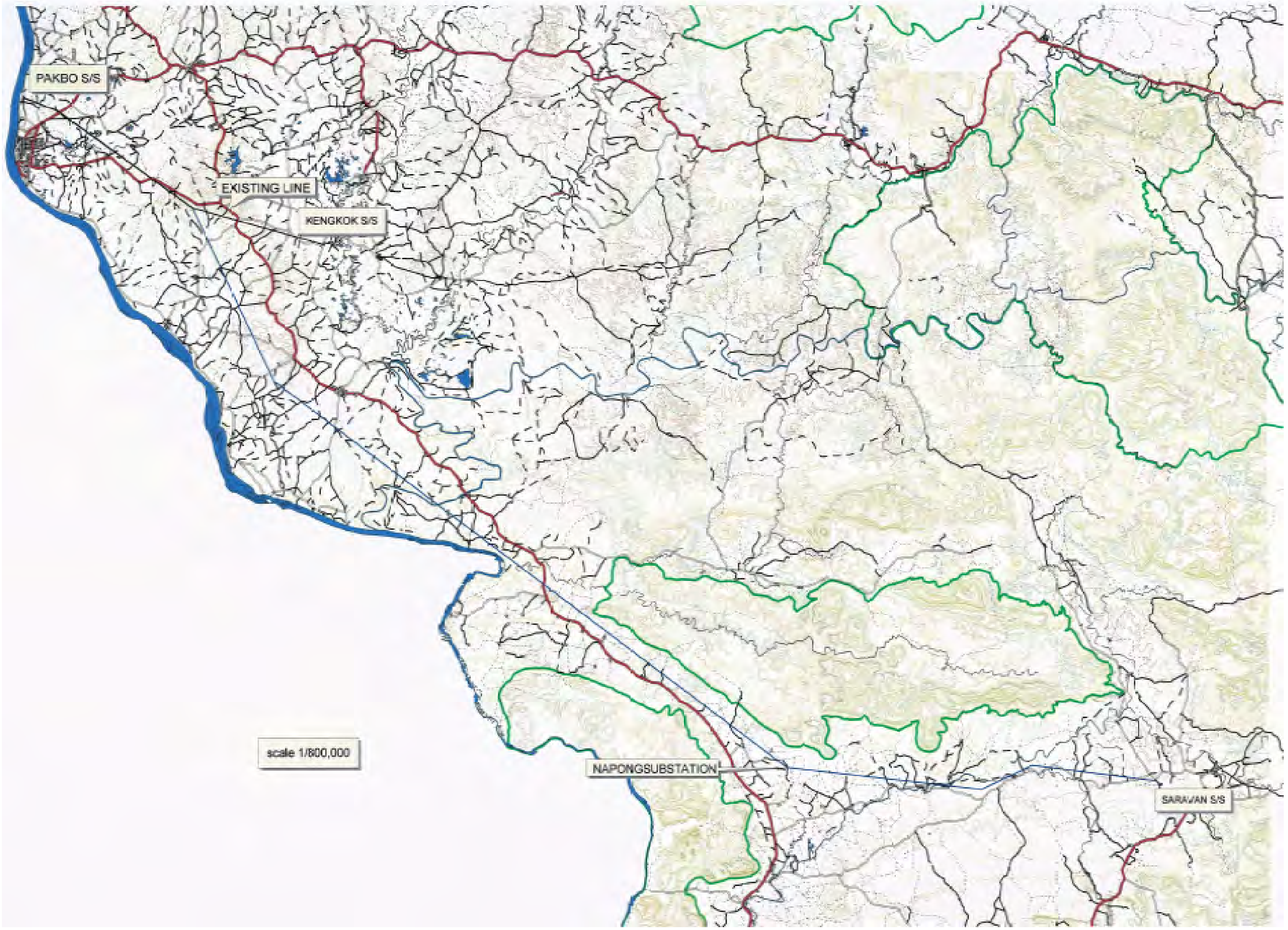

Figure 8.5-1 The Location Map of the Highest Prioritized Project

8.6 Benefits of Highest Prioritized Project

Benefits of the highest prioritized project have been examined by a series of simulations based on demand forecasts (base case), which the study team has analyzed and the power development plan that was provided by DOE and EDL. The benefits to be had if the highest prioritized project is implemented are compared to the benefits to be had if the project is not implemented. Simulations calculate the benefits quantitatively as a reduction in power imports from Thailand and the curtailed reserve capacity from reliability improvements by the project. The benefits from implementation of the highest prioritized project consist of reduction in power import from Thailand by power supply to the Laos Central 2 system from the Laos South system and incremental power export in rainy season through the highest prioritized project.

(1) Conditions for Simulations

A capacity of interconnection between the Central 2 system and the South system by the highest prioritized project is 180 MW, which takes into consideration two (2) circuits of 115 kV transmission lines and a single circuit of 115 kV transmission line from the Xepon hydropower station to the Saravan substation through the Xepon mines under N-1 criteria. There is no interconnection between the Central 2 system and the South system under N-1 criteria when the highest prioritized project would not be constructed.[2]

(2) Results of Simulations

Figure 8.6-1 illustrates the power exchanges of the Laos North & Central 1, the Central 2 and the South, when the highest prioritized project is implemented. The transmission line from Pakbo to Saravan provides 434 GWh (in the year 2015) from the Laos South system to the Laos Central 2. It curtails power imports from Thailand.

The surplus power in the Laos South flows to the Laos Central 2 through the Thai system, when the highest prioritized project is not implemented. The tariff on imported energy is higher than that for exported energy. No implementation of the project will cause an economic loss in Lao PDR.

The amounts of different power exchanges in with and without the project have been calculated by a simulation of balancing the supply/demand from 2014 to 2020. The difference in power exchanges is shown in Table 8.6-1. Benefits from the project are shown every year even if a balance between supply and demand causes some fluctuations. The averages of benefits are over 230 GWh.

Power import export with Thailand in 2015, when the highest prioritized project is implemented, is illustrated in Figure 8.6-2. Amount of import from Thailand in the Laos North & Central 1 system can be curtailed because the power supply conducts from the Laos South system to the Laos Central 2 system.

Benefits of reduction in reserve capacity from the system reliability improvement from interconnection between the Laos Central 2 system and the Laos South system by the highest prioritized project are illustrated in Figure 8.6-3. A reduction in reserve capacity is saturated in 0.1 MW at 100 MW of interconnection capacity in 2015. The benefits of improved system reliability by the project is equal to a 0.1 MW reduction of hydropower plants.

[2] Transmission line from Xepon hydropower to Saravan substation is transmission from a power station. It is not considered a capacity as an interconnection. It is also a single line transmission line. A single line transmission is not utilized to an interconnection under N-1 criteria.

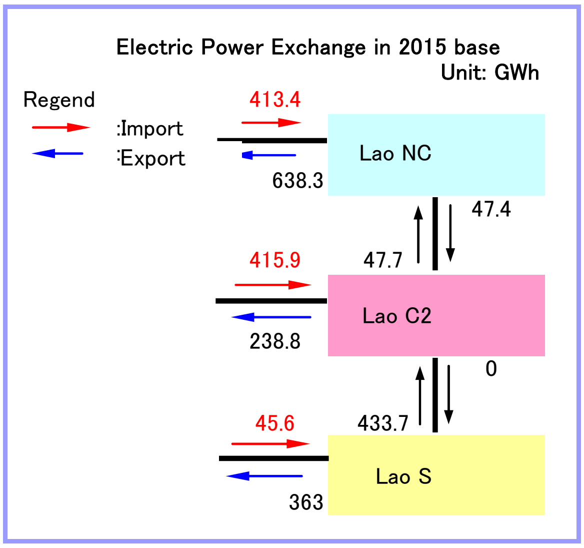

Figure 8.6-1 Power Exchanges of Laos Systems in the Project Implementation (2015)

Table 8.6-1 Amount of Different of Power Exchanges in with and without the Project

(GWh)

	2014	2015	2016	2017	2018	2019	2020	Ave.
Incremental Export to Thailand	-100.2	91.7	82	20.9	238.2	227.8	306.4	123.8
Curtailed Import from Thailand	-244.3	-169.8	-84.9	-189	-28.1	-15	-29.4	-108.6
Benefits	144.1	261.5	166.9	209.9	266.3	242.8	335.8	232.5

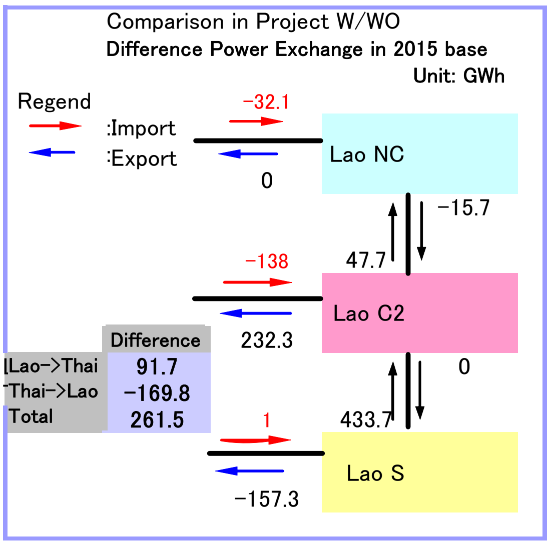

Figure 8.6-2 Power Import Export between Laos and Thailand with the Project in 2015

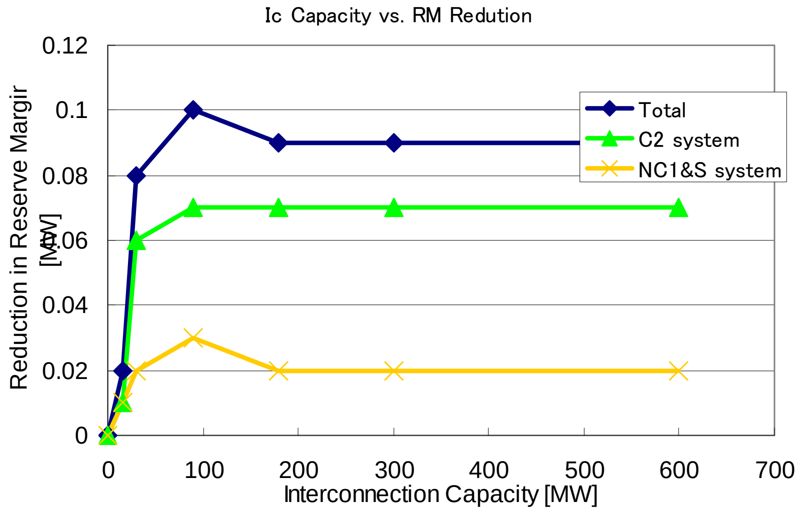

Figure 8.6-3 Reduction in Reserve Capacity vs. Interconnection Capacity with the Project in 2015

8.7 Project Evaluation on the Highest Prioritized Project

This sub-section analyzes the prioritized project selected in the first phase of this study from an economic point of view. The methodology is to conduct a cost benefit analysis to examine cases with and without the project. The cases to be analyzed are shown in Table 8.7-1.

Table 8.7-1 The Cases to be Analyzed

A) Base case:	The case connecting Central 2 region with the South region with 115 kV transmission line. The existing Power Development Plan also incorporates this case.
B) Import case:	The case without the 115 kV transmission line. In this case, the Central 2 region will be supplied electricity from the South region through EGAT's grid

Figure 8.7-1 shows the power flow for each case.

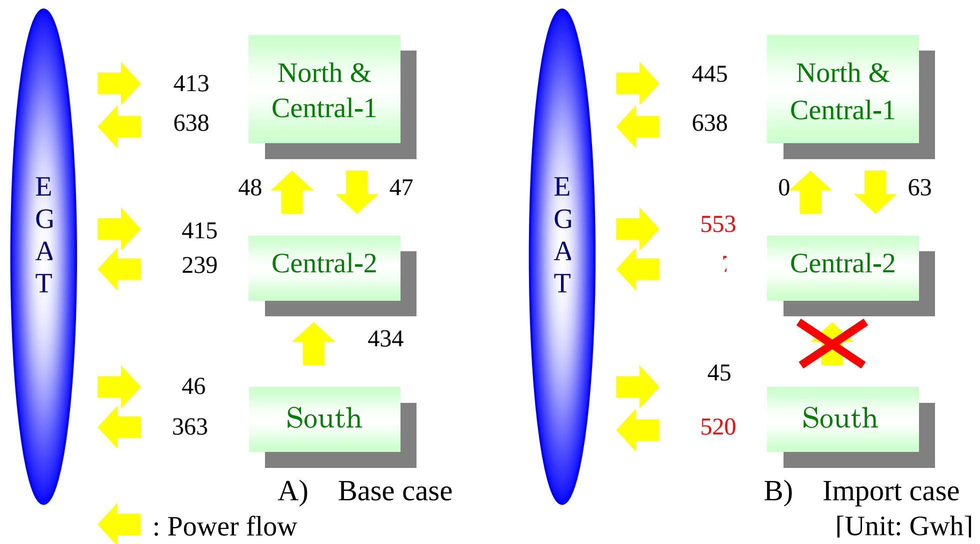

Figure 8.7-1 Power Flow in 2016

(Note: Developed by the JICA Study Team based on the interview with EDL)

The major difference between the two cases is the amount of Lao's power exchange with Thailand, including the electricity transmitted from the South region to the Central 2 region. The numbers in red in Figure 8.7-1 represent those with a large difference value.

The analysis assumed the evaluation period to be 33 years, including a construction period of 3 years. The construction costs, including operations and maintenance cost (O&M cost), are set as cost parameters because the purpose of the evaluation is to compare the difference between the two cases, with and without the prioritized project. The amount of the O&M cost is assumed to be 1% of the total construction cost for transmission lines, and 1.5% for substations.

The analysis set electricity sale revenue as benefit parameters. Because there are no difference in domestic sales between the two cases, only the balance of import and export sales is regarded as a benefit parameter. In order to make the calculation simple, peak rates are used as representative rate for import/ export tariffs. For the amount of power import and export, the average values of each during 2014 to 2020, which are shown in Table 8.6-1 "Amount of Different of Power Exchanges in with and without the Project" in the former section, are used. Table 8.7-2 shows the assumption for this analysis.

Table 8.7-2 Figures Used for the Evaluation

Item		Item	
Export tariff to EGAT (peak time)	1.60 THB/kWh	Lifetime of transmission facilities	30 years
Import tariff from EGAT (peak time)	1.79 THB/kWh	Inflation rate	10%
Currency Exchange rate as of 2009.Aug., 27.	2.75 JPY/THB		

*THB: Thai baht, JPY: Japanese Yen

The result of the analysis is shown in Table 8.7-3.

Table 8.7-3 The Result of Economic Analysis

Unit: Million USD

Fiscal Year	Cost Construction O&M cost	Gross Benefit Energy (GWh/year) exp	save-imp	Tariff (US Cent/ kWh) Expport	Import	Total Benefit	NET
FY2011	11.78	0	0	0	0	0	-11.78
FY2012	11.78	0	0	0	0	0	-11.78
FY2013	11.78	0	0	0	0	0	-11.78
FY2014	0.38	124	110	4.7	5.3	11.63	11.25
FY2015	0.38	124	110	4.7	5.3	11.63	11.25
FY2016	0.38	124	110	4.7	5.3	11.63	11.25
FY2017	0.38	124	110	4.7	5.3	11.63	11.25
FY2018	0.38	124	110	4.7	5.3	11.63	11.25
FY2019	0.38	124	110	4.7	5.3	11.63	11.25
FY2020	0.38	124	110	4.7	5.3	11.63	11.25
FY2021	0.38	124	110	4.7	5.3	11.63	11.25
FY2022	0.38	124	110	4.7	5.3	11.63	11.25
FY2023	0.38	124	110	4.7	5.3	11.63	11.25
FY2024	0.38	124	110	4.7	5.3	11.63	11.25
FY2025	0.38	124	110	4.7	5.3	11.63	11.25
FY2026	0.38	124	110	4.7	5.3	11.63	11.25
FY2027	0.38	124	110	4.7	5.3	11.63	11.25
FY2028	0.38	124	110	4.7	5.3	11.63	11.25
FY2029	0.38	124	110	4.7	5.3	11.63	11.25
FY2030	0.38	124	110	4.7	5.3	11.63	11.25
FY2031	0.38	124	110	4.7	5.3	11.63	11.25
FY2032	0.38	124	110	4.7	5.3	11.63	11.25
FY2033	0.38	124	110	4.7	5.3	11.63	11.25
FY2034	0.38	124	110	4.7	5.3	11.63	11.25
FY2035	0.38	124	110	4.7	5.3	11.63	11.25
FY2036	0.38	124	110	4.7	5.3	11.63	11.25
FY2037	0.38	124	110	4.7	5.3	11.63	11.25
FY2038	0.38	124	110	4.7	5.3	11.63	11.25
FY2039	0.38	124	110	4.7	5.3	11.63	11.25
FY2040	0.38	124	110	4.7	5.3	11.63	11.25
FY2041	0.38	124	110	4.7	5.3	11.63	11.25
FY2042	0.38	124	110	4.7	5.3	11.63	11.25
FY2043	0.38	124	110	4.7	5.3	11.63	11.25
TOTAL	46.65	3,720	3,300			348.76	302.11

NPV2009@10%	45.80

The result shows that case-A (Base case) would bring 45.8 Million USD (at 93.4 JPY/ USD as of Aug. 27, 2009, by Yahoo Finance) more than case-B (Import case) from economic aspect. Therefore, the 115 kV Transmission project linking the Central 2 region with the South region would be superior also from economic points of view.

8.8 Power Flow and Voltage Analysis Considering the Highest Prioritized Project

In this section, the power system analysis taking into consideration the most prioritized project selected in the former section was conducted. For the transmission line, either Kengkok or Pakbo can be the candidate starting point and either Saravan or Ban Jianxai can be the candidate ending point. Besides, there is a concept underlying the placing of the Napong switching station, 55 km westward from Saravan substation. The new switching station was also considered for the system analyses and several candidate system configurations were compared.

8.8.1 Conductor Size

Conductor sizes which satisfy both the system planning criteria and economic efficiency simultaneously were determined through the study of relationship between power flow and annual costs (sum of construction cost, O&M cost, and cost of transmission line losses) by conductor sizes. As the cost of transmission line loss, the export tariff for Thailand (hourly average) was applied since the income from power exports to Thailand will decrease due to the transmission line loss. Calculation conditions are shown in Table 8.8-1.

Table 8.8-1 Calculation Conditions

Conductor Size	115 kV ACSR	115 kV TACSR	115 kV ACSR	115 kV ACSR	115 kV ACSR
	240 mm^2	240 mm^2	410 mm^2	240 mm^2	410 mm^2
	Single	Single	Single	Double	Double
Construction Cost (2 cct) [USD/km]	146,400	159,600	178,500	249,700	296,900
Discount Rate : i	7%				
Life Time of Transmission Line: n	30 years				
Capital Recovery Factor*1	0.090				
O&M Cost Ratio of Transmission Line	1% of Construction Cost				
Resistance of Transmission Line (at 100 MVA Base) [%/km]	0.091	0.091	0.055	0.046	0.028
Power Factor of Power Flow: P_f	95%				
Annual Load Factor: L_f	85%				
Loss Factor*2	0.432				
Cost of Transmission Line Loss: Export Tariff	0.0284 USD/kWh				

*1: Capital Recovery Factor = $1 / [\{1 - 1 / (1 + i)^n\} / i]$
*2: Loss Factor = $(0.3 \times L_f) + (0.7 \times L_f^2)$
*3: Export Tariff (Hourly average) = (3.5 h x 0.0301 USD/kWh + 20.5 h x 0.0281 USD/kWh)/24 h

Table 8.8-2 Relationship between the Least-Annual-Cost Conductor Size and Power Flow

Conductor Size with Least Annual Cost	Power Flow		
	ACSR 240 mm^2 (Single)	ACSR 410 mm^2 (Single)	ACSR 410 mm^2 (Double)
Double Circuit Tower	～61 MW	61～135 MW	135 MW～

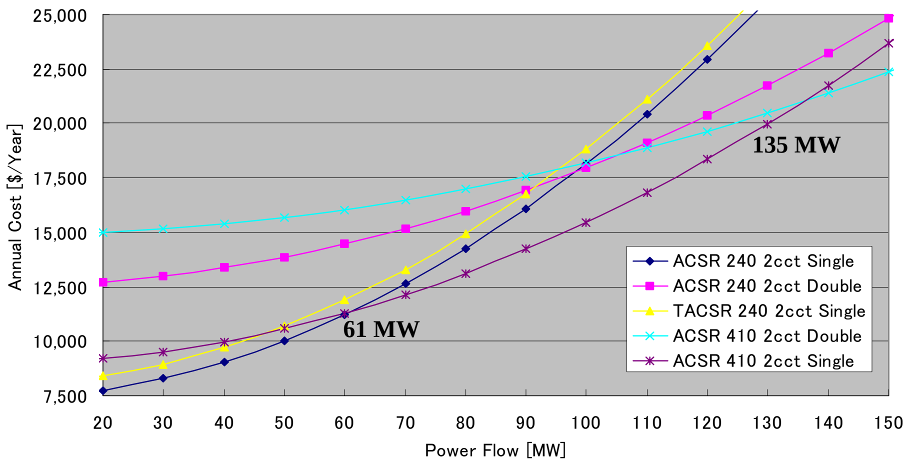

Figure 8.8-1 Relationship between Power Flow and Annual Cost

Based on the calculation result in the Section 7.4.4, the power flow of the target transmission line is about 42 MW/cct. Therefore, as of 2016, the most economical conductor type is the ACSR 240 mm^2 (single) according to Figure 8.8-1. After 2016, the power flow of the same section is expected to exceed 61 MW/cct, the crossing point of the curves above that the most economical conductor changes from an ACSR 240 mm^2 (Single) to an ACSR 410 mm^2 (Single). However, in this study, the ACSR 240 mm^2 (Single) was selected for the system analysis since this has severer conditions than that with the ACSR 410 mm^2 (Single).

8.8.2 Power Flow and Voltage Analysis

The power flow and voltage analysis study cases are shown in the Table 8.8-3. The connection pattern “Pakbo – Kengkok 1 cct, Kengkok – Napong – Saravan 2 cct” was rejected from the study cases since not only did the three circuits between Ban Jianxai and Bang Yo became subject to overloading but the bus voltages at the Sirindhom and Ubon substations also fell below 0.95 p.u, violating the voltage criteria for cases of one circuit fault in the secton between Pakbo and Kengkok.

Table 8.8-3 Power Flow and Voltage Analysis Study Cases

Dry/Wet	Case	Connection Patterns and Number of Circuits									
Dry Season	PF-D2	Pakbo	-	Kengkok	2	Kengkok	-	Napong	-	Ban Jianxai	2
	PF-D3	Pakbo	-	Kengkok	1	Pakbo	-	Napong	-	Saravan	2
	PF-D4	Pakbo	-	Kengkok	1	Pakbo	-	Napong	-	Ban Jianxai	2
Wet Season	PF-W2-80	Pakbo	-	Kengkok	2	Kengkok	-	Napong	-	Ban Jianxai	2
	PF-W3-80	Pakbo	-	Kengkok	1	Pakbo	-	Napong	-	Saravan	2
	PF-W4-80	Pakbo	-	Kengkok	1	Pakbo	-	Napong	-	Ban Jianxai	2

(1) Dry Season (PF-D2 to PF-D4)

The power flow and bus voltage analyses results under normal operations is shown in Appendix 8.8-1. Under normal operating conditions, no overloading of transmission lines or abnormal voltages at substation buses occur. Under the single contingency condition, the results of the power flow and voltage analyses were the same as those of case PF-D1, mentioned in 7.4.4 (1) PDP dry season condition. (Table 8.8-4 (a) to (c)) Switching operations and/or installation of static condensers can solve the voltage violation problems.

Table 8.8-4 (a) Power Flow and Voltage Analysis under Single Contingency Condition (PF-D2)

Fault Location					Analysis Result	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

Table 8.8-4 (b) Power Flow and Voltage Analysis under Single Contingency Condition (PF-D3)

Fault Location					Analysis Result	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

Table 8.8-4 (c) Power Flow and Voltage Analysis under Single Contingency Condition (PF-D4)

Fault Location					Analysis Result	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

(2) Wet Season (PF-W2-80 to PF-W4-80)

Under normal operating conditions, no overloading of transmission lines or abnormal voltage at substation buses occurs. (See Appendix 8.8-1) Under the single contingency condition, the results of the voltage analyses were the same as those of case PF-W1-80, mentioned in 7.4.4 (2). (Table 8.8-5 (a) to (c)) Switching operations and/or installation of static condensers can solve the voltage violation problems. For case PF-W2-80, overload occurs to the remaining two circuits for the section "Kengkok substation – Napong switching station – Ban Jianxai substation" under the single contingency condition identical to the case PF-W1-80, PDP wet season condition. The cause of overloading is the same as what is mentioned in 7.4.4 (2).

Table 8.8-5 (a) Power Flow and Voltage Analysis under Single Contingency Condition (PF-W2-80)

Fault Location					Analysis Results	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Ban Jianxai	115	Bang Yo	115	1	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 2
Ban Jianxai	115	Bang Yo	115	1	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 3
Ban Jianxai	115	Bang Yo	115	2	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 1
Ban Jianxai	115	Bang Yo	115	2	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 3
Ban Jianxai	115	Bang Yo	115	3	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 1
Ban Jianxai	115	Bang Yo	115	3	Overload	From Ban Jianxai 115kV To Bang Yo 115kV cct 2
Saravan	115	Sekong	115	1	Overload	From Saravan 115kV To Sekong 115kV cct 2
Saravan	115	Sekong	115	2	Overload	From Saravan 115kV To Sekong 115kV cct 1
Boun Neua	115	Boun Neua	22	1	Overload	From Xieng Nguen 115kV To Luangprabang 1 115kV cct 1
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

Table 8.8-5 (b) Power Flow and Voltage Analysis under Single Contingency Condition (PF-W3-80)

Fault Location					Analysis Results	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Saravan	115	Sekong	115	1	Overload	From Saravan 115kV To Sekong 115kV cct 2
Saravan	115	Sekong	115	2	Overload	From Saravan 115kV To Sekong 115kV cct 1
Boun Neua	115	Boun Neua	22	1	Overload	From Xieng Nguen 115kV To Luangprabang 1 115kV cct 1
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

Table 8.8-5 (c) Power Flow and Voltage Analysis under Single Contingency Condition (PF-W4-80)

Fault Location					Analysis Results	
From		To		cct	Type of Problem	Problem Location
Name	KV	Name	KV			
Saravan	115	Sekong	115	1	Overload	From Saravan 115kV To Sekong 115kV cct 2
Saravan	115	Sekong	115	2	Overload	From Saravan 115kV To Sekong 115kV cct 1
Boun Neua	115	Boun Neua	22	1	Overload	From Xieng Nguen 115kV To Luangprabang 1 115kV cct 1
Xieng Nguen	115	Luangprabang 1	115	1	Over Voltage	Xieng Nguen 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Thongkhoun 115kV
Thongkhoun	115	Nam Bak 2	115	1	Voltage Drop	Phubia 115kV
Boun Neua	115	Boun Neua	22	1	Over Voltage	Boun Neua 115kV

8.8.3 Transmission Line Loss

Transmission line losses of the whole system for domestic power supply for the year 2016 for both dry and wet seasons (excluding losses of the system for exports) are shown in Table 8.8-6. Where, the annual energy loss is calculated using the formula below:

$$\text{Annual Engery Loss} = \text{kW Loss x Loss Factor x 8760 hours}$$

The Loss Factor, although its value would be varied according to load curves, is calculated approximately by the Buller-Woodrow experimental formula below; where f is the annual load factor.

$$\text{Loss Factor} = 0.3 \times f + 0.7 \times f^2$$

Therefore,

$$\text{Annual Energy Loss} = \text{kW Loss} \times (0.3 \times f + 0.7 \times f^2) \times 8760 \text{ hours}$$

As the annual load factor, 0.7 was assumed. Also, the annual energy loss values in the right most columns were calculated assuming that the long-term marginal cost for high voltage is 0.0407 USD/kWh.

The calculation results shows that the system configuration of "Pakbo – Napong – Saravan 2 cct" as of 2016 has the minimum transmission line loss.

Table 8.8-6 Transmission Line Loss for Domestic Power Supply System in Laos

Dry/Wet	Case	KW Loss [MW]	Annual Energy Loss [MWh]	Annual Energy Loss [million USD]
Dry Season	PF-D1	54.1	262,075.55	10.7
	PF-D2	55.5	268,857.54	10.9
	PF-D3	54.0	261,591.12	10.6
	PF-D4	55.2	267,404.26	10.9
Wet Season	PF-W1-80	113.0	547,403.64	22.3
	PF-W2-80	115.6	559,998.77	22.8
	PF-W3-80	112.5	544,981.50	22.2
	PF-W4-80	115.0	557,092.20	22.7

8.8.4 Fault Current Analysis

Maximum three-phase short circuit fault currents were calculated for the system taking into consideration the system configurations for the section between Pakbo and Saravan or Ban Jianxai, which are candidate prioritized projects, as of 2016. As Table 8.8-7 shows, the maximum three-phase short circuit fault currents are below the allowable level.

Table 8.8-7 Maximum Three-phase Short Circuit Fault Currents and Locations

System Configuration	230 kV Bus		115 kV Bus		22 kV Bus	
Pakbo-Kengkok: 2 cct Kengkok-Napong: 2 cct Napong-Saravan: 2 cct	20.5 kA	Ban Sok	11.7 kA	Naxaithong	23.1 kA	Phonetong
Pakbo-Kengkok: 2 cct Kengkok-Napong: 2 cct Napong-Ban Jianxai: 2 cct	20.5 kA	Ban Sok	11.7 kA	Naxaithong	23.1 kA	Phonetong
Pakbo-Kengkok: 1 cct Pakbo-Napong: 2 cct Napong-Saravan: 2 cct	18.7 kA	Ban Sok	11.8 kA	Naxaithong	23.6 kA	Phonetong
Pakbo-Kengkok: 1 cct Pakbo-Napong: 2 cct Napong-Ban Jianxai: 2 cct	20.5 kA	Ban Sok	11.7 kA	Naxaithong	23.1 kA	Phonetong
Allowable Maximum Fault Current	40～50 kA		25～31.5 kA		25～31.5 kA	

8.8.5 Basic Stability Analysis

Stability analysis for the planned system in 2016 was conducted. As the stability analysis tool, PSS/E version 31, which is introduced in the Section 7.4.2 Analysis Tools, was utilized.

(1) Analysis Cases

When all of the synchronous generators in the system are able to maintain synchronized operations even in the event of an equipment fault occurring, which constitutes the system, the system can be considered stable. The calculations were executed under the criteria that “when the oscillations of the phase angles among roters of synchronous generators which constitute the system tends to converge even in the case of the severest single contingency, the system is stable.”

Analysis cases are summarized in the Table 8.8-8.

Generator models for the analysis were those provided by EDL. For the models for some of the planned generators of which the model types were unknown, a salient-pole machine model was applied as shown in Table 8.8-9.

The simple exciter model was applied to planned generators. The simple exciter model is not a type of special exciter system but shows general characteristics of a wide variety of exciters that were appropriately set as shown in Table 8.8-10.

For the generators shown in Table 8.8-11, Power System Stabilizers (PSS) were applied. All governers in the Laos system were set at “out-of-service”. The PSS model used for the analysis is as shown in Table 8.8-12.

Behaviors of phase difference angle oscillation between generators in the North and Central 1 areas and Xeset 1 (the South area) are shown in Appendix 8.8-2. A summary of the results is shown in Table 8.8-13.

In dry season, for any candidate system configurations between Kengkok or Pakbo and Saravan or Ban Jianxai, the oscillation waveforms of phase angle differences were found converged. Therefore, it was confirmed that the four candidate systems could be stably operated even in the case of a severe fault condition. In wet season, for those cases that have a connection between Napong and Ban Jianxai, the amplitudes of the oscillation waveforms of phase angle differences were larger than those for the cases that have a connection between Napong and Saravan although the waveforms did not diverge. From the above results, the connection pattern “Pakbo-Kengkok with 1 cct (existing) and Pakbo-Napong-Saravan with 2 cct” is considered the best connection pattern in terms of stability among the candidate connection patterns.

Table 8.8-8 Stability Analysis Cases

Dry/Wet	Case	Number of Circuits (Pakbo-Kengkok)	Number of Circuits Kengkok or Pakbo – Saravan or Ban Jianxai						Fault Section (1cct)		
Dry Season	ST-D1-1	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-D1-2								NPO	-	KKO
	ST-D2-1						BJI	2	BJI	-	NPO
	ST-D2-2								NPO	-	KKO
	ST-D3-1	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-D3-2								NPO	-	PBO
	ST-D4-1						BJI	2	BJI	-	NPO
	ST-D4-2								NPO	-	PBO
Wet Season	ST-W1-1	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-W1-2								NPO	-	KKO
	ST-W2-1						BJI	2	BJI	-	NPO
	ST-W2-2								NPO	-	KKO
	ST-W3-1	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-W3-2								NPO	-	PBO
	ST-W4-1						BJI	2	BJI	-	NPO
	ST-W4-2								NPO	-	PBO
	ST-W1-1P	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-W1-2P								NPO	-	KKO
	ST-W2-1P						BJI	2	BJI	-	NPO
	ST-W2-2P								NPO	-	KKO
	ST-W3-1P	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO
	ST-W3-2P								NPO	-	PBO
	ST-W4-1P						BJI	2	BJI	-	NPO
	ST-W4-2P								NPO	-	PBO
Fault Sequence		0ms	Single Circuit Three-phase Short Circuit Fault								
		140ms	Fault Clearance (1cct Open)								
		10s	End of Calculation								

*PBO：Pakbo, KKO：Kengkok, SRV：Saravan, BJI：Ban Jianxai, NPO：Napong

Table 8.8-9 Generator Model for the Unknown Planned Generator: GENSAL

T'_{d0}	T''_{d0}	T''_{q0}	H	D	X_d	X_q	X'_d	X''_d	X_l	S(1.0)	S(1.2)
6.27	0.041	0.047	4.01	0	0.93	0.61	0.31	0.2	0.13	0.1	0.37

Table 8.8-10 Exciter Model: SEXS

T_A/T_B	T_B	K	T_E	E_{MIN}	E_{MAX}
0.1	10	200	0.05	0	5

Table 8.8-11 Generators with PSS

Large-scale IPP Unit	Nam Ngum 2, Nam Ngum 3, Nam Theun 1, Nam Ngiep 1, Hongsa Lignite, Theun Hinboun, Nam Theun 2, Houay Ho, Xekaman 3, Xekaman 1, Xekong 4*, Xekong 5*
Domestic Supply Unit	Nam Tha 1, Nam Khan 2, Houaylamphan*

* For Xekong 4, Xekong 5, and Houaylamphan power stations, both with and without PSS cases were analyzed.

Table 8.8-12 PSS Model: IEEEST

A1	A2	A3	A4	A5	A6	T1	T2	T3
0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.18	0.06
T4	T5	T6	Ks	Lsmax	Lsmin	Vcu	Vcl	
0.18	5.00	5.00	-0.75	0.10	-0.10	0.00	0.00	

Table 8.8-13 Stability Analysis Results

Dry/ Wet	Case	Number of Circuits Pakbo -Kengkok	Number of Circuits Kengkok or Pakbo – Saravan or Ban Jianxai						Fault Section (1cct)			Results
Dry Season	ST-D1-1	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-D1-2								NPO	-	KKO	Stable
	ST-D2-1						BJI	2	BJI	-	NPO	Stable
	ST-D2-2								NPO	-	KKO	Stable
	ST-D3-1	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-D3-2								NPO	-	PBO	Stable
	ST-D4-1						BJI	2	BJI	-	NPO	Stable
	ST-D4-2								NPO	-	PBO	Stable
Wet Season	ST-W1-1	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-W1-2								NPO	-	KKO	Stable
	ST-W2-1						BJI	2	BJI	-	NPO	Stable
	ST-W2-2								NPO	-	KKO	Stable
	ST-W3-1	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-W3-2								NPO	-	PBO	Stable
	ST-W4-1						BJI	2	BJI	-	NPO	Stable
	ST-W4-2								NPO	-	PBO	Stable
	ST-W1-1P	2	KKO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-W1-2P								NPO	-	KKO	Stable
	ST-W2-1P						BJI	2	BJI	-	NPO	Stable
	ST-W2-2P								NPO	-	KKO	Stable
	ST-W3-1P	1	PBO	-	NPO	-	SRV	2	SRV	-	NPO	Stable
	ST-W3-2P								NPO	-	PBO	Stable
	ST-W4-1P						BJI	2	BJI	-	NPO	Stable
	ST-W4-2P								NPO	-	PBO	Stable

*For Wet Season cases, the last character "P" indicates that PSSs are in-service at Xekong 4, Xekong 5, and Houaylamphan.

8.9 Construction Section of the Highest Prioritized Project

As mentioned in the Section 8.8.2, there are four candidate connection patterns starting from either Kengkok or Pakbo and ending at either Saravan or Ban Jianxai substations for the most prioritized projects. Construction costs of the four candidate connection patterns were compared in order to confirm the least cost construction section among them. The comparison results are shown in Table 8.9-1. The construction costs in the table constitute construction costs of transmission and substation facilities as well as costs for UXO investigation and disposal.

As Table 8.9-1 shows, case 3 is the cheapest connection pattern. This case also has the minimum transmission line loss and shows the minimum generator oscillation in the case of the faults considered in this section.

From the viewpoints of cost, loss, and stability, therefore, we recommend that the construction section of the most prioritized project be from Pakbo to Saravan substations.

The idea of placing the Napong switching/sub station between Pakbo and Saravan substations seems feasible from the perspectives of both stability improvement and power supply to the surrounding area by EDL. The necessity of locating the Napong switching/sub station was described in the Section 11.1 Selection of Facilities[3].

Table 8.9-1 Construction Costs

No.	Case	Connection Pattern	Construction Cost (1,000 USD)
1	PF-D1 PF-W1-80	Pakbo – Kengkok 2 cct (existing + 1 cct) Kengkok – Napong – Saravan 2 cct	33,281
2	PF-D2 PF-W2-80	Pakbo – Kengkok 2 cct (existing + 1 cct) Kengkok – Napong – Ban Jianxai 2 cct	34,973
3	PF-D3 PF-W3-80	Pakbo – Kengkok 1 cct (existing only) Kengkok – Napong – Saravan 2 cct	32,926
4	PF-D4 PF-W4-80	Pakbo – Kengkok 1 cct (existing only) Kengkok – Napong – Ban Jianxai 2 cct	34,619

8.10 Study on the Other Candidate Prioritized Project

There is a generator expansion plan for the Nam Ngum 1 power station, and after operations commence, the southbound power flow is expected to increase. Hence the necessity of reinforcing (addition of another circuit) the 115 kV transmission line between Nam Leuk, Nam Mang 3, Khoksaad, Thanaleng and Nong Khai was was investigated.

(1) Methodology

In wet season in 2016, the power flow between Thanaleng and Nong Khai will be 97 MW and the direction is from Tanaleng to Nong Khai (export). In order to calculate the power flow only for domestic supply, a condition in which the power flow between Tanaleng and Nong Khai became 0 MW was modeled by restricting the output of the generators in both the North and Central 1 areas. This study was done only for the system configuration that had the connection pattern “Pakbo-Kengkok 1 cct (existing) and the Pakbo-Napong-Saravan 2 cct”, of which the stability was the best among the candidate connection patterns in the Section 8.8.5.

(2) Results

The power export of the section between Thanaleng and Nong Khai became almost 0 MW when outputs of all generators in the Central 1 area and a part of those in the North area were

[3] “Taothan” described in Chapter 11 is the same station as “Napong” or “Nongsano” written in this Chapter.

restricted to 70% of the installed capacitiy as shown in Figure 8.10-1.

After creating the above conditions, making the number of circuits in the section Nam Leuk-Nam Mang 3-Khoksaad-Thanaleng-Nong Khai single circuit, and simulating single circuit faults in each section, conditions of the remaining system, such as overloading and voltage criteria violations, were analyzed.

No overloading, or voltage drop at the substation buses occurred in any case where there was one circuit fault between Nam Leuk and Nam Mang3, Nam Mang3 and Khoksaad, Khoksaad and Thanaleng, and Thanaleng and Nong Khai as shown in Figures 8.10-2 to Figure 8.10-5.

Therefore, it has been concluded that one circuit is enough for the section Nam Leuk-Nam Mang 3-Khoksaad-Thanaleng-Nong Khai without considering power export to Thailand in wet seasons and that adding another circuit to form 2 cct section is not a high priority.

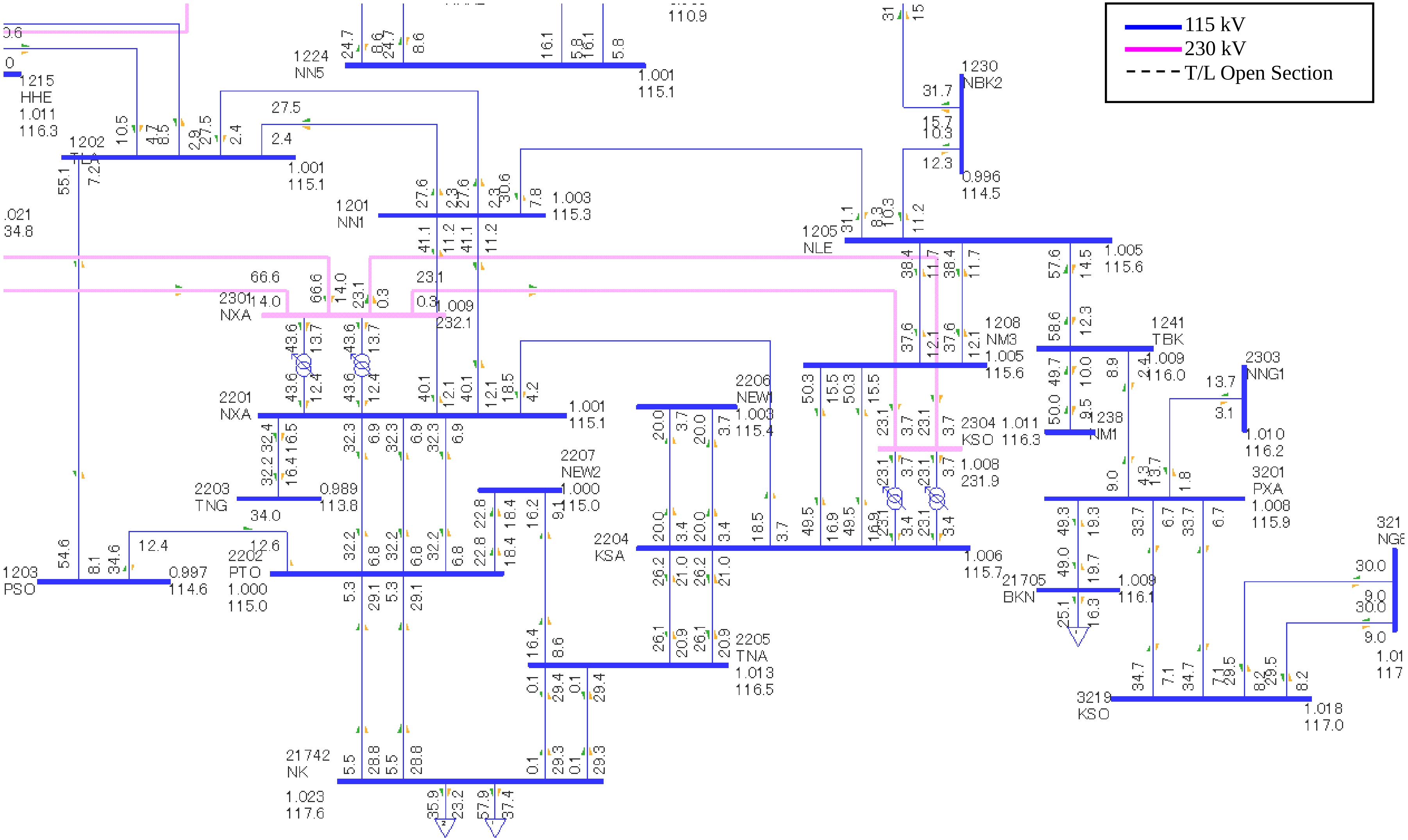

Figure 8.10-1 The Condition in which Power Flow between Thanaleng and Nong Khai becomes almost 0 MW

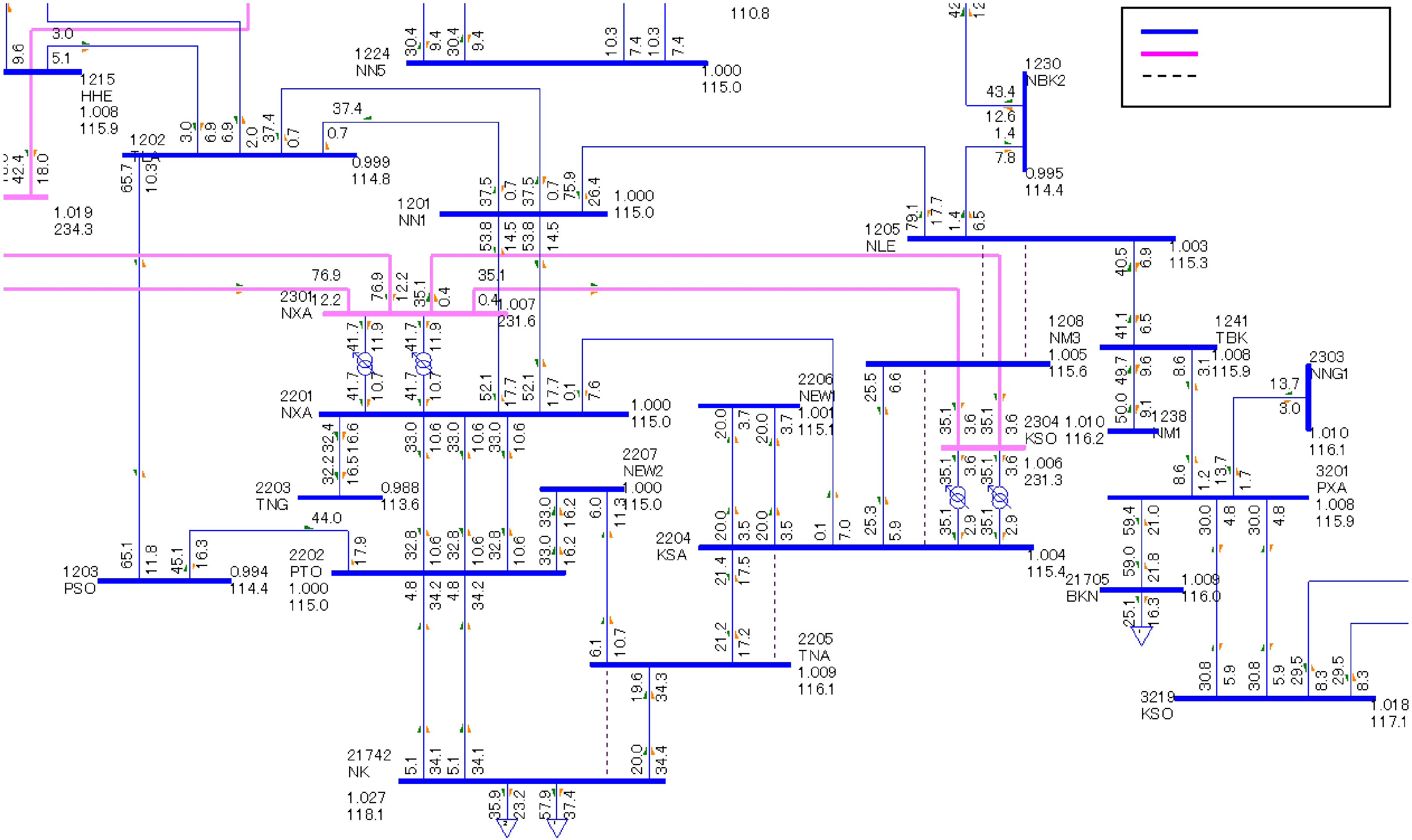

Figure 8.10-2 Nam Leuk - Nam Mang 3 - Khoksaad - Thanaleng - Nong Khai: 1 cct, Single Circuit Fault: Nam Leuk - Nam Mang 3

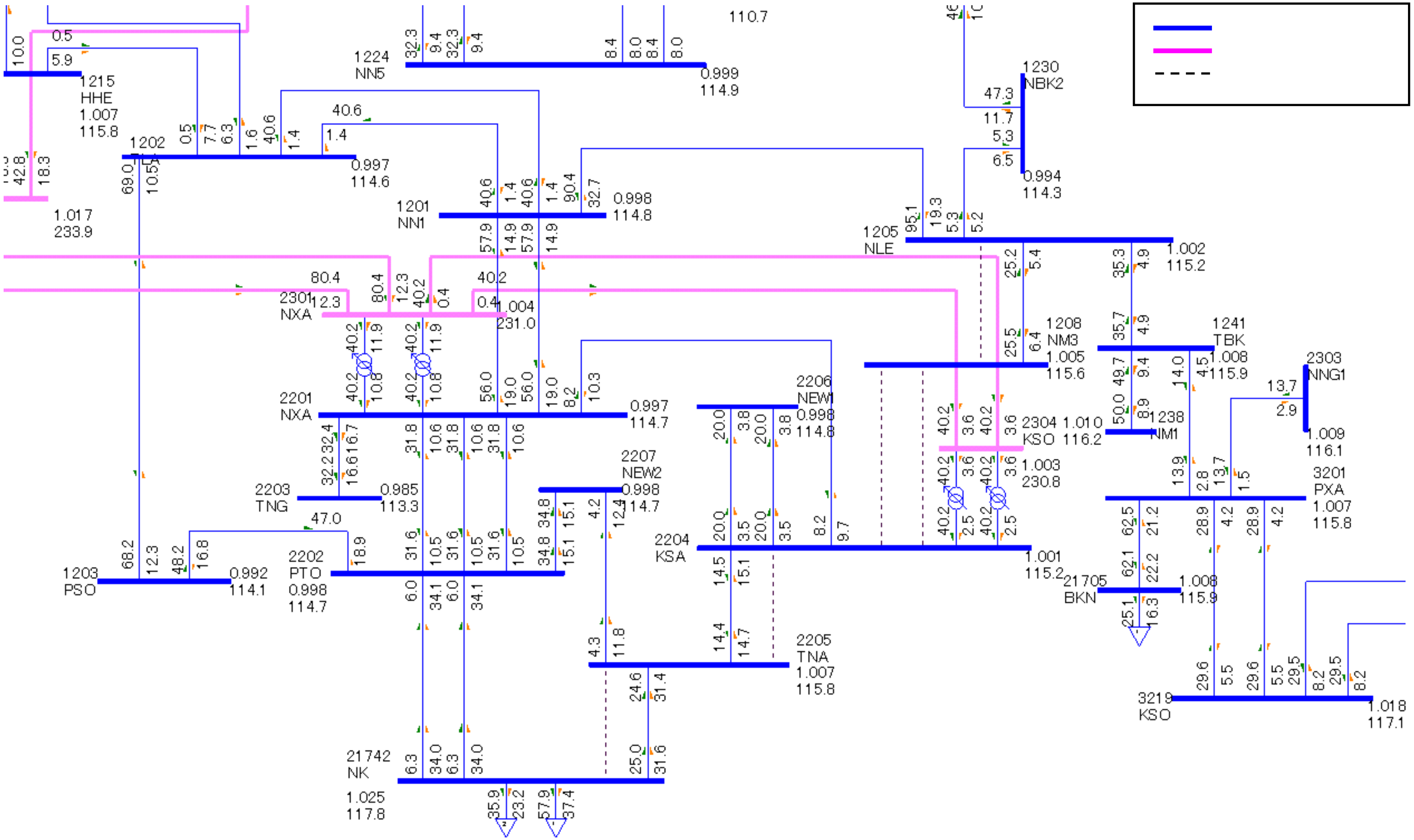

Figure 8.10-3 Nam Leuk - Nam Mang 3 - Khoksaad - Thanaleng - Nong Khai: 1 cct, Single Circuit Fault: Nam Mang 3 - Khoksaad

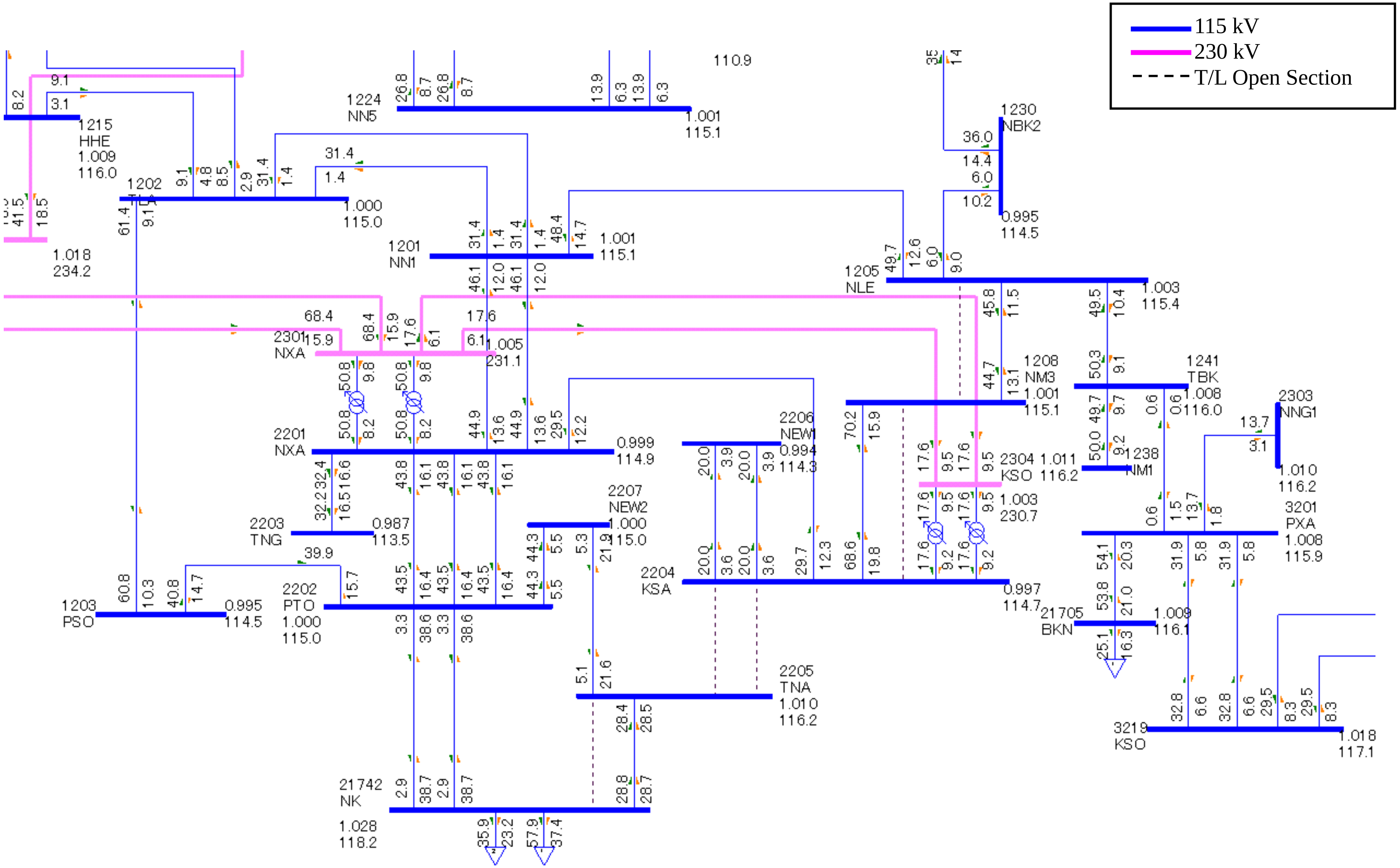

Figure 8.10-4 Nam Leuk - Nam Mang 3 - Khoksaad - Thanaleng - Nong Khai: 1 cct, Single Circuit Fault: Khoksaad - Thanaleng

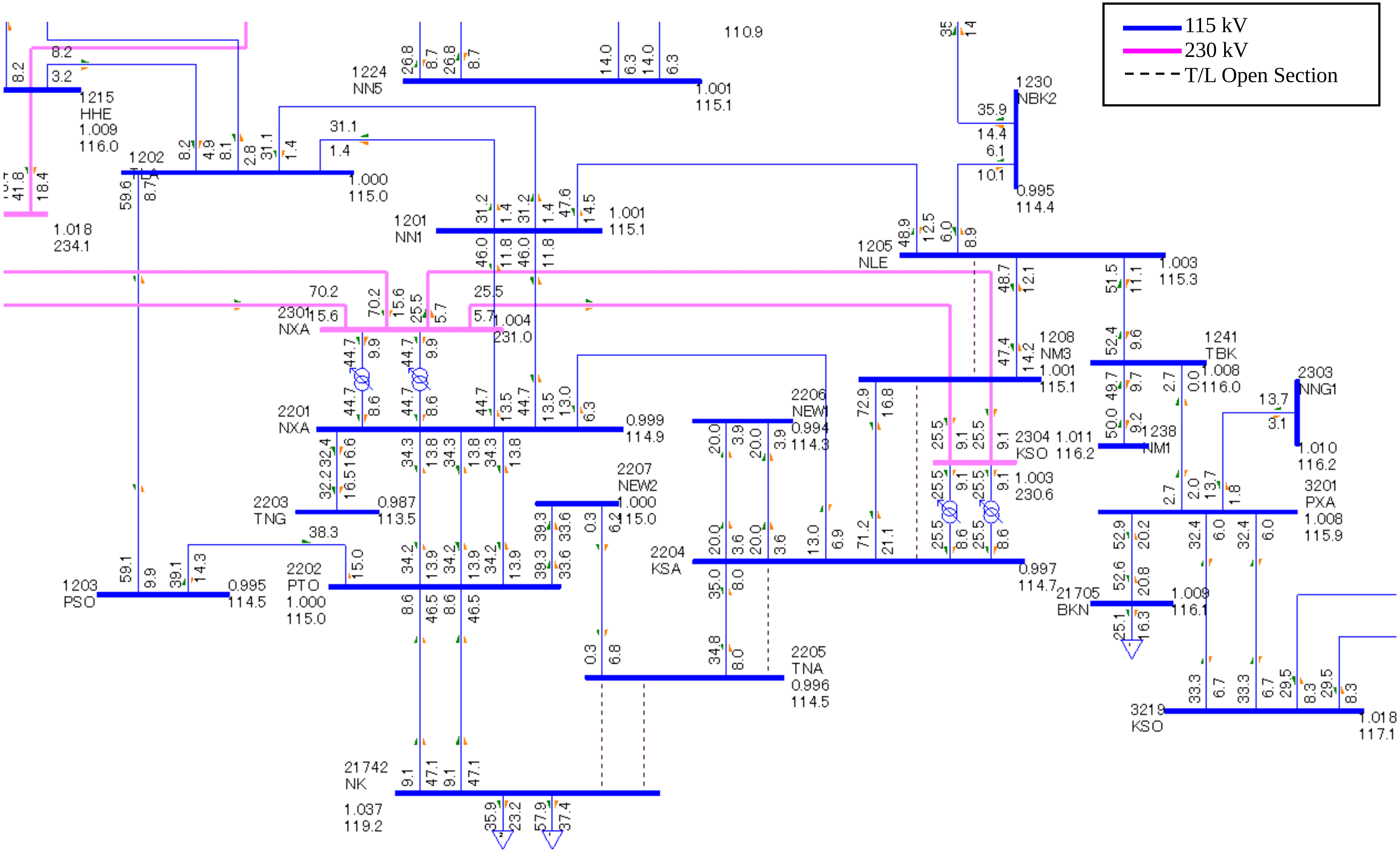

Figure 8.10-5 Nam Leuk - Nam Mang 3 - Khoksaad - Thanaleng - Nong Khai: 1 cct, Single Circuit Fault: Thanaleng - Nong Khai

Chapter 9
Power System Planning Up To 2030

Chapter 9 Power System Planning Up To 2030

9.1 The Methodology of the Study of the Power System Plan up to 2030

The PDP up to 2016 made by EDL has been reviewed in Chapter 7. In this chapter, the power system plan up to 2030 was made based on the power generation plan up to 2030 and the power demand forecast described in section 6.7 reflecting the increase in the population, the GDP growing and the improvement of the rural electrification rate. The targeted years were 2020 and 2030.

The excess and deficiency of the electric power in each province has to be compensated by the power transmission from the neighboring provinces. The power demand supply balancing during the peak demand period of time has been calculated based on the demand forecast and the power generation plans in order to estimate the required capacity of the interconnections. The preliminary power network plan was made based on the result of the estimated required capacity of the interconnections and the adequacy of the plan was assessed in regard to meeting the technical criteria through the power system analysis including the power flow and voltage calculation, the fault current calculation and the stability calculation.

The locations of the power consumptions generally need to be specialized for creating the power system plans, however, the locations of the non-identified special power consumers cannot be specialized although the total amount of power consumption of the whole of Laos can be estimated. Thus, the power system plan in 2030 has been made as the plan of the facilities taking the roles of the power trade among the regions in the whole of Laos and the power system plan in 2020 has been made in detail including 115 kV transmission systems.

The concrete subprojects based on the power network system plan confirmed in this Chapter are described in Chapter 10.

9.2 Power Development Plan by 2030 (Including IPP)

The power development plan was utilized with a same plan for basic simulations. The power development plan after 2017 was based on the interview with the DOE and EDL because the government of Lao has not yet authorized it yet.

9.2.1 Power Development Plan for Domestic Supply

The power development plan of domestic supply for detailed simulation is shown in Table 9.2-1~Table 9.2-3. Cooperation with Lao counterpart personnel for the power development plan for domestic supply by 2030 has been assumed. The nominated power plants are mainly hydropower plants.

When the balance between supply and demand of Laos whole systems, the system constraines of interconnection capacity should be considered even in 2030. The Laos whole systems balance between supply and demand in 2030 should be simulated by the Nouth & Central 1 system, the Central 2 system and the South system in taking account power exchanges among the systems.

Table 9.2-1 Power Development Plan for Domestic Supply (Existing Plants)

	Power Plant	Inst. Cap (MW)	Generating Type	Comm. Year	Remark	Region
1	Nam Dong	1.0	Run of river	1961	Existing	NC1
2	Xeladam	5.0	Run of river	1961	Existing	S
3	Nam Ngum 1	155.0	Reservoir	1971	Existing	NC1
4	Xeset 1	45.0	Run of river	1991	Existing	S
5	Nam Ko	1.5	Run of river	1996	Existing	NC1
6	Theun HinBoun (Local)	8.0	Run of river	1998	Existing	C2
7	Houay Ho (Local)	2.1	Reservoir	1999	Existing	S
8	Nam Leuk	60.0	Reservoir	2000	Existing	NC1
9	Nam Mang 3	40.0	Reservoir	2005	Existing	NC1
10	Nam Ngay	1.2	Run of river	2006	Existing	NC1

Table 9.2-2 Power Development Plan for Domestic Supply (2009-2016)

	Power Plant	Inst. Cap (MW)	Generating Type	Comm. Year	Remark	Region
11	Xeset 2	76.0	Run of river	2009	UC	S
12	Nam Theun 2	75.0	Reservoir	2009	UC	C2
13	Nam Nhon	2.4	Run of river	2010	UC	NC1
14	Nam Ham	3.5	Run of river	2010	PC	NC1
15	Nam Lik 1/2	100.0	Reservoir	2010	UC	NC1
16	Nam Ngum 5	120.0	Reservoir	2011	UC	NC1
17	Nam Lik 1	60.0	Reservoir	2011	MOU	NC1
18	Xelabam ext.	7.7	Run of river	2012	Planned	S
19	Nam Tha 1	168.0	Reservoir	2012	PDA	NC1
20	Nam Sim	8.0	Run of river	2012	PDA	NC1
21	Xekatam	61.0	Reservoir	2012	PDA	S
22	Nam Nguang 8	60.0	Reservoir	2012	UC	C2
23	NamNgum 1 ext.	40.0	Reservoir	2013	Planned	NC1
24	Tadslen	3.2	Run of river	2013	PPA	C2
25	Xekaman 1	32.0	Reservoir	2014	MOU	S
26	Houaychampi	2.0	Run of river	2014	Planned	S
27	Hongsa Lignite (Local)	100.0	Thermal	2015	Planned	NC1
28	Nam Boun	8.0	Run of river	2015	Planned	NC1
29	Nam Phak	45.0	Run of river	2015	Planned	NC1
30	Nam Mang 1	50.0	Reservoir	2015	Planned	NC1
31	Xeset 3	22.0	Run of river	2015	Planned	S
32	Xeset 4	8.0	Run of river	2015	Planned	S
33	Nam Bak 2	80.0	Reservoir	2016	Planned	NC1
34	Xepian/Xenamnoy	2.0	Reservoir	2016	MOU	S
35	Houaylamphan	86.7	Reservoir	2016	FS	S
36	Nam San 3	48.0	Reservoir	2016	MOU	NC1
37	Xe kong 4	70.0	Reservoir	2016	Planned	S
38	Mekong Luangpravang	140.0	Run of river	2016	Planned	NC1
39	Nam Long	5.0	Run of river	2016	MOU	NC1
40	Donsahong	60.0	Run of river	2016	Planned	S
41	Nam Ma1	60.0	Run of river	2016	Planned	NC1
42	Nam Ma2	24.0	Run of river	2016	Planned	NC1
43	Nam Ma3	36.0	Run of river	2016	Planned	NC1

Table 9.2-3 Power Development Plan for Domestic Supply (2017-2030)

	Power Plant	Inst. Cap (MW)	Generating Type	Comm. Year	Remark	Region
44	Xeneua	30.0	Reservoir	2017	MOU	C2
45	Nam Ngiep Regulating	20.0	Reservoir	2017	PPA	NC1
46	Xepon 2	30.0	Reservoir	2017	Planned	C2
47	Xepon 3	70.0	Reservoir	2017	Planned	C2
48	Nam Theun 1 (Local)	13.0	Reservoir	2017	Planned	NC1
49	Nam Ou 6 (Local)	90.0	Reservoir	2017	Planned	NC1
50	Nam Ngiep 2	180.0	Reservoir	2017	MOU	NC1
51	Xekong 3 (Upper)	152.0	Reservoir	2017	MOU	S
52	Xekong 3 (Lower)	96.0	Reservoir	2017	MOU	S
53	Nam Khan 2	145.0	Reservoir	2018	MOU	NC1
54	Nam Khan 3	66.0	Reservoir	2018	Planned	NC1
55	Sedon 2	20.0	Reservoir	2018	Planned	S
56	Sedon 3	6.0	Reservoir	2018	Planned	S
57	Nam Ngum 4	50.0	Run of river	2019	Planned	NC1
58	Xelanong 2	45.0	Reservoir	2020	MOU	S
59	Nam Nga	60.0	Reservoir	2020	MOU	NC1
60	Nam Beng	45.0	Run of river	2020	MOU	NC1
61	Nam Mo1	60.0	Reservoir	2020	Planned	NC1
62	Nam kong 3	30.0	Run of river	2020	Planned	S
63	Nam Phay	50	Reservoir	2021	Planned	NC1
64	Nam Peun 1,2	70	Reservoir	2022	Planned	NC1
65	XebanHieng 1	60.0	Reservoir	2025	Planned	C2
66	XeXou	59.0	Reservoir	2025	Planned	S
67	Nam Souang 1	31.0	Run of river	2026	MOU	NC1
68	Nam Feung 1	28.0	Run of river	2026	Planned	NC1
69	Nam Feung 2	25.0	Run of river	2027	Planned	NC1
70	Nam Feung 3	20.0	Run of river	2028	Planned	NC1
71	Xebangnouan 2	18.0	Reservoir	2030	MOU	S
72	Viengphokha Lignite	60.0	Thermal	2030	Planned	NC1
73	Nam phouan	90.0	Reservoir	2030	Planned	NC1

UC: Under construction, PC: Perpetrating construction, NC1: North & Central1, C2: Central2, S: South

9.2.2 Power Development Plan for Export

The nominated projects for power export based on the information from the DOE are shown in Table 9.2-4. The status of IPP projects is classified as FS by the MOU (Plan), PDA (Power Development Agreement), CA (Concession Agreement), PPA (Power Purchase Agreement). The projects are concentrated in the North, Vientiane suburbanan and the South areas. The seven hydropower projects in the Mekong main stream are in the FS stages as of August 2009.

Table 9.2-4 Power Development Plan for Export

No.	Project	Capacity (MW)	COD	Location	Status	Planned Market
1	Nam Theun 2	1080	2009	Khammouan	UC	EGAT/EDL
2	Xeset 2	76	2009	Saravan	UC	EDL/EGAT
3	Xekaman 3	250	2010	Xe Kong	UC	EVN/EDL
4	Theun Hinboun Ext.	60	2012	Bolikhamxay	UC	EGAT/EDL
5	Nam Ngum 2	615	2013	Vientiane	UC	EGAT
6	Nam Koung 1	75	2012	Attapu	PDA	TBD
7	Nam Ou	1100	2013-2015	Phongsali	PDA	EGAT/EDL/CSG
8	Hongsa Lignite	1800	2013	Xaignabouli	PDA	EGAT/EDL
9	Xekaman 1	320	2013	Attapu	PDA	EVN/EDL
10	Xekong 4	300	2013	Xe Kong	PDA	TBD
11	Nam Mo	150	2014	Xieng Khouang	PDA	EVN/EDL
12	Nam Ngum 3	440	2014	Vientiane	PDA	EGAT
13	Nam Ngiep 1	278	2015	Bolikhamxay	PDA	EGAT/EDL
14	Don Sahong	240	2015	Chanpasak	PDA	EGAT/EDL
15	Xepian-Xenemnoy	390	2015	Attapu	PDA	EGAT/EDL
16	Nam Theun 1	523	2016	Bolikhamxay	PDA	EGAT/EDL
17	Xayaburi (Mekong)	1260	TBD	Xaignabouli	PDA	EGAT/EDL
18	Ban Khoum (Mekong)	2330	TBD	Chanpasak	FS	EGAT/EDL
19	Dak Emeule	130	TBD	Xe Kong	FS	EVN/EDL
20	Lat Sua (Mekong)	686	TBD	Chanpasak	FS	TBD
21	Louangprabang(Mekong)	1410	TBD	Luangprabang	FS	TBD
22	Nam Bak 1	132	TBD	Vientiane	FS	EGAT
23	Nam Khan 2	130	TBD	Luangprabang	FS	TBD
24	Nam Khan 3	95	TBD	Luangprabang	FS	TBD
25	Nam Ngiep 2	155	TBD	Vientane	FS	EGAT/EDL
26	Nam Ngum 4A&B	120	TBD	Vientane	FS	EVN/EDL
27	Nam Phoun	60	TBD	Xaignabouli	FS	TBD
28	Nam Seuang 2	220	TBD	Luangprabang	FS	TBD
29	Nam Theun 4	110	TBD	Bolikhamxay	FS	TBD
30	Pak Lay (Mekong)	1320	TBD	Xaignabouli	FS	EGAT/EDL
31	Sanakham (Mekong)	500	TBD	Xaignabouli	FS	TBD
32	Xekong 3 Upper/Lower	150	TBD	Xe Kong	FS	EVN
33	Xe Kong 5	330	TBD	Xe Kong	FS	TBD
34	Xekaman 4	220	TBD	Xe Kong	FS	EVN
35	Selanong 1	80	TBD	Savannakhet	FS	TBD
36	Xebanghieng 1	65	TBD	Savannakhet	FS	TBD
37	Xebanghieng 2	250	TBD	Khammouan	FS	TBD
38	Xe Pon 3	100	TBD	Saravan	FS	TBD
	UC	2,081				
	PDA	6,876				
	FS	8,593				
	TOTAL	17,854				

UC: Under Construction, PDA: Project Development Agreement, FS: Feasibility Study, TBD: To be decided, (Mekong): Mekong main stream project. (Source: Documents of DOE MEM, Dec. 2008)

9.3 Detailed Simulation

9.3.1 Conditions of Detailed Simulation

(1) Demand Forecast

Base case of demand forecasts for the detailed simulation is shown in the Table 9.3-1 and the high case is shown in the Table 9.3-2. Demand forecasts in 2016 and 2020 of Thai system have been quoted from the EGAT PDP 2007. Demand forecast in 2030 has been estimated by a trand of annuarly growth rate of EGAT PDP. Demand forecasts of Thai systems have been adopted as a base case, because the supply and demand in Thai systems should be balanced for the simulation in this study. The demand forecast at the generation terminal has been used in this section.

Table 9.3-1 Demand Forecast for Detailed Simulation (Base Case)

Year		Laos North + Central1	Laos Cenratl2	Laos South	Thai Northeast	Thai Central + South
2016	Peak demand (MW)	1,012	353	228	3,587	30,744
	Energy (GWh)	4,316	1,504	972	17,547	201,792
	Load factor (%)	49	49	49	56	75
2020	Peak demand (MW)	1,146	412	255	4,061	38,369
	Energy (GWh)	4,957	1,780	1,097	21,932	252,212
	Load factor (%)	49	49	49	62	75
2030	Peak demand (MW)	2,064	746	436	5,248	59,676
	Energy (GWh)	9,690	3,500	2,026	34,198	393,274
	Load factor (%)	54	54	53	74	75

(Source: Team assumed based on EDL and EGAT data)

Table 9.3-2 Demand Forecast for Detailed Simulation (High Case)

Year		Laos North + Central 1	Laos Cenrat l2	Laos South
2016	Peak demand (MW)	1,067	376	242
	Energy (GWh)	4,552	1,606	1,030
	Load factor (%)	49	49	49
2020	Peak demand (MW)	1,276	464	283
	Energy (GWh)	5,533	2,010	1,226
	Load factor (%)	50	50	49
2030	Peak demand (MW)	3,757	1,377	784
	Energy (GWh)	17,485	6,408	3,627
	Load factor (%)	53	53	53

(Source: Team assumed based on EDL data) Base case demand was adopted as a demand of Thai systems)

(2) Power Development Plan

The power development plan for detailed simulation is shown in the aforementioned section. (see the Section 10.2.1)

(3) Interconnection

The interconnected systems are examined in the year of 2030 based on the demand forecast in this study and the power development plan agreed upon by the DOE and EDL. The capacities of interconnections with neighboring countries have been assumed based on the existing plan and to secure power exports during the rainy season as much as possible. The capacities of interconnection among systems are described in Table 9.3-3. The configuration of interconnected systems is illustrated in Figure 9.3-1.

Table 9.3-3 Capacity of Interconnection (2030)

Interconnection	Capacity of Interconnection (MW)
Lao North + Central 1 – Lao Central 2	90
Lao Central 2 – Lao South	300
Lao North + Central 1 – Thai Northeast	600
Lao Central 2 – Thai Northeast	120
Lao South – Thai Northeast	270
Thai Northeast – Thai Central + South	1,300

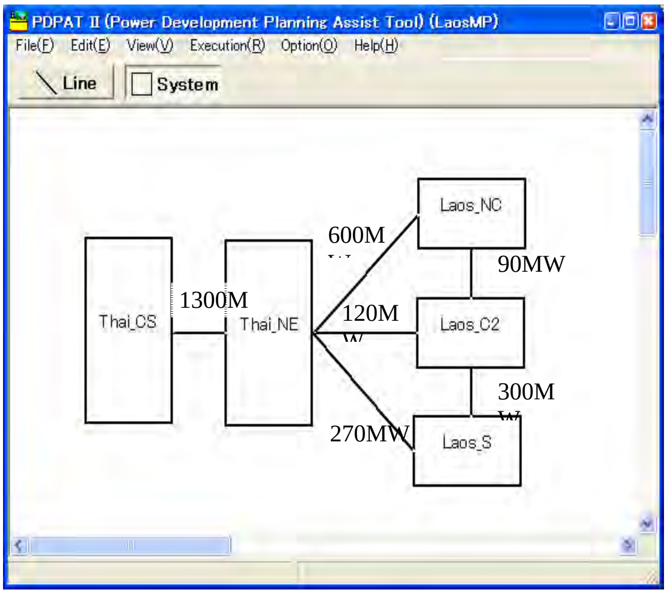

Figure 9.3-1 Interconnected Systems (2030)

(4) Loss of Interconnection

Losses have been assumed based on the results of operation by EDL and system analysis, as follows.

- 115 kV: 4.2% = (8% x 1/2 + 4% x 1/2) x 0.7
  - Rainy season peak: 8%
  - Dry season peak: 4%
  - Loss factor: 70%
- 230 kV and 500 kV: 2 - 3%

9.3.2 Cases of Detailed Simulations

Scenarios to secure demand in 2030 for detailed simulation have been selected in considering the results of simulating the balance of supply and demand by 2020 based on the existing power development plan. The policy of power development is that the supplies for domestic demands should seek in the Lao territory first, when scenarios are selected.

(1) Situation of System Reliability

The situation of system reliability on the base demand in 2030 is illustrated in Figure 9.3-2 as the results of the simulation. The reserve margin capacity of 56 MW is required to secure the Lao planning criterion of system reliability; LOLE 24 hours. The results of the simulation addressed that the reserve capacity of 300 MW could be prepared in all of Lao's systems. The reserve capacities in the Lao Central 2 systems have remained at a 200 MW shortage after power from interconnected systems. Additional measurements are necessary to secure their demand.

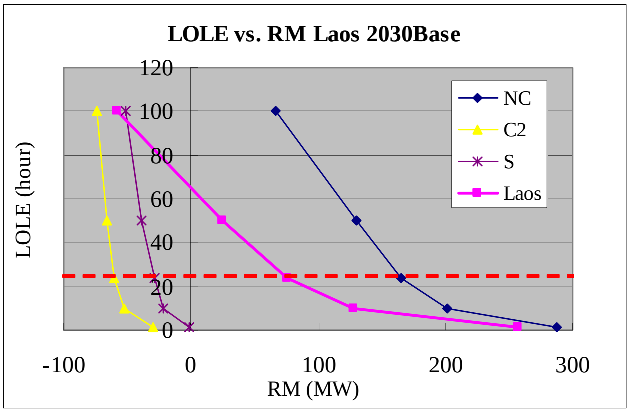

Figure 9.3-2 Situation of System Reliability in Lao Systems (2030 Base Case)

(2) Situation of Balancing Supply and Demand

(a) Cases of Base Demand Forecast (Base Case)

Simulations have been conducted on the base demand as a 7%/year GDP growth basis, which are based on existing power development plans and latent power development within Lao territory. The results show that there will be a power shortage in 2020. The Lao Central 2 system will have a power shortage from 2028. The results of simulation balancing supply and demand in 2030 are illustrated in the Figure 9.3-3 -Figure 9.3-5. Power exchange in November would decrease because the thermal plants in Thai system stoped due to the scheduled annual inspection.

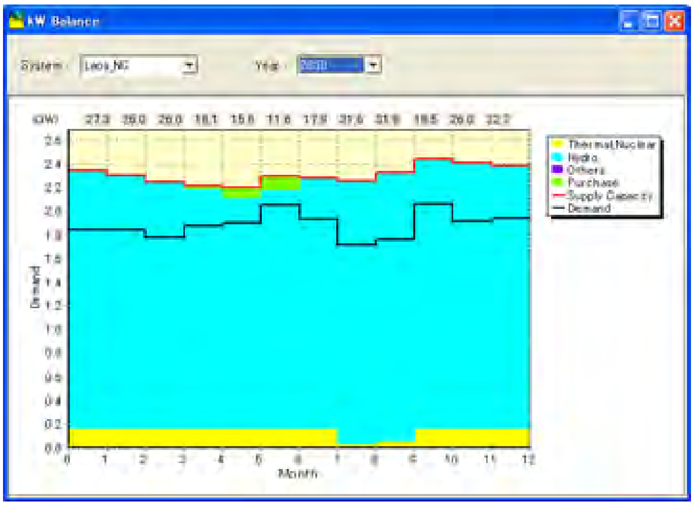

Figure 9.3-3 Monthly Balance Supply/Demand in Lao North/Central 1 (2030 Base Case)

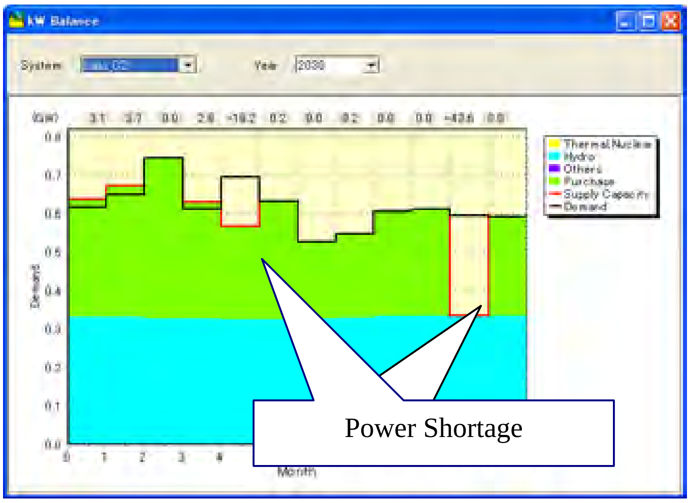

Figure 9.3-4 Monthly Balance Supply/Demand in Lao Central 2 (2030 Base Case)

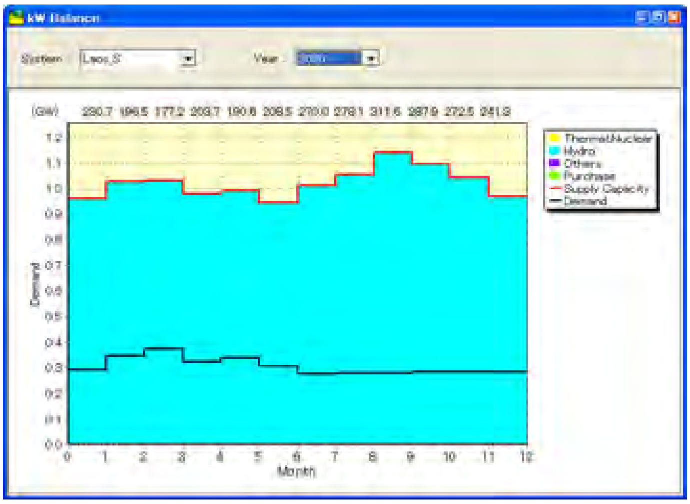

Figure 9.3-5 Monthly Balance Supply/Demand in Lao South (2030 Base Case)

(b) Case of High demand (High Case)

Simulations have been conducted on the high demand as 9%/year GDP growth basis, which are based on the existing power development plan and latent power development in the Lao territory. In the results, there is any power shortage in 2020. In the Lao Central 2 system has power shortage from dry season in 2024. The North and Central 1 system has power shortage from dry season of 2028. The results of simulation balancing supply and demand in 2030 are illustrated in Figures 9.3-6 to 9.3-8.

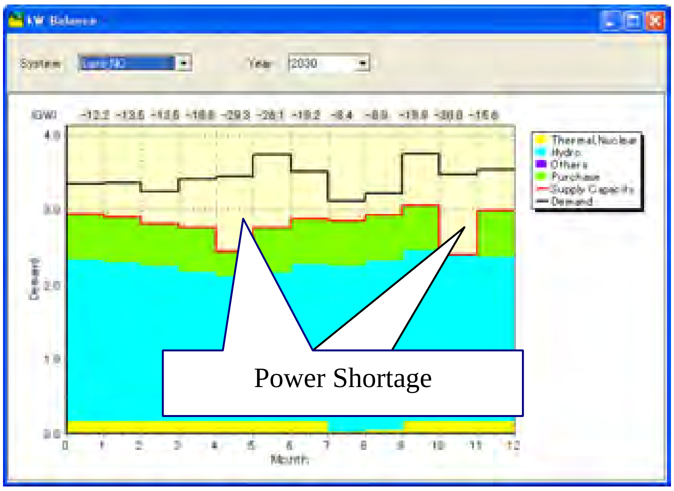

Figure 9.3-6 Monthly Balance Supply/Demand in Lao North/Central 1 (2030 High Case)

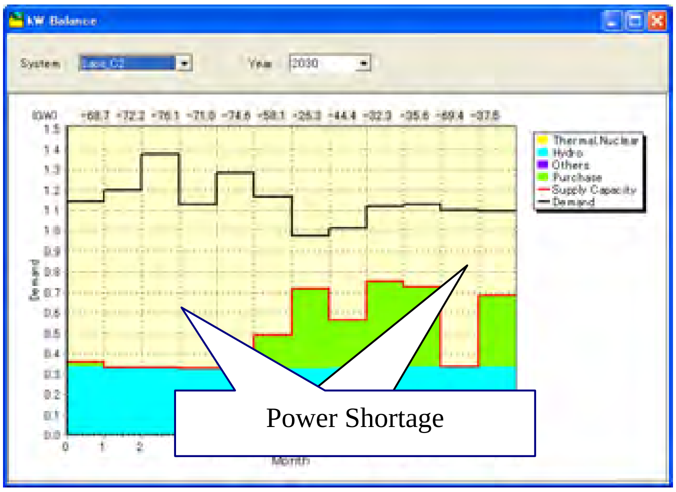

Figure 9.3-7 Monthly Balance Supply/Demand in Lao Central 2 (2030 High Case)

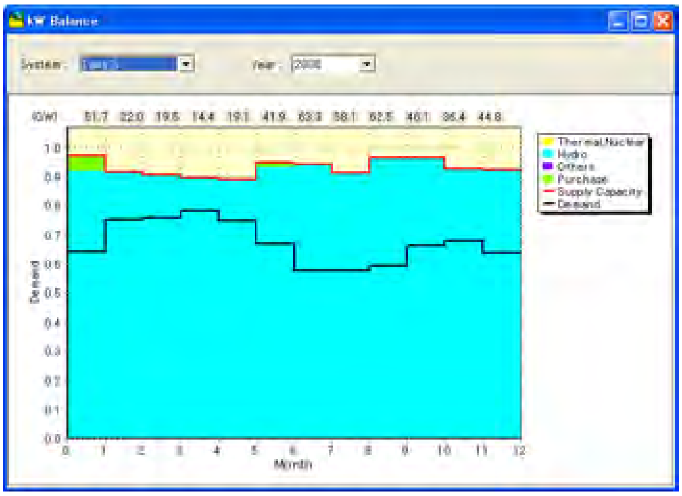

Figure 9.3-8 Monthly Balance Supply/Demand in Lao South (2030 High Case)

(c) Balance Supply and Demand in 2030

The results of the simulation on balance supply and demand show that the development of 125 MW of additional supply capacity is required during the dry season of May in the year 2030 to meet the demand. The Lao North and Central 1 and Central 2 systems will have power shortages throughout the year in 2030 under a high demand forecast case. 1,000 MW of additional power supply should be installed in Lao's North and Central 1 system. 900 MW of additional power supply should be installed in Lao's Central 2 systems. An additional 1,900 MW of power supply should be developed. Both systems should develop a power supply to be secured during the dry season. Hydropower whose installed capacity is curtailed one third (1/3) during the dry season, should make up for this by developing three times as much during the dry season in order to meet the necessary peak supply capacity.

(3) Situation of Development on Latent Primary Energy

(a) Potential of hydropower development

The 13,669 MW of hydropower plants are available for development to meet domestic demands, switching over from export projects. A lot of them are located in the North area. The projects that can connect to the Central 2 and South system are shown in Table 9.3-4.

Table 9.3-4 Potential Hydropower Development in the Lao South

Project	Estimated Capacity (MW)	COD
Sekong 4	300	TBD
Sekong 5	330	TBD
Xe Pian/XeNamnoy	390	2015
Nam Kong 1	75	2012
Xekaman 4	220	TBD
Xe Pone 3	100	TBD
Latsua (Mekong)	686	TBD
Donsahong	240	2015
Total	2,341	

According to the DOE, almost all projects have pre-determined customers. 320 MW of them are still undecided as to whether or not they will become customers.

In addition, Houay Ho hydropower (216 MW) will transfer over to the Lao side after its contract PPA expires in 2024 in conformity with the BOT scheme. Thus, the amount of available hydropower from development potential projects totals 536 MW.

(b) Coal development potential

According to the information from the DOE, the latent coal reserve within Lao territory is described in the Table 9.3-5.

Coal reserves are located in the North area of Lao PDR. In Central 2 areas, some anthracite reserve might be located. The amount of available generation that is calculated roughly is equal to operating a 450 MW coal thermal plant for 20 years, where its heat rate is 30%, capacity factor is 70% and the coal calorific value is 6,000 kcal/kg. Anthracite is high quality coal. The government of Lao applies it towards exports to earn foreign currency.

Table 9.3-5 Latent Coal Reserve in Lao PDR

No.	Anthracite	Location	C1 (Tons)	C2 (Tons)	P (Tons)	Total(Tons)
1	B. Vang ky,	Vientiane	_	_	400,000	400,000
2	B. Bo Cham	Vientiane	2,010,000	2,144,000	4,000,000	8,154,000
3	B. Nam Thom	Vientiane	_	_	400,000	400,000
4	B. Vangmieng	Xienkhang	830,000	1,310,000	_	2,140,000
5	B. Chakheun	Saravan	_	92,000	27,890,000	27,982,000
6	Phongsaly	Phongsaly	_	_	24,500,000	24,500,000
	Total:		2,840,000	3,546,000	57,190,500	63,576,500
	Lignite	Location	C1 (Tons)	C2 (Tons)	P (Tons)	Total (Tons)
1	Kanpanieng	Xiengkhang	_	2,526,413	_	2,526,413
2	B. Mouangpan	Xiengkhuang	35,837,536	13,910,771	_	49,748,307
3	Hongsa	Xayabuly	505,825,339	5,200,000	_	511,025,339
4	Viengpoukha	Luangnamtha	12,727,356	_	_	12,727,356
5	B. Nam Ngeu	Oudomxay	_	510,000	_	510,000
6	B. Ai	Oudomxay	_	_	115,450	115,450
	Total:		554,390,231	22,147,184	115,450	576,652,865

(Source: DOE)

Coal consumption in thermal power

<Annual Generating Energy> (Capacity Factor 70%)

450 (MW) x 8,760 (hour) x 0.7 = 2,759.4 (GWh/year)

<Annual Coal consumption > (Heat rate 30%, Coal calorific value 6,000 kcal/kg)

2.7594 x 109 (kWh) x 860 (kcal/kWh) ÷ 0.3 = 7,910.28 x 109 (kcal/year)

7,910.28 x 109 (kcal) ÷ 6000 (kcal/kg) ≒ 1,318,380 (t/year)

<For 20 years>

1,318,380 (t/year) x 20 (year) = 26,367,600 (t)

(Latent reserve at B. Chakheun Mine is 27,982,000 t)

(4) Scenarios of Detailed Simulation Balancing Supply/Demand

The peak supply capacity of the Lao systems excluding the South system during the dry season is dependent on power imported from the Thai system in consideration of the results of balancing the supply and demand simulation. The supply capacity in the Lao Central 2 system is insufficient and the Lao South system has enough surplus supply capacity. The reinforcement capacity between the Central 2 system and the South system is recommended as one alternative countermeasure.

Power imports from neighboring countries and the development of thermal power plants can be recommended as countermeasures for insufficient power supply during the dry season. For insufficient supply power in the Lao Central 2 system, there are recommended countermeasures such as the development of coal thermal plants located in the Saravan district, reinforcement of interconnections between the Central 2 system and the South system, and IPP power purchases. Some IPP plants will be connect to the Lao domestic system, after their PPA expires around 2030 such as the Nam Theun Hinboun, Houay Ho and Nam Theun2.

It causes system reliability defects such as having a large share of power supply dependent on imported power from neighboring countries. The blackout in the Vientiane capital in early 2009 cased by the interruption of power imports from Thai due to Thai system failures. Self-sufficiency of power supply within the Lao system should be applied as a policy of system planning when scenarios are selected for simulation of long-term plan

The scenarios are nominated in consideration of the aforementioned.

(a) Coal thermal power located in Saravan (Power supply for dry season, for Central 2 system)

(b) Reinforcement of interconnections between Lao Central 2 and South

(c) Connection of Houay Ho hydropower (140 MW) into Lao system
The scenarios for detailed simulations were selected based on discussions with counterpart personnel in the DOE and EDL. Besides, the government of Lao has a plan to develop bauxite existing in the Laos South area as a development policy. The plans for the bauxite mine could be selected such as utilization of export projects located in the South area, development of thermal power plants and import power from neighboring countries. The bauxite mine plan of development is still unclear wirruof has not made clear its required capacity and timing of power supply yet.

(d) Power supply for a bauxite-mine located in the South area (including IPP, power import)
Available capacity by 2030 and issues of supply to the bauxite mine will be examined.

9.3.3 Results of Detailed Simulation for Supply/Demand Balance

Scenarios for detailed simulation have been selected considering a balance between supply and demand, a latent primary energy potential in Lao territory and available amount of power import based on the interviews. The required capacity by each scenario has been studied with series of simulation between supply and demand.

(1) Coal thermal power plant development Scenario
450 MW of coal thermal power plants are required between 2017 and 2030 in the Central 2 area at the base demand basis. For high demand cases, additional thermal power plants will be required as 1,000 MW located in the North/Central 1 system and 900 MW located in the Central2 system. The unit size should be selected appropriately, when a thermal power plant is planned. When a large unit size of thermal power is applied to the system, it shows good economic performance, but frequency fluctuations are large at its operation failures and maintenance causes a tight balance between supply and demand.

150 MW is the appropriate largest unit size based on the simulation under given demand forecasts and aforementioned power development plans. To decide the least cost unit sizes, a detailed analysis should be conducted related to affects to frequency at off peak time and power flow at maintenance periods based on the N-1 criteria.

Table 9.3-6 Thermal Power Requirement Capacity by 2030

Project	Capacity(MW)	Fuel Type	COD	Location
Thermal power 1	150	Coal	2027	Saravan
Thermal power 2	150	Coal	2028	Saravan
Thermal power 3	150	Coal	2029	Saravan
Total	450			

(2) Reinforcement of Interconnection Capacity between the Lao Central 2 and South
The improvement of system reliability is not obtained when capacity increases from original planning capacity of 300 MW in the base demand case. (Refer the Figure 9.3-9) The balance

between supply and demand will not improve if interconnection capacity increases over 30 MW because surplus supply capacity in the South system decreases in dry season.

9.3.4 System Reliability

The benefits of system reliability improvements from interconnections can hardly be expected, even if interconnection capacity is increased.

The benefits of system reliability improvement form interconnection are not expected

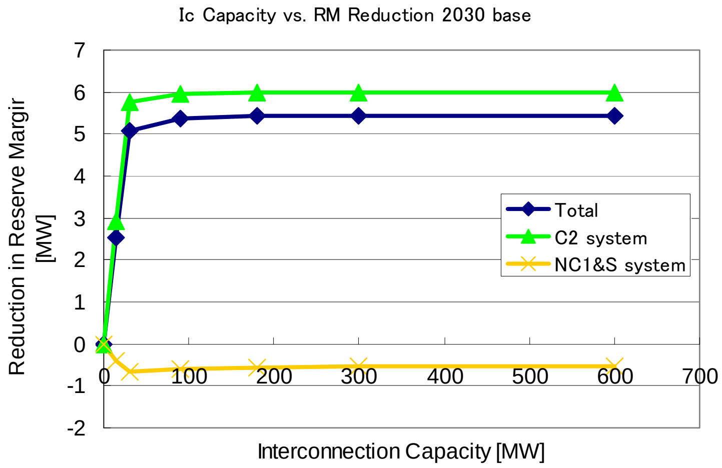

Figure 9.3-9 Interconnection Capacity between Lao Central 2 and South vs. Reduction in Reserve Capacity (2030)

(3) Utilization of Houay Ho Hydropower into Lao System

The Houay Ho hydropower plant (140 MW) is connected directly to the EGAT system through the 230kV transmission line. The Lao system can use the power supply from Houay Ho in addition to the hydropower development of 536 MW. The Lao system can utilize 230 kV transmission line as an interconnection with Thai system when Houay Ho hydropower plant is connected to the Lao South system. It is difficult to identify quantitatively the balance between supply and demand considering the connection of Houay Ho into Lao system, because demand forecast and power development plan of Thai system in 2030 have not been drafted. The basic policy of power development in Lao system is self-sufficient of power balance within their country. Therefore, this scenario should be an alternative for high demand case.

(4) Power Supply for a Bauxite Mine located in the South Area

The countermeasures of power supply for Bauxite mine located in the South area after supplying domestic demand are necessary to develop additional thermal power plants and power import from neighboring countries even in the base demand case. In case of additional thermal power plant development, the energy infrastructure should be developed with least cost manner based on the long term energy balance in considering the industrial promotion policy of Lao government. The foreign currency is required to import fuel from abroad. The foreign currency reserve will be produced by some industries. The costs of necessary energy infrastructure development should be shared among these industries and an electricity industry.

9.4 Detailed Simulation

(1) Establishment of Primary Energy Masterplan

Electric power development of 500 MW scale is needed in around 2030 as the power demand increases. It is necessary to develop three to five times of the necessary supply capacity in dry season to compensate for an output decrease, when only hydropower plants supply the incremental demand. The hydropower plants should create surplus outputs over Lao domestic demand in the rainy season. The surplus power during the rainy season causes over flow from their reservoirs. The profits of hydropower plant will be damaged by the water discharge. Thus, thermal power plants will be economical supplied during the dry season. The infrastructure for import fuel has not developed. It is necessary to decided the sharing costs of fuel infrastructure to secure benefits from the national economy whether electricity tariff bears it or not, after adjusting the national estate development plan and the industry promotion development plan. The government of Lao PDR needs to establish the primary energy masterplan.

(2) Development of Power Supply in Dry Season

Social infrastructure such as roads, bridges is developed in the Central region of Lao PDR based on the national estate development policy. The electric power demand will grow with the social development. The economical hydropower projects have developed for export projects. They can supply to the Lao system after 2035 based on their PPA. The power supply in dry season should be developed in the most leastly cost manner. The feasibility study of thermal power plant for appropriate fuel usage should be conducted from effectively developing primary energy in the Lao PDR and the energy master plan aspects. Environmental conservation standards for thermal power plants have not yet been established such as air and water quality conservation regulations. Capacity building should be necessary on the environmental conservation for thermal power plants.

(3) Establishment of System Operation and Reinforcement Plan for Introducing IPP into Lao system

Almost all power plants for export are connected to the Thai system or Vietnamese system. The power plants directory connected to the Lao system are Nam Nugum 1 and some small plants only. The system reinforcement plan and system operation rule should be established to operate system stably and economical when large IPPs are connected into the Lao system after their PPA expires. The capacity building of system operations should support in order to secure a stable and economic system operation.

9.5 Preliminary Power System Plan

The main power sources are owing to hydropower in Laos and the locations of the power generations are varied among the regions. While the power generation outputs are reduced in dry seasons, the power demand does not become lower. Thus, the scales of the transmission lines should be examined so as to transmit the power to the areas where the power shortage is expected to occur during the dry seasons and to utilize the hydropower for the sufficient power export in wet seasons. Thus, the regional power supply demand balance has been studied both for wet and dry seasons as preliminary power system planning and the required power transmission abilities has been estimated for the interregional power trade.

9.5.1 Power Supply Demand Balance for Each Province

The power supply demand balances has been confirmed for each province both in wet and dry seasons based on the information about the power generation plans in 2020, the locations and the loads of 115/22 kV substations and the special power consumers.

Figure 9.5-1 shows the results of the study. The numbers in the circled area indicating the provinces show the surplus power when positive and the insufficient power when negative and the unit of the numbers is MW.

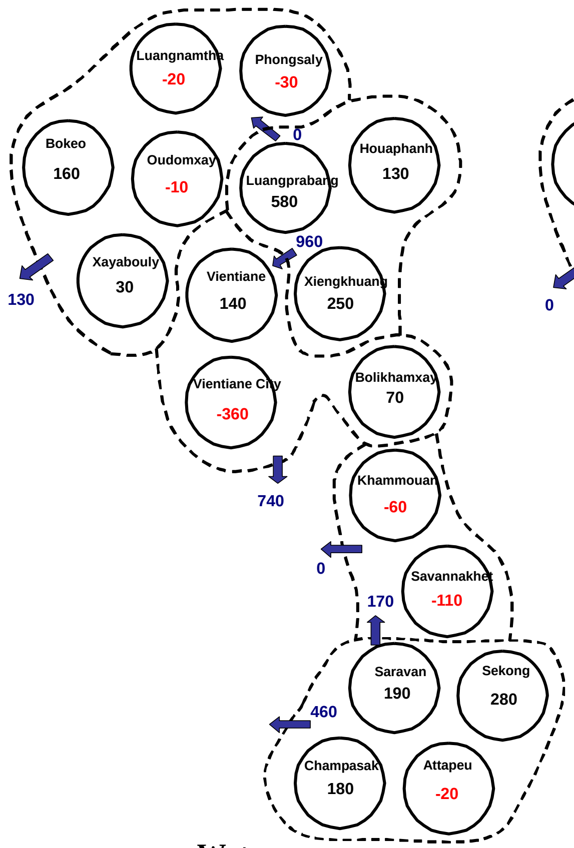

Figure 9.5-1 Power Supply Demand Balance for Each Province in 2020

The surplus power is expected in the northeast area so as to produce 940 MW from Houaphanh, Luangpraban, Xiengkhuang and Bolokhamxay to Vientinane, 90 MW to Thailand and 740 MW from Vientiane to Thailand. Thus the new transmission lines from Luangprabang and Xiengkhuang to Vientiane will be required.

The surplus power is expected in the northwest area so as to produce the power of from Bokeo and Xayabouly to Thailand. This amount of power can be transmitted by the interconnection that has been already planned from Bokeo and Xayabuly to Thailand.

The surplus power is expected in the South area so as to produce 170 MW from Saravan, Sekong, Champasak and Attapeu to Khammouan and Savannakhet, 46 MW to Thailand. This power transmission from the South to the Central will be possible by the transmission line proposed as the highest prioritized project examined in Chapter 8, however, the reinforcement of the interconnection will be required for power exports to Thailand.

Power transmission will be possible in dry seasons via the aforementioned system that is able to respond during the wet seasons.

9.5.2 Preliminary Power System Plan

The candidates of the further transmission lines required until 2020 are as follows.

- The transmission lines able to transmit power of around 900-1,000 MW from Luangprabang or Xiengkhuang to Vientiane
  - Thus, the 230 kV transmission line with double circuits form Xiengkuang to Vientiane will be required in addition to the 230 kV transmission lines from Luangprabang to Vientiane that has been already planned.
- The reinforcement of the interconnection from Vientinane to Thailand
  - The increase in the number of circuits from Vientiane to Thailand for power export to Thailand of the surplus power in the Laos North region. [1]
- The reinforcement of the interconnection from the South to Thailand
  - The increase in the number of circuits from the South region of Laos to Thailand for power export to Thailand of the surplus power in the South region.[2]
- The transmission line to the appearing special consumers and the 115/22 kV substations
- The transmission line from the appearing power stations to the main grid

until 2030 are as follows.

- The transmission lines able to transmit the power of around 200-400 MW from the thermal station appeared in Saravan to Savanhakhet and Kammoun
  - Thus, the 230 kV transmission line with double circuits from around Saravan to the Central 2 region will be required.

9.6 Power System Analysis for the System in 2020

In this section, the power system analysis of the future transmission system for domestic power supply was conducted. The transmission system was planned up to the year 2020 in order to meet the requirements on demand increase, progress of power development, and increase in power import/export between Thailand on the basis of the system configuration in 2016 of PDP prepared by EDL, considering the results of the section 10.4 “Preliminary System Planning”. The same study conditions as the Section 7.4.3 “Fundamental Technical Criteria and Study Conditions” were applied.

9.6.1 Power Flow and Voltage Analysis

Power flow and voltage analysis for both dry and wet seasons were conducted for the power system as of 2020. Both normal operation and single contingency conditions were considered.

(1) Assumptions

Assumptions for the power flow analysis are as follows:

- For both dry and wet seasons, peak loads were applied for substation loads.

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[1] Adding 1 circuit, the 115 kV transmission line of the section between Phonetong-Thanaleng shall be consisted of 3 circuits. Detailed study on the construction method would be necessary on the feasibility study stage since the existing transmission line of the same section has already been constructed using double-circuit towers.

[2] The 115 kV transmission line of the section between Ban Jianxai and Sirindhom shall be consisted of 4 circuits. Application of 230 kV transmission line may have to be considered on the feasibility study stage if some difficulties in construction works are anticipated due to significant increase in the number of circuits.

- Planned power stations listed in the Annex D: Estimated Generation in Dry Season and Dry year, which were mutually agreed between the counterpart and the JICA Study Team on July 11, 2009 were considered for the power system analysis.
- Dry season outputs in the aforementioned Annex D were used for the power stations (both existing and planned) whose dry season output values were stated. For the power stations whose dry season outputs are unknown, 70% of their installed capacities (reservoir type) and 30% (run-of-river type) were assumed.
- In the wet season, power outputs of the generators were set in order for the total output of all generators in Laos to become 93.9% of the sum of the total generator outputs so that stability analysis calculation can converge.
- For some substations, shunt capacitors were installed in order to maintain bus voltages within allowable range.
- Phase shifters are assumed to be installed at for both circuit No.1 and No.2 of the 115 kV bus of Hongsa substation in order to restrict the power flow through the 500/115 kV transformer at the substation up to 100 MW from EGAT system to EDL system in Dry season since the transformer will be used only for power import from Thailand. In the wet season, the phase shifter angle was set in order for the power flow from EDL system to EGAT system to be 0 MW. (Dry Season: 19.29 degrees, Wet Season: -39.55 degrees)

(2) Analysis Results (Dry Season)

(a) Normal operation condition
Under normal operating conditions, no overloading of transmission lines or abnormal voltage at substation buses occur. The power flow of North and Central 1 areas and Central 2 and South areas are shown in the Figure 9.6-1 (a) and (b), respectively. (Refer to the Appendix 9.6-1 for detailed power flow diagrams).

(b) Single contingency condition
Under any single contingency condition, no overloading of transmission lines or abnormal voltage at substation buses occurs to Laos system.

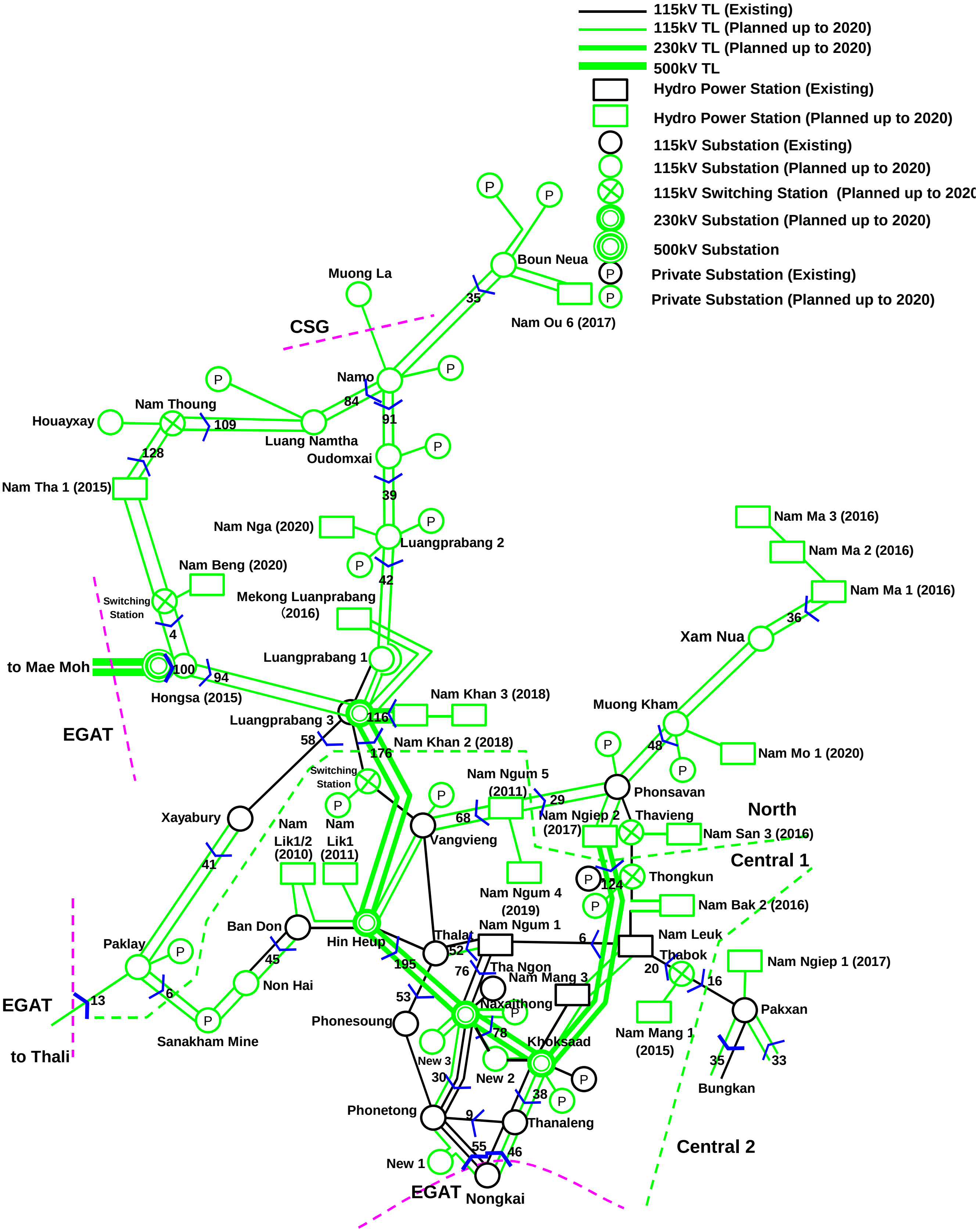


Figure 9.6-1 (a) Power Flow in 2020 (Dry Season: North and Central 1 Areas)

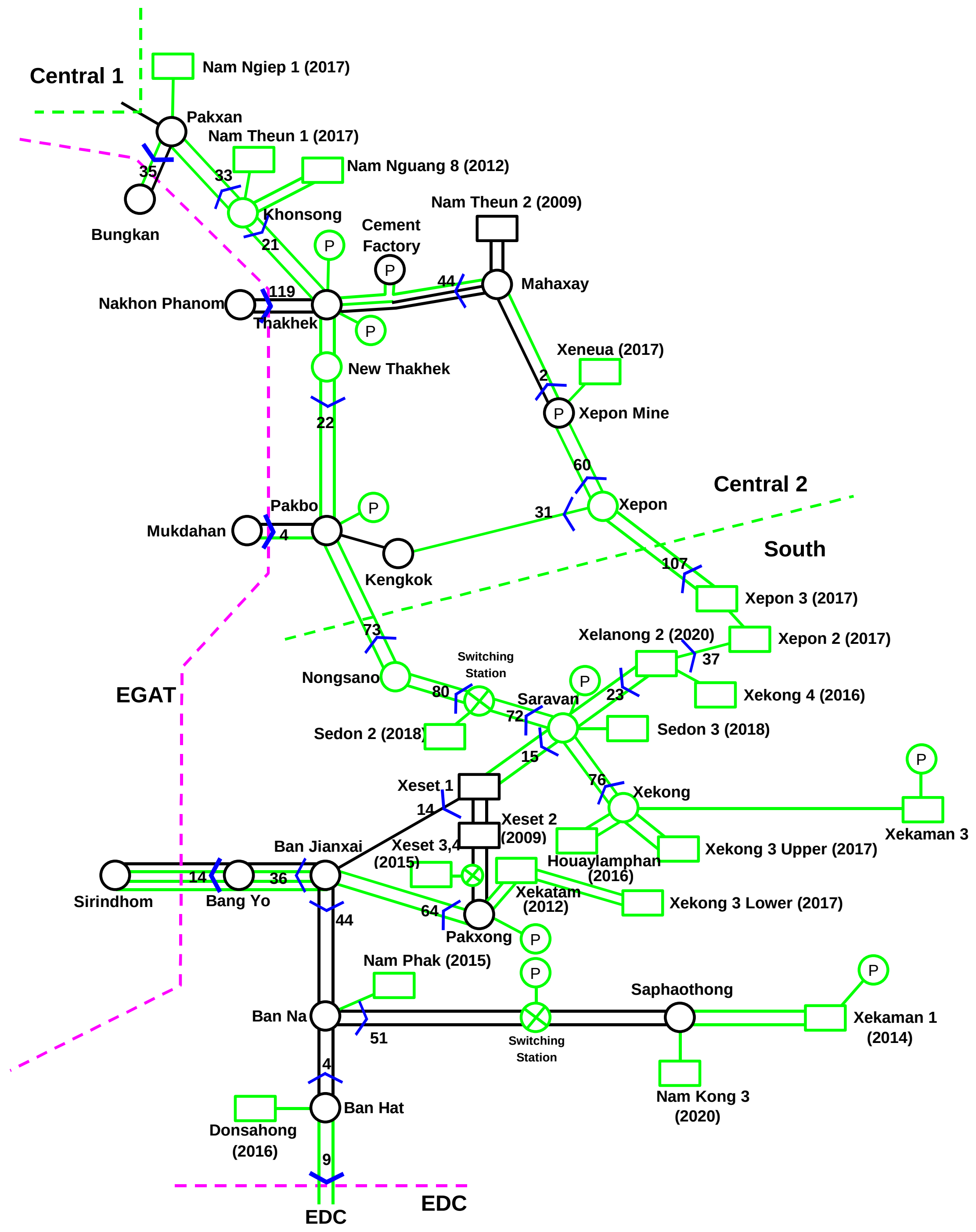


Figure 9.6-1 (b) Power Flow in 2020 (Dry Season: Central 2 and South Areas)

(3) Analysis Results (Wet Season)

(a) Normal operation condition

Under normal operating conditions, no overloading of transmission lines or abnormal voltage at substation buses occurs. The power flow of North and Central 1 areas and Central 2 and South areas are shown in Figures 9.6-2 (a) and (b), respectively. (Refer to the Appendix 9.6-1 for detailed power flow diagrams).

(b) Single contingency condition

The power flow and voltage analysis results under single contingency condition are shown in Table 9.6-1. Overloading occurred to the remaining circuits of the following sections in the event of a single circuit fault of the 115kV transmission lines in question resulting from huge surplus power exported to the EGAT system through the lines. Setting the high overall average operation rate of generators, 93.9%, caused the surplus power.

- Hongsa substation - new switching station
- Phonetong substation - New 1 substation
- Khoksaad substation - Thanaleng substation

In order to solve the overloading problem, such countermeasures as increasing the number of circuits and/or replacement of the conductors with ones with larger transmission capacities should be considered. From the system's operational point of view, further study on the generator operation in wet season should be considered.

Table 9.6-1 Power Flow and Voltage Analysis Results in Case of Single Contingency Condition (Year 2020, Wet Season)

Fault Location					Analysis Result								
From		To		cct	Type of Problem	Problem Location							
Name	KV	Name	KV										
Hongsa	115	Switching Station	115	1	Overloading	From	Hongsa	115kV	To	Switching Station	115kV	ckt	2
Hongsa	115	Switching Station	115	2	Overloading	From	Hongsa	115kV	To	Switching Station	115kV	ckt	1
Phonetong	115	New 1	115	1	Overloading	From	Phonetong	115kV	To	New 1	115kV	ckt	2
Phonetong	115	New 1	115	2	Overloading	From	Phonetong	115kV	To	New 1	115kV	ckt	1
Khoksaad	115	Thanaleng	115	1	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	2
Khoksaad	115	Thanaleng	115	1	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	3
Khoksaad	115	Thanaleng	115	2	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	1
Khoksaad	115	Thanaleng	115	2	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	3
Khoksaad	115	Thanaleng	115	3	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	1
Khoksaad	115	Thanaleng	115	3	Overloading	From	Khoksaad	115kV	To	Thanaleng	115kV	ckt	2

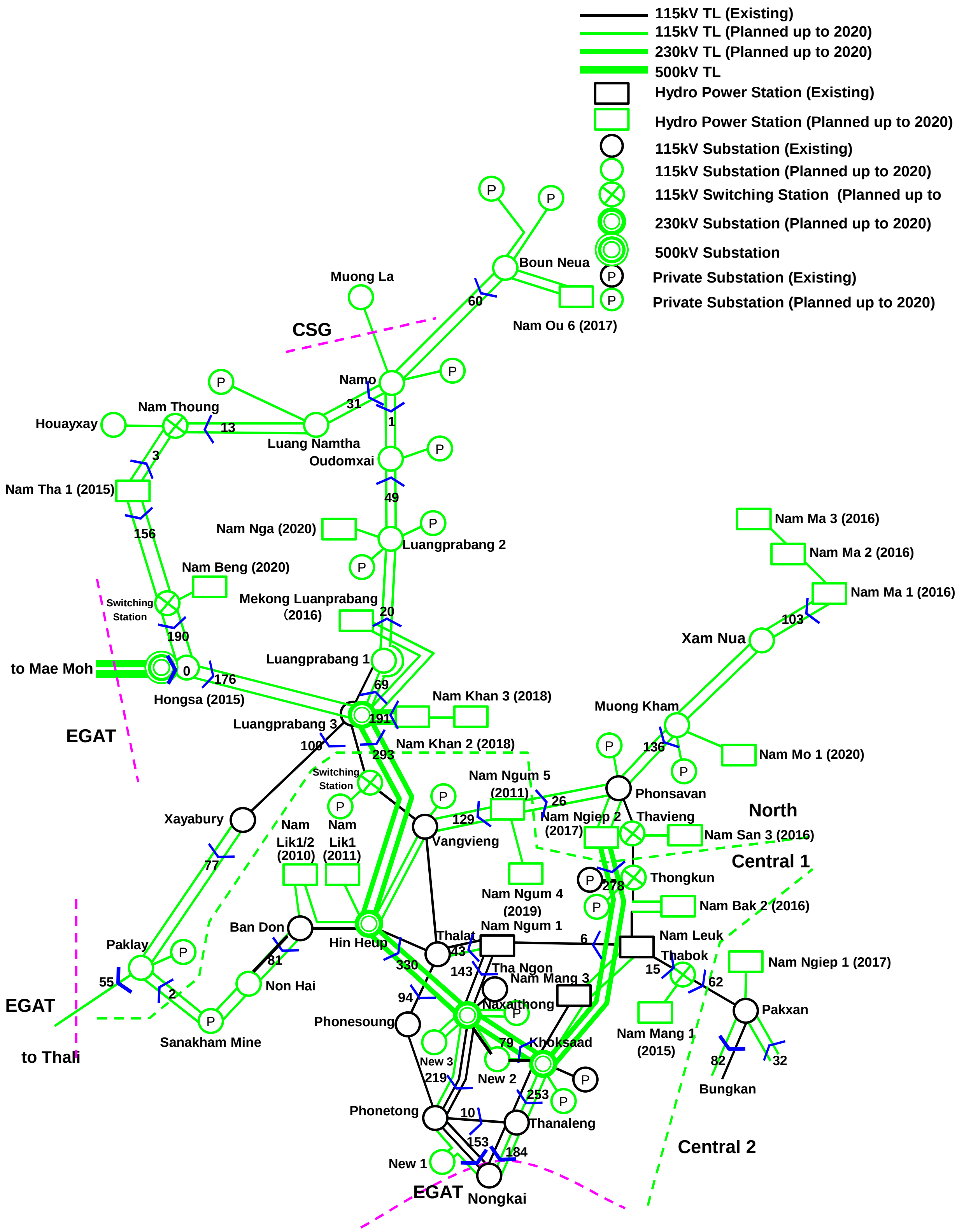


Figure 9.6-2 (a) Power Flow in 2020 (Wet Season: North and Central 1 Areas)

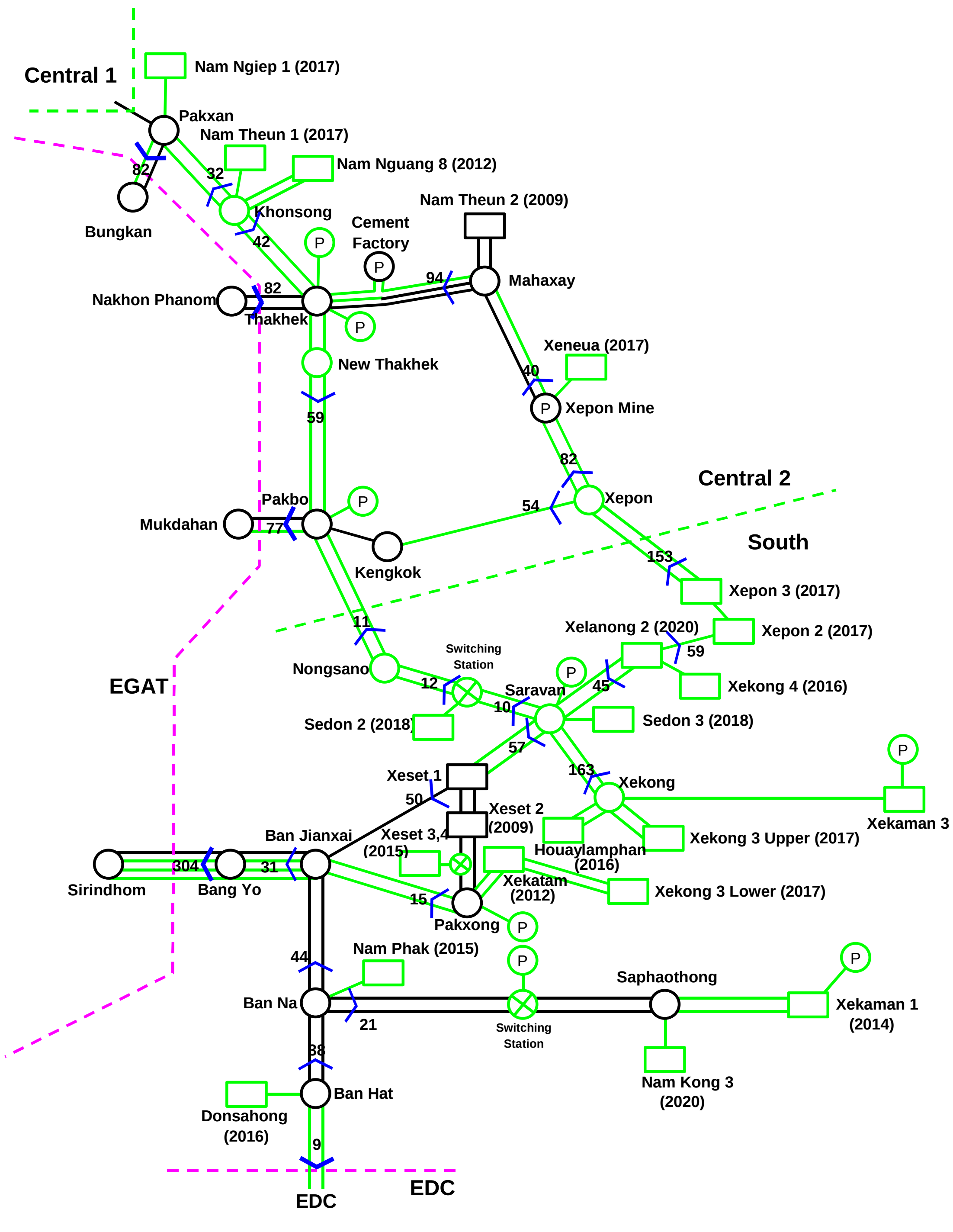


Figure 9.6-2 (b) Power Flow in 2020 (Wet Season: Central 2 and South Areas)

(4) Operation of the Phase-shifter Installed in Hongsa Lignite

In this study, power flow analysis for certain load cases, namely, peak loads at all substations in the 2020 power system, was conducted, thus setting the phase angle of the phase shifter at Hongsa substation to satisfy the power flow limit at the 500/115 kV transformer; however, the power flow at the transformer varies continuously depending on the changes in the demand of the loads and the generator outputs. It is necessary to control the phase angle of the phase shifter accordingly. Therefore, further study on the control range and method of the phase angle of the phase shifter is considered necessary.

9.6.2 Transmission Line Loss

Transmission line losses of the whole system for domestic power supply as of year 2020 for both dry and wet seasons (excluding losses of the system for exports) are shown in Table 9.6-2. The same assumptions and calculation methods as the Section 8.8.3 “Transmission Line Loss” were applied to the calculation of annual energy loss.

- Annual load factor: 0.7
- Long-term marginal cost for high voltage: 0.0407 USD/kWh

Table 9.6-2 Transmission Line Loss for Domestic Power Supply System in Laos

Season	kW Loss [MW]	Annual Energy Loss [MWh]	Annual Energy Loss [million USD]
Dry	70	339,100	13.8
Wet	201	975,154	39.7

9.6.3 Fault Current Analysis

Maximum three-phase short circuit fault currents were calculated for the power system in 2020.The maximum three-phase short circuit current values and the locations whose values become the maximum are shown in Table 9.6-3. The three-phase short circuit current values of the planned system are maintained within the allowable maximum fault current level.

Table 9.6-3 Maximum Three-phase Short Circuit Fault Currents and Locations

Year	230kV Bus	115kV Bus	22kV Bus
2020	22.1kA Ban Sok SS	15.3kA Naxaithong SS	23.7kA Phonetong SS
Allowable maximum fault curren	40-50kA	25-31.5kA	25-31.5kA

9.6.4 Stability Analysis

Stability analysis for the planned system in 2020 was conducted.

(1) Study Cases

Table 9.6-4 shows the study cases for the stability analysis. Fault locations were selected taking into consideration both typical heavy-loaded sections in North and Central-1 areas and the interconnecting lines between the Central-2 and South areas.

Table 9.6-4 Stability Analysis Cases

Dry/Wet	Case	Fault Section (1cct)		
Dry Season	ST-D1	Saravan	-	Nongsano
	ST-D2	Xepon 3	-	Xepon
	ST-D3	Phonsavan	-	Nam Ngiep 2
	ST-D4	Hongsa	-	Nam Tha 1
Wet Season	ST-W1	Saravan	-	Nongsano
	ST-W2	Xepon 3	-	Xepon
	ST-W3	Phonsavan	-	Nam Ngiep 2
	ST-W4	Hongsa	-	Nam Tha 1
Fault Sequence	0ms	Single Circuit Three-phase Short Circuit Fault		
	140ms	Fault Clearance (1cct Open)		
	10s	End of Calculation		

(2) Analysis Conditions

The stability analysis was conducted under the following conditions:

- As same as the Section 8.8.5. Basic Stability Analysis, generator models for the analysis were ones provided by EDL. For the generators whose models were unknown, the salient-pole generator model, shown in Table 8.8-9, were applied. (Note: Planned power stations for domestic power supply up to the year 2020 are all hydropower stations.)
- Identical to the Section 8.8.5. Basic Stability Analysis, the simple exciter model (SEXS), shown in Table 8.8-10, was applied as the exciter models for the planned power stations.
- Application of the Power System Stabilizer (PSS) and Governor was assumed for the power stations with the installed capacities of more than 60 MW that were listed in the Table 9.6-5. As the PSS model, the IEEEST model, which was shown in Table 8.8-12, was applied. As the governor model, the HYGOV model shown in Table 9.6-6 was applied. For the existing power stations with the installed capacity of more than 60 MW, the PSS and governor were considered in accordance with actual conditions.
- Phase angle of the phase shifter at Hongsa substation was assumed to be unchanged throughout the analysis period.

Table 9.6-5 Generators with PSS and/or Governor

Power Plant	Inst. Cap (MW)	PSS	GOV	Comm. Year
Nam Ngum 1	155.0		Y	1971
Nam Leuk	60.0		Y	2000
Nam Mang 3	40.0		Y	2005
Nam Theun 2	75.0	Y	Y	2009
Xeset 2	76.0	Y	Y	2009
Nam Lik 1/2	100.0	Y	Y	2010
Nam Lik 1	60.0	Y		2011
Nam Ngum 5	120.0	Y	Y	2011
Nam Nguang 8 (Theun Hinbun Ext	60.0	Y	Y	2012
Nam Tha 1	168.0	Y		2012
Xekatam	61.0	Y	Y	2012
Hongsa Lignite TPP (Local)	100.0	Y		2015
Nam Bak 2	80.0	Y	Y	2016
Nam Ma1	60.0	Y	Y	2016
Mekong Luangprabang	140.0	Y		2016
Houaylamphan	86.7	Y		2016
Donsahong	60.0		Y	2016
Xekong 4	70.0	Y		2016
Nam Ou 6 (Local)	90.0	Y		2017
Nam Ngiep 2	180.0	Y	Y	2017
Xekong 3 (Upper)	152.0	Y	Y	2017
Xekong 3 (Lower)	96.0	Y	Y	2017
Xepon 3 (Upstream)	70.0	Y		2017
Nam Khan 2	145.0	Y	Y	2018
Nam Khan 3	66.0	Y		2018
Nam Nga	60.0	Y		2020
Nam Mo1	60.0	Y	Y	2020

*Y: Applied, Yellow Cell: Existing Plant

Table 9.6-6 Governor Model: HYGOV

R	r	Tr	Tf	Tg	VELM
0.05	0.075	8	0.05	0.5	0.2
0.04	0.35	6.5	0.05	0.2	0.083
GMAX	GMIN	TW	At	Dturb	qNL
1	0	1.3	1.1	0	0.08
1	0	2.21	1.11	0.5	0.1

(3) Analysis Results

Table 9.6-7 shows the stability analysis results for each case in Table 9.6-4. Behaviors of phase angle oscillation for the cases were shown in Appendix 9.6-2.

Table 9.6-7 Stability Analysis Results

Dry/Wet	Case	Fault Section (1cct)			Result
Dry	ST-D1	Saravan	-	Nongsano	Stable
	ST-D2	Xepon 3	-	Xepon	Stable
	ST-D3	Phonsavan	-	Nam Ngiep 2	Stable
	ST-D4	Hongsa	-	Nam Tha 1	Stable
Wet	ST-W1	Saravan	-	Nongsano	Stable
	ST-W2	Xepon 3	-	Xepon	Stable
	ST-W3	Phonsavan	-	Nam Ngiep 2	Stable
	ST-W4	Hongsa	-	Nam Tha 1	Stable

For the planned system in the year 2020, the oscillation waveforms of phase angle differences were found converged in both dry and wet seasons in the case of a single circuit fault of the primary heavy-loaded sections in the North and the Central 1 areas and the fault of the interconnection lines between the Central 2 and the South areas. Therefore, it was confirmed that the planned system was stably operated under such severe conditions.

9.7 System Analysis of Bulk Transmission System in 2030

In the year 2030, system configuration between specific demands and the EDL 115 kV grid cannot be specified even with the power demand data of the residential usage and the power development plan due to lack of available data on the sizes and locations of the large-scale demands such as mining and commercial sectors. Therefore, the rough stability analysis on the bulk transmission system that constitutes 230 kV bulk transmission lines, which interconnect between areas, was conducted using the model with the gross loads of the 4 each area (North, Central 1, Central 2, and South) connected to the representative substations in these areas as concentrated loads. Based on the results of the Section 9.5 Preliminary Power System Plan, the voltage level of 230 kV was applied to the transmission lines in the case of bulk power transmission from large-scale power stations, taking into consideration length, power flow, and stability of the lines. Figure 9.7-1 (a) and 9.7-1 (b) show the planned system as of 2030 of the North and the Central 1 areas and the Central 2 and the South areas, respectively.

Due to the aforementioned reason, the 115kV transmission system except the transmission lines from the new power stations, which are planned from 2020 to 2030, to the 115 kV grid, was colored gray for reference purposes without changing the system configuration as of the year 2020.

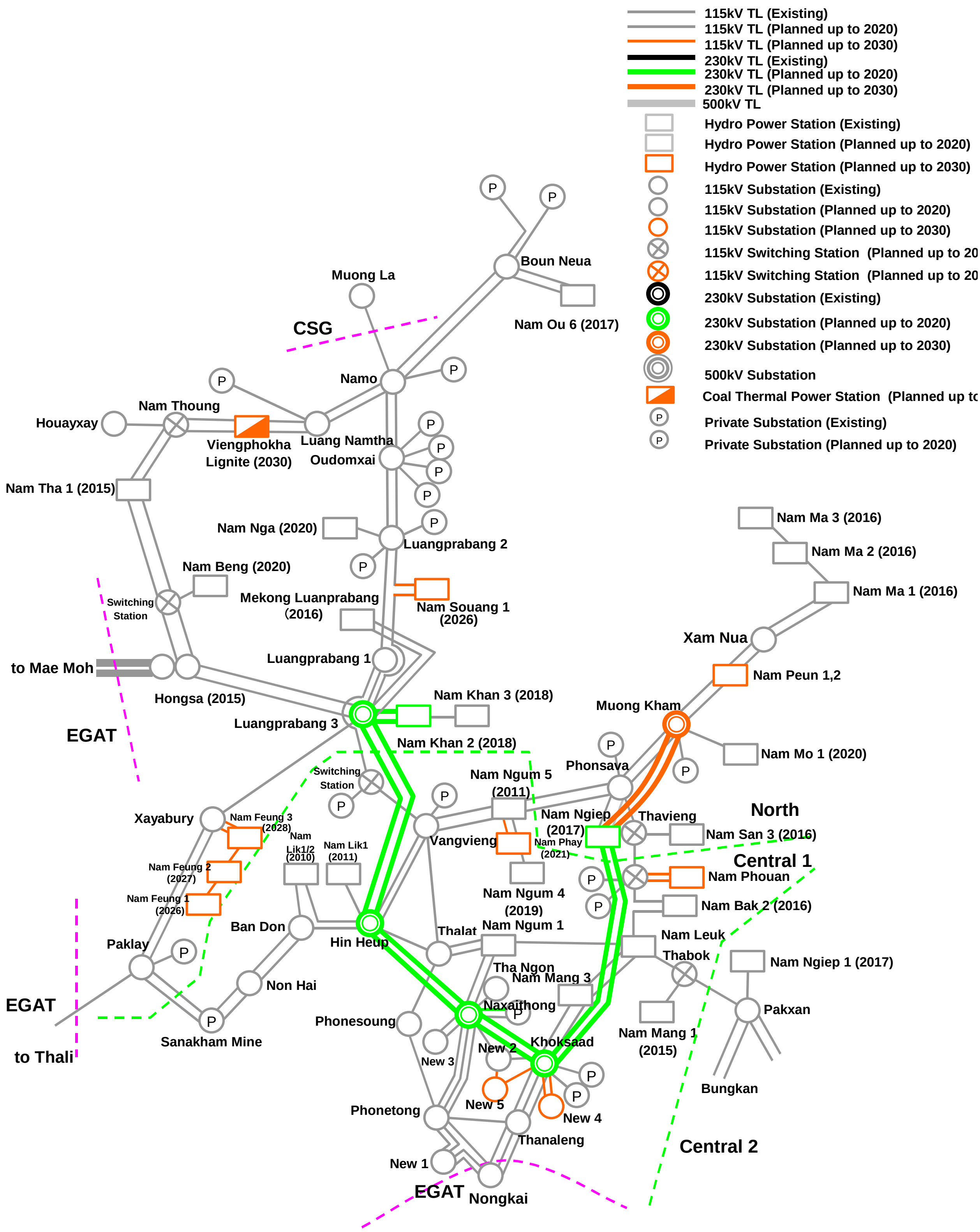


Figure 9.7-1 (a) Bulk Power Transmission System in 2030 (North and Central 1 Areas)

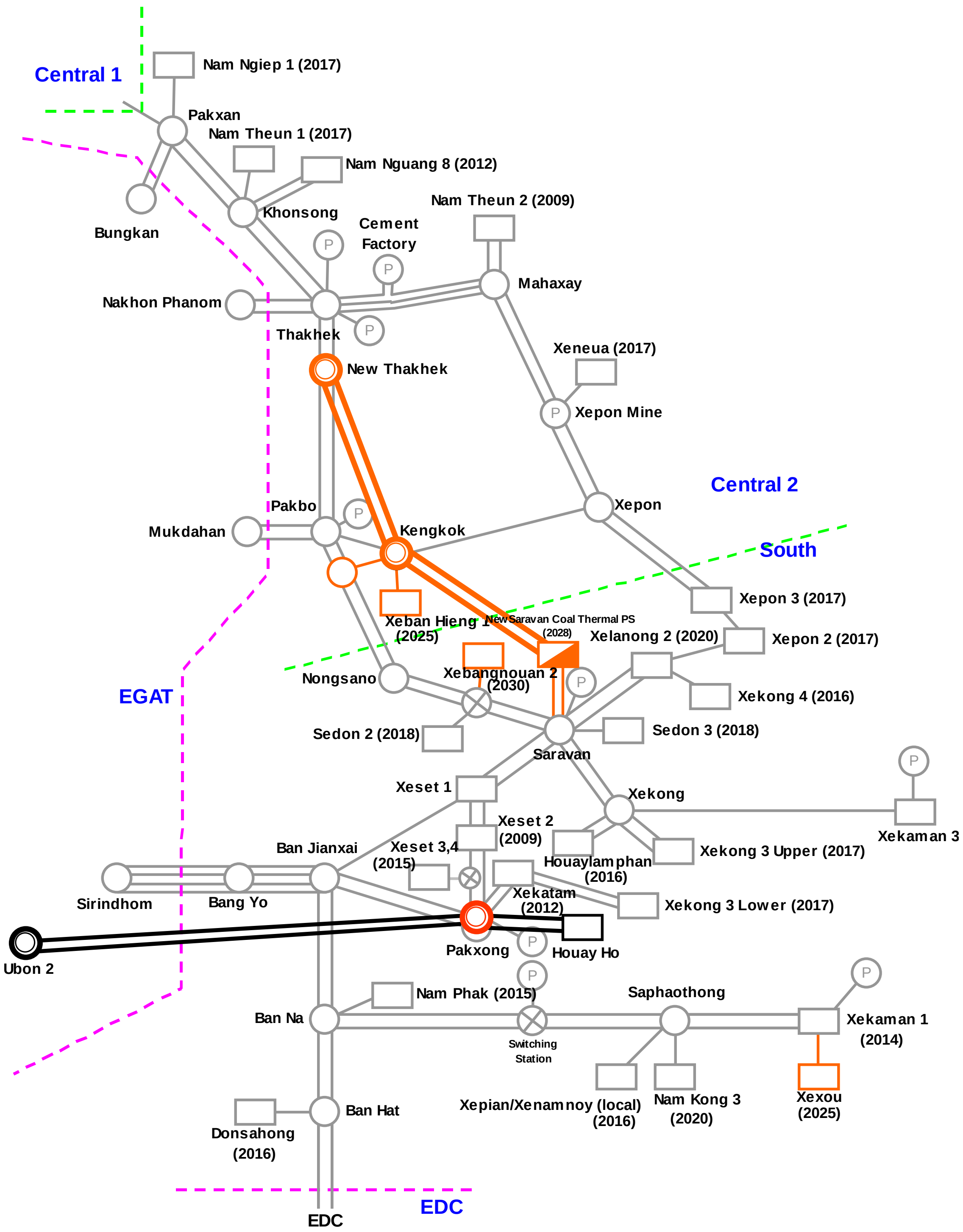


Figure 9.7-1 (b) Bulk Power Transmission System in 2030 (Central 2 and South Areas)

(1) Study Cases

Table 9.7-1 shows the study cases for the stability analysis. The target transmission lines are all 230kV bulk transmission lines. Fault locations were selected taking into consideration both typical heavy-loaded sections in the North and the Central 1 areas and the interconnecting lines between the Central 2 and the South areas.

Table 9.7-1 Stability Analysis Cases

Dry/Wet	Case	Fault Section (1cct)		
Dry Season	ST-D1-30	New Saravan Coal Thermal P/S	-	Kengkok
	ST-D2-30	Nam Ngiep 2	-	Khoksaad
	ST-D3-30	Luangprabang 3	-	Hin Heup
Wet Season	ST-W1-30	New Saravan Coal Thermal P/S	-	Kengkok
	ST-W2-30	Nam Ngiep 2	-	Khoksaad
	ST-W3-30	Luangprabang 3	-	Hin Heup
Fault Sequence	0ms	Single Circuit Three-phase Short Circuit Fault		
	100ms	Fault Clearance (1cct Open)		
	10s	End of Calculation		

(2) Analysis Conditions

The stability analysis was conducted under the following conditions:

- Identical to the Section 8.8.5 Basic Stability Analysis, generator models for the analysis were the ones provided by EDL. For the generators whose models were unknown, either the salient-pole generator model (hydropower stations), shown in Table 8.8-9, or the round rotor generator model (thermal power station), shown in Table 9.7-2 were applied. The constants applied to the models were same as those of the generators with similar installed capacities.
- Identical to the Section 8.8.5 Basic Stability Analysis and the Section 9.6.4 Stability Analysis, the simple exciter model (SEXS), shown in Table 8.8-10, was applied as the exciter models for the planned power stations.
- Application of the Power System Stabilizer (PSS) was assumed for the power stations with the installed capacities of more than 60 MW that were listed in Table 9.7-3. The same PSS models as the Section 9.6.4 Stability Analysis was used.
- Identical to the Section 9.6.4 Stability Analysis, the phase angle of the phase shifter at Hongsa substation was assumed to be unchanged throughout the analysis period.

Table 9.7-2 Round Rotor Generator Model: GENROU

Name	T'do	T"do	T'qo	T"qo	H	D	Xd	Xq
Viengphokha Lignite	6	0.05	1.5	0.05	3.08	0	2.186	2.077
New Saravan Coal Thermal PS	5.5	0.04	1.5	0.08	8.4	0	1.68	1.61
Name	X'd	X'q	X"d=X"q	Xl	S(1.0)	S(1.2)		
Viengphokha Lignite	0.318	0.413	0.246	0.186	0.03	0.4		
New Saravan Coal Thermal PS	0.26	0.32	0.18	0.1	0.12	0.61		

Table 9.7-3 Generators with PSS

Power Plant	Inst. Cap (MW)	PSS	GOV	Comm. Year
Nam Peun 1,2	70.0	Y		2022
XebanHieng 1	60.0	Y		2025
Nam phouan	90.0	Y		2030
Viengphokha Lignite	60.0	Y		2030

*Y: Applied

(3) Analysis Results

Table 9.7-4 shows the stability analysis results for each case in Table 9.7-1. Behaviours of phase angle oscillation for the cases were shown in Appendix 9.6-2.

Table 9.7-4 Stability Analysis Results

Dry/Wet	Case	Fault Section (1cct)			Result
Dry	ST-D1-30	New Saravan Coal Thermal P/S	-	Kengkok	Stable
	ST-D2-30	Nam Ngiep 2	-	Khoksaad	Stable
	ST-D3-30	Luangprabang 3	-	Hin Heup	Stable
Wet	ST-W1-30	New Saravan Coal Thermal P/S	-	Kengkok	Stable
	ST-W2-30	Nam Ngiep 2	-	Khoksaad	Stable
	ST-W3-30	Luangprabang 3	-	Hin Heup	Stable

For the planned bulk transmission system in the year 2030, the oscillation waveforms of phase angle differences were found converged in both dry and wet seasons in the case of a single circuit fault of the primary 230 kV heavy-loaded sections in the North and Central 1 areas and the fault of the interconnecting 230 kV transmission lines between the Central 2 and South areas. Therefore, it was confirmed that the planned system was being stably operated under such severe conditions.

(4) Recommendations

In dry season in 2030, a huge amount of power will be exported through the interconnecting lines between the EGAT and EDL systems in the North and the Central 1 areas due to lack of generating capacity. The power inflow through the 500/115 kV transformer at the Hongsa substation from the EGAT side will substantially exceed the contracted capacity of 100 MW even with control of the phase shifter’s phase angle, and the interconnecting lines between Central 1 area and the EGAT system will be overloaded. Similar issues are predicted as long as the EDL relies heavily on power imports from the EGAT. Therefore, further study on power development and/or international interconnection lines may be necessary.

Chapter 10
Evaluation for the Sub-project

Chapter 10 Evaluation for the Sub-Projects

10.1 Transmission Line Sub-Projects

Based on the optimum transmission system formulated in Chapter 10, the sub-projects from 2010 to 2030 of the reinforcement plan are identified in this Section. The required quantities for construction works of each subproject were estimated in accordance with the preliminary design stated in the Sections 5.2 and 5.3.

The following table shows the number of circuits, size of conductors, land of the line routes, and line length of each transmission sub-project identified from the optimum transmission system.The conditions of the UXO remnant (Contamination degreed and contamination length) was also mentioned for each sub-project. (Reffer to Fig 10.1-1(High Contamination Areas: Bombing points at residential areas such as villages from 1965 to 1975, Light Contamination Areas: Bombing points at farming lands near residential areas such as paddy fields from 1965 to 1975））

Table10.1-1 Sub-Projects from 2010 to 2011

Year	from	to	Voltage (kV)	Cct	Conductor ACSR (mm^2)	Land	UXO Rement Condition	Length [km] (total in a year)	
2010	Luang Namtha	Cu Mining	115	1	240	Mountain	None	60.0	(276.7)
	Luangprabang 2	Cement Factory	115	1	240	Mountain	Light	25.0	
	Luangprabang 2	United	115	1	240	Mountain	Light	15.0	
	Vangvieng	Iron/Coal Mine	115	1	240	Mountain	None	20.0	
	Nam Lik 1/2	Hin Heup	115	1	240	Plain	None	31.0	
	Nam Lik 1/2	Ban Don	115	1	240	Plain	None	15.0	
	Thakhek	Cement Factory	115	1	240 *CAC	Plain	None	27.0	
	Thakhek	Lao Cement Industry	115	1	240	Plain	None	15.0	
	Thakek	Many Companies	115	1	240	Plain	None	5.0	
	Pakbo	Savan Park	115	1	240	Plain	None	5.0	
	Pakbo	Mukudahan	115	1	240 *CAC	Plain	-	13.7	
	Pakxong	Ban Jianxai	115	2	240	Mountain	None	45.0	
2011	Xam Neua	Muong Kham	115	2	240	Mountain	Heavy	146.0	(1061.7)
	Muong Kham	Fe Mining	115	1	240	Mountain	Heavy	40.0	
	Phonsavan	Muong Kham	115	2	410	Mountain	Heavy	56.2	
	Vangvieng	Nam Ngum 5	115	2	410	Mountain	None	74.8	
	Phonsavan	Nam Ngum 5	115	2	240	Mountain	Heavy	66.9	
	Vangvieng	Hin Heup	115	1	240	Mountain	None	40.8	
	New Switching Station (VV)	VV Mining	115	1	240	Mountain	None	15.0	
	Nam Lik 1	Hin Heup	115	1	240	Plain	None	10.0	
	Nam Leuk	Nam Mang 3	115	2	240	Mountain	None	56.0	
	Nam Mang 3	Khoksaad	115	1	240 *CAC	平坦	-	34.6	
	Khoksaad	Thanaleng	115	1	240	Plain	None	16.8	
	Khoksaad	KF	115	1	240	Plain	None	10.0	
	Thanaleng	Nongkai	115	1	240	Plain	None	10.9	
	Phonetong	Nongkai	115	1	240	Plain	None	25.7	
	Pakxan	Pakbo	115	2	240	Plain	None	275.0	
	Mahaxay	Xepon Mine	115	1	240	Mountain	Heavy	117.0	
	Saravan	Cement Factory	115	1	240	Plain	Heavy	10.0	
	Xeset 1	Saravan	115	2	240	Plain	Light	26.0	
	Ban Hat	Cambodia Border	115	2	240	Plain	None	30.0	

Table10.1-2 Sub-Projects from 2012 to 2016

Year	from	to	Voltage (kV)	Cct	Conductor ACSR (mm^2)	Land	UXO Rement Condition	Length [km]	(total in a year)
2012	Boun Neua	Namo	115	2	240	Mountain	None	96.0	(1086.4)
	Boun Neua	Cu Mining	115	1	240	Mountain	None	65.0	
	Luang Namtha	Nam Thoung	115	2	240	Mountain	None	91.0	
	Nam Thoung	Houayxai	115	1	240	Mountain	None	40.0	
	Nam Thoung	Nam Tha 1	115	2	240	Mountain	None	42.0	
	Namo	Cu Mining	115	1	240	Mountain	None	15.0	
	Namo	Cement Factory	115	1	240	Mountain	None	5.0	
	Oudomxai	THLC Mining	115	1	240	Mountain	None	20.0	
	Phonsavan	Fe Mining	115	1	240	Mountain	Heavy	20.0	
	Luangprabang 3	Hin Heup	230	2	610*2	Mountain	Light:100 km	210.0	
	Thongkun	IPF	115	1	240	Mountain	None	20.0	
	Hin Heup	Naxaythong	230	2	610*2	Plain	None	83.2	
	Naxaythong	Khoksaad	230	2	610*2	Plain	None	83.2	
	Naxaythong	Steam Making Plant	115	2	240	Plain	None	10.0	
	Ban Don	Non Hai	115	1	240	Plain	None	54.0	
	Non Hai	Sanakham Mine	115	2	240	Plain	None	72.8	
	Paklay	Sanakham Mine	115	2	240	Plain	None	31.2	
	Nam Nguang 8	Khonsong	115	2	240	Plain	Light	58.0	
	Pakxong	Xekatam	115	2	410	Mountain	Light	35.0	
	Pakxong	Sinoma	115	1	240	Mountain	Light	20.0	
	New Switching Station	Sinoma	115	1	240	Plain	Light	15.0	
2013	Oudomxai	Namo	115	1	240*CAC	Plain	-	41.0	(402.5)
	Luangprabang 2	Oudomxai	115	1	240*CAC	Mountain	-	51.8	
	Luangprabang 1	Luangprabang 2	115	1	240*CAC	Mountain	-	86.9	
	Luangprabang 1	Luangprabang 3	115	2	240	Mountain	None	15.0	
	Thalat	Nam Ngum 1	115	1	240	Plain	None	4.8	
	Saravan	Xekong	115	2	410	Plain	Light	58.0	
	Xepon	Xepon Mine	115	2	240	Mountain	Heavy	45.0	
	Kengkok	Xepon	115	1	240	Plain	Heavy: 50km Light: 50km	100.0	
2014	Boun Neua	Cu Mining	115	1	240	Mountain	None	65.0	(599.2)
	Xayabury	Paklay	115	2	240	Plain	None	134.0	
	Paklay	Cu Mining	115	1	240	Mountain	None	25.0	
	Paklay	Thali	115	1	240	Plain	None	86.2	
	Saphaothong	Xekaman 1	115	2	240	Plain	Light	51.0	
	Pakbo	Saravan	115	2	T240	Plain	Light:60 km	220.0	
	Houaylamphan	Xekong	115	2	240	Plain	Light	18.0	
2015	Luang Namtha	Namo	115	1	240*CAC	Mountain	-	42.7	(326.7)
	Nam Tha 1	Hongsa	115	2	410	Mountain	None	93.0	
	Hongsa	Luangprabang 3	115	2	410	Mountain	None	100.0	
	Nam Mang 1	Tabok	115	1	240	Plain	None	13.0	
	New Swithcing Station	Xeset 3_4	115	1	240	Mountain	Light	2.0	
	Nam Phak	Ban Na	115	1	240	Plain	None	56.0	
	Xekaman 1	AMC	115	1	240	Mountain	Light	20.0	
2016	Mekong Luangprabang	Luangprabang 3	115	2	410	Mountain	Light	40.0	(512.0)
	Nam Ma 1	Nam Ma 2	115	1	240	Mountain	Light	20.0	
	Nam Ma 2	Nam Ma 3	115	1	240	Mountain	Light	20.0	
	Nam Ma 1	Xam Neua	115	2	240	Mountain	Heavy	40.0	
	New Switching Station (Thavieng)	Nam San 3	115	1	240	Mountain	Light	28.0	
	π-Junction	Nam Bak 2	115	2	240	Mountain	None	5.0	
	Xekong 4	Saravan	115	1	240	Mountain	Heavy	150.0	
	Xekong	Xekaman 3	115	1	240	Mountain	Light	100.0	
	Xekaman 3	Lao Aluminium	115	1	240	Mountain	Light	15.0	
	Ban Jianxai	Bang Yo	115	2	T240	Plain	None	8.0	
	Bang Yo	Sirindhom	115	2	T240	Plain	None	61.0	
	Donsahong	Ban Hat	115	1	240	Plain	None	25.0	
						Total		4,265.2 km	

(*CAC=Conductor Additional Construction)

Table10.1-3 Sub-Projects from 2017 to 2030

Year	from	to	Voltage (kV)	Cct	Conductor ACSR (mm^2)	Land	UXO Rement Condition	Length [km] (total in a year)	
2017	Nam Ou 6	Boun Neua	115	2	240	Mountain	None	40.0	(506.0)
	Phonsavan	Nam Ngiep 2	115	2	410	Mountain	Heavy	30.0	
	Nam Ngiep 2	Khoksaad	230	2	610	Mountain	None	130.0	
	Naxaythong	Phonetong	115	1	240	Plain	None	12.0	
	Nam Ngiep 1	Pakxan	115	1	240	Plain	None	40.0	
	Pakxan	Bungkan	115	1	240 *CAC	Plain	-	11.0	
	Nam Theun 1	Khonsong	115	1	240	Plain	None	35.0	
	Xeneua	Xepon Mine	115	1	240	Mountain	Heavy	60.0	
	Xepon	Xepon 3	115	2	410	Plain	Heavy	102.0	
	Xepon 2	Xepon 3	115	1	240	Mountain	Heavy	6.0	
	Xekong 3 Upper	Xekong	115	2	410	Mountain	None	10.0	
	Xekong 3 Lower	Xekatam	115	2	240	Mountain	None	30.0	
2018	Nam Khan 2	Nam Khan 3	115	1	240	Mountain	Light	45.0	(131.0)
	Luangprabang 3	Nam Khan 2	230	2	610	Mountain	None	36.0	
	New Switching Station	Sedon 2	115	1	240	Plain	Light	35.0	
	Saravan	Sedon 3	115	1	240	Plain	Heavy	15.0	
2019	Nam Ngum 4	Nam Ngum 5	115	1	240	Mountain	None	25.0	(25.0)
2020	Nam Beng	Switching Station	115	1	240	Mountain	None	15.0	(265.0)
	Nam Nga	Luangprabang 2	115	1	240	Mountain	None	15.0	
	Nam Mo 1	Muong Kham	115	1	240	Mountain	Heavy	45.0	
	Naxaythong	New 3	115	2	240	Plain	None	15.0	
	Xepon 2	Xelanong 2	115	1	240	Mountain	Heavy	75.0	
	Xelanong 2	Saravan	115	1	240	Mountain	Heavy	75.0	
	Saphaothong	Nam Kong 3	115	1	240	Plain	Light	25.0	
						Total			972.0 km
2021	Nam Phay	Nam Ngum 5	115	1	240	Mountain	None	15.0	(15.0)
2022	Moung Kham	Nam Ngiep 2	230	2	610	Mountain	Heavy	75.0	(85.0)
2023	Khoksaad	New 4	115	1	240	Plain	None	5,0	
2024	Khoksaad	New 5	115	1	240	Plain	None	5.0	
2025	Xebang Hieng 1	Kengkok	115	1	240	Plain	None	80.0	(105.0)
	Xesou	Xekaman 1	115	1	240	Plain	Light	25.0	
2026	Nam Feung 1	Xayabury	115	1	240	Mountain	None	65.0	(65.0)
2028	New Thakhek	Kengkok	230	2	610*2	Plain	None	100.0	(320.0)
	New Savanakhet	Kengkok	115	1	240	Plain	None	50.0	
	Kengkok	NSCT	230	2	610*2	Plain	Light	150.0	
	NSCT	Saravang	230	2	610*2	Plain	Light	20.0	
2030	Xebangnouan 2	Switching Station	115	1	240	Plain	Light	30.0	(50.0)
	Nam Phouan	Thongkun	115	2	240	Mountain	None	20.0	
						Total			640.0 km

(*CAC=Conductor Additional Construction)

10.2 Substation Sub-Projects

The system reinforcement sub-projects for substations include the following.

1) Construction of New Substations/Switching Stations

According to system planning up until 2030, construction of new substations and switching stations including the ADB and WB programs have been planned. The number of units and the unit capacity of transformers required for the stations were determined in the following item 3) "Plans for Addition, Replacement and Transfer of Transformers". Stations that would need the additional transmission line bays and/or transformer bays in the future should secure a sufficient space for them.

2) Upgrading the Substation Voltage Level

According to system planning up to 2030, upgrading the existing 115 kV substations to 230 kV stations has been planned.

3) 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.

a) The ‘N-1’ criteria should be applied to the stations in the Vientiane Capital after 2011. In such a case, a short duration transformer overload would be permitted to 110% of the rating. On the other hand, the overload of transformers 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.

b) The total capacity of transformers of each substation in each year up to 2030 has been estimated based on the peak MVA applying the power factor to be 0.95 for the substations in the Vientiane Capital and 0.85 to the forecasted power demand of each substation in other areas.

c) Unit capacity of newly installed transformers should be selected from 10, 20 and 30 MVA ratings.

d) As described in the Section 5.4.3, maximum unit numbers of transfomers in one substation are four (4) units and the standard numbers of 22 kV outgoing feeders per transformer are, in principle, three (3).

e) To utilize the existing transformers effectively, the transfer program of transformers among the substations was planned. The transfer has been programmed in examination of a parallel operation with existing transformers, the lifespan of transformers, transfer timing, etc. The lifetime of the existing transformers was assumed to be 40 years, and the equipment replacement program was prepared.

Tables 10.2-1 (a) to 10.2-1 (d) show the program for the addition, replacement and transfer of 115 kV transformers.

Regarding the unit number and unit capacity of 230 kV transformers, the installation of one 200 MVA transformer is being planned for oll of the 230 kV substations except two 200 MVA transformers in Luangprabang 2 Substation based on the result of system analysis.

4) Additional Transmission Line Bays

According to the system planning and generation development plan, the additional transmission line bays to the particular substations have been planned.

5) Installation of Static Capacitors

Based on the system analysis in Chapter 9, 22 kV static capacitors have been planned to maintain the system voltage within the allowable range. Installation of static capacitors has been planned at the same timing of construction and/or extension of the aforementioned substations.

The following tables show the substation sub-projects including those under construction from 2010 to 2030 in each power supply area.

Table 10.2-2 Substation Sub-Projects (North Area)

id	Stations	Voltage	Year	Status	Scope
Phongsaly Province					
1	Boun Neua SS	115 kV	2012	New	1x10 MVA TR, 4xTL bays (including 2xprivate)
		115 kV	2017	add TL bay	2 TL bays for Nam Ou 6
Luang Namtha Province					
1	Luang Namtha SS	115 kV	2010	add TL bay	1 TL bay for Cu mining (P)
		115 kV	2012	add TL bay	2 TL bays for Houayxai SS & Nam Tha 1 HPS
		115 kV	2022	add TR	additional 1x20 MVA TR
		115 kV	2030	add TR	additional 1x20 MVA TR
Oudomxai Province					
1	Oudomxai SS	115 kV	2012	add TL bay	1 TL bay for THL-C mining (P)
		115 kV	2013	add TL bay	2 TL bays for Na Mo SS & Lunang Prabang-2 (Pakson) SS
2	Namo SS	115 kV	2012	New	1x10 MVA TR, 8xTL bays (including 2xprivate)
3	New SwS for Nam Beng HPS	115 kV	2020	New	5xTL bays
Bokeo Province					
1	Huayxai SS	115 kV	2012	New	1x30 MVA TR, 1xTL bays
		115 kV	2024	add TR	additional 1x30 MVA TR
2	Nam Thoung SwS	115 kV	2015	New	5 TL bays for Nam Tha 1(2), Luang Namtha (2) & Huaixai (1)
Houaphanh Province					
1	Xam Neua SS	115 kV	2011	New	1x10 MVA TR, 2xTL bays
		115 kV	2016	add TL bay	2 TL bays for Nam Ma-1 HPS
Luang Prabang Province					
1	Luang Prabang-1 SS	115 kV	2013	add TL bay	2 TL bays for LP-2 SS & LP-3 SS
2	Luang Prabang-2 (Pakson) SS	115 kV	2010	add TL bay	2 TL bays for Cement Factory (P) & United (P)
		115 kV	2013	add TL bay	2 TL bays for LP-1 SS & Oudomxai SS
		115 kV	2020	add TL bay	1 TL bay for Nam Nga HPS
3	Luang Prabang-3 SS	230 kV	2013	New	2x200 MVA 230kV TR, 20 MVA 115kV TR, 2x230 kV & 2x115 kV TL bays
		115 kV	2015	add TL bay	2x115 kV TL bays for Hongsa SS
		115 kV	2016	add TL bay	2x115 kV TL bays for Mekong Lunag Praban HPS
		230 kV	2018	add TL bay	2x230 kV TL bays for Nam Khan-2 HPS
		115 kV	2022	add TR	additional 1x20 MVA 115/22 kV TR
Xayaboury Province					
1	Hongsa SS	115 kV	2013	New	1x20 MVA TR, 4xTL bays
		115 kV	2022	add TR	additional 1x20 MVA TR
2	Xayaboury SS	115 kV	2014	add TL bay	2 TL bays for Paklay SS
		115 kV	2019	add TR	additional 1x16 MVA TR from Phonesavan SS
		115 kV	2026	add TL bay	1 TL bay for Nam Feung-3 HPS
		115 kV	2027	add TR	additional 1x16 MVA TR from Vangvieng SS
3	Paklay SS	115 kV	2014	New	1x20 MVA TR, 5xTL bays (including 2xprivate)
		115 kV	2028	add TR	additional 1x20 MVA TR
Xiengkouang Province					
1	Phonesavan SS	115 kV	2011	add TL bay	5 TL bays for NN-5 (2), MK (2), Thongkun & Cu mine (P)
		115 kV	2017	add TL bay	2 TL bays for Nam Ngiep 2
		115 kV	2019	add TR	replacement of 1x16 MVA TR to 1x30 MVA
		115 kV	2025	add TR	additional 1x30 MVA TR
2	Moung Kham	115 kV	2011	New	1x10 MVA TR, 5xTL bays (including 1xprivate)
		115 kV	2020	add TL bay	1 TL bay for Nam Mo-1 HPP
		230 kV	2022	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays
		115 kV	2028	add TR	additional 1x10 MVA TR
3	New SwS for Nam Sam-3 HPS	115 kV	2016	New	3 TL bays

Table 10.2-3 Substation Sub-Projects (Central 1 Area)

id	Stations	voltage	Year	Status	Scope
Vientiane Province					
1	Phonsoung SS	115 kV	2011	replace TR	replacement of 1x22 MVA TR to 1x30 MVA
		115 kV	2020	add TR	additional 1x30 MVA TR
		115 kV	2030	add TR	additional 1x30 MVA TR
2	Vangvieng SS	115 kV	2010	add TL bay	1 TL bays for Iron/Coal Mine (P)
		115 kV	2011	add TL bay	3 TL bays for Nam Ngum-5 (2) & Hin Huep
		115 kV	2015	replace TR	replacement of 2x16 MVA TR to 2x30 MVA
3	New Vangvieng SS	115 kV	2024	New	2x30 MVA TR, 4xTL bays
4	Thalat SS	115 kV	2022	add TR	additional 1x30 MVA TR
5	Ban Don SS	115 kV	2010	(U/C)	1 TL bay for Nam Lik 1-2 HPS
		115 kV	2012	add TL bay	1 TL bay for Non Hai SS
6	Hin Heup SS	115 kV	2010	(U/C)	1 TL bay for Nam Lik 1-2 HPS
		115 kV	2011	add TL bay	2 TL bays for Nam Lik-1 & Vangvieng
		230 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 1x 10 MVA 115/22 kV TR, 4x230 kV TL bays, 2x115 kV TL bay
7	Non Hai SS	115 kV	2012	add TL bay	3 TL bays for Ban Don (1) & Sanakham Mine (2 cct, P)
		115 kV	2026	add TR	additional 1x16 MVA TR from Vangvieng SS
8	Thongkun SwS	115 kV	2012	add TL bay	1 TL bays for Iron Pressing Factory (P)
		115 kV	2030	add TL bay	2 TL bays for Nam Phouan HPS
9	Nam Leuk HPS	115 kV	2011	add TL bay	2 TL bays for Nam Mang-3 HPS
10	Nam Mang-3 HPS	115 kV	2011	add TL bay	3 TL bays for Nam Leuk (2) & Khaksaad SS (1)
11	New SwS for Vangvien Mining Co.,	115 kV	2011	New	3 TL bays for VVN, LP-3 & Vangvien Mine (P)
Vientiane Capital					
1	Phonetong SS	115 kV	2017	replace TR	replacement of old 1x30 MVA TR to new one
		115 kV	2017	add TL bay	1 TL bay for Naxaythong SS
2	Tanaleng SS	115 kV	2011	add TL bay	2 TL bays for Khaksaad SS & Nongkai
		115 kV	2016	add TR	additional 1x30 MVA TR
3	Naxaythong SS	230 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 4x230kV & 2x115kV TL bays (for Steel Melting Factory (P))
		115 kV	2017	add TL bay	1 TL bay for Phonetong SS
		115 kV	2020	add TL bay	2 TL bays for Nongteng (New-3)
4	Khaksaad SS	115 kV	2011	add TL bay	3 TL bays for Nam Mang-3, Tanaleng & Iron Kaly Factory (P)
		230 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays
		230 kV	2017	add TL bay	2x230 kV TL bays for Nam Ngiep 2 HPP
		115 kV	2023	add TL bay	2 TL bays for New-4 SS
		115 kV	2024	add TL bay	1 TL bay for New-5 SS
5	Tha Ngon SS	115 kV	2011	replace TR	replacement of 1x22 MVA TR to 1x30 MVA
		115 kV	2020	add TR	additional 1x30 MVA TR
6	Gnangsoum (New -1) SS	115 kV	2011	New	2x30 MVA TR, 4xTL bays
		115 kV	2026	add TR	additional 1x30 MVA TR
7	Nonkor (New-2) SS	115 kV	2013	New	2x30 MVA TR, 3xTL bays
8	Nongteng (New-3) SS	115 kV	2020	New	2x30 MVA TR, 2xTL bays
9	New 4 SS	115 kV	2023	New	2x30 MVA TR, 2xTL bays
10	New 5 SS	115 kV	2024	New	2x30 MVA TR, 2xTL bays

Table 10.2-4 Substation Sub-Projects (Central 2 and South Area)

Id	Stations (Central 2)	voltage	Year	Status	Scope
Bolikhamxai Province					
1	Pakxan SS	115 kV	2011	(U/C)	2 TL bays for Thakhek SS
		115 kV	2017	add TL bay	2 TL bays for Nam Ngiep-1 HPS & Bungkan SS
		115 kV	2021	replace TR	replacement of 2x16 MVA TR to 2x30 MVA
		115 kV	2028	add TR	additional 1x30 MVA TR
2	Khonsoung SS	115 kV	2012	New	1x20 MVA TR, 6xTL bays (Nam Nguang8(2) , Pakxan(2), Thakhek(2))
3	Thabok SwS	115 kV	2015	New	3 TL bays for Nam Mang-1 HPS, Nam Leuk HPS & Pakxan SS
Khammouan Province					
1	Thakhek SS	115 kV	2010	add TL bay	2 TL bays for Lao Cement Industry (P) & many companies (P)
		115 kV	2011	(U/C)	4 TL bays for Pakxan SS & Pakbo SS
		115 kV	2027	add TR	additional 1x30 MVA TR
2	Mahaxai SS	115 kV	2011	add TL bay	1 TL bay for Xepon Mine (P)
3	New Thakhek SS	115 kV	2019	New	2x30 MVA TR, 4xTL bays
		115 kV	2027	add TR	additional 1x30 MVA TR
		230 kV	2028	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays
Savannakhet Province					
1	Pakbo SS	115 kV	2010	add TL bay	1 TL bay for Mukudahan SS
		115 kV	2011	(U/C)	2 TL bays for Thakhek SS
		115 kV	2013	replace TR	replacement of 2x20 MVA TR to 2x30 MVA
		115 kV	2014	add TL bay	2 TL bays for Taothan SS
		115 kV	2019	add TR	additional 1x30 MVA TR
2	New Savannakhet SS	115 kV	2021	New	2x30 MVA TR, 4xTL bays
		115 kV	2028	add TL bay	1 TL bay for Kengkok SS
3	Kengkok SS	115 kV	2013	replace TR	replacement of 2x10 MVA TR to 2x20 MVA
		115 kV	2014	add TL bay	1 TL bay for Xepon SS
		115 kV	2025	add TR	additional 1x20 MVA TR
		115 kV	2025	add TL bay	1 TL bay for Xeban Hieng HPS
		230 kV	2028	Upgrade	1x200 MVA 230/115 kV TR, 4x230 kV TL bays, 1x115 kV TL bays
4	Xepon SS	115 kV	2014	New	1x20 MVA TR, 3xTL bays
		115 kV	2017	add TL bay	2 TL bays for Xepon-3 HPS
		115 kV	2025	add TR	additional 1x20 MVA TR
Id	**Stations (South)**	**voltage**	**Year**	**Status**	**Scope**
Saravan Province					
1	Saravan SS	115 kV	2011	(U/C)	2x20 MVA TR, 2xTL bays
		115 kV	2011	add TL bay	1 TL bay for Cement Factory (P)
		115 kV	2013	add TL bay	2 TL bays for Xekong SS
		115 kV	2014	add TL bay	2 TL bays for Taothan SS
		115 kV	2016	add TL bay	2 TL bays for Xekong-4 HPS
		115 kV	2028	add TL bay	2 TL bays for New Saravan Coal Thermal PS
		115 kV	2029	add TR	additional 1x20 MVA TR
2	Xeset-1 HPS	115 kV	2011	(U/C)	2 TL bays for Saravan SS
3	Taothan SS	115 kV	2014	New	1x20 MVA TR, 4xTL bays
4	New SwS for Xedong-2	115 kV	2018	New	3 TL bays
		115 kV	2030	add TL bay	1 TL bay Xebangnouan-2 HPS
Xekong Province					
1	Xekong SS	115 kV	2013	New	2x20 MVA TR, 3xTL bays (including Lao Aluminium Industry (P))
		115 kV	2016	add TL bay	3 TL bays for Houaylamphan (2) & Xekaman 3 (1)
		115 kV	2017	add TL bay	2 TL bays for Xekong-3 (upper) HPS
Attapeu Province					
1	Saphaothong (Attapeu)	115 kV	2014	add TL bay	2 TL bays for Xekaman-1 HPS
		115 kV	2020	add TL bay	1 TL bay for Nam Kong-3 HPS
2	New SwS for SIMOA (P)	115 kV	2012	New	5 TL bays
Champasak Province					
1	Bang Yo SS	115 kV	2016	add TL bay	4 TL bays for Jianxai SS & Siridhorn SS
		115 kV	2022	replace TR	replacement of 2x25 MVA TR to 2x30 MVA
2	Jianxai SS	115 kV	2010	(U/C)	2 TL bays for Paksong SS
		115 kV	2010	add TR	add 1x30 MVA TR
		115 kV	2016	add TL bay	2 TL bays for Bang Yo SS
		115 kV	2022	add TR	additional 1x30 MVA TR
3	Paksong SS	115 kV	2010	(U/C)	2 TL bays for Jianxai SS
		115 kV	2012	add TL bay	2 TL bays for Xekatam HPS & SIMOA (P)
		115 kV	2020	add TR	additional 1x10 MVA TR
		230 kV	2023		Connect to 230 kV Huay Ho Line (switchger is existing)
4	Ban Na SS	115 kV	2015	add TL bay	1 TL bay for Nam Phak HPS
5	Ban Hat SS	115 kV	2011	add TL bay	2 TL bays for Stung Treng
		115 kV	2016	add TL bay	1 TL bay for Donsahong HPS
6	New SwS for Xeset 3-4	115 kV	2015	New	3 TL bays

10.3 Construction Cost Estimation

The construction costs of each sub-project identified in the former sections have been estimated based on the ICB prices in 2009.

10.3.1 Construction Costs for Transmission Line Sub-Projects

Standard unit prices of transmission lines were estimated based on the standard quantities as shown in Table 10.3-1.

(1) Standard Unit Prices

Table 10.3-1 shows the standard unit prices per km applied to the cost estimation of transmission line projects.

The table has been prepared referring to recent contract prices of such international competitive bidding projects as the “Greater Mekong Power Network Development Project (JICA)”. Various ICB price data owned by the Team has also been referred to.

For estimation, construction costs are divided into CIF (Cost, Insurance and Freight) and LTE (Local Transportation and Erection), and the costs per km were computed for the transmission lines passing through the plainous or mountainous area. Since the construction difficulties are more concentrated in mountainous areas, the estimated costs for the LTE in the mountainous area resulted in 1.2 times more than plainous areas.

The standard unit prices for 115 kV transmission lines per k are shown in Table 7.5-1. The details of the estimation are shown in Tables 11.3-2 (1) to (8).

Table 10.3-1 Standard Unit Prices for 115 and 230 kV Transmission Lines per km

(Unit; USD)

Voltage	Number of Circuit	Conductor	Area	
			Plain	Mountain
115	1	ACSR240mm^2 (Hawk) *1	80,788	95,479
115	1	ACSR410mm^2 (Drake)*1	99,984	117,336
115	2	ACSR240mm^2 (Hawk) *1	122,327	148,241
115	2	TACSR240mm^2 (T-Hawk) *1	135,030	-
115	2	ACSR410mm^2 (Drake)*2	146,080	172,112
230	2	ACSR610mm^2 (Bittern)*1	200,356	230,544
230	2	ACSR610mm^2 (Bittern)*2	305,295	356,398
115	1	ACSR240 mm^2 (Hawk) *1 Conductor additional construction	26,421	29,891

(2) Estimation of UXO Investigation and Clearance Costs

Since many UXO exist in the country, it is necessary to carry out an investigation and clearance prior to the construction works. Costs for the UXO investigation and clearance were added to the ordinary construction cost of transmission lines (Table 10.3-1), because costs for the investigation and clearance would share a large portion of the construction costs for transmission lines. The costs estimated for each planned transmission line are as follows.

(a) Rates of UXO investigation and clearance

The rates were set for two classified areas with reference to to information given by a firm for UXO investigation and clearance in Vientiane.

[230 kV Transmission Lines]

- Heavy UXO remnant area:
  17,000 USD/km (6,800 USD/ha for the 25m wide ROW of 115 kV transmission lines)
- Light UXO remnant area:
  12,000 USD/km (4,800 USD/ha for the 25m wide ROW of 115 kV transmission lines)

[230 kV Transmission Lines]

- Heavy UXO remnant area:
  27,200 USD/km (6,800 USD/ha for the 40m wide ROW of 230 kV transmission lines)
- Light UXO remnant area:
  19,200 USD/km (4,800 USD/ha for the 40m wide ROW of 230 kV transmission lines)

(b) UXO investigation and clearance for each transmission line project

Classification of the work (heavy and light UXO remnant areas) was assumed referring to Figure 7.5-20.

(3) Construction Costs of the Transmission Line Projects

Construction costs of the transmission line projects have been estimated as follows.

(a) The costs were estimated in such a way so that the unit cost per km (Table 11.3-1) multiplied by the length of each line and adding the UXO survey and clearance costs of each line.

(b) The costs were estimated in foreign currency (USD) portion (FC) and local currency (USD conversion) portion (LC)[1] based on Table 11.3-3.

(c) Costs for such miscellaneous work items such as land compensation, erection insurance, camp expenses, etc. were added to the sum of cost for each work at an amount equivalent to 10% of the sum.

The estimated construction costs for transmission line projects up to the year 2030 (excluding projects presently in progress in the country) are shown in Table 10.3-4. The construction costs for each subproject are detailed in Table 10.3-5.

Table 10.3-3 Share of FC and LC for Each Work Item

	Work item	FC share	LC share
CIF	Tower, Conductor, GW, Insulator sets, Accessories	100%	0%
LTE	UXO survey and clearance	30%	70%
	Route survey & design	40%	60%
	Access road construction	30%	70%
	Inland transportation	0%	100%
	Clearing of ROW, Foundation work	20%	80%
	Tower erection work, stringing work	30%	70%
	Others (% to total LTE)	15%	15%

(LTE: Local Transport and Erection)

[1] Term “FC” used in this report means expenditures spent abroad for procurement, ocean freight and insurance of the imported equipment and materials of the facilities and other general works for the local installation of the facilities including a part of investigation and clearance of UXO. Term “LC” means all expenditures spent in the Lao PDR including costs for expatriate persons, procurement of local products, labours, inland transportation, insurance, hiring of heavy equipment, installation of facilities, a part of investigation and clearance of UXO, compensation of lands, houses and vegetation and others. “LC” does not always mean the amount contributed by the Government of Lao PDR.

Table10.3-4 Construction Costs for Transmission Line Projects

[Unit: 1,000 USD]

Commissioning Year	Particulars	Construction Costs FC	LC	Total
2010 to 2015	Construction	343,731.0	161,537.0	505,268.0
	UXO clearance	8,137.0	16,528.0	24,665.0
	Sub-total	**351,868.0**	**178,065.0**	**529,933.0**
2016 to 2020	Construction	81,515.0	44,237.0	125,752.0
	UXO clearance	2,506.0	5,086.0	7,592.0
	Sub-total	**84,021.0**	**49,323.0**	**133,344.0**
2021to 2025	Construction	20,207.0	9,676.0	29,883.0
	UXO clearance	166.0	338.0	504.0
	Sub-total	**20,373.0**	**10,014.0**	**30,387.0**
2026 to 2030	Construction	68,404.0	24,680.0	93,084.0
	UXO clearance	1,196.0	2,429.0	3,625.0
	Sub-total	**69,600.0**	**27,109.0**	**96,709.0**
	Total	**525,862.0**	**264,511.0**	**790,373.0**

10.3.2 Construction Costs for Substation Sub-Projects

The construction costs for each sub-project identified in the Section 10.2 have been estimated based on the standard constitution of equipment described in the Section 5.3 and the standard unit prices.

(1) Standard Unit Prices

Table 10.3-6 shows the standard unit prices applied to the cost estimation of substation projects.

The table has been prepared referring to the recent contract prices of such international competitive bidding projects as the Greater Mekong Power Network Development Projects (JICA funded), the Greater Mekong Subregion Power Trade Project (IDA funded), and the Northern Area Power Transmission Development Projects (ADB funded). Various ICB price data, especially for 230 kV equipment owned by the Study Team has also served asa basis for referrence.

(2) Estimate Conditions

The cost estimate conditions are as follows;

a) All substation equipment will be procured from abroad and the prices will be estimated in US dollars for CIF prices.

b) The estimated costs of civil and erection works are divided into foreign currency (FC) (USD) and local currency (LC) (USD conversion) portions.

c) The costs for the improvement of the busbar system and/or switchgear and the costs for the installation of the static capacitors are included in the costs for such sub-projects as the addition of transmission line bays and transformers.

d) The costs for investigation and clearance of UXO are included in the construction costs for new stations.

e) Considering the price escalations and costs for such miscellaneous work items as land compensation, erection insurance, camp expenses, etc., an amount equivalent to 7% of the total cost of equipment and civil works is to be added.

(3) Construction Costs for Substation Sub-Projects

The summary of estimated construction costs for substation sub-projects from 2010 to 2030, excluding the costs of on-going projects, are shown in the following table. The construction costs for each sub-project are detailed in Table 10.4-4.

Table 10.3-7 Construction Costs for Substation Sub-Projects

[Unit: 1,000 USD]

Year	Construction Costs		
	FC	LC	Total
2010～2015	144,674.7	31,668.2	176,342.9
2016～2020	43,997.7	8,407.5	52,405.2
2021～2025	38,962.9	6,871.9	45,834.8
2026～2030	23,704.4	4,131.6	27,836.0
Total	**251,339.7**	**51,079.2**	**302,418.9**

10.3.3 Total Construction Costs

As shown in the following table, the total construction costs for the development of a transmission system from 2010 to 2030, excluding the costs of on-going projects, has been estimated at 1,092.8 million USD.

Table 10.3-8 Total Construction Costs for the Development of Transmission System

[Unit: 1,000 USD]

Year	Particulars	Construction Costs		
		FC	LC	Total
2010～2015	TL	351,868.0	178,065.0	529,933.0
	SS	144,674.7	31,668.2	176,342.9
	sub-total	**496,542.7**	**209,733.2**	**706,275.9**
2016～2020	TL	84,021.0	49,323.0	133,344.0
	SS	43,997.7	8,407.5	52,405.2
	sub-total	**128,018.7**	**57,730.5**	**185,749.2**
2021～2026	TL	20,373.0	10,014.0	30,387.0
	SS	38,962.9	6,871.9	45,834.8
	sub-total	**59,335.9**	**16,885.9**	**76,221.8**
2026～2030	TL	69,600.0	27,109.0	96,709.0
	SS	23,704.4	4,131.6	27,836.0
	sub-total	**93,304.4**	**31,240.6**	**124,545.0**
	Total	**777,201.7**	**315,590.2**	**1,092,791.9**

10.4 Implementation Schedule and Cost Disbursement Schedule

10.4.1 Implementation Schedule

(1) Implementation Schedule for Transmission Line Sub-Projects

Construction periods required for the planned transmission sub-projects are slightly different among sub-projects due to the various line lengths and route terrain. It is assumed from experience gained from past similar projects in the country that the construction period for sub-projects for over more than 10 km would take 24 months over three calendar years, commencing during April of the first year and reaching completion in March of the third year, taking into account the efficient field works during the dry season. While, the construction period for the conductor sub-projects would take an additional 12 months over 1 calendar year, commencing on the conclusion of contract.

(2) Implementation Schedule for Substation Projects

Although construction periods for each substation project are slightly different, it is assumed from past similar project experience that the period for new substation construction would take 24 months over three calendar years, commencing on April of the first year reaching completion in March of the third year, taking into account the efficient field works during the dry season as shown in Figure 10.4-2. Regarding the design and manufacturing period of main transformers, since they are small and middle scale 115 kV and 230 kV class transformers, it assumed to be 12 months. While, the construction period of the other sub-projects such as the addition of transmission line bays, replacement of transformers, etc. is assumed to take over 12 - 16 months over two calendar years, commencing on the conclusion of the contract.

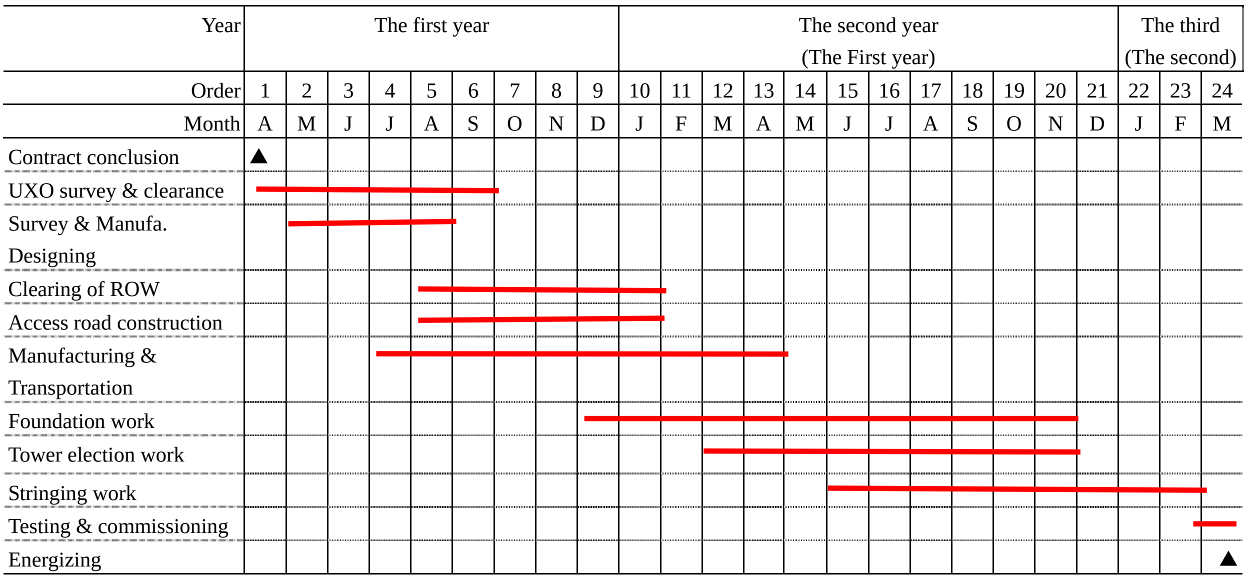


Figure 10.4-1 Implementation Schedule for Transmission Line Projects

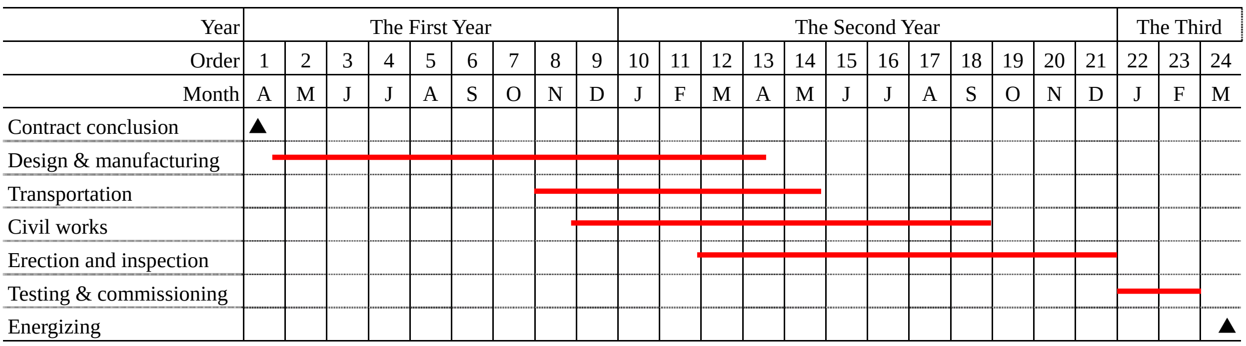


Figure 10.4-2 Implementation Schedule for New Substation Construction Projects

10.4.2 Disbursement Schedule of the Project Costs

The disbursement schedule of the project costs is prepared from the implementation schedule of the sub-projects discussed above.

Disbursement of the project costs is assumed pursuant to the schedule in Table 11.4-1 for all sub-projects.

Table 10.4-1 Disbursement Schedule of Project Costs

	Procurement & Delivery of Equipment	Civil & Erection Works
Commencement (Advance payment)	10%	10%
Submission of shipping document	80%	-
Approval of the progress	-	80%
Issue of completion certificate	10%	10%

(1) Disbursement Schedule of Transmission Line Sub-Projects

Based on the implementation schedule and Table 10.4-1, the disbursement of costs for each work item for the transmission line sub-project in each year is assumed at the percentage shown in Table 10.4-2. We assumed that 10 % of total construction cost will be disbursed as advanced payment and completion certificate, respectively and 80 % of that will be disbursed as each work payment of implemented year.

Table 10.4-2 Disbursement Schedule of TL Projects

Year	Item	Ratio
The first year	Total construction cost (Advanced payment)	10%
	UXO clearance	80%
	Survey & designing	80%
The second year	Clearing of ROW	80%
	Access Road construction	80%
	Inland transportation	80%
	CIF (Tower, Conductor, Insulator set, etc)	80%
	Foundation work	80%
	Tower Erection work	80%
The third year	Stringing work	80%
	Miscellaneous, General expenses, etc	80%
	Total construction cost (Completion certificate)	10%

Table 10.3-5 shows the implementation and disbursement schedule of each sub-project estimated on the basis of the above percentages up to 2030.

(2) Disbursement Schedule of Substation Sub-Projects

According to Table 10.4-1, it is assumed that 10%, 80% and 10% of the total construction costs of the new substation construction project are to be disbursed over three years. Regarding the other sub-projects, 100% of total costs for over one year or 50% and 50% of total costs for over two years are to be disbursed contingent on the project scale.

Table 10.4-4 shows the implementation and disbursement schedule of each substation sub-project up to 2030.

(3) Disbursement Schedule of Investment Up to 2030

The yearly investment schedule for the development of transmission and substation systems excluding the costs of on-going projects from 2010 to 2030 is estimated in the following table.

The above costs include costs for investigation and UXO clearance, the abstract of which is based on Table 10.3-5.

Table 10.4-4 Disbursement Schedule for Development of TL & SS System

[Unit: 1,000 USD]

	Transmission Line Sub-Projects			Substation Sub-Projects			Total		
year	FC	LC	Total	FC	LC	total	FC	LC	Total
2010	73,735.0	38,915.0	112,650.0	21,478.3	4,474.3	25,952.6	95,213.3	43,389.3	138,602.6
2011	120,497.0	50,806.0	171,303.0	52,036.5	11,371.5	63,408.0	172,533.5	62,177.5	234,711
2012	40,912.0	28,821.0	69,733.0	32,692.4	6,438.6	39,131.0	73,604.4	35,259.6	108,864
2013	44,589.0	18,064.0	62,653.0	19,548.5	4,790.4	24,338.9	64,137.5	22,854.4	86,991.9
2014	33,004.0	20,602.0	53,606.0	11,166.6	2,975.9	14,142.5	44,170.6	23,577.9	67,748.5
2015	39,131.0	20,857.0	59,988.0	7,752.3	1,617.6	9,369.9	46,883.3	22,474.6	69,357.9
2016	44,943.0	22,090.0	67,033.0	7,396.4	1,202.6	8,599.0	52,339.4	23,292.6	75,632
2017	15,902.0	11,061.0	26,963.0	6,434.7	1,333.9	7,768.6	22,336.7	12,394.9	34,731.6
2018	5,608.0	5,508.0	11,116.0	7,948.6	1,539.1	9,487.7	13,556.6	7,047.1	20,603.7
2019	12,595.0	5,518.0	18,113.0	12,114.3	2,506.6	14,620.9	24,709.3	8,024.6	32,733.9
2020	4,973.0	5,146.0	10,119.0	10,103.6	1,825.4	11,929.0	15,076.6	6,971.4	22,048
2021	8,825.0	3,497.0	12,322.0	10,181.9	1,782.1	11,964.0	19,006.9	5,279.1	24,286
2022	1,924.0	1,946.0	3,870.0	10,696.9	1,881.5	12,578.4	12,620.9	3,827.5	16,448.4
2023	978.0	610.0	1,588.0	11,777.3	2,334.0	14,111.3	12,755.3	2,944.0	15,699.3
2024	4,847.0	1,845.0	6,692.0	3,653.8	538.8	4,192.6	8,500.8	2,383.8	10,884.6
2025	3,799.0	2,116.0	5,915.0	2,653.0	335.5	2,988.5	6,452.0	2,451.5	8,903.5
2026	8,597.0	5,302.0	13,899.0	3,442.0	560.4	4,002.4	12,039.0	5,862.4	17,901.4
2027	48,233.0	12,852.0	61,085.0	13,120.4	2,545.3	15,665.7	61,353.4	15,397.3	76,750.7
2028	9,608.0	7,306.0	16,914.0	3,760.1	577.8	4,337.9	13,368.0	7,883.8	21,251.8
2029	2,655.0	1,071.0	3,726.0	1,937.0	251.5	2,188.5	4,592.0	1,322.5	5,914.5
2030	507.0	578.0	1,085.0	1,444.9	196.6	1,641.5	1,951.9	774.6	2,726.5
合計	**525,862.0**	**264,511.0**	**790,373.0**	**251,339.5**	**51,079.4**	**302,418.9**	**777,201.4**	**315,590.4**	**1,092,791.8**

10.5 Environmental and Social Consideration on the Sub-Projects

Based on the environmental and social issues described in Chapter 7 5.3, the sub-projects were screened in adherence to environmental and social measures such as resettlement, protected areas (including conservation areas) and minority people in the project design phase. The following are the results of this environmental screening. The sub-projects were selected taking into account environmental and social considerations and categorized into four regions, namely the North, the Central 1, the Central 2 and the South. The screening uses the same method referring to the same sources and evaluation criteria employed in Chapter 8.4 (3) “screening for short-listed projects from the points of environmental and social considerations”. The screening for UXO risks, which is also used as the screening measure in Chapter 8.4 (3), is addressed in the previous section Table 10.1-1.

North: (Luang Namtha Province, Phonsay Province, Bokeo Province, Oudomxay Province, Houapahnh Province, Xayaboury Province, Luang Prabang Province, Xieng Khuang Province)

The following sub-projects are adjacent to protected areas such as the NBCA or protection forest areas.

Luang Namtha-Cu Mining (year 2010), Luang Prabang2-Cement Factory (2010), Luang Prabang2-United (2010), Xam Neua-Muong Kham (2011), Nam Thoung-Hougyxai (2012), Huayxai SS (2012), Namo-Cu Minig (2012), Namo-Cement Factory (2012), Luang Namtha-Nam Thoung (2012), Xayabury-Paklay (2014), Paklay-Thali (2014), Paklay SS (2014), Luang Namtha-Namo (2015), Namo SS (2012)

At the time of designing transmission line routes or substation sites, special effort should be made for those subprojects in order to avoid protected areas.

In addition, considering the high rate of ethnic minority distribution in the Northern region, special attention needs to be paid to their socio-economic conditions and appropriate mitigation measures need to be taken as deemed necessary.

Central 1(Vientiane Province, Vientiane City)

The transmission line sub-project Nam Ngiep2-Khoksaad (2017) is adjacent to the NBCA. The alignment of transmission lines needs to avoid those protected areas.

The area near the Phonetong Substation of the Naxaythong-Phonetong (2017) project is located near residential areas. Special attention needs to be paid to minimizing resettlement in this area.

Central 2 (Bolikhamxay Province, Kahmmouan Province, Savannakhet Province)

The areas of the sub-projects Xepon Mine-Xepon (2013), Xepon SS (2014), Xepon-Xepon 3(2017) are expected to have a high rate of ethnic distribution. Special attention needs to be paid to their socio-economic conditions and appropriate mitigation measures need to be taken as deemed necessary.

South (Saravan Province, Sekong Province, Champasack Province, Attapeu Province)

The transmission line sub-project Nam Ngiep2-Khoksaad (2017) Xekaman 3-Xekong (2016) and Xekaman3-L.A.I (2016) are adjacent to the NBCA. The alignment of transmission lines must avoid those protected areas.

The areas of the sub-projects Xepon 3-Xepon 2 (2017), Xepon 2-Xelanong 2 (2020), Xelanong 2-Saravan (2020), Sarvan-Xekong (2013), Xekong SS (2011), Xekaman1-Xexou (2025), Xekaman1-A.M.C (2015) are expected to have a high rate of ethnic distribution. Special attention needs to be paid to socio-economic conditions and mitigation measures need to be taken when deemed necessary.

Only the locations of protected areas at the national level are to be examined at this time. Therefore, a further survey for protected areas at the provincial and district level is necessary. Given the population increase in the near future, the necessity for minimizing resettlement of sub-projects near national roads is expected to be augmented.

10.6 Economic Analysis of the Optimum Transmission System

This section undertakes the economic analysis of the optimum transmission system plan, or the Optimum Plan hereafter, which is comprised of the transmission and the substation sub-projects listed in the Section 10.1 and 10.2. In another word, the section assesses the investment efficiency of the project which constructs/ expands EdL’s transmission and substation system from 2010 to 2030 from the perspective of national development goal.

Firstly, the optimum transmission system plan is presumed to reflect the concept of “economic efficiency” in terms of resource allocation. The “efficiency” of the Optimum Plan would be proved by comparison of the economic internal rate of return (EIRR) of the system to the opportunity cost of capital (OCC). This study set down the value of OCC for this analysis as 12%, as cited from Asian Development’s guideline (Guidelines for the economic analysis of projects, February, 1997) and from a similar power-related project of the Lao PDR[2]. If the value of the Optimum Plan's EIRR is larger than the OCC, the plan can be described as economically viable. To restate this, if it turns out that the investment in a power project, which expands its power system from 2010 to 2030 would bring a higher return to Lao PDR than investing in an alternative project, the power project can be regarded as an economically efficient project for Lao PDR's economy to continue to prosper.

10.6.1 Premises

The EIRR would be calculated by identifying the Optimum Plan's costs and benefits. The assumptions and conditions for the analysis are given as follows:

(1) The evaluation period is set as 30 years from the fiscal year of 2010 to that of 2040 (the fiscal year in this report is defined to start in April and to end in March. Because annual expense is assumed to be paid out in March, the first annual expense is to appear in March 2011. Therefore, the first year of the analysis was set as 2010.).

(2) Both the costs and benefits are expressed in real term, valued at a 2009 constant price.

(3) Economic benefits would be obtained by multiplying incremental electricity demand, which can be supplied by the implementation of the Optimum Plan, with Willingness to Pay (WTP) per electricity consumption (kWh). This analysis quoted the value of the WTP from the latest ADB study, which is also mentioned above. The transmission and substation portion of the WTP is used for the calculation. That is, the generation and distribution portion of the WTP per kWh is subtracted from the original WTP.

(4) This study assumes the project expense related to the Optimum Plan as an economic cost. Expenses consists of construction costs and other relevant operations and maintenance (O&M) costs. Annual O&M costs are estimated to be 1% of the investment costs for transmission line facilities, and 1.5% for substation facilities.

(5) Internal transfer payment such as tax and subsidies are not taken into account for this economic analysis.

(6) Incremental electricity sales volume is estimated in this study, Chapter 6.

To summarize the above, the economic analysis of the Optimum Plan is undertaken in the following manner:

- Description of the project: the expansion of EdL's transmission and substation system nationwide.
- Economic costs: the construction costs and the O&M costs of the Optimum Plan
- Economic benefits: benefits obtained by multiplying the incremental demand with the transmission and substation portion of WTP.

The following subsections will explain the calculation process of benefits and costs.

10.6.2 Economic Benefits

As mentioned above, the economic benefits will be obtained by multiplying WTP withincremental electricity demand, both of which are also restated as the economic value unit of this plan and the energy consumption respectively. Here is a description on how to obtain these two factors.

[2] Asian Development Bank TA No. 4816-LAO Preparing the Greater Mekong Subregion Northern Power Transmision Project, Oct. 2008.

(1) Economic Value

This study employs the willingness-to-pay, or WTP, as an economic value. The aforementioned ADB's study derived WTP by the consumer category based on the willigness-to-pay method3. Table 10.6-1 shows the result.

Table 10.6-1 Willingness-to-pay (WTP) of Lao PDR for Electricity

Consumer category	WTP
Residential	3,012 Kip/ kWh (0.35 USD/ kWh)
Non-residential	2,669 Kip/ kWh (0.31 USD/ kWh)
Non-residential (major loads)	2,003 Kip/ kWh (0.24 USD/ kWh)

(Source: Preparing the Greater Mekong Subregion Northern Power Transmission Project, ADB, Oct. 2008)

To make the calculation simple, this analysis employed a weighted average of WTP, which is derived from the above three WTPs in the table. The Study team led the value by an average weighted method, taking into account each consumer category's share in the total incremental electricity demand, which is shown in Figure 10.6-1.

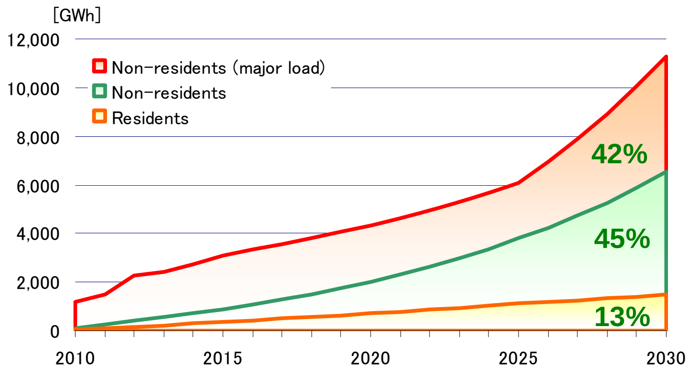


Figure 10.6-1 The Share of Incremental Demand by Consumer Category of Lao PDR from Year 2010 to 2030

The weighted average of the WTP is estimated to be 2,434 Kip/kWh (0.29 USD/kWh, with an exchange rate of 8,515 Kip/USD as of August 27, 2009 by Yahoo Finance.).

As mentioned before, because the Optimum Plan targets only transmission lines and substation-related facilities, the analysis employs the corresponding portion of the weighted average of WTP. In order to derive this portion, the Study Team referred to the data calculated in the recent World Bank's study on Lao PDR's electricity tariff system[4]. According to their final report, the long run marginal cost (LRMC) of Lao PDR's power development plan during

[3] The basic approach conducted in their study is to regard the energy supply cost, which satisfies energy demand such as light and motor by alternative way other than electricity as WTP. For example, kerosene fuel cost is set as WTP for light demand of residential consumer category, and installing as well as maintaining battery cost is set as WTP for the demand of appliances such as television and radios of residential consumer category. Likewise, electricity supply cost by means of diesel engines (average installement capacity as 5 kW for normal loads, and 5 MW for major loads.) is regarded as WTP for non-residential consumer category.

[4] Tariff Study Update Project, Final Report, International Development Association, June 2009.

the period between 2010 and 2016 is estimated as shown in Table 10.6-2. The table shows that the LRMC of transmission and substation portion is led as 103 Kip/kWh (0.01 USD/kWh), which occupies 14% of the total LRMC).

Table 10.6-2 Long Run Marginal Cost of Lao PDR Based on Its Power Development Plan 2007-2016

Category	[Kip/kWh]	Share [%]
Generation	448	60.5
Transmission and substation	103	13.9
Distribution	189	25.5

(Source: Tariff Study Update Project, IDA, June 2009)

Finally, the WTP to be used for this analysis is obtained by multiplying the aforementioned weighted average WTP with this share of the transmission and substation category, resulting in 0.04 USD/kWh. From now on, the study refers to this value as the economic value of the Optimum Plan's economic analysis.

(2) Energy Consumption

This analysis set incremental electricity demand resulted from electricifation thanks to EDL's grid expansion as energy consumption, or the other benefit factor. (See Figure 10.6-2) [5]

The incremental demand is set as constant after year 2030 because of the corresponding investment that finished in the year 2030, although the evaluation period lasts until year 2040. Figure 10.6-3 shows the total demand forecast of Lao PDR from 2010 to 2040 used in this study.

[5]**The Choice of Benefitiary**

Strictly speaking, the following beneficiaries marked as II to IV in the table below are included as benefit resulting from the Optimum Plan besides the beneficiary of electrified consumers by implementing this Optimum Plan.

The type of beneficiary	Energy consumption	Economic value
I. Newly electrified residents and major loads by grid expansion.	Incremental demand	WTP.
II. The already-electrified villages via grid with growing power consumption by household thanks to the life standard improvement.	Incremental demand	Existing electricity tariff.
III. The already-electrified villages by way of imported electricity from the adjusent country.	Non-incremental demand	Saved foreign currency (saved import).
IV. The already-electrified villages by way of off-grid power generation.	Non-incremental demand	Saved production cost by alternative means (e.g. diesel engine).

Therefore, strictly speaking, the beneficiaries such as those of II to IV should be included for the economic analysis, though this study does not because those beneficiaries' contribution to the analysis result is regarded small because of the following reasons:

II. The demand forecast employed in 6.7 assumes that the annual growth rate of the power comsumption by already-electrified household as 3% per person. The total accumulated consumption occupies just three percent of the total accumulated incremental demand.

III. Because the Study Team designs the Optimum Plan basically to satisfy domestic demand increase, the effect by saved import is hardly taken into account.

IV. According to Electricity Statistics Yearbook 2007 of Lao PDR, the annual domestic electricity consumption is recorded as 1,311 GWh nationwide and as 1,298 GWh for those supplied by EdL's grid. Therefore, the gap of 13 GWh can be regarded as the consumption supplied by off-grid power generators. The share of such consumption is, however, less than one percent of the total domestic consumption.

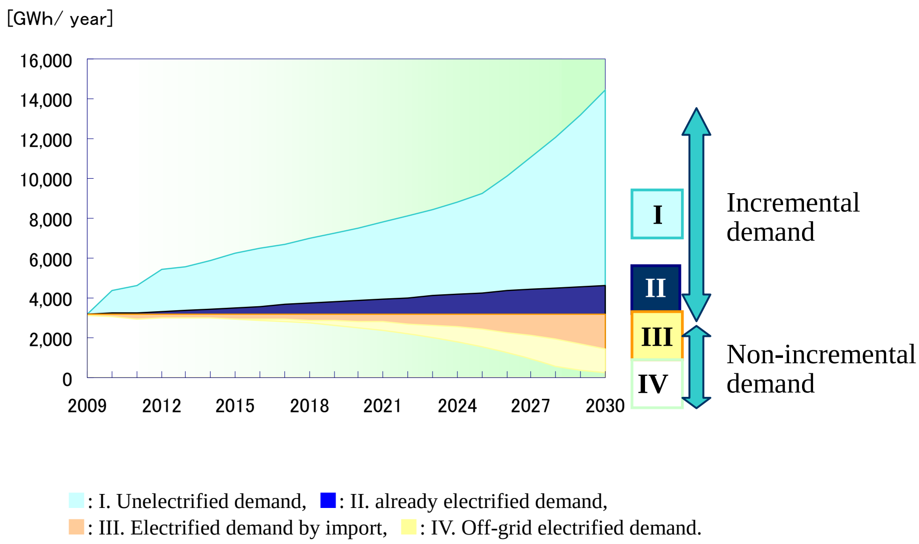


Figure 10.6-2 The Image of Beneficiaries in Demand Forecast of Lao PDR from 2010 to 2030

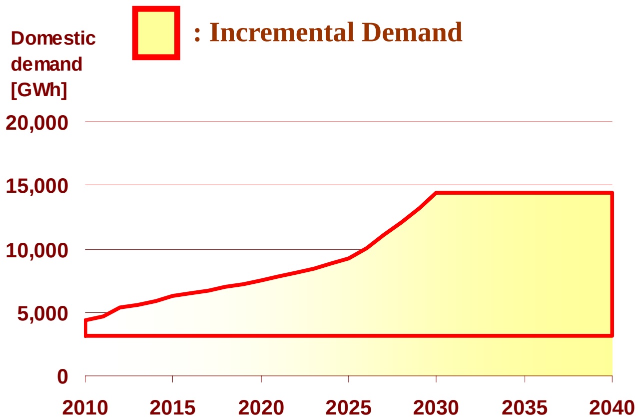


Figure 10.6-3 Demand Forecast of Lao PDR between 2010 and 2040

(3) Economic benefit

From the discussion above, this study calculated the economic benefit by multiplying the economic value, or WTP, derived in (1) with the energy consumption, or incremental demand, led in (2). The flow of economic benefits and of energy consumption is shown in Table 10.6c-1.

10.6.3 Economic Costs

The figures shown in the disbursement schedule for the Optimum Plan in Table 10.4-4 “Disbursement Schedule for Development of TL & SS System” are in financial values, and therefore, they are to be converted into the disbursement flow valued at the economic price. Since the foreign currency portion is valued at the border price, this portion is assumed to be equivalent to the economic value of resource costs. The attention is to be paid to the local currency portion, often distorted by the government regulations and subsidy policies. The standard conversion factor (SCF) is employed to convert local costs at prices distorted to that at border price. SCF was presumed to be 0.9, also quoted from the aforementioned ADB's study[6]. Consequently, the economic value of the disbursement schedule was expressed by the following formula, and the flow of economic costs is presented in Table 10.6c-1 with the project benefits:

Economic costs of the project = Foreign currency (FC) x 1.0 + Local currency (LC) x 0.9

Because the disbursement schedule in Table 10.4-4 "Disbursement Schedule for Development of TL & SS System" does not include the cost of on-going TL & SS sub-projects, this economic analysis added the cost based on the information provided by EDL. The Study Team developed a disbursement plan of these on-going projects in the same approach as employed in the Section 10.4: total project period of three years, the ratio of the local currency portion to the foreign currency portion as 1 to 4. Table 10.6-3 shows the identified on-going sub-projects and their disbursement plan.

Table 10.6-3 The Disbursement Plan of On-going Sub-Projects

Fiscal Year	T/L (transmission line)		SS (substation)	
	FC	LC	FC	LC
2010	19,468	9,081	7,636	1,527
2011	9,240	5,683	1,802	360
Total	28,708	14,764	9,438	1,887

The list of on-going sub-projects

- Nam Lik 1/2- Hin Heup/ Ban Don
- Nam Ngum 5 – Vangvieng/ Phonsavan
- Pakxan – Pakbo
- Xeset 1 – Saravan
- Pakxong – Ban Jianxai

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

10.6.4 Analysis Result

The cash flow was prepared to estimate EIRR of the Optimum Plan (Table 10.6c-1). Because the EIRR was calculated to be 20.4%, which turns out to be higher than the benchmark OCC (12%) as a reference index, the Study Team concludes that the Optimum Plan is considered economically viable.

10.6.5 Sensitivity Analysis

The aforementioned result that the optimum plan is economically viable is under the limited condition which is considered to be the most appropriate with the data available currently (hereinafter called Base case). In reality, however, things in future are uncertain, e.g. the recent increase of construction material costs triggered by high oil prices. Likewise, the economic evaluation result here could change influenced by such unexpected events. The Study Team conducted a sensitivity analysis, developing five future scenarios, in order to confirm the robustness of the results even against such future uncertainty. The analysis also led the boundary condition by scenario beyond which the optimum plan will no longer be economically

[6] Asian Development Bank TA No. 4816-LAO Preparing the Greater Mekong Subregion Northern Power Transmision Project, Oct. 2008.

viable. The Study Team calls such a value of the scenario's variable as Boundary value. This makes the Optimum Plan's economically-viable range visible so that it succeeds in measuring the impact caused by uncertainty parameters. The following describes the detail of each scenario.

(1) Capital Cost rise Scenario

The first scenario assumed that the capital cost would rise by 15% due to events such as global inflation of construction material market and the volatility of currency exchange rate. Because a recent EDL's transmission project has experienced a similar situation, it would be worthwhile to measure its impact for the optimum plan, too.

(2) Benefit Decrease Scenario

The second scenario assumed that the economic benefits would fall by 10% resulting from events such as tariff reduction and uncollected bills.

(3) Half Value of WTP Scenario

While the value of WTP has been cited from recent ADB's study on transmission project in Lao PDR, the value could be lower than that depending on condition. Taking into account such a possibility, the third scenario assumed an extreme case, that is, the condition that the value of WTP is decreased to be half of the value set in Base case. Table 10.6-4 shows the value of WTP used for this sensitivity analysis.

Table 10.6-4 Willingness-to-Pay (WTP) Used for This Analysis

	Average value of WTP		TL&SS portion of average WTP
	[Kip/kWh]	[USCent/ kWh]	[USCent/kWh]
Base case	2,434	29.0	4
Half-value of WTP	1,217	14.5	**2**

To be noted is that the half value of the originally employed WTP can be realized only if its cost of kerosene, the fuel cost which occupies the majority of the WTP, drops down below half of its original value, i.e. less than 3,000 Kip/ l or 35 USCent/l for residential consumers, according to the referred ADB's study report. Similarly, for non-residential consumers, the cost of diesel engine's fuel, which is the main component of the WTP, decreases to less than one third of its original price, i.e. 2,000 Kip/l or 23 USCent/l.

(4) Demand Slow Down Scenario

The fourth scenario assumed that the electricity demand or the sales volume of electricity per annum would fall by 30% due to events like the economic downturn. This condition corresponds to the one that the average electricity demand growth rate which averaged rates over consumer categories would be 4% for next thirty years, while Base case assumes the rate of 6%.

(5) Operation and Maintenance (O&M) Cost Increase Scenario

The final scenario assumed that the O&M cost rises by 50%, predicting the increase of maintenance material costs and labor costs. This condition is equivalent to the one that O&M cost including labor costs increases by 5% every year (excluding inflation effect), which is estimated based on the net present value of total O&M cost during the period between fiscal year 2010 to year 2040.

The cash flow of each scenario's result is shown in Table 10.6c-2. The result is summarized in

Table 10.6-5.

Table 10.6-5 Results of Economic Analysis and Its Sensitivity Analysis

Scenario	EIRR [%]	NPV 2009 [Million USD]	Elasticity	Boundary value
Base case	20.4	523.9	-	-
1. Capital Cost Increase +15%	17.9	417.7	- 0.82	+80%
2. Benefit Decrease –10%	18.5	400.7	0.94	-45%
3. Half Value of WTP	10.4	-92.0	0.99	-45%
4. Demand Slow Down –30%	14.6	154.4	0.95	-45%
5. O&M Cost Increase +50%	19.9	494.9	- 0.05	n.a. (17.5% of EIRR with +300%

Note: NPV: Net Present Value (calculated at 12% of discount rate).
Boundary value: the value of key parameter beyond which the EIRR value can be less than 12% of OCC.

As shown in the table, the value of the EIRR exceeds the benchmark of 12% for all scenarios except Half Value of WTP scenario, which is an extreme case, the Study Team concludes that the economic viability of the optimum plan is considered robust.

For Half Value of WTP scenario, whose parameter, WTP, gives the largest impact on the economic evaluation result among paramters, the EIRR would be less than 12%. Therefore, the Optimum Plan might no longer be economically viabil if such future is predicted. Such future, however, seems less realistic because such future would come true only with the fuel cost of less than 23 to 25 USCent/l Table 10.6-4 shows the correlation between EIRR of the optimum plan and the range of WTP decrease.

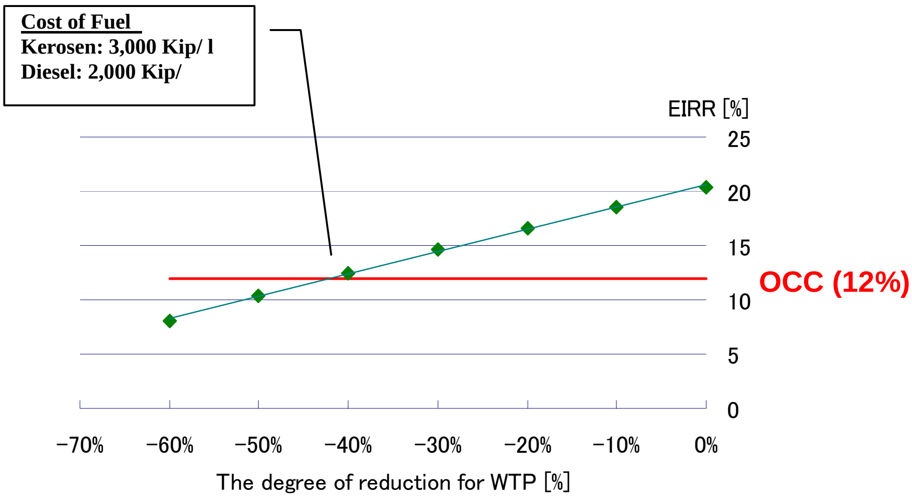


Figure 10.6-4 The Degree of Decresing WTP and the Plan's EIRR

In addition to the calculation of EIRR, the sensitivity analysis delved into further investigation to measure the uncertainty range in future. The investigation consists of two parts: elasticity test and viable range test. The elasticity test is about the degree of impact on the economic evaluation result by key parameter of each scenario, such as capital cost and power trading amount, to find out the most influential parameter. Its result tells that the degree of impact by the second to fourth scenario is large (in other words, the elasticity is large.), which means that the electricity tariff and demand are the key parameters to keep the Optimum Plan economically viable.

The viable range test is about the boundary condtion by scenario, the condition within which the optimum plan would remain economically viable. In other words, the value of the Plan's EIRR keeps higher than its benchmark, OCC (12%) with the scenario's parameter, whose value keeps lower than its boundary value.

The study team analyzed the scenario of Demand Slow Down, because the impact on the economic evaluation result by its parameter, demand, turned to be the second largest. The result shows that the Plan might turn to be economically non-viable if the demand decreases by more than 45% for coming 20 years, or the average demand growth rate over the all consumer categories is expected to be less than 3% for the period.
For Capital Cost Increase scenario, whose parameter (capital cost)'s impact turns to be relatively small, its EIRR would be no less than 12% unless the spending on capital cost would be extravagant, like more than 1.8 times large as original value. Therefore, it can be concluded that revision of capital budget, such as reduction of capital expenditure and implementation postpone of sub-projects would be unnecessary.
For O&M Cost INcrease scenario, its EIRR is derived as 17.5% exceeding 12% of OCC even if the O&M cost increases to three times as large as its original value. The team concluded that it is less likely that this parameter would make the Plan economically viable.
Figure 10.6-5 summarizes the above result.

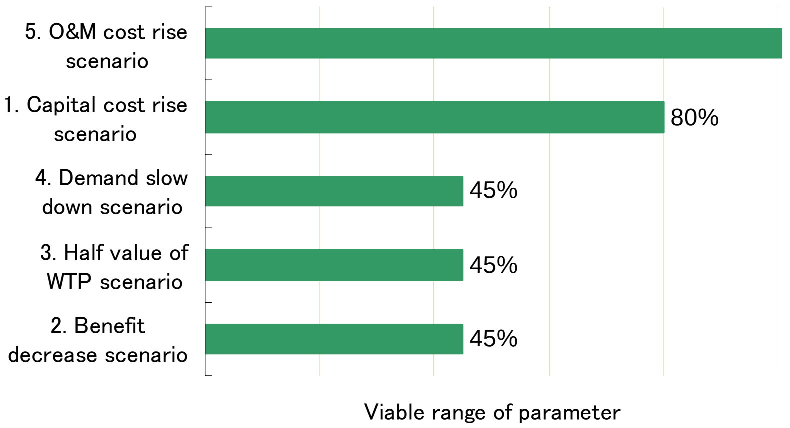


Figure 10.6-5 The Range of Parameters Guaranteeing Economic Viability of the Plan

The bar shows the viable range, where the Optimum Plan remains economically viable. The bar itself represents the uncertain range set by input parameter. Short bar means that the selected parameter could cause larger impact on the economic viability of the Optimum Plan than the parameters with long bar.

10.6.6 Financial Analysis of the Optimum Plan

This sub-section analyzes the financial viability of the optimum plan from the view of the project-operating entity, i.e. EDL, while the economic analysis above measured the effect of the plan on the national economy.

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 sales to energy users. This indicates uncertainty of hand-over or wholesale prices between generation outlets and transmission inlets. Furthermore, this Optimum Plan is to develop the transmission and sub-station facilities over the country; the plan covers many remote and scattered demand points; and the power tariff includes subsidy. Under these conditions, exact revenue related to the transmission lines and substations is difficult to identify.

For analysis, expenditures include construction costs and O&M costs. The local currency portion of the costs is not adjusted with a conversion factor like the one during the case of economic analysis. Financial benefit is obtained by multiplying existing tariff (average retail tariff) with incremental electricity demand. According to the existing tariff system, the rate is planned to rise by 5% annually. Table 10.6-6 shows the projected future tariff rates based on the existing tariff system.

Table 10.6-6 Estimated Future Average Retail Tariff Based on the Current System

Fiscal year	US cent/ kWh
2007	5.44
2008	5.71
2009	6.00
2010	6.30
2011	6.61
2012	6.94
2013	7.29
2014	7.65

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

The financial internal rate of return (FIRR) for the optimum plan is calculated to be 8.3%. Considering the weighted average cost of capital (WACC) of similar power projects of Lao PDR[7] varies around 2 to 8%, the JICA Study Team conludes that the Optimum Plan is considered financially viable.

As a sensitivity analysis, the team also simulated a case where the EdL adopts the proposed tariff system by the recent World Bank's study (Tariff Study Update, June 2009). Table 10.6-7 shows the projected future retail tariff rates in the Bank's study.

[7] "TA No. 4816-LAO: Preparing the Greater Mekong Subregion Northern Power Transmission Project", Oct. 2008, Asian Development Bank;
"Feasibility Study on Xeset-1 to Saravan 115 kV Transmission Line System and associated Substation at Saravan", Final Report, EdL;
"Power Import and Export Study: Feasibility Study of Ban Hat-Stung Treng 115 kV-Line and Substation", Ministry of Industry and Handicraft and Electricite du Laos;
"Study on Ownership and Benefit-Sharing for the Proposed 500kV Interconnection Between China, Laos and Thailand: Specific recommendations to the China – Laos – Thailand 500kV transmission line", Department of Electricity, The Ministry of Energy and Mines, Lao PDR.

Table 10.6-7 Proposed Electricity Tariff (Average Retail Tariff)

Fiscal year	Proposed new tariff system		Alternative new tariff system	
	Kip/kWh	US cent/kWh	Kip/kWh	US cent/kWh
2010	698	**8.20**	600	**7.05**
2011	813	**9.55**	680	**7.99**
2012	904	**10.62**	705	**8.28**
2013	971	**11.40**	705	**8.28**
2014	1,064	**12.50**	712	**8.36**
2015	1,176	**13.81**	725	**8.51**
2016	1,274	**14.96**	749	**8.80**
2017	1,274	**14.96**	749	**8.80**

(Source: Developed by JICA Study team based on the following: Tariff Study Update, IDA, June 2009; interview with EDL.)

The alternative new tariff which is set as half as that of the originally proposed one is also suggested later because the original one seems so expensive to be realized. Table 10.6-7 also shows the rate of alternative new tariff system. The analysis assumes that the rate is kept constant after year 2017, because the rate of roposed new system reaches the 100% cost recovery level in 2017 according to the Bank's final report. To be fair with this assumption, the analysis for the base case also set the tariff rate constant after it reaches the same level, 1,274 Kip/kWh. Figure 10.6-6 shows the projection of both tariff systems.

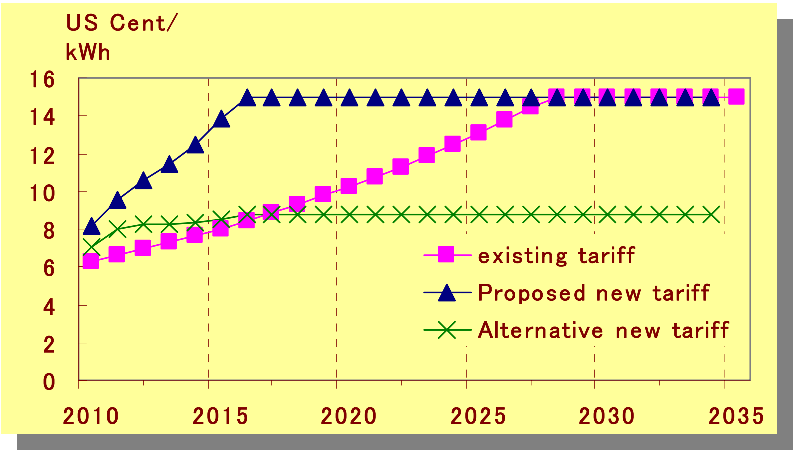


Figure 10.6-6 The Projection of Electricity Tariff Used for This Financial Analysis

The estimated FIRR is 10.0% for the originally proposed new tariff system, while the FIRR is 5.1% for the alternative new tariff system. Table 10.6-8 summarizes the results of financial analysis and its sensitivity analysis. Table 10.6c-3 shows the cash flow for the base case, while Table 10.6c-4 shows the one for the case to adopt the proposed tariff system.

Table 10.6-8 Results of Financial Analysis and its Sensitivity Analysis

Scenario	FIRR [%]	NPV 2009 [Million USD]
Base case	8.3	1,168
Adoption of proposed tariff system	10.0	1,420
Adooption of alternative new tariff system	5.1	365

~~(~~Note: NPV: Net Present Value (calculated at 2.7% of discount rate)~~)~~

Table 10.6c-1 EIRR Calculation for TL/SS Development Project

(Base Case) Unit: Thousand US$

FY	Economic Costs									Gross Benefits		Net
	TL		SS		Total Capital		O&M:TL	O&M:SS	Total	Incre. Energy	Total	
	FC	LC	FC	LC	FC	LC	FC+LC	FC+LC	Cost	(GWh)	Benefit	
FY2010	93,203	43,196	29,114	5,401	122,317	48,598	0	0	170,915	0	0	−170,915
FY2011	129,737	50,840	53,838	10,559	183,575	61,399	1,364	518	246,856	1,484	59,384	−187,472
FY2012	40,912	25,939	32,692	5,795	73,604	31,734	3,170	1,484	109,991	2,263	90,575	−19,417
FY2013	44,589	16,258	19,549	4,311	64,138	20,569	3,838	2,061	90,606	2,416	96,676	6,071
FY2014	33,004	18,542	11,167	2,678	44,171	21,220	4,447	2,419	72,256	2,707	108,335	36,078
FY2015	39,131	18,771	7,752	1,456	46,883	20,227	4,962	2,627	74,699	3,096	123,905	49,206
FY2016	44,943	19,881	7,396	1,082	52,339	20,963	5,541	2,765	81,609	3,336	133,504	51,895
FY2017	15,902	9,955	6,435	1,200	22,337	11,155	6,189	2,892	42,573	3,546	141,894	99,320
FY2018	5,608	4,957	7,949	1,385	13,557	6,342	6,448	3,006	29,353	3,815	152,660	123,306
FY2019	12,595	4,966	12,114	2,256	24,709	7,222	6,554	3,146	41,632	4,061	162,501	120,869
FY2020	4,973	4,631	10,104	1,643	15,077	6,274	6,729	3,362	31,442	4,327	173,171	141,729
FY2021	8,825	3,147	10,182	1,604	19,007	4,751	6,825	3,538	34,122	4,616	184,732	150,610
FY2022	1,924	1,751	10,697	1,693	12,621	3,445	6,945	3,715	26,726	4,934	197,435	170,709
FY2023	978	549	11,777	2,101	12,755	2,650	6,982	3,901	26,288	5,283	211,409	185,122
FY2024	4,847	1,661	3,654	485	8,501	2,145	6,997	4,109	21,752	5,668	226,796	205,044
FY2025	3,799	1,904	2,653	302	6,452	2,206	7,062	4,171	19,892	6,091	243,758	223,866
FY2026	8,597	4,772	3,442	504	12,039	5,276	7,119	4,215	28,650	6,934	277,473	248,823
FY2027	48,233	11,567	13,120	2,291	61,353	13,858	7,253	4,275	86,738	7,882	315,421	228,682
FY2028	9,608	6,575	3,760	520	13,368	7,095	7,851	4,506	32,820	8,917	356,846	324,025
FY2029	2,655	964	1,937	226	4,592	1,190	8,013	4,570	18,365	10,047	402,058	383,694
FY2030	507	520	1,445	177	1,952	697	8,049	4,602	15,300	11,280	451,397	436,097
FY2031	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2032	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2033	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2034	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2035	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2036	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2037	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2038	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2039	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
FY2040	0	0	0	0	0	0	8,059	4,627	12,686	11,280	451,397	438,711
Total	554,570	251,348	260,778	47,670	815,348	299,018	202,930	112,148	1,429,444	215,508	8,623,901	7,194,457

Economic Internal Rate of Return for the Project: 20.4%
Net Present Value (at 12%): 523,915

OER	250 Kip/THB	(Aug.27, 2009 by Yahoo)
OER	8,515 Kip/USD	(Aug.27, 2009 by Yahoo)
Applied currency and unit:	US$ thousand	
Base year:	Year 2009	

Cost side

SCF for Local Currency Portion: 0.9

O&M cost: 1% for transmission, 1.5% for substation of capital cost.

Benefit side

WTP on average	0.29 USD/kWh	2,434 Kip/ kWh
TL&SS portion of WTP (14%) Year 2009	14% (Source: WB Tariff update study, Aug.20,2009)	
Benefit corresponding to this project	0.04 USD/kWh	

Table 10.6c-2 EIRR Calculation for TL/SS Development Project (Sensitivity Analysis)

SA1) Capital Costs +15% (15%) / SA2) Benefits −10% (−10%)

FY	SA1 Economic Costs: Total Capital FC	Total Capital LC	O&M:TL FC+LC	O&M:SS FC+LC	Total Cost	Net	SA2 Benfit	Net
FY2010	140,665	55,887	0	0	196,552	−196,552	0	−170,915
FY2011	211,112	70,609	1,569	595	283,884	−224,500	53,445	−193,410
FY2012	84,645	36,494	3,645	1,706	126,490	−35,915	81,517	−28,474
FY2013	73,758	23,654	4,414	2,370	104,197	−7,520	87,009	−3,597
FY2014	50,796	24,403	5,114	2,782	83,095	25,240	97,501	25,245
FY2015	53,916	23,261	5,707	3,021	85,904	38,001	111,515	36,816
FY2016	60,190	24,108	6,372	3,179	93,850	39,654	120,154	38,545
FY2017	25,687	12,829	7,118	3,326	48,959	92,934	127,704	85,131
FY2018	15,590	7,294	7,415	3,457	33,756	118,903	137,394	108,040
FY2019	28,416	8,306	7,537	3,618	47,876	114,625	146,251	104,619
FY2020	17,338	7,215	7,739	3,866	36,158	137,012	155,854	124,412
FY2021	21,858	5,464	7,849	4,069	39,240	145,492	166,258	132,137
FY2022	14,514	3,961	7,987	4,272	30,735	166,701	177,692	150,966
FY2023	14,669	3,047	8,029	4,486	30,231	181,178	190,268	163,981
FY2024	9,776	2,467	8,047	4,725	25,015	201,781	204,117	182,365
FY2025	7,420	2,537	8,121	4,797	22,875	220,882	219,382	199,490
FY2026	13,845	6,068	8,187	4,848	32,947	244,526	249,726	221,076
FY2027	70,556	15,936	8,341	4,916	99,749	215,672	283,879	197,140
FY2028	15,373	8,160	9,029	5,182	37,743	319,102	321,161	288,341
FY2029	5,281	1,369	9,215	5,255	21,120	380,939	361,853	343,488
FY2030	2,245	802	9,256	5,293	17,595	433,802	406,258	390,957
FY2031	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2032	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2033	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2034	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2035	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2036	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2037	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2038	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2039	0	0	9,268	5,321	14,589	436,808	406,258	393,572
FY2040	0	0	9,268	5,321	14,589	436,808	406,258	393,572
Total	937,650	343,870	233,370	128,971	1,643,861	6,980,041	7,761,511	6,332,067
Economic Internal Rate of Return for the Project						17.9%		18.5%
Net Present Value (at 12%)						417,723		400,729

SA3) Half Value of WTP (−50%) / SA4) Incremental Demand −30% (−30%) / SA5) O&M Cost +50% (50%)

SA3 Gross Benefits: Benfit	SA3 Net	SA4 Gross Benefits: Incre. Energy (GWh)	SA4 Total Benefit	SA4 Net	SA5 Economic Costs: O&M (TL+SS)	SA5 Total Cost	SA5 Net
0	−170,915	0	0	−170,915	0	170,915	−170,915
29,692	−217,164	1,039	41,569	−205,287	2,823	247,797	−188,413
45,287	−64,704	1,584	63,402	−46,589	6,980	112,318	−21,743
48,338	−42,268	1,691	67,673	−22,932	8,849	93,555	3,121
54,167	−18,089	1,895	75,834	3,578	10,298	75,689	32,646
61,953	−12,746	2,167	86,734	12,035	11,383	78,494	45,412
66,752	−14,857	2,335	93,453	11,844	12,459	85,762	47,742
70,947	28,373	2,482	99,325	56,752	13,622	47,114	94,779
76,330	46,976	2,670	106,862	77,508	14,182	34,081	118,579
81,250	39,619	2,843	113,751	72,119	14,550	46,482	116,019
86,585	55,143	3,029	121,220	89,777	15,137	36,488	136,683
92,366	58,244	3,231	129,312	95,191	15,545	39,303	145,428
98,718	71,992	3,454	138,205	111,479	15,990	32,056	165,379
105,705	79,417	3,698	147,986	121,699	16,324	31,729	179,680
113,398	91,646	3,967	158,758	137,005	16,659	27,305	199,491
121,879	101,987	4,264	170,630	150,739	16,850	25,508	218,249
138,736	110,087	4,854	194,231	165,581	17,002	34,317	243,156
157,710	70,972	5,518	220,795	134,056	17,291	92,502	222,919
178,423	145,603	6,242	249,792	216,972	18,535	38,998	317,847
201,029	182,664	7,033	281,441	263,076	18,874	24,656	377,402
225,699	210,398	7,896	315,978	300,678	18,977	21,626	429,771
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
225,699	213,013	7,896	315,978	303,292	19,029	19,029	432,368
4,311,951	2,882,507	150,855	6,036,731	4,607,287	472,618	1,586,983	7,036,918
	10.4%			14.6%			19.9%
	−92,016			154,356			494,892

Table 10.6c-3 FIRR Calculation for TL/SS Development Project

(Base Case) Unit: Thousand US$

FY	Economic Costs									Gross Benefits		Total	Net
	TL		SS		Total Capital		O&M:TL	O&M:SS	Total	Incre. Energy	$equivalent	Revenue	
	FC	LC	FC	LC	FC	LC	FC+LC	FC+LC	Cost	(GWh)	($/MWh)		
FY2010	93,203	47,996	29,114	6,001	122,317	53,997	0	0	176,315	0	9	0	-176,315
FY2011	129,737	56,489	53,838	11,732	183,575	68,221	1,412	527	253,735	1,484	9	13,738	-239,997
FY2012	40,912	28,821	32,692	6,439	73,604	35,260	3,274	1,510	113,649	2,263	10	22,001	-91,648
FY2013	44,589	18,064	19,549	4,790	64,138	22,854	3,972	2,097	93,061	2,416	10	24,657	-68,404
FY2014	33,004	20,602	11,167	2,976	44,171	23,578	4,598	2,462	74,809	2,707	11	29,012	-45,797
FY2015	39,131	20,857	7,752	1,618	46,883	22,475	5,134	2,674	77,167	3,096	11	34,841	-42,326
FY2016	44,943	22,090	7,396	1,203	52,339	23,293	5,734	2,815	84,181	3,336	12	39,417	-44,764
FY2017	15,902	11,061	6,435	1,334	22,337	12,395	6,404	2,944	44,080	3,546	12	43,989	-91
FY2018	5,608	5,508	7,949	1,539	13,557	7,047	6,674	3,061	30,338	3,815	13	49,693	19,355
FY2019	12,595	5,518	12,114	2,507	24,709	8,025	6,785	3,203	42,722	4,061	14	55,541	12,819
FY2020	4,973	5,146	10,104	1,825	15,077	6,971	6,966	3,422	32,436	4,327	14	62,147	29,711
FY2021	8,825	3,497	10,182	1,782	19,007	5,279	7,067	3,601	34,955	4,616	15	69,611	34,656
FY2022	1,924	1,946	10,697	1,881	12,621	3,827	7,191	3,781	27,420	4,934	16	78,118	50,698
FY2023	978	610	11,777	2,334	12,755	2,944	7,229	3,969	26,898	5,283	17	87,829	60,931
FY2024	4,847	1,845	3,654	539	8,501	2,384	7,245	4,181	22,311	5,668	17	98,933	76,622
FY2025	3,799	2,116	2,653	335	6,452	2,451	7,312	4,244	20,460	6,091	18	111,648	91,189
FY2026	8,597	5,302	3,442	560	12,039	5,862	7,371	4,289	29,561	6,934	19	133,445	103,884
FY2027	48,233	12,852	13,120	2,545	61,353	15,397	7,510	4,349	88,610	7,882	20	159,280	70,671
FY2028	9,608	7,306	3,760	578	13,368	7,884	8,121	4,584	33,957	8,917	21	189,209	155,252
FY2029	2,655	1,071	1,937	251	4,592	1,322	8,290	4,649	18,854	10,047	21	213,182	194,328
FY2030	507	578	1,445	197	1,952	775	8,328	4,682	15,736	11,280	21	239,343	223,607
FY2031	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2032	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2033	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2034	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2035	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2036	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2037	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2038	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2039	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
FY2040	0	0	0	0	0	0	8,338	4,706	13,045	11,280	21	239,343	226,298
Total	554,570	279,275	260,778	52,967	815,348	332,242	210,004	114,104	1,471,698	215,508	0	4,149,062	2,677,364

Financial Internal Rate of Return for the Project	8.3%
Net Present Value (at 2.7%)	1,167,959

OER 250 Kip/THB (Aug.27, 2009 by Yahoo)
OER 8,515 Kip/USD (Aug.27, 2009 by Yahoo)
Applied currency and unit: US$ thousand
Base year: Year 2009

Cost side
SCF for Local Currency Portion 0.9
O&M cost: 1% for transmission, 1.5% for substation of capital cost.

Benefit side
Existing average tariff 5.44 USC/kWH FY2007 : increase by 5% annually.
TL&SS portion of tariff 14% (Source: WB Tariff update study, Aug.20,2009)
US$ equivalent tariff of TL&SS portion 7.6 US$/MWh FY2007

Table 10.6c-4 FIRR Calculation for TL/SS Development Project (Sensitivity Analysis

Left: originally proposed new tariff system; Right: Alternative new tariff system)

New Tariff System

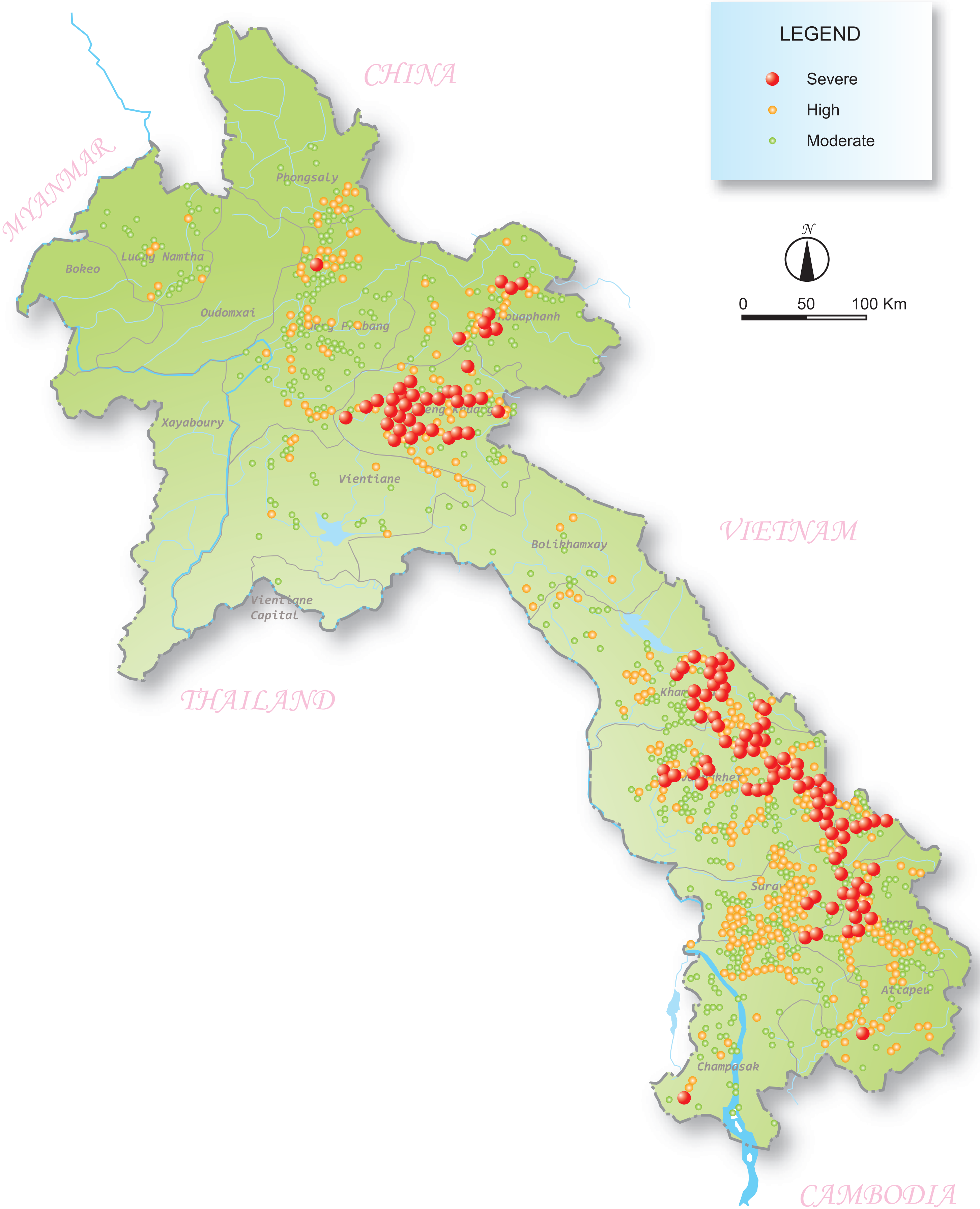
FY	Gross Benefits New Tariff (Kip/kWh)	Gross Benefits $equivalent ($/MWh)	Total Revenue	Net
FY2010	98	11	0	-176,315
FY2011	114	13	19,836	-233,899
FY2012	127	15	33,642	-80,007
FY2013	136	16	38,569	-54,491
FY2014	149	17	47,360	-27,449
FY2015	165	19	59,869	-17,298
FY2016	178	21	69,882	-14,299
FY2017	178	21	74,274	30,194
FY2018	178	21	79,909	49,571
FY2019	178	21	85,060	42,339
FY2020	178	21	90,646	58,209
FY2021	178	21	96,697	61,742
FY2022	178	21	103,347	75,927
FY2023	178	21	110,661	83,763
FY2024	178	21	118,716	96,405
FY2025	178	21	127,594	107,134
FY2026	178	21	145,242	115,681
FY2027	178	21	165,106	76,496
FY2028	178	21	186,789	152,833
FY2029	178	21	210,456	191,602
FY2030	178	21	236,282	220,547
FY2031	178	21	236,282	223,238
FY2032	178	21	236,282	223,238
FY2033	178	21	236,282	223,238
FY2034	178	21	236,282	223,238
FY2035	178	21	236,282	223,238
FY2036	178	21	236,282	223,238
FY2037	178	21	236,282	223,238
FY2038	178	21	236,282	223,238
FY2039	178	21	236,282	223,238
FY2040	178	21	236,282	223,238
Total	5,247		4,462,759	2,991,061

Financial Internal Rate of Return for the Project	10.0%
Net Present Value (at 2.7%)	1,419,852

Revised New Tariff System

FY	Gross Benefits New Tariff (Kip/kWh)	Gross Benefits $equivalent ($/MWh)	Total Revenue	Net
FY2010	84	10	0	-176,315
FY2011	95	11	16,591	-237,144
FY2012	99	12	26,236	-87,412
FY2013	99	12	28,003	-65,057
FY2014	100	12	31,692	-43,117
FY2015	102	12	36,909	-40,258
FY2016	105	12	41,085	-43,097
FY2017	105	12	43,666	-414
FY2018	105	12	46,980	16,641
FY2019	105	12	50,008	7,286
FY2020	105	12	53,292	20,855
FY2021	105	12	56,849	21,895
FY2022	105	12	60,759	33,339
FY2023	105	12	65,059	38,161
FY2024	105	12	69,794	47,484
FY2025	105	12	75,014	54,555
FY2026	105	12	85,390	55,828
FY2027	105	12	97,068	8,458
FY2028	105	12	109,816	75,859
FY2029	105	12	123,730	104,876
FY2030	105	12	138,913	123,178
FY2031	105	12	138,913	125,869
FY2032	105	12	138,913	125,869
FY2033	105	12	138,913	125,869
FY2034	105	12	138,913	125,869
FY2035	105	12	138,913	125,869
FY2036	105	12	138,913	125,869
FY2037	105	12	138,913	125,869
FY2038	105	12	138,913	125,869
FY2039	105	12	138,913	125,869
FY2040	105	12	138,913	125,869
Total	0	0	2,645,985	1,174,287

Financial Internal Rate of Return for the Project	5.1%
Net Present Value (at 2.7%)	365,142



UXO Map

Figure10.1-1: UXO Map in Laos

Source: UXO Lao

Table 10.2-1 (a): Transformer Additional and Replacement Program in Northern Area

Northern Area

Xam Nua SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)				1.4	1.6	1.7	1.9	2.1	2.3	2.5	2.8	3.0	3.3	3.6	4.0	4.3	4.8	5.2	5.7	6.3	6.9	7.5	8.3
Peak MVA (pf=0.85)				1.7	1.8	2.0	2.2	2.5	2.7	3.0	3.3	3.6	3.9	4.3	4.7	5.1	5.6	6.1	6.7	7.4	8.1	8.9	9.8
total capacity (MVA)				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
balance (MVA)				8.3	8.2	8.0	7.8	7.5	7.3	7.0	6.7	6.4	6.1	5.7	5.3	4.9	4.4	3.9	3.3	2.6	1.9	1.1	0.2
over load factor (%)				17%	18%	20%	22%	25%	27%	30%	33%	36%	39%	43%	47%	51%	56%	61%	67%	74%	81%	89%	98%
numbers (nos)				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2011			(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
no.2																							

Boun Neua SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.2	2.4
Peak MVA (pf=0.85)					0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4	2.6	2.8
total capacity (MVA)					10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
balance (MVA)					9.1	9.1	9.0	9.0	8.9	8.8	8.7	8.6	8.5	8.5	8.4	8.2	8.1	8.0	7.9	7.7	7.6	7.4	7.2
over load factor (%)					9%	9%	10%	10%	11%	12%	13%	14%	15%	15%	16%	18%	19%	20%	21%	23%	24%	26%	28%
numbers (nos)					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2013				(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Luang Namtha SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)		3.9	4.3	4.8	5.3	5.9	6.6	7.4	8.2	9.2	10.2	11.4	12.6	13.9	15.4	17.1	19.0	21.1	23.4	25.9	28.9	32.1	35.8
Peak MVA (pf=0.85)		4.5	5.1	5.6	6.3	7.0	7.8	8.7	9.7	10.8	12.0	13.4	14.8	16.4	18.1	20.1	22.3	24.8	27.5	30.5	33.9	37.8	42.2
total capacity (MVA)		20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	60.0
balance (MVA)		15.5	14.9	14.4	13.7	13.0	12.2	11.3	10.3	9.2	8.0	6.6	5.2	3.6	21.9	19.9	17.7	15.2	12.5	9.5	6.1	2.2	17.8
over load factor (%)		23%	25%	28%	31%	35%	39%	43%	48%	54%	60%	67%	74%	82%	45%	50%	56%	62%	69%	76%	85%	94%	70%
numbers (nos)		1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3
units no.1 2009	(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
no.2 2022														(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
no.3 2030																						(new TR)	20.0

Oudomxai SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)		2.5	2.7	2.9	2.6	2.8	3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	8.0	8.7	9.5	10.3	11.3	12.4
Peak MVA (pf=0.85)		2.9	3.2	3.5	3.0	3.3	3.6	4.0	4.3	4.7	5.2	5.7	6.1	6.7	7.3	7.9	8.6	9.4	10.2	11.1	12.2	13.3	14.5
total capacity (MVA)		20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)		17.1	16.8	16.5	17.0	16.7	16.4	16.0	15.7	15.3	14.8	14.3	13.9	13.3	12.7	12.1	11.4	10.6	9.8	8.9	7.8	6.7	5.5
over load factor (%)		14%	16%	17%	15%	17%	18%	20%	22%	24%	26%	28%	31%	33%	36%	39%	43%	47%	51%	56%	61%	66%	73%
numbers (nos)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2009	(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
no.2																							

Na Mo SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					5.6	5.7	5.8	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.7	6.8	7.0	7.2	7.4	7.6	7.8	8.1
Peak MVA (pf=0.85)					6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.7	7.9	8.0	8.2	8.4	8.7	8.9	9.2	9.5
total capacity (MVA)					10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
balance (MVA)					3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.3	2.1	2.0	1.8	1.6	1.3	1.1	0.8	0.5
over load factor (%)					66%	67%	68%	69%	70%	71%	72%	73%	74%	75%	77%	79%	80%	82%	84%	87%	89%	92%	95%
numbers (nos)					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2012				(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Huayxai SS (Bokeo)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					7.3	8.2	9.1	10.1	11.3	12.6	14.1	15.7	17.3	19.2	21.3	23.6	26.2	29.1	32.3	35.9	39.9	44.5	49.6
Peak MVA (pf=0.85)					8.6	9.6	10.7	11.9	13.3	14.8	16.5	18.4	20.4	22.6	25.0	27.7	30.8	34.3	38.0	42.2	47.0	52.3	58.4
total capacity (MVA)					30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)					21.4	20.4	19.3	18.1	16.7	15.2	13.5	11.6	9.6	7.4	5.0	2.3	29.2	25.7	22.0	17.8	13.0	7.7	1.6
over load factor (%)					29%	32%	36%	40%	44%	49%	55%	61%	68%	75%	83%	92%	51%	57%	63%	70%	78%	87%	97%
numbers (nos)					1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
units no.1 2012				(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2024																(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Luang Prabang 2 (Pakmong) SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)		2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.9	5.1	5.4	5.7	6.0	6.3	6.7	7.0
Peak MVA (pf=0.85)		2.7	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.7	4.9	5.2	5.4	5.7	6.0	6.3	6.7	7.0	7.4	7.8	8.3
total capacity (MVA)		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
balance (MVA)		7.3	7.2	7.0	6.8	6.6	6.4	6.2	6.0	5.8	5.6	5.3	5.1	4.8	4.6	4.3	4.0	3.7	3.3	3.0	2.6	2.2	1.7
over load factor (%)		27%	28%	30%	32%	34%	36%	38%	40%	42%	44%	47%	49%	52%	54%	57%	60%	63%	67%	70%	74%	78%	83%
numbers (nos)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2011	(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Luang Prabang 1 SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	13.7	14.5	15.3	16.2	17.1	7.2	7.6	8.1	8.5	9.0	9.5	10.1	10.6	11.1	11.7	12.3	12.9	13.6	14.3	15.1	15.9	16.8	17.8
Peak MVA (pf=0.85)	16.1	17.0	18.0	19.0	20.1	8.5	9.0	9.5	10.0	10.6	11.2	11.9	12.4	13.1	13.7	14.4	15.2	16.0	16.9	17.8	18.7	19.8	21.0
total capacity (MVA)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
balance (MVA)	33.9	33.0	32.0	31.0	29.9	41.5	41.0	40.5	40.0	39.4	38.8	38.1	37.6	36.9	36.3	35.6	34.8	34.0	33.1	32.2	31.3	30.2	29.0
over load factor (%)	32%	34%	36%	38%	40%	17%	18%	19%	20%	21%	22%	24%	25%	26%	27%	29%	30%	32%	34%	36%	37%	40%	42%
numbers (nos)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units no.1 2007	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
no.2 2007	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0

Luang Prabang 3 (Xieng Nguen) SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)						10.8	11.5	12.1	12.8	13.5	14.3	15.1	15.9	16.7	17.5	18.4	19.4	20.4	21.5	22.6	23.9	25.2	26.7
Peak MVA (pf=0.85)						12.8	13.5	14.2	15.1	15.9	16.8	17.8	18.7	19.6	20.6	21.7	22.8	24.1	25.3	26.6	28.1	29.7	31.4
total capacity (MVA)						20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
balance (MVA)						7.2	6.5	5.8	4.9	4.1	3.2	2.2	1.3	0.4	19.4	18.3	17.2	15.9	14.7	13.4	11.9	10.3	8.6
over load factor (%)						64%	67%	71%	75%	80%	84%	89%	93%	98%	51%	54%	57%	60%	63%	67%	70%	74%	79%
numbers (nos)						1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
units no.1 2013					(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
no.2														(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Xayabury SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	4.1	5.5	6.1	6.6	7.3	8.0	8.7	9.6	10.5	11.5	12.6	13.8	15.0	16.3	17.8	19.4	21.2	23.2	25.3	27.6	30.2	33.0	36.2
Peak MVA (pf=0.85)	4.8	6.5	7.1	7.8	8.6	9.4	10.3	11.3	12.4	13.5	14.8	16.3	17.7	19.2	20.9	22.8	24.9	27.3	29.7	32.5	35.5	38.9	42.6
total capacity (MVA)	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	48.0	48.0	48.0	48.0
balance (MVA)	11.2	9.5	8.9	8.2	7.4	6.6	5.7	4.7	3.6	2.5	1.2	15.7	14.3	12.8	11.1	9.2	7.1	4.7	2.3	15.5	12.5	9.1	5.4
over load factor (%)	30%	41%	45%	49%	54%	59%	64%	70%	77%	85%	93%	51%	55%	60%	65%	71%	78%	85%	93%	68%	74%	81%	89%
numbers (nos)	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3
units no.1 2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
no.2 2003											(from Phonesavan SS)	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
no.3 2007																			(from Vangvieng)	16.0	16.0	16.0	16.0

Table 10.2-1 (a): Transformer Additional and Replacement Program in Northern Area

Northern Area

Hongsa SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)								5.5	6.0	6.6	7.2	7.9	8.6	9.5	10.3	11.2	12.2	13.3	14.5	15.9	17.3	18.9	20.7	22.6	24.8
Peak MVA (pf=0.85)								6.4	7.0	7.7	8.5	9.3	10.2	11.1	12.1	13.2	14.3	15.6	17.1	18.7	20.4	22.2	24.3	26.6	29.2
total capacity (MVA)								20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0
balance (MVA)								13.6	13.0	12.3	11.5	10.7	9.8	8.9	7.9	6.8	5.7	4.4	2.9	1.3	19.6	17.8	15.7	13.4	10.8
over load factor (%)								32%	35%	39%	42%	46%	51%	56%	61%	66%	72%	78%	85%	93%	51%	56%	61%	67%	73%
numbers (nos)								1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
units	no.1	2013					(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
																				(new TR)	20.0	20.0	20.0	20.0	20.0

Paklay SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)									5.2	5.7	6.3	6.9	7.5	8.3	9.0	9.8	10.6	11.6	12.7	13.9	15.1	16.5	18.0	19.8	21.7
Peak MVA (pf=0.85)									6.2	6.7	7.4	8.1	8.9	9.7	10.6	11.5	12.5	13.7	14.9	16.3	17.8	19.4	21.2	23.3	25.5
total capacity (MVA)									20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0
balance (MVA)									13.8	13.3	12.6	11.9	11.1	10.3	9.4	8.5	7.5	6.3	5.1	3.7	2.2	0.6	18.8	16.7	14.5
over load factor (%)									31%	34%	37%	40%	44%	49%	53%	58%	63%	68%	75%	82%	89%	97%	53%	58%	64%
numbers (nos)									1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
units	no.1	2014						(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	2028																				(new TR)	20.0	20.0	20.0

Phonsavan SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			4.4	4.8	5.4	6.0	6.6	7.4	8.2	9.1	10.2	11.3	12.6	14.0	15.5	17.1	18.9	21.0	23.3	25.8	28.6	31.7	35.2	39.2	43.7
Peak MVA (pf=0.85)			5.2	5.7	6.3	7.0	7.8	8.7	9.7	10.8	12.0	13.3	14.8	16.5	18.2	20.1	22.3	24.7	27.4	30.4	33.6	37.3	41.4	46.1	51.4
total capacity (MVA)			16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			10.8	10.3	9.7	9.0	8.2	7.3	6.3	5.2	4.0	2.7	1.2	13.5	11.8	9.9	7.7	5.3	2.6	29.6	26.4	22.7	18.6	13.9	8.6
over load factor (%)			32%	35%	39%	44%	49%	54%	60%	67%	75%	83%	93%	55%	61%	67%	74%	82%	91%	51%	56%	62%	69%	77%	86%
numbers (nos)			1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
units	no.1	2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0 to Xayaboury SS												
	no.1	2019											(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2025																	(new TR)	30.0	30.0	30.0	30.0	30.0	30.0

Muong Kham SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)						1.5	1.7	1.9	2.1	2.3	2.6	2.9	3.2	3.6	3.9	4.3	4.8	5.3	5.9	6.6	7.3	8.0	8.9	9.9	11.1
Peak MVA (pf=0.85)						1.8	2.0	2.2	2.5	2.7	3.0	3.4	3.8	4.2	4.6	5.1	5.7	6.3	6.9	7.7	8.5	9.5	10.5	11.7	13.0
total capacity (MVA)						10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	20.0	20.0	20.0
balance (MVA)						8.2	8.0	7.8	7.5	7.3	7.0	6.6	6.2	5.8	5.4	4.9	4.3	3.7	3.1	2.3	1.5	0.5	9.5	8.3	7.0
over load factor (%)						18%	20%	22%	25%	27%	30%	34%	38%	42%	46%	51%	57%	63%	69%	77%	85%	95%	53%	58%	65%
numbers (nos)						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1
units	no.1	2011			(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	no.2	2028																				(new TR)	10.0	10.0	10.0

Table 10.2-1 (b): Transformer Additional and Replacement Program in Central-1 Area

Central 1 Area

Phonesoung SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	8.2	10.3	11.2	12.1	13.2	14.3	15.5	16.8	18.2	19.8	21.5	23.3	25.1	27.0	29.2	31.5	34.0	36.8	39.8	43.0	46.6	50.5	54.9
Peak MVA (pf=0.90)	9.1	11.5	12.4	13.5	14.6	15.9	17.2	18.7	20.3	22.0	23.9	25.9	27.9	30.0	32.4	35.0	37.8	40.9	44.2	47.8	51.8	56.1	61.0
total capacity (MVA)	22.0	22.0	22.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0
balance (MVA)	12.9	10.5	9.6	16.5	15.4	14.1	12.8	11.3	9.7	8.0	6.1	4.1	2.1	0.0	27.6	25.0	22.2	19.1	15.8	12.2	8.2	3.9	29.0
over load factor (%)	41%	52%	56%	45%	49%	53%	57%	62%	68%	73%	80%	86%	93%	100%	54%	58%	63%	68%	74%	80%	86%	94%	68%
numbers (nos)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3
units no.1 1977	22.0	22.0	22.0	(scrap)																			
no.1 2011			(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2022														(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.3 2030																						(new TR)	30.0

Vangvieng SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	14.3	18.0	19.5	21.1	22.9	24.9	27.0	29.3	31.8	34.5	37.4	40.6	43.8	47.1	50.8	54.9	29.7	32.1	34.7	37.5	40.6	44.0	47.8
Peak MVA (pf=0.85)	16.8	21.1	22.9	24.9	27.0	29.3	31.8	34.5	37.4	40.6	44.1	47.8	51.5	55.5	59.8	64.6	34.9	37.8	40.8	44.1	47.8	51.8	56.3
total capacity (MVA)	32.0	32.0	32.0	32.0	32.0	32.0	32.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)	15.2	10.9	9.1	7.1	5.0	2.7	0.2	25.5	22.6	19.4	15.9	12.2	8.5	4.5	0.2	-4.6	25.1	22.2	19.2	15.9	12.2	8.2	3.7
over load factor (%)	53%	66%	72%	78%	84%	92%	99%	57%	62%	68%	73%	80%	86%	92%	100%	108%	58%	63%	68%	74%	80%	86%	94%
numbers (nos)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units no.1 2007	16.0	16.0	16.0	16.0	16.0	16.0	16.0	(to Xayaboury)															
no.1 2015							(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2007	16.0	16.0	16.0	16.0	16.0	16.0	16.0	(to Non Hai)															
no.2 2015							(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

New SS for Vangvieng	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)																	29.7	32.1	34.7	37.5	40.6	44.0	47.8
Peak MVA (pf=0.85)																	34.9	37.8	40.8	44.1	47.8	51.8	56.3
total capacity (MVA)																	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)																	25.1	22.2	19.2	15.9	12.2	8.2	3.7
over load factor (%)																	58%	63%	68%	74%	80%	86%	94%
numbers (nos)																	2	2	2	2	2	2	2
units no.1 2024																(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2024																(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Thalat SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	7.9	10.0	10.8	11.7	12.7	13.8	15.0	16.3	17.6	19.1	20.8	22.5	24.3	26.1	28.2	30.4	32.9	35.6	38.5	41.6	45.0	48.9	53.1
Peak MVA (pf=0.90)	8.8	11.1	12.0	13.0	14.1	15.3	16.6	18.1	19.6	21.3	23.1	25.0	27.0	29.0	31.3	33.8	36.6	39.6	42.7	46.2	50.0	54.3	59.0
total capacity (MVA)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)	21.2	18.9	18.0	17.0	15.9	14.7	13.4	11.9	10.4	8.7	6.9	5.0	3.0	1.0	28.7	26.2	23.4	20.4	17.3	13.8	10.0	5.7	1.0
over load factor (%)	29%	37%	40%	43%	47%	51%	55%	60%	65%	71%	77%	83%	90%	97%	52%	56%	61%	66%	71%	77%	83%	90%	98%
numbers (nos)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
units no.1 2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2022														(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Ban Don SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	2.7	3.4	3.7	4.0	3.2	3.5	3.8	4.2	4.5	4.9	5.3	5.8	6.2	6.7	7.2	7.8	8.4	9.1	9.8	10.6	11.5	12.5	13.5
Peak MVA (pf=0.85)	3.2	4.0	4.3	4.7	3.8	4.1	4.5	4.9	5.3	5.7	6.2	6.8	7.3	7.9	8.5	9.1	9.9	10.7	11.6	12.5	13.5	14.7	15.9
total capacity (MVA)	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
balance (MVA)	12.8	12.0	11.7	11.3	12.2	11.9	11.5	11.1	10.7	10.3	9.8	9.2	8.7	8.1	7.5	6.9	6.1	5.3	4.4	3.5	2.5	1.3	0.1
over load factor (%)	20%	25%	27%	29%	24%	26%	28%	31%	33%	36%	39%	42%	46%	49%	53%	57%	62%	67%	72%	78%	85%	92%	100%
numbers (nos)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0

Hin Heup SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.3	3.5	3.8	4.2	4.5
Peak MVA (pf=0.85)					1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.2	4.5	4.9	5.3
total capacity (MVA)					10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
balance (MVA)					8.7	8.6	8.5	8.4	8.2	8.1	7.9	7.7	7.6	7.4	7.2	7.0	6.7	6.4	6.1	5.8	5.5	5.1	4.7
over load factor (%)					13%	14%	15%	16%	18%	19%	21%	23%	24%	26%	28%	30%	33%	36%	39%	42%	45%	49%	53%
numbers (nos)					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units no.1 2012				(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Non Hai SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	3.0	3.8	4.1	4.4	4.8	5.2	5.7	6.1	6.7	7.2	7.9	8.5	9.2	9.9	10.7	11.5	12.5	13.5	14.6	15.7	17.0	18.5	20.1
Peak MVA (pf=0.85)	3.5	4.4	4.8	5.2	5.7	6.1	6.7	7.2	7.8	8.5	9.2	10.0	10.8	11.6	12.5	13.5	14.6	15.9	17.1	18.5	20.0	21.7	23.6
total capacity (MVA)	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	32.0	32.0	32.0	32.0	32.0
balance (MVA)	12.5	11.6	11.2	10.8	10.3	9.9	9.3	8.8	8.2	7.5	6.8	6.0	5.2	4.4	3.5	2.5	1.4	0.1	14.9	13.5	12.0	10.3	8.4
over load factor (%)	22%	28%	30%	33%	35%	38%	42%	45%	49%	53%	58%	63%	67%	73%	78%	85%	92%	99%	54%	58%	63%	68%	74%
numbers (nos)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
units no.1 2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
no.2 2026																		(from Vnagvieng)	16.0	16.0	16.0	16.0	16.0

Phonetong SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	86.0	91.1	96.4	76.5	81.0	68.6	72.6	76.8	81.3	86.1	91.1	96.5	76.0	79.9	84.0	88.5	70.0	74.0	77.9	82.2	86.8	91.8	97.3
Peak MVA (pf=0.95)	90.5	95.9	101.5	80.6	85.3	72.2	76.4	80.9	85.6	90.6	95.9	101.5	80.0	84.1	88.5	93.2	73.7	77.8	82.0	86.5	91.4	96.7	102.4
total capacity (MVA)	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
balance (MVA)	29.5	24.1	18.5	39.4	34.7	47.8	43.6	39.1	34.4	29.4	24.1	18.5	40.0	35.9	31.5	26.8	46.3	42.2	38.0	33.5	28.6	23.3	17.6
over load factor (%)	75%	80%	85%	67%	71%	60%	64%	67%	71%	76%	80%	85%	67%	70%	74%	78%	61%	65%	68%	72%	76%	81%	85%
numbers (nos)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
units no.1 1997	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 1997	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.3 1977	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0 (to be retired)														
no.3 2017									(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.4 2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Tanaleng SS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)	37.7	40.0	42.3	44.7	47.3	50.1	53.0	56.1	59.4	62.9	66.6	70.5	74.1	77.8	81.9	51.8	54.6	57.6	60.7	64.0	67.6	71.6	75.8
Peak MVA (pf=0.95)	39.7	42.1	44.5	47.1	49.8	52.7	55.8	59.1	62.6	66.2	70.1	74.2	78.0	81.9	86.2	54.5	57.5	60.7	63.9	67.4	71.2	75.3	79.8
total capacity (MVA)	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
balance (MVA)	20.3	17.9	15.5	12.9	10.2	7.3	4.2	0.9	27.4	23.8	19.9	15.8	12.0	8.1	3.8	35.5	32.5	29.3	26.1	22.6	18.8	14.7	10.2
over load factor (%)	66%	70%	74%	78%	83%	88%	93%	99%	70%	74%	78%	82%	87%	91%	96%	61%	64%	67%	71%	75%	79%	84%	89%
numbers (nos)	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
units no.1 2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.2 2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
no.3 1977								(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Table 10.2-1 (b): Transformer Additional and Replacement Program in Central-1 Area

Central 1 Area

Naxaythong SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			8.2	13.7	14.2	14.7	15.3	15.9	16.5	17.2	17.9	18.7	19.4	20.3	21.1	21.9	22.8	23.7	24.7	25.8	27.0	28.2	29.5	30.9	32.4
Peak MVA (pf=0.95)			8.6	14.4	14.9	15.5	16.1	16.7	17.4	18.1	18.8	19.6	20.5	21.4	22.2	23.0	24.0	25.0	26.0	27.2	28.4	29.6	31.0	32.5	34.1
total capacity (MVA)			60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			51.4	45.6	45.1	44.5	43.9	43.3	42.6	41.9	41.2	40.4	39.5	38.6	37.8	37.0	36.0	35.0	34.0	32.8	31.6	30.4	29.0	27.5	25.9
over load factor (%)			14%	24%	25%	26%	27%	28%	29%	30%	31%	33%	34%	36%	37%	38%	40%	42%	43%	45%	47%	49%	52%	54%	57%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2003	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2003	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Khoksaad SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			15.0	15.9	16.8	17.8	18.8	19.9	21.1	22.3	23.6	25.0	26.5	28.0	29.5	31.0	32.6	34.3	36.2	38.2	40.3	42.5	44.9	47.5	50.3
Peak MVA (pf=0.95)			15.8	16.7	17.7	18.7	19.8	21.0	22.2	23.5	24.9	26.3	27.9	29.5	31.0	32.6	34.3	36.1	38.1	40.2	42.4	44.7	47.2	50.0	52.9
total capacity (MVA)			60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			44.2	43.3	42.3	41.3	40.2	39.0	37.8	36.5	35.1	33.7	32.1	30.5	29.0	27.4	25.7	23.9	21.9	19.8	17.6	15.3	12.8	10.0	7.1
over load factor (%)			26%	28%	30%	31%	33%	35%	37%	39%	41%	44%	46%	49%	52%	54%	57%	60%	63%	67%	71%	74%	79%	83%	88%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2004	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2004	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Tha Ngon SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			14.9	15.7	16.6	17.6	18.6	19.7	20.9	22.1	23.4	24.8	26.2	27.8	29.2	30.7	32.3	34.0	35.8	37.8	39.9	42.0	44.4	47.0	49.8
Peak MVA (pf=0.95)			15.6	16.6	17.5	18.5	19.6	20.8	22.0	23.3	24.6	26.1	27.6	29.2	30.7	32.3	33.9	35.8	37.7	39.8	41.9	44.2	46.7	49.5	52.4
total capacity (MVA)			22.0	22.0	22.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			6.4	5.4	4.5	11.5	10.4	9.2	8.0	6.7	5.4	3.9	2.4	0.8	29.3	27.7	26.1	24.2	22.3	20.2	18.1	15.8	13.3	10.5	7.6
over load factor (%)			71%	75%	80%	62%	65%	69%	73%	78%	82%	87%	92%	97%	51%	54%	57%	60%	63%	66%	70%	74%	78%	82%	87%
numbers (nos)			1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
units	no.1	1968	22.0	22.0	22.0	(to be retired)																			
	no.1	2011			(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2020												(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Gnangsoum (New -1)			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)						25.5	27.0	28.6	30.2	32.0	33.9	35.9	38.0	40.2	42.2	44.4	46.7	49.2	51.9	54.8	57.7	60.9	64.3	68.0	72.1
Peak MVA (pf=0.95)						26.9	28.4	30.1	31.8	33.7	35.7	37.8	40.0	42.3	44.5	46.7	49.2	51.8	54.6	57.7	60.7	64.1	67.7	71.6	75.9
total capacity (MVA)						60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0	90.0	90.0
balance (MVA)						33.1	31.6	29.9	28.2	26.3	24.3	22.2	20.0	17.7	15.5	13.3	10.8	8.2	5.4	2.3	29.3	25.9	22.3	18.4	14.1
over load factor (%)						45%	47%	50%	53%	56%	59%	63%	67%	71%	74%	78%	82%	86%	91%	96%	67%	71%	75%	80%	84%
numbers (nos)						2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
units	no.1	2011			(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2011			(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.3	2026																		(new TR)	30.0	30.0	30.0	30.0	30.0

Nonkor (New-2)			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)								17.1	18.1	19.2	20.3	21.5	22.8	24.1	25.3	26.6	28.0	29.5	31.1	32.9	34.6	36.5	38.6	40.8	43.2
Peak MVA (pf=0.95)								18.0	19.1	20.2	21.4	22.7	24.0	25.4	26.7	28.0	29.5	31.1	32.8	34.6	36.4	38.4	40.6	43.0	45.5
total capacity (MVA)								60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)								42.0	40.9	39.8	38.6	37.3	36.0	34.6	33.3	32.0	30.5	28.9	27.2	25.4	23.6	21.6	19.4	17.0	14.5
over load factor (%)								30%	32%	34%	36%	38%	40%	42%	44%	47%	49%	52%	55%	58%	61%	64%	68%	72%	76%
numbers (nos)								2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2013					(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2013					(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Nongteng (New-3)			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)															25.3	26.6	28.0	29.5	31.1	32.9	34.6	36.5	38.6	40.8	43.2
Peak MVA (pf=0.95)															26.7	28.0	29.5	31.1	32.8	34.6	36.4	38.4	40.6	43.0	45.5
total capacity (MVA)															60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)															33.3	32.0	30.5	28.9	27.2	25.4	23.6	21.6	19.4	17.0	14.5
over load factor (%)															44%	47%	49%	52%	55%	58%	61%	64%	68%	72%	76%
numbers (nos)															2	2	2	2	2	2	2	2	2	2	2
units	no.1	2020												(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2020												(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

New 4 SS for Tanaleng			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)																		34.5	36.4	38.4	40.5	42.7	45.1	47.7	50.5
Peak MVA (pf=0.95)																		36.3	38.3	40.4	42.6	44.9	47.5	50.2	53.2
total capacity (MVA)																		60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)																		23.7	21.7	19.6	17.4	15.1	12.5	9.8	6.8
over load factor (%)																		61%	64%	67%	71%	75%	79%	84%	89%
numbers (nos)																		2	2	2	2	2	2	2	2
units	no.1	2030															(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2030															(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

New 5 SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)																			23.3	24.7	26.0	27.4	28.9	30.6	32.4
Peak MVA (pf=0.95)																			24.6	25.9	27.3	28.8	30.5	32.2	34.1
total capacity (MVA)																			60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)																			35.4	34.1	32.7	31.2	29.5	27.8	25.9
over load factor (%)																			41%	43%	46%	48%	51%	54%	57%
numbers (nos)																			2	2	2	2	2	2	2
units	no.1	2030																(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2030																(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Table 10.2-1 (c): Transformer Additional and Replacement Program in Central-2 Area

Central 2 Area

Pakxan SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			9.7	10.6	11.5	12.5	13.6	14.9	16.2	17.6	19.2	20.9	22.8	24.8	26.9	29.0	31.4	34.1	37.0	40.2	43.6	47.3	51.4	56.0	61.1
Peak MVA (pf=0.85)			11.4	12.4	13.5	14.7	16.0	17.5	19.0	20.7	22.6	24.6	26.8	29.2	31.6	34.2	37.0	40.1	43.5	47.3	51.3	55.7	60.5	65.9	71.8
total capacity (MVA)			32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0
balance (MVA)			20.6	19.6	18.5	17.3	16.0	14.5	13.0	11.3	9.4	7.4	5.2	2.8	0.4	25.8	23.0	19.9	16.5	12.7	8.7	4.3	29.5	24.1	18.2
over load factor (%)			36%	39%	42%	46%	50%	55%	60%	65%	71%	77%	84%	91%	99%	57%	62%	67%	73%	79%	85%	93%	67%	73%	80%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
units	no.1	2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0 to ??? SS										
	no.1	2021													(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2003	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0 to ??? SS										
	no.2	2021													(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.3	2028																				(new TR)	30.0	30.0	30.0

Khonsoung SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)							2.2	2.4	2.6	2.8	3.0	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.9	6.4	6.9	7.5	8.2	8.9	9.7
Peak MVA (pf=0.85)							2.5	2.8	3.0	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.9	6.4	6.9	7.5	8.1	8.8	9.6	10.4	11.4
total capacity (MVA)							20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)							17.5	17.2	17.0	16.7	16.4	16.1	15.7	15.4	15.0	14.6	14.1	13.6	13.1	12.5	11.9	11.2	10.4	9.6	8.6
over load factor (%)							13%	14%	15%	16%	18%	20%	21%	23%	25%	27%	29%	32%	35%	37%	41%	44%	48%	52%	57%
numbers (nos)							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units	no.1	2003				(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Thakhek SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			23.9	25.9	28.1	30.5	33.1	36.0	39.1	42.4	46.0	50.0	54.2	29.4	31.7	34.2	36.9	39.8	43.1	46.7	50.4	54.5	59.1	64.1	69.6
Peak MVA (pf=0.85)			28.1	30.5	33.1	35.9	39.0	42.3	45.9	49.9	54.1	58.8	63.8	34.6	37.3	40.2	43.4	46.9	50.7	54.9	59.3	64.1	69.5	75.4	81.9
total capacity (MVA)			60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0	90.0
balance (MVA)			31.9	29.5	26.9	24.1	21.0	17.7	14.1	10.1	5.9	1.2	-3.8	25.4	22.7	19.8	16.6	13.1	9.3	5.1	0.7	25.9	20.5	14.6	8.1
over load factor (%)			47%	51%	55%	60%	65%	71%	77%	83%	90%	98%	106%	58%	62%	67%	72%	78%	84%	91%	99%	71%	77%	84%	91%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
units	no.1	2003	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2003	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.3	2027																			(new TR)	30.0	30.0	30.0	30.0

Mahaxai SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)				4.1	4.5	4.8	5.3	5.7	6.2	6.7	7.3	7.9	8.6	9.3	10.1	10.9	11.7	12.6	13.7	14.8	16.0	17.3	18.8	20.3	22.1
Peak MVA (pf=0.85)				4.8	5.3	5.7	6.2	6.7	7.3	7.9	8.6	9.3	10.1	11.0	11.8	12.8	13.8	14.9	16.1	17.4	18.8	20.4	22.1	23.9	26.0
total capacity (MVA)				40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
balance (MVA)				35.2	34.7	34.3	33.8	33.3	32.7	32.1	31.4	30.7	29.9	29.0	28.2	27.2	26.2	25.1	23.9	22.6	21.2	19.6	17.9	16.1	14.0
over load factor (%)				12%	13%	14%	15%	17%	18%	20%	21%	23%	25%	27%	30%	32%	34%	37%	40%	44%	47%	51%	55%	60%	65%
numbers (nos)				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2009		20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	2009		20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

New SS for Thakhek			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)														29.4	31.7	34.2	36.9	39.8	43.1	46.7	50.4	54.5	59.1	64.1	69.6
Peak MVA (pf=0.85)														34.6	37.3	40.2	43.4	46.9	50.7	54.9	59.3	64.1	69.5	75.4	81.9
total capacity (MVA)														60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0	90.0
balance (MVA)														25.4	22.7	19.8	16.6	13.1	9.3	5.1	0.7	25.9	20.5	14.6	8.1
over load factor (%)														58%	62%	67%	72%	78%	84%	91%	99%	71%	77%	84%	91%
numbers (nos)														2	2	2	2	2	2	2	2	3	3	3	3
units	no.1	2019											(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2019											(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.3	2027																			(new TR)	30.0	30.0	30.0	30.0

Pakbo SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			26.5	28.2	30.0	31.8	33.9	36.0	38.3	40.7	43.3	46.0	48.9	52.0	54.9	29.0	30.6	32.4	34.3	36.4	38.5	40.8	43.3	46.0	48.9
Peak MVA (pf=0.85)			31.2	33.2	35.2	37.5	39.8	42.3	45.0	47.9	50.9	54.1	57.5	61.2	64.6	34.1	36.0	38.1	40.4	42.8	45.3	48.0	50.9	54.1	57.6
total capacity (MVA)			40.0	40.0	40.0	40.0	40.0	60.0	60.0	60.0	60.0	60.0	60.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
balance (MVA)			8.8	6.8	4.8	2.5	0.2	17.7	15.0	12.1	9.1	5.9	2.5	28.8	25.4	55.9	54.0	51.9	49.6	47.2	44.7	42.0	39.1	35.9	32.4
over load factor (%)			78%	83%	88%	94%	100%	71%	75%	80%	85%	90%	96%	68%	72%	38%	40%	42%	45%	48%	50%	53%	57%	60%	64%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
units	no.1	2003	20.0	20.0	20.0	20.0	20.0 (to Kengkok)																		
	no.1	2013					(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2003	20.0	20.0	20.0	20.0	20.0 (to Kengkok)																		
	no.2	2013					(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.3	2019											(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

New SS for Savannakhet			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)																29.0	30.6	32.4	34.3	36.4	38.5	40.8	43.3	46.0	48.9
Peak MVA (pf=0.85)																34.1	36.0	38.1	40.4	42.8	45.3	48.0	50.9	54.1	57.6
total capacity (MVA)																60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)																25.9	24.0	21.9	19.6	17.2	14.7	12.0	9.1	5.9	2.4
over load factor (%)																57%	60%	63%	67%	71%	75%	80%	85%	90%	96%
numbers (nos)																2	2	2	2	2	2	2	2	2	2
units	no.1	2021													(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2021													(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Kengkok SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			12.8	13.6	14.5	15.4	16.4	17.4	18.5	19.7	20.9	22.2	23.6	25.1	26.5	28.0	29.6	31.3	33.2	35.2	37.2	39.4	41.8	44.5	47.3
Peak MVA (pf=0.85)			15.1	16.0	17.0	18.1	19.3	20.5	21.8	23.1	24.6	26.2	27.8	29.6	31.2	32.9	34.8	36.8	39.0	41.4	43.8	46.4	49.2	52.3	55.7
total capacity (MVA)			20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			4.9	4.0	3.0	1.9	0.7	19.5	18.2	16.9	15.4	13.8	12.2	10.4	8.8	7.1	5.2	3.2	1.0	18.6	16.2	13.6	10.8	7.7	4.3
over load factor (%)			75%	80%	85%	91%	96%	51%	54%	58%	62%	65%	70%	74%	78%	82%	87%	92%	98%	69%	73%	77%	82%	87%	93%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
units	no.1	1996	10.0	10.0	10.0	10.0	10.0																		
	no.1	2003					(from Pakbo)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	1996	10.0	10.0	10.0	10.0	10.0																		
	no.2	2003					(from Pakbo)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.3	2025																	(new TR)	20.0	20.0	20.0	20.0	20.0	20.0

Xepon SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)									9.0	9.6	10.2	10.8	11.5	12.2	12.9	13.6	14.4	15.2	16.1	17.1	18.1	19.2	20.3	21.6	23.0
Peak MVA (pf=0.85)									10.6	11.2	12.0	12.7	13.5	14.4	15.2	16.0	16.9	17.9	19.0	20.1	21.3	22.6	23.9	25.4	27.1
total capacity (MVA)									20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0	40.0
balance (MVA)									9.4	8.8	8.0	7.3	6.5	5.6	4.8	4.0	3.1	2.1	1.0	19.9	18.7	17.4	16.1	14.6	12.9
over load factor (%)									53%	56%	60%	64%	68%	72%	76%	80%	85%	90%	95%	50%	53%	56%	60%	64%	68%
numbers (nos)									1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
units	no.1	2014						(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	2025																	(new TR)	20.0	20.0	20.0	20.0	20.0	20.0

Table 10.2-1 (d): Transformer Additional and Replacement Program in Southern Area

Southern Area

Saravan SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					10.0	10.8	9.0	9.7	10.5	11.4	12.4	13.5	14.6	15.9	17.1	18.4	19.8	21.4	23.2	25.1	27.1	29.3	31.7	34.4	37.3
Peak MVA (pf=0.85)					11.7	12.7	10.5	11.4	12.4	13.5	14.6	15.8	17.2	18.7	20.1	21.6	23.3	25.2	27.3	29.5	31.8	34.4	37.3	40.4	43.9
total capacity (MVA)					40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	60.0	60.0
balance (MVA)					28.3	27.3	29.5	28.6	27.6	26.5	25.4	24.2	22.8	21.3	19.9	18.4	16.7	14.8	12.7	10.5	8.2	5.6	2.7	19.6	16.1
over load factor (%)					29%	32%	26%	29%	31%	34%	37%	40%	43%	47%	50%	54%	58%	63%	68%	74%	80%	86%	93%	67%	73%
numbers (nos)					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
units	no.1	2010		(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	2010		(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.3	2029																					(new TR)	20.0	20.0

Taothan SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)									3.2	3.5	3.8	4.1	4.5	4.9	5.3	5.7	6.1	6.6	7.1	7.7	8.3	9.0	9.8	10.6	11.5
Peak MVA (pf=0.85)									3.8	4.1	4.5	4.9	5.3	5.7	6.2	6.7	7.2	7.8	8.4	9.1	9.8	10.6	11.5	12.4	13.5
total capacity (MVA)									20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)									16.2	15.9	15.5	15.1	14.7	14.3	13.8	13.3	12.8	12.2	11.6	10.9	10.2	9.4	8.5	7.6	6.5
over load factor (%)									19%	21%	22%	24%	26%	29%	31%	33%	36%	39%	42%	45%	49%	53%	57%	62%	68%
numbers (nos)									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units	no.1	2012						(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Xekong SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)								3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.7	6.2	6.7	7.3	7.9	8.7	9.4	10.3	11.2	12.2	13.4
Peak MVA (pf=0.85)								3.6	4.0	4.3	4.7	5.2	5.6	6.2	6.7	7.3	7.9	8.6	9.4	10.2	11.1	12.1	13.2	14.4	15.8
total capacity (MVA)								20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)								16.4	16.0	15.7	15.3	14.8	14.4	13.8	13.3	12.7	12.1	11.4	10.6	9.8	8.9	7.9	6.8	5.6	4.2
over load factor (%)								18%	20%	22%	24%	26%	28%	31%	33%	36%	39%	43%	47%	51%	55%	60%	66%	72%	79%
numbers (nos)								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units	no.1	2013					(new TR)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Saphaothong (Attapeu)			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			2.0	2.7	2.9	3.1	3.3	3.6	3.9	4.2	4.5	4.9	5.3	5.7	6.1	6.5	7.0	7.5	8.1	8.7	9.3	10.0	10.8	11.6	12.6
Peak MVA (pf=0.85)			2.4	3.1	3.4	3.6	3.9	4.2	4.6	4.9	5.3	5.7	6.2	6.7	7.2	7.7	8.2	8.8	9.5	10.2	11.0	11.8	12.7	13.7	14.8
total capacity (MVA)			20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)			17.6	16.9	16.6	16.4	16.1	15.8	15.4	15.1	14.7	14.3	13.8	13.3	12.8	12.3	11.8	11.2	10.5	9.8	9.0	8.2	7.3	6.3	5.2
over load factor (%)			12%	16%	17%	18%	20%	21%	23%	25%	27%	29%	31%	33%	36%	38%	41%	44%	47%	51%	55%	59%	63%	68%	74%
numbers (nos)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
units	no.1	2006	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Bang Yo SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			24.0	25.1	14.1	15.0	16.0	17.0	18.1	19.3	20.5	21.8	23.2	24.7	26.0	27.5	29.1	30.8	32.6	34.6	36.6	38.9	41.2	43.86	46.7
Peak MVA (pf=0.85)			28.2	29.6	16.6	17.7	18.8	20.0	21.3	22.7	24.1	25.6	27.3	29.0	30.6	32.4	34.2	36.2	38.4	40.7	43.1	45.7	48.5	51.6	54.9
total capacity (MVA)			50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			21.8	20.4	33.4	32.3	31.2	30.0	28.7	27.3	25.9	24.4	22.7	21.0	19.4	17.6	25.8	23.8	21.6	19.3	16.9	14.3	11.5	8.4	5.1
over load factor (%)			56%	59%	33%	35%	38%	40%	43%	45%	48%	51%	55%	58%	61%	65%	57%	60%	64%	68%	72%	76%	81%	86%	92%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	1991	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	(to be retired)								
	no.1	2022														(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	1991	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	(to be retired)								
	no.2	2022														(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Jianxai SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)					12.6	13.4	14.2	15.1	16.1	17.1	18.2	19.4	20.6	21.9	23.1	24.4	25.8	27.4	29.0	30.8	32.6	34.5	36.7	39.0	41.5
Peak MVA (pf=0.85)					14.8	15.7	16.7	17.8	18.9	20.1	21.4	22.8	24.2	25.8	27.2	28.8	30.4	32.2	34.1	36.2	38.3	40.6	43.1	45.9	48.8
total capacity (MVA)					30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)					15.2	14.3	13.3	12.2	11.1	9.9	8.6	7.2	5.8	4.2	2.8	1.2	29.6	27.8	25.9	23.8	21.7	19.4	16.9	14.1	11.2
over load factor (%)					49%	52%	56%	59%	63%	67%	71%	76%	81%	86%	91%	96%	51%	54%	57%	60%	64%	68%	72%	76%	81%
numbers (nos)					1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
units	no.1	2010		(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2022														(new TR)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Pakson SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)				4.4	4.7	5.0	5.3	5.7	6.0	6.4	6.8	7.3	7.7	8.2	8.7	9.2	9.7	10.3	10.9	11.5	12.2	13.0	13.7	14.6	15.6
Peak MVA (pf=0.85)				5.2	5.5	5.9	6.3	6.7	7.1	7.6	8.0	8.5	9.1	9.7	10.2	10.8	11.4	12.1	12.8	13.6	14.4	15.2	16.2	17.2	18.3
total capacity (MVA)				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
balance (MVA)				4.8	4.5	4.1	3.7	3.3	2.9	2.4	2.0	1.5	0.9	0.3	9.8	9.2	8.6	7.9	7.2	6.4	5.6	4.8	3.8	2.8	1.7
over load factor (%)				52%	55%	59%	63%	67%	71%	76%	80%	85%	91%	97%	51%	54%	57%	60%	64%	68%	72%	76%	81%	86%	92%
numbers (nos)				1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2009	ew TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	no.2	2020												(new TR)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Ban Na SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			4.1	5.1	5.4	5.8	6.1	6.5	6.9	7.4	7.9	8.4	8.9	9.5	10.0	10.5	11.2	11.8	12.5	13.3	14.1	14.9	15.8	16.8	17.9
Peak MVA (pf=0.85)			4.9	6.0	6.4	6.8	7.2	7.7	8.2	8.7	9.2	9.8	10.5	11.1	11.7	12.4	13.1	13.9	14.7	15.6	16.5	17.5	18.6	19.8	21.1
total capacity (MVA)			60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
balance (MVA)			55.1	54.0	53.6	53.2	52.8	52.3	51.8	51.3	50.8	50.2	49.5	48.9	48.3	47.6	46.9	46.1	45.3	44.4	43.5	42.5	41.4	40.2	38.9
over load factor (%)			8%	10%	11%	11%	12%	13%	14%	14%	15%	16%	17%	19%	20%	21%	22%	23%	25%	26%	28%	29%	31%	33%	35%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	no.2	2005	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Ban Hat SS			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast Peak (MW)			2.3	2.8	3.0	3.2	3.4	3.6	3.9	4.1	4.4	4.6	4.9	5.3	5.5	5.9	6.2	6.6	7.0	7.4	7.8	8.3	8.8	9.3	9.9
Peak MVA (pf=0.85)			2.7	3.3	3.5	3.8	4.0	4.3	4.5	4.8	5.1	5.5	5.8	6.2	6.5	6.9	7.3	7.7	8.2	8.7	9.2	9.7	10.3	11.0	11.7
total capacity (MVA)			40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
balance (MVA)			37.3	36.7	36.5	36.2	36.0	35.7	35.5	35.2	34.9	34.5	34.2	33.8	33.5	33.1	32.7	32.3	31.8	31.3	30.8	30.3	29.7	29.0	28.3
over load factor (%)			7%	8%	9%	9%	10%	11%	11%	12%	13%	14%	15%	15%	16%	17%	18%	19%	20%	22%	23%	24%	26%	27%	29%
numbers (nos)			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
units	no.1	2005	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	no.2	2005	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Table 10.3-2(1) Assumpted Estimation for TL Construction Cost Vol.1
"Voltage; 115kV, Conductor; Hawk, Single, Soil Condition; Normal, Passing Area; Plain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 90% of Suspenssion Towers (27units), 10% of Tenssion Towers (3units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	115kV, 1cct, (10km) Condutcor : Hawk, Single						115kV, 2cct, (10km) Condutcor : Hawk, Single						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	123	2,100	258,300	258,300	0	ton	150	2,100	315,000	315,000	0	
	2	Conductor	km	30	4,900	147,000	147,000	0	km	60	4,900	294,000	294,000	0	
	3	OPGW 60mm2	km	0	6,100	0	0	0	km	0	6,100	0	0	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	81	400	32,400	32,400	0	set	162	400	64,800	64,800	0	
	6	Tension Insulator String	set	18	600	10,800	10,800	0	set	36	600	21,600	21,600	0	
	7	Accessories	lot	1	6%	27,840	27,840	0	lot	1	6%	42,654	42,654	0	
		Subtotal				491,840	491,840	0				753,554	753,554	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,000	20,000	6,000	14,000	km	20	1,000	20,000	6,000	14,000	
	3	Land Clearing	km	10	1,000	10,000	2,000	8,000	km	10	1,000	10,000	2,000	8,000	
	4	Foundation (Volume of Concrete)	m^3	140	750	105,000	21,000	84,000	m^3	227	750	170,250	34,050	136,200	
	5	Tower Erection	ton	123	240	29,520	8,856	20,664	ton	150	240	36,000	10,800	25,200	
	6	Stringing	km	10	3,000	30,000	9,000	21,000	km	20	3,000	60,000	18,000	42,000	
	7	Inland Transportion			CIF*12%	59,021	0	59,021			CIF*12%	90,426	0	90,426	
	8	Miscellaneous	lot	1	5%	13,677	2,743	10,934	lot	1	5%	20,334	3,943	16,391	
	9	General Expenses	lot	1	10%	28,722	5,760	22,962	lot	1	10%	42,701	8,279	34,422	
		Subtotal				315,940	63,359	252,581				469,711	91,072	378,640	
		Total				807,780	555,199	252,581				1,223,265	844,626	378,640	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(2) Assumpted Estimation for TL Construction Cost Vol.2
"Voltage; 115kV, Conductor; Hawk, Single, Soil Condition; Normal, Passing Area; Plain&Mountain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers: 10%; Plain Area, 30%; Mountain Area
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	115kV, 1cct Addition, (10km) Condutcor : Hawk, Single, Plain Area						115kV, 1cct Addition, (10km) Condutcor : Hawk, Single, Mountain Area						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	0	2,100	0	0	0	ton	0	2,100	0	0	0	
	2	Conductor	km	30	4,900	147,000	147,000	0	km	30	4,900	147,000	147,000	0	
	3	OPGW 60mm2	km	0	6,100	0	0	0	km	0	6,100	0	0	0	
	4	OH G.W.	km	0	1,550	0	0	0	km	0	1,550	0	0	0	
	5	Suspension Insulator String	set	81	400	32,400	32,400	0	set	63	400	25,200	25,200	0	
	6	Tension Insulator String	set	18	600	10,800	10,800	0	set	54	600	32,400	32,400	0	
	7	Accessories	lot	1	6%	11,412	11,412	0	lot	1	6%	12,276	12,276	0	
		Subtotal				201,612	201,612	0				216,876	216,876	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	0	2,000	0	0	0	km	0	2,000	0	0	0	
	2	Access Construction	km	0	1,000	0	0	0	km	0	1,000	0	0	0	
	3	Land Clearing	km	0	1,000	0	0	0	km	0	1,000	0	0	0	
	4	Foundation (Volume of Concrete)	m^3	0	750	0	0	0	m^3	0	750	0	0	0	
	5	Tower Erection	ton	0	240	0	0	0	ton	0	240	0	0	0	
	6	Stringing	km	10	3,000	30,000	9,000	21,000	km	10	4,500	45,000	13,500	31,500	
	7	Inland Transportion			CIF*12%	24,193	0	24,193			CIF*12%	26,025	0	26,025	
	8	Miscellaneous	lot	1	5%	2,710	450	2,260	lot	1	5%	3,551	675	2,876	
	9	General Expenses	lot	1	10%	5,690	945	4,745	lot	1	10%	7,458	1,418	6,040	
		Subtotal				62,593	10,395	52,198				82,034	15,593	66,442	
		Total				264,205	212,007	52,198				298,910	232,469	66,442	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(3) Assumpted Estimation for TL Construction Cost Vol.3
"Voltage; 115kV, Conductor; Hawk, Single, Soil Condition; Normal, Passing Area; Plain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 90% of Suspenssion Towers (27units), 10% of Tenssion Towers (3units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	V, 1cct,	115kV, 2cct, (10km) Condutcor : T-Hawk, Single						Remarks
			Unit	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	ton	172	2,100	361,200	361,200	0	
	2	Conductor	km	km	60	5,800	348,000	348,000	0	
	3	OPGW 60mm2	km	km	0	6,100	0	0	0	
	4	OH G.W.	km	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	set	162	400	64,800	64,800	0	
	6	Tension Insulator String	set	set	36	600	21,600	21,600	0	
	7	Accessories	lot	lot	1	6%	48,666	48,666	0	
		Subtotal					859,766	859,766	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	km	20	1,000	20,000	6,000	14,000	
	3	Land Clearing	km	km	10	1,000	10,000	2,000	8,000	
	4	Foundation (Volume of Concrete)	m^3	m^3	227	750	170,250	34,050	136,200	
	5	Tower Erection	ton	ton	172	240	41,280	12,384	28,896	
	6	Stringing	km	km	20	3,000	60,000	18,000	42,000	
	7	Inland Transportion				CIF*12%	103,172	0	103,172	
	10	Miscellaneous	lot	lot	1	5%	21,235	4,022	17,213	
	11	General Expenses	lot	lot	1	10%	44,594	8,446	36,148	
		Subtotal					490,531	92,901	397,629	
		Total					1,350,297	952,667	397,629	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(4) Assumpted Estimation for TL Construction Cost Vol.4
"Voltage; 115kV, Conductor; Drake, Single, Soil Condition; Normal, Passing Area; Plain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 90% of Suspenssion Towers (27units), 10% of Tenssion Towers (3units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	115kV, 1cct, (10km) Condutcor : Drake, Single						115kV, 2cct, (10km) Condutcor : Drake, Single						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	153	2,100	321,300	321,300	0	ton	201	2,100	422,100	422,100	0	
	2	Conductor	km	30	6,200	186,000	186,000	0	km	60	6,200	372,000	372,000	0	
	3	OPGW 60mm2	km	0	6,100	0	0	0	km	0	6,100	0	0	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	81	400	32,400	32,400	0	set	162	400	64,800	64,800	0	
	6	Tension Insulator String	set	18	600	10,800	10,800	0	set	36	600	21,600	21,600	0	
	7	Accessories	lot	1	6%	33,960	33,960	0	lot	1	6%	53,760	53,760	0	
		Subtotal				599,960	599,960	0				949,760	949,760	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,000	20,000	6,000	14,000	km	20	1,000	20,000	6,000	14,000	
	3	Land Clearing	km	10	1,000	10,000	2,000	8,000	km	10	1,000	10,000	2,000	8,000	
	4	Foundation (Volume of Concrete)	m^3	210	750	157,500	31,500	126,000	m^3	227	750	170,250	34,050	136,200	
	5	Tower Erection	ton	153	240	36,720	11,016	25,704	ton	201	240	48,240	14,472	33,768	
	6	Stringing	km	10	3,000	30,000	9,000	21,000	km	20	3,000	60,000	18,000	42,000	
	7	Inland Transportion			CIF*12%	71,995	0	71,995			CIF*12%	113,971	0	113,971	
	8	Miscellaneous	lot	1	5%	17,311	3,376	13,935	lot	1	5%	22,123	4,126	17,997	
	9	General Expenses	lot	1	10%	36,353	7,089	29,263	lot	1	10%	46,458	8,665	37,794	
		Subtotal				399,879	77,981	321,898				511,043	95,313	415,730	
		Total				999,839	677,941	321,898				1,460,803	1,045,073	415,730	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(5) Assumpted Estimation for TL Construction Cost Vol.5
"Voltage; 115kV, Conductor; Drake, Single, Soil Condition; Normal, Passing Area; Plain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 90% of Suspenssion Towers (27units), 10% of Tenssion Towers (3units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	230kV, 2cct, (10km) Condutcor : Bittern, Single						230kV, 2cct, (10km) Condutcor : Bittern, Double						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	251	2,100	527,100	527,100	0	ton	361	2,100	758,100	758,100	0	
	2	Conductor	km	60	8,400	504,000	504,000	0	km	120	8,400	1,008,000	1,008,000	0	
	3	OPGW 60mm2	km	10	6,100	61,000	61,000	0	km	10	6,100	61,000	61,000	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	162	600	97,200	97,200	0	set	162	800	129,600	129,600	0	
	6	Tension Insulator String	set	36	800	28,800	28,800	0	set	36	1,000	36,000	36,000	0	
	7	Accessories	lot	1	6%	70,356	70,356	0	lot	1	6%	116,832	116,832	0	
		Subtotal				1,303,956	1,303,956	0				2,125,032	2,125,032	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,000	20,000	6,000	14,000	km	20	1,000	20,000	6,000	14,000	
	3	Land Clearing	km	10	1,000	10,000	2,000	8,000	km	10	1,000	10,000	2,000	8,000	
	4	Foundation (Volume of Concrete)	m^3	372	750	279,000	55,800	223,200	m^3	429	750	321,750	64,350	257,400	
	5	Tower Erection	ton	251	240	60,240	18,072	42,168	ton	361	240	86,640	25,992	60,648	
	6	Stringing	km	20	3,000	60,000	18,000	42,000	km	30	3,000	90,000	27,000	63,000	
	7	Inland Transportion			CIF*12%	156,475	0	156,475			CIF*12%	255,004	0	255,004	
	8	Miscellaneous	lot	1	5%	30,286	5,394	24,892	lot	1	5%	40,170	6,667	33,503	
	9	General Expenses	lot	1	10%	63,600	11,327	52,273	lot	1	10%	84,356	14,001	70,355	
		Subtotal				699,601	124,592	575,008				927,920	154,010	773,910	
		Total				2,003,557	1,428,548	575,008				3,052,952	2,279,042	773,910	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(6) Assumpted Estimation for TL Construction Cost Vol.6
"Voltage; 115kV, Conductor; Hawk, Single, Soil Condition; Normal, Passing Area; Mountain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 70% of Suspenssion Towers (21units), 30% of Tenssion Towers (9units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	115kV, 1cct, (10km) Condutcor : Hawk, Single						115kV, 2cct, (10km) Condutcor : Hawk, Single						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	128	2,100	268,800	268,800	0	ton	156	2,100	327,600	327,600	0	
	2	Conductor	km	30	4,900	147,000	147,000	0	km	60	4,900	294,000	294,000	0	
	3	OPGW 60mm2	km	0	6,100	0	0	0	km	0	6,100	0	0	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	63	400	25,200	25,200	0	set	126	400	50,400	50,400	0	
	6	Tension Insulator String	set	54	600	32,400	32,400	0	set	108	600	64,800	64,800	0	
	7	Accessories	lot	1	6%	29,334	29,334	0	lot	1	6%	45,138	45,138	0	
		Subtotal				518,234	518,234	0				797,438	797,438	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,500	30,000	9,000	21,000	km	20	1,500	30,000	9,000	21,000	
	3	Land Clearing	km	10	1,300	13,000	2,600	10,400	km	10	1,300	13,000	2,600	10,400	
	4	Foundation (Volume of Concrete)	m^3	147	1,100	161,700	32,340	129,360	m^3	262	1,100	288,200	57,640	230,560	
	5	Tower Erection	ton	128	360	46,080	13,824	32,256	ton	156	360	56,160	16,848	39,312	
	6	Stringing	km	10	4,500	45,000	13,500	31,500	km	20	4,500	90,000	27,000	63,000	
	7	Inland Transportion			CIF*12%	62,188	0	62,188			CIF*12%	95,693	0	95,693	
	8	Miscellaneous	lot	1	5%	18,898	3,963	14,935	lot	1	5%	29,653	6,054	23,598	
	9	General Expenses	lot	1	10%	39,687	8,323	31,364	lot	1	10%	62,271	12,714	49,556	
		Subtotal				436,553	91,550	345,003				684,976	139,857	545,119	
		Total				954,787	609,784	345,003				1,482,414	937,295	545,119	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(7) Assumpted Estimation for TL Construction Cost Vol.7
"Voltage; 115kV, Conductor; Drake, Single, Soil Condition; Normal, Passing Area; Mountain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 70% of Suspenssion Towers (21units), 30% of Tenssion Towers (9units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	115kV, 1cct, (10km) Condutcor : Drake, Single						115kV, 2cct, (10km) Condutcor : Drake, Single						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	159	2,100	333,900	333,900	0	ton	205	2,100	430,500	430,500	0	
	2	Conductor	km	30	6,200	186,000	186,000	0	km	60	6,200	372,000	372,000	0	
	3	OPGW 60mm2	km	0	6,100	0	0	0	km	0	6,100	0	0	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	63	400	25,200	25,200	0	set	126	400	50,400	50,400	0	
	6	Tension Insulator String	set	54	600	32,400	32,400	0	set	108	600	64,800	64,800	0	
	7	Accessories	lot	1	6%	35,580	35,580	0	lot	1	6%	55,992	55,992	0	
		Subtotal				628,580	628,580	0				989,192	989,192	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,500	30,000	9,000	21,000	km	20	1,500	30,000	9,000	21,000	
	3	Land Clearing	km	10	1,300	13,000	2,600	10,400	km	10	1,300	13,000	2,600	10,400	
	4	Foundation (Volume of Concrete)	m^3	210	1,100	231,000	46,200	184,800	m^3	262	1,100	288,200	57,640	230,560	
	5	Tower Erection	ton	159	360	57,240	17,172	40,068	ton	205	360	73,800	22,140	51,660	
	6	Stringing	km	10	4,500	45,000	13,500	31,500	km	20	4,500	90,000	27,000	63,000	
	7	Inland Transportion			CIF*12%	75,430	0	75,430			CIF*12%	118,703	0	118,703	
	8	Miscellaneous	lot	1	5%	23,583	4,824	18,760	lot	1	5%	31,685	6,319	25,366	
	9	General Expenses	lot	1	10%	49,525	10,130	39,396	lot	1	10%	66,539	13,270	53,269	
		Subtotal				544,778	111,425	433,353				731,927	145,969	585,958	
		Total				1,173,358	740,005	433,353				1,721,119	1,135,161	585,958	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-2(8) Assumpted Estimation for TL Construction Cost Vol.8
"Voltage; 115kV, Conductor; Drake, Single, Soil Condition; Normal, Passing Area; Plain "
for
Laos (Lao People's Democratic Republic)

Assumption:
(1) Length: 10km
(2) Ratio of Tenssion Towers for All Towers: 70% of Suspenssion Towers (21units), 30% of Tenssion Towers (9units)
(3) Average Span: 350m
(4) Foundation Type: 100% of Pad Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	230kV, 2cct, (10km) Condutcor : Bittern, Single						230kV, 2cct, (10km) Condutcor : Bittern, Double						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	259	2,100	543,900	543,900	0	ton	369	2,100	774,900	774,900	0	
	2	Conductor	km	60	8,400	504,000	504,000	0	km	120	8,400	1,008,000	1,008,000	0	
	3	OPGW 60mm2	km	10	6,100	61,000	61,000	0	km	10	6,100	61,000	61,000	0	
	4	OH G.W.	km	10	1,550	15,500	15,500	0	km	10	1,550	15,500	15,500	0	
	5	Suspension Insulator String	set	126	600	75,600	75,600	0	set	126	800	100,800	100,800	0	
	6	Tension Insulator String	set	108	800	86,400	86,400	0	set	108	1,000	108,000	108,000	0	
	7	Accessories	lot	1	6%	73,524	73,524	0	lot	1	6%	120,432	120,432	0	
		Subtotal				1,359,924	1,359,924	0				2,188,632	2,188,632	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	10	2,000	20,000	8,000	12,000	km	10	2,000	20,000	8,000	12,000	
	2	Access Construction	km	20	1,500	30,000	9,000	21,000	km	20	1,500	30,000	9,000	21,000	
	3	Land Clearing	km	10	1,300	13,000	2,600	10,400	km	10	1,300	13,000	2,600	10,400	
	4	Foundation (Volume of Concrete)	m^3	372	1,100	409,200	81,840	327,360	m^3	543	1,100	597,300	119,460	477,840	
	5	Tower Erection	ton	259	360	93,240	27,972	65,268	ton	369	360	132,840	39,852	92,988	
	6	Stringing	km	20	4,500	90,000	27,000	63,000	km	30	4,500	135,000	40,500	94,500	
	7	Inland Transportion			CIF*12%	163,191	0	163,191			CIF*12%	262,636	0	262,636	
	8	Miscellaneous	lot	1	5%	40,932	7,821	33,111	lot	1	5%	59,539	10,971	48,568	
	9	General Expenses	lot	1	10%	85,956	16,423	69,533	lot	1	10%	125,031	23,038	101,993	
		Subtotal				945,519	180,656	764,863				1,375,346	253,421	1,121,925	
		Total				2,305,443	1,540,580	764,863				3,563,978	2,442,053	1,121,925	

Estimated Condition ; Aluminum base LME 1550US$/ton, Exchange Rate ; 100Yen/US$, 3.0Yen/THB

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Northern																																
Boun Neua	Namo	115	2012	2	ACSR240	96.0	Mountain	N/A	14,231	FC	8,998.0	990	6,748	1,260																		
			2012							LC	5,233.2	628	3,035	1,570																		
Boun Neua	Cu Mining	115	2012	1	ACSR240	65.0	Mountain	N/A	6,206	FC	3,963.6	436	2,973	555																		
			2012							LC	2,242.5	269	1,301	673																		
Boun Neua	Cu Mining	115	2014	1	ACSR240	65.0	Mountain	N/A	6,206	FC	3,963.6			436	2,973	555																
			2014							LC	2,242.5			269	1,301	673																
Luang Namtha	Cu Mining	115	2010	1	ACSR240	60.0	Mountain	N/A	5,729	FC	3,658.7	3,659																				
			2010							LC	2,070.0	2,070																				
Namo	Cu Mining	115	2012	1	ACSR240	15.0	Mountain	N/A	1,432	FC	914.7	101	686	128																		
			2012							LC	517.5	62	300	155																		
Nam Ou 6	Boun Neua	115	2017	2	ACSR240	40.0	Mountain	N/A	5,930	FC	3,749.2						412	2,812	525													
			2017							LC	2,180.5						262	1,265	654													
Luang Namtha	Nam Thoung	115	2012	2	ACSR240	91.0	Mountain	N/A	13,490	FC	8,529.3	938	6,397	1,194																		
			2012							LC	4,960.6	595	2,877	1,488																		
Luang Namtha	Namo	115	2015	1*	ACSR240	42.7	Mountain	N/A	1,276	FC	992.6						993															
			2015							LC	283.7						284															
Nam Thoung	Houayxai	115	2012	1	ACSR240	40.0	Mountain	N/A	3,819	FC	2,439.1	268	1,829	341																		
			2012							LC	1,380.0	166	800	414																		
Nam Thoung	Nam Tha 1	115	2012	2	ACSR240	42.0	Mountain	N/A	6,226	FC	3,936.6	433	2,952	551																		
			2012							LC	2,289.5	275	1,328	687																		
Nam Tha 1	Hongsa	115	2015	2	ACSR410	93.0	Mountain	N/A	16,006	FC	10,557.0				1,161	7,918	1,478															
			2015							LC	5,449.4				654	3,161	1,635															
Nam Beng	Switching Station	115	2020	1	ACSR240	15.0	Mountain	N/A	1,432	FC	914.7									101	686	128										
			2020							LC	517.5									62	300	155										
Oudomxai	Namo	115	2013	1*	ACSR240	41.0	Mountain	N/A	1,226	FC	953.1				953																	
			2013							LC	272.4				272																	
Luangprabang 2	Oudomxai	115	2013	1*	ACSR240	51.8	Mountain	N/A	1,548	FC	1,204.2				1,204																	
			2013							LC	344.2				344																	
Oudomxai	THLC Mining	115	2012	1	ACSR240	20.0	Mountain	N/A	1,910	FC	1,219.6	134	915	171																		
			2012							LC	690.0	83	400	207																		
Luangprabang 2	Cement Factory	115	2010	1	ACSR240	25.0	Mountain	Light	2,387	FC	1,524.5	1,524																				
			2010							LC	862.5	863																				
			2010						300	FC	99.0	99																				
			2010							LC	201.0	201																				
Luangprabang 2	United	115	2010	1	ACSR240	15.0	Mountain	Light	1,432	FC	914.7	915																				
			2010							LC	517.5	518																				
			2010						180	FC	59.4	59																				
			2010							LC	120.6	121																				
Nam Nga	Luangprabang 2	115	2020	1	ACSR240	15.0	Mountain	N/A	1,432	FC	914.7									101	686	128										
			2020							LC	517.5									62	300	155										
Luangprabang 1	Luangprabang 2	115	2013	1*	ACSR240	86.9	Mountain	Light	2,598	FC	2,020.2		222	1,515	283																	
			2013							LC	577.4		69	335	173																	
			2013						1,043	FC	344.1		310		34																	
			2013							LC	698.7		629		70																	
Luangprabang 1	Luangprabang 3	115	2013	2	ACSR240	15.0	Mountain	N/A	2,224	FC	1,405.9		155	1,054	197																	
			2013							LC	817.7		98	474	245																	
Hongsa	Luangprabang 3	115	2015	2	ACSR410	100.0	Mountain	N/A	17,211	FC	11,351.6				1,249	8,514	1,589															
			2015							LC	5,859.6				703	3,399	1,758															
Mekong Luangprabang	Luangprabang 3	115	2016	2	ACSR410	40.0	Mountain	Light	6,884	FC	4,540.6					499	3,405	636														
			2016							LC	2,343.8					281	1,359	703														
			2016						480	FC	158.4					143		16														
			2016							LC	321.6					289		32														
Nam Ma 1	Nam Ma 2	115	2016	1	ACSR240	20.0	Mountain	Light	1,910	FC	1,219.6					134	915	171														
			2016							LC	690.0					83	400	207														
			2016						240	FC	79.2					71		8														
			2016							LC	160.8					145		16														
Nam Ma 2	Nam Ma 3	115	2016	1	ACSR240	20.0	Mountain	Light	1,910	FC	1,219.6					134	915	171														
			2016							LC	690.0					83	400	207														
			2016						240	FC	79.2					71		8														
			2016							LC	160.8					145		16														
Nam Ma 1	Xam Neua	115	2016	2	ACSR240	40.0	Mountain	Heavy	5,930	FC	3,749.2					412	2,812	525														
			2016							LC	2,180.5					262	1,265	654														
			2016						680	FC	224.4					202		22														
			2016							LC	455.6					410		46														
Xam Neua	Muong Kham	115	2011	2	ACSR240	146.0	Mountain	Heavy	21,643	FC	13,684.4	11,769	1,916																			
			2011							LC	7,958.8	5,571	2,388																			

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			2011						2,482	FC	819.1	737	82																			
			2011							LC	1,662.9	1,497	166																			
Nam Khan 2	Nam Khan 3	115	2018	1	ACSR240	45.0	Mountain	Light	4,297	FC	2,744.0							302	2,058	384												
			2018							LC	1,552.5							186	900	466												
			2018						540	FC	178.2							160		18												
			2018							LC	361.8							326		36												
Luangprabang 3	Nam Khan 2	230	2018	2	ACSR610	36.0	Mountain	N/A	8,300	FC	5,546.1							610	4,160	776												
			2018							LC	2,753.5							330	1,597	826												
Nam Mo 1	Muong Kham	115	2020	1	ACSR240	45.0	Mountain	Heavy	4,297	FC	2,744.0									302	2,058	384										
			2020							LC	1,552.5									186	900	466										
			2020						765	FC	252.5									227		25										
			2020							LC	512.6									461		51										
Muong Kham	Fe Mining	115	2011	1	ACSR240	40.0	Mountain	Heavy	3,819	FC	2,439.1	2,098	341																			
			2011							LC	1,380.0	966	414																			
			2011						680	FC	224.4	202	22																			
			2011							LC	455.6	410	46																			
Phonsavan	Muong Kham	115	2011	2	ACSR410	56.2	Mountain	Heavy	9,673	FC	6,379.6	5,486	893																			
			2011							LC	3,293.1	2,305	988																			
			2011						955	FC	315.3	284	32																			
			2011							LC	640.1	576	64																			
Phonsavan	Fe Mining	115	2012	1	ACSR240	20.0	Mountain	Heavy	1,910	FC	1,219.6	134	915	171																		
			2012							LC	690.0	83	400	207																		
			2012						340	FC	112.2	101		11																		
			2012							LC	227.8	205		23																		
Xayabury	Paklay	115	2014	2	ACSR240	134.0	Plain	N/A	16,392	FC	11,318.0			1,245	8,489	1,585																
			2014							LC	5,073.8			609	2,943	1,522																
Paklay	Cu Mining	115	2014	1	ACSR240	25.0	Mountain	N/A	2,387	FC	1,524.5			168	1,143	213																
			2014							LC	862.5			104	500	259																
Paklay	Thali	115	2014	1	ACSR240	86.2	Plain	N/A	6,963	FC	4,785.8			526	3,589	670																
			2014							LC	2,177.2			261	1,263	653																
New Switching Station (	Nam San 3	115	2016	1	ACSR240	28.0	Mountain	Light	2,673	FC	1,707.4					188	1,281	239														
			2016							LC	966.0					116	560	290														
			2016						336	FC	110.9					100		11														
			2016							LC	225.1					203		23														
Namo	Cement Factory	115	2012	1	ACSR240	5.0	Mountain	N/A	477	FC	304.9			34	229	43																
			2012							LC	172.5			21	100	52																
	TL Construction				**Northern Total**				**213,416**	FC	**139,254.00**	28,885	26,942	9,349	21,470	20,865	13,800	5,466	6,743	1,664	3,430	640	0	0	0	0	0	0	0	0	0	0
										LC	**74,162.00**	14,454	14,398	7,474	8,498	10,544	7,923	3,842	3,151	1,602	1,500	776	0	0	0	0	0	0	0	0	0	0
	UXO Removal				**Northern Total**				**9,262**	FC	**3,055.00**	1,482	446	11	34	587	0	225	0	245	0	25	0	0	0	0	0	0	0	0	0	0
										LC	**6,207.00**	3,010	905	23	70	1,192	0	459	0	497	0	51	0	0	0	0	0	0	0	0	0	0
Central-1																																
Luangprabang 3	Hin Heup	230	2012	2	ACSR610*2	210.0	Mountain	L100	74,844	FC	51,283.1	5,641	38,462	7,180																		
			2012							LC	23,560.5	2,827	13,665	7,068																		
			2012						1,920	FC	633.6	570		63																		
			2012							LC	1,286.4	1,158		129																		
Vangvieng	Iron/Coal Mine	115	2010	1	ACSR240	20.0	Mountain	N/A	1,910	FC	1,219.6	1,220																				
			2010							LC	690.0	690																				
Nam Ngiep 2	Khoksaad	230	2017	2	ACSR610	130.0	Mountain	N/A	29,971	FC	20,027.5						2,203	15,021	2,804													
			2017							LC	9,943.2						1,193	5,767	2,983													
Vangvieng	Hin Heup	115	2011	1	ACSR240	40.8	Mountain	N/A	3,896	FC	2,487.9	2,140	348																			
			2011							LC	1,407.6	985	422																			
Nam Ngum 4	Nam Ngum 5	115	2019	1	ACSR240	25.0	Mountain	N/A	2,387	FC	1,524.5								168	1,143	213											
			2019							LC	862.5								104	500	259											
New Switching Station (	VV Mining	115	2011	1	ACSR240	15.0	Mountain	N/A	1,432	FC	914.7	787	128																			
			2011							LC	517.5	362	155																			
Thalat	Nam Ngum 1	115	2013	1	ACSR240	4.8	Plain	N/A	388	FC	266.5		29	200	37																	
			2013							LC	121.2		15	70	36																	
Thongkun	IPF	115	2012	1	ACSR240	20.0	Mountain	N/A	1,910	FC	1,219.6	134	915	171																		
			2012							LC	690.0	83	400	207																		
π-Junction	Nam Bak 2	115	2016	2	ACSR240	5.0	Mountain	N/A	741	FC	468.6					52	351	66														
			2016							LC	272.6					33	158	82														
Nam Lik 1	Hin Heup	115	2011	1	ACSR240	10.0	Plain	N/A	808	FC	555.2	477	78																			
			2011							LC	252.6	177	76																			
Hin Heup	Naxaythong	230	2012	2	ACSR610*2	83.2	Plain	N/A	25,401	FC	18,961.6	2,086	14,221	2,655																		
			2012							LC	6,438.9	773	3,735	1,932																		

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Naxaythong	Khoksaad	230	2012	2	ACSR610*2	83.2	Plain	N/A	25,401	FC	18,961.6	2,086	14,221	2,655																		
			2012							LC	6,438.9	773	3,735	1,932																		
Naxaythong	Steam Making Plant	115	2012	2	ACSR240	10.0	Plain	N/A	1,223	FC	844.6	93	633	118																		
			2012							LC	378.6	45	220	114																		
Naxaythong	Phonetong	115	2017	1	ACSR240	12.0	Plain	N/A	969	FC	666.2						73	500	93													
			2017							LC	303.1						36	176	91													
Naxaythong	New 3	115	2020	2	ACSR240	15.0	Plain	N/A	1,835	FC	1,266.9									139	950	177										
			2020							LC	568.0									68	329	170										
Ban Don	Non Hai	115	2012	1	ACSR240	54.0	Plain	N/A	4,362	FC	2,998.1	330	2,249	420																		
			2012							LC	1,363.9	164	791	409																		
Non Hai	Sanakham Mine	115	2012	2	ACSR240	72.8	Plain	N/A	8,905	FC	6,148.9	676	4,612	861																		
			2012							LC	2,756.5	331	1,599	827																		
Paklay	Sanakham Mine	115	2012	2	ACSR240	31.2	Plain	N/A	3,817	FC	2,635.2	290	1,976	369																		
			2012							LC	1,181.4	142	685	354																		
Nam Leuk	Nam Mang 3	115	2011	2	ACSR240	56.0	Mountain	N/A	8,301	FC	5,248.8	4,514	735																			
			2011							LC	3,052.7	2,137	916																			
Nam Mang 3	Khoksaad	115	2011	1*	ACSR240	34.6	Plain	N/A	914	FC	733.6		734																			
			2011							LC	180.6		181																			
Khoksaad	Thanaleng	115	2011	1	ACSR240	16.8	Plain	N/A	1,357	FC	932.7	802	131																			
			2011							LC	424.3	297	127																			
Khoksaad	KF	115	2011	1	ACSR240	10	Plain	N/A	808	FC	555.2	477	78																			
			2011							LC	252.6	177	76																			
Thanaleng	Nongkai	115	2011	1	ACSR240	10.9	Plain	N/A	880	FC	605.2	520	85																			
			2011							LC	275.3	193	83																			
Phonetong	Nongkai	115	2011	1	ACSR240	25.7	Plain	N/A	2,076	FC	1,426.9	1,227	200																			
			2011							LC	649.1	454	195																			
Nam Mang 1	Tabok	115	2015	1	ACSR240	13.0	Plain	N/A	1,050	FC	721.8				79	541	101															
			2015							LC	328.4				39	190	99															
Phonsavan	Nam Ngiep 2	115	2017	2	ACSR410	30.0	Mountain	Heavy	5,163	FC	3,405.5						375	2,554	477													
			2017							LC	1,757.9						211	1,020	527													
			2017						510	FC	168.3						151		17													
			2017							LC	341.7						308		34													
Nam Phay	Nam Ngum 5	115	2021	1	ACSR240	15.0	Mountain	N/A	1,432	FC	914.7										101	686	128									
			2021							LC	517.5										62	300	155									
Moung Kham	Nam Ngiep 2	230	2022	2	ACSR610	75.0	Mountain	Heavy	17,291	FC	11,554.4											1,271	8,666	1,618								
			2022							LC	5,736.5											688	3,327	1,721								
			2022						2,040	FC	673.2											606		67								
			2022							LC	1,366.8											1,230		137								
Nam Feung 1	Xayabury	115	2026	1	ACSR240	65.0	Mountain	N/A	6,206	FC	3,963.6															436	2,973	555				
			2026							LC	2,242.5															269	1,301	673				
Nam Phouan	Thongkun	115	2030	2	ACSR240	20.0	Mountain	N/A	2,965	FC	1,874.6																			206	1,406	262
			2030							LC	1,090.2																			131	632	327
Khoksaad	New 4	115	2023	1	ACSR240	5.0	Plain	N/A	404	FC	277.6												31	208	39							
			2023							LC	126.3												15	73	38							
Khoksaad	New 5	115	2024	1	ACSR240	5.0	Plain	N/A	404	FC	277.6													31	208	39						
			2024							LC	126.3													15	73	38						
	TL Construction				**Central-1 Total**				**239,453**	FC	**164,945**	23,500	79,835	14,629	116	593	3,103	18,141	3,542	1,282	1,264	2,134	8,825	1,857	247	475	2,973	555	0	206	1,406	262
										LC	**74,508**	10,610	27,076	12,913	75	223	1,697	7,045	3,705	568	650	1,158	3,497	1,809	111	307	1,301	673	0	131	632	327
	UXO Removal				**Central-1 Total**				**4,470**	FC	**1,474**	570	0	63	0	0	151	0	17	0	0	606	0	67	0	0	0	0	0	0	0	0
										LC	**2,996**	1,158	0	129	0	0	308	0	34	0	0	1,230	0	137	0	0	0	0	0	0	0	0
Central-2																																
Nam Ngiep 1	Pakxan	115	2017	1	ACSR240	40.0	Plain	N/A	3,231	FC	2,220.8						244	1,666	311													
			2017							LC	1,010.3						121	586	303													
Pakxan	Bungkan	115	2017	1*	ACSR240	11.0	Plain	N/A	291	FC	233.2								233													
			2017							LC	57.4								57													
Nam Theun 1	Khonsong	115	2017	1	ACSR240	35.0	Plain	N/A	2,827	FC	1,943.2						214	1,457	272													
			2017							LC	884.0						106	513	265													
Nam Nguang 8	Khonsong	115	2012	2	ACSR240	58.0	Plain	Light	7,095	FC	4,898.9	539	3,674	686																		
			2012							LC	2,196.1	264	1,274	659																		
			2012						696	FC	229.7	207		23																		
			2012							LC	466.3	420		47																		
Thakhek	Lao Cement Industry	115	2010	1	ACSR240	15.0	Plain	N/A	1,212	FC	832.8	833																				
			2010							LC	378.9	379																				
Thakhek	Many Companies	115	2010	1	ACSR240	5.0	Plain	N/A	404	FC	277.6	278																				
			2010							LC	126.3	126																				

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mahaxay	Xepon Mine	115	2011	1	ACSR240	117.0	Mountain	Heavy	11,171	FC	7,134.4	6,136	999																			
			2011							LC	4,036.5	2,826	1,211																			
			2011						1,989	FC	656.4	591	66																			
			2011							LC	1,332.6	1,199	133																			
Xeneua	Xepon Mine	115	2017	1	ACSR240	60.0	Mountain	Heavy	5,729	FC	3,658.7						402	2,744	512													
			2017							LC	2,070.0						248	1,201	621													
			2017						1,020	FC	336.6						303		34													
			2017							LC	683.4						615		68													
Pakbo	Savan Park	115	2010	1	ACSR240	5.0	Plain	N/A	404	FC	277.6	278																				
			2010							LC	126.3	126																				
Pakbo	Mukudahan	115	2010	1*	ACSR240	13.7	Plain	N/A	362	FC	290.5	290																				
			2010							LC	71.5	72																				
Xepon	Xepon Mine	115	2013	2	ACSR240	45.0	Mountain	Heavy	6,671	FC	4,217.8		464	3,163	590																	
			2013							LC	2,453.0		294	1,423	736																	
			2013						765	FC	252.5		227		25																	
			2013							LC	512.6		461		51																	
Kengkok	Xepon	115	2013	1	ACSR240	100.0	Plain	H50, L50	8,078	FC	5,552.0		611	4,164	777																	
			2013							LC	2,525.8		303	1,465	758																	
			2013						1,450	FC	478.5		431		48																	
			2013							LC	971.5		874		97																	
Pakbo	Saravan	115	2014	2	TACSR240	220.0	Plain	L60	29,707	FC	20,958.7			2,305	15,719	2,934																
			2014							LC	8,747.9			1,050	5,074	2,624																
			2014						720	FC	237.6			214		24																
			2014							LC	482.4			434		48																
Xepon	Xepon 3	115	2017	2	ACSR410	102.0	Plain	Heavy	14,900	FC	10,659.7						1,173	7,995	1,492													
			2017							LC	4,240.4						509	2,459	1,272													
			2017						1,734	FC	572.2						515		57													
			2017							LC	1,161.8						1,046		116													
Thakhek	Cement Factory	115	2010	1*	ACSR240	27.0	Plain	N/A	713	FC	572.4	572																				
			2010							LC	140.9	141																				
New Savannakhet	Kengkok	115	2028	1	ACSR240	50.0	Plain	N/A	4,039	FC	2,776.0																	305	2,082	389		
			2028							LC	1,262.9																	152	732	379		
Xebang Hieng 1	Kengkok	115	2025	1	ACSR240	80.0	Plain	N/A	6,462	FC	4,441.6														489	3,331	622					
			2025							LC	2,020.6														242	1,172	606					
New Thakhek	Kengkok	230	2028	2	ACSR610*2	100.0	Plain	N/A	30,530	FC	22,790.4																	2,507	17,093	3,191		
			2028							LC	7,739.1																	929	4,489	2,322		
Kengkok	NSCT	230	2028	2	ACSR610*2	150.0	Plain	Light	45,794	FC	34,185.6																	3,760	25,639	4,786		
			2028							LC	11,608.7																	1,393	6,733	3,483		
			2028						2,880	FC	950.4																	855		95		
			2028							LC	1,929.6																	1,737		193		
	TL Construction				**Central-2 Total**				**179,619**	FC	127,921	8,926	5,748	10,318	17,086	2,934	2,033	13,862	2,820	0	0	0	0	0	489	3,331	622	6,572	44,814	8,366	0	0
										LC	51,698	3,934	3,082	4,597	6,568	2,624	984	4,759	2,518	0	0	0	0	0	242	1,172	606	2,474	11,954	6,184	0	0
	UXO Removal				**Central-2 Total**				**11,254**	FC	3,715	798	724	237	73	24	818	0	91	0	0	0	0	0	0	0	0	855	0	95	0	0
										LC	7,539	1,619	1,468	481	148	48	1,661	0	184	0	0	0	0	0	0	0	0	1,737	0	193	0	0
Southern																																
Xepon 2	Xepon 3	115	2017	1	ACSR240	6.0	Mountain	Heavy	573	FC	365.9						40	274	51													
			2017							LC	207.0						25	120	62													
			2017						102	FC	33.7						30		3													
			2017							LC	68.3						62		7													
Xepon 2	Xelanong 2	115	2020	1	ACSR240	75.0	Mountain	Heavy	7,161	FC	4,573.4									503	3,430	640										
			2020							LC	2,587.5									311	1,501	776										
			2020						1,275	FC	420.8									379		42										
			2020							LC	854.3									769		85										
Xekong 4	Saravan	115	2016	1	ACSR240	150.0	Mountain	Heavy	14,322	FC	9,146.7					1,006	6,860	1,281														
			2016							LC	5,175.0					621	3,002	1,553														
			2016						2,550	FC	841.5					757		84														
			2016							LC	1,708.5					1,538		171														
Xelanong 2	Saravan	115	2020	1	ACSR240	75.0	Mountain	Heavy	7,161	FC	4,573.4									503	3,430	640										
			2020							LC	2,587.5									311	1,501	776										
			2020						1,275	FC	420.8									379		42										
			2020							LC	854.3									769		85										
Saravan	Cement Factory	115	2011	1	ACSR240	10.0	Plain	Heavy	808	FC	555.2	477	78																			
			2011							LC	252.6	177	76																			
			2011						170	FC	56.1	50	6																			
			2011							LC	113.9	103	11																			

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Switching Station	Sedon 2	115	2018	1	ACSR240	35.0	Plain	Light	2,827	FC	1,943.2							214	1,457	272												
			2018							LC	884.0							106	513	265												
			2018						420	FC	138.6							125		14												
			2018							LC	281.4							253		28												
Saravan	Sedon 3	115	2018	1	ACSR240	15.0	Plain	Heavy	1,212	FC	832.8							92	625	117												
			2018							LC	378.9							45	220	114												
			2018						255	FC	84.2							76		8												
			2018							LC	170.9							154		17												
Saravan	Xekong	115	2013	2	ACSR410	58.0	Plain	Light	8,473	FC	6,061.4		667	4,546	849																	
			2013							LC	2,411.2		289	1,399	723																	
			2013						696	FC	229.7		207		23																	
			2013							LC	466.3		420		47																	
Houaylamphan	Xekong	115	2014	2	ACSR240	18.0	Plain	Light	2,202	FC	1,520.3			167	1,140	213																
			2014							LC	681.6			82	395	204																
			2014						216	FC	71.3			64		7																
			2014							LC	144.7			130		14																
Xekong 3 Upper	Xekong	115	2017	2	ACSR410	10.0	Mountain	N/A	1,721	FC	1,135.2						125	851	159													
			2017							LC	586.0						70	340	176													
Xekong	Xekaman 3	115	2016	1	ACSR240	100.0	Mountain	Light	9,548	FC	6,097.8					671	4,573	854														
			2016							LC	3,450.0					414	2,001	1,035														
			2016						1,200	FC	396.0					356		40														
			2016							LC	804.0					724		80														
Xekaman 3	Lao Aluminium	115	2016	1	ACSR240	15.0	Mountain	Light	1,432	FC	914.7					101	686	128														
			2016							LC	517.5					62	300	155														
			2016						180	FC	59.4					53		6														
			2016							LC	120.6					109		12														
Xekong 3 Lower	Xekatam	115	2017	2	ACSR240	30.0	Mountain	N/A	4,447	FC	2,811.9						309	2,109	394													
			2017							LC	1,635.4						196	949	491													
Pakxong	Xekatam	115	2012	2	ACSR410	35.0	Mountain	Light	6,024	FC	3,973.1	437	2,980	556																		
			2012							LC	2,050.9	246	1,189	615																		
			2012						420	FC	138.6	125		14																		
			2012							LC	281.4	253		28																		
New Switching Station	Xeset 3_4	115	2015	1	ACSR240	2.0	Mountain	Light	191	FC	122.0				13	91	17															
			2015							LC	69.0				8	40	21															
			2015						24	FC	7.9				7		1															
			2015							LC	16.1				14		2															
Pakxong	Sinoma	115	2012	1	ACSR240	20.0	Mountain	Light	1,910	FC	1,219.6	134	915	171																		
			2012							LC	690.0	83	400	207																		
			2012						240	FC	79.2	71		8																		
			2012							LC	160.8	145		16																		
Ban Jianxai	Bang Yo	115	2016	2	TACSR240	8.0	Plain	N/A	1,080	FC	762.1					84	572	107														
			2016							LC	318.1					38	185	95														
Bang Yo	Sirindhom	115	2016	2	TACSR240	61.0	Plain	N/A	8,237	FC	5,811.3					639	4,358	814														
			2016							LC	2,425.5					291	1,407	728														
Nam Phak	Ban Na	115	2015	1	ACSR240	56.0	Plain	N/A	4,524	FC	3,109.1				342	2,332	435															
			2015							LC	1,414.4				170	820	424															
Saphaothong	Xekaman 1	115	2014	2	ACSR240	51.0	Plain	Light	6,239	FC	4,307.6			474	3,231	603																
			2014							LC	1,931.1			232	1,120	579																
			2014						612	FC	202.0			182		20																
			2014							LC	410.0			369		41																
Saphaothong	Nam Kong 3	115	2020	1	ACSR240	25.0	Plain	Light	2,019	FC	1,388.0									153	1,041	194										
			2020							LC	631.5									76	366	189										
			2020						300	FC	99.0									89		10										
			2020							LC	201.0									181		20										
Xekaman 1	AMC	115	2015	1	ACSR240	20.0	Mountain	Light	1,910	FC	1,219.6				134	915	171															
			2015							LC	690.0				83	400	207															
			2015						240	FC	79.2				71		8															
			2015							LC	160.8				145		16															
Donsahong	Ban Hat	115	2016	1	ACSR240	25.0	Plain	N/A	2,019	FC	1,388.0					153	1,041	194														
			2016							LC	631.5					76	366	189														
New Switching Station	Sinoma	115	2012	1	ACSR240	15.0	Plain	Light	1,212	FC	832.8	92	625	117																		
			2012							LC	378.9	45	220	114																		
			2012						180	FC	59.4	53		6																		
			2012							LC	120.6	109		12																		
Ban Hat	Cambodia Border	115	2011	2	ACSR240	112.0	Plain	N/A	13,701	FC	9,459.9	8,135	1,324																			
			2011							LC	4,240.8	2,969	1,272																			
Xesou	Xekaman 1	115	2025	1	ACSR240	25.0	Plain	Light	2,019	FC	1,388.0														153	1,041	194					

Table 10.3-5: Transmission Line Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

origination	terminal	voltage (kV)	year	No. of cct	conductor type	length (km)	area	UXO pollution	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			2025							LC	631.5														76	366	189					
			2025						300	FC	99.0														89		10					
			2025							LC	201.0														181		20					
NSCT	Saravan	230	2028	2	ACSR610*2	20.0	Plain	Light	6,106	FC	4,558.1																	501	3,419	638		
			2028							LC	1,547.8																	186	898	464		
			2028						384	FC	126.7																	114		13		
			2028							LC	257.3																	232		26		
Xebangnouan 2	Switching Station	115	2030	1	ACSR240	30.0	Plain	Light	2,423	FC	1,665.6																			183	1,249	233
			2030							LC	757.7																			91	439	227
			2030						360	FC	118.8																			107		12
			2030							LC	241.2																			217		24
	TL Construction				**Southern Total**				**121,499**	FC	81,737	9,275	6,589	6,031	5,709	6,808	19,187	6,918	2,686	1,548	7,901	1,474	0	0	153	1,041	194	501	3,419	821	1,249	233
										LC	39,762	3,520	3,446	2,649	2,499	3,545	8,204	5,315	1,462	1,077	3,368	1,741	0	0	76	366	189	186	898	555	439	227
	UXO Removal				**Southern Total**				**11,400**	FC	3,761	299	213	274	101	1,193	39	331	3	869	0	94	0	0	89	0	10	114	0	120	0	12
										LC	7,639	610	431	555	206	2,426	80	670	7	1,764	0	190	0	0	181	0	20	232	0	243	0	24
	TL Construction				**Grand Total**				753,987	FC	513,857	70,586	119,114	40,327	44,381	31,200	38,123	44,387	15,791	4,494	12,595	4,248	8,825	1,857	889	4,847	3,789	7,628	48,233	9,393	2,655	495
										LC	240,130	32,518	48,002	27,633	17,640	16,936	18,808	20,961	10,836	3,247	5,518	3,675	3,497	1,809	429	1,845	2,096	3,333	12,852	6,870	1,071	554
	UXO Removal				**Grand Total**				36,386	FC	12,005	3,149	1,383	585	208	1,804	1,008	556	111	1,114	0	725	0	67	89	0	10	969	0	215	0	12
										LC	24,381	6,397	2,804	1,188	424	3,666	2,049	1,129	225	2,261	0	1,471	0	137	181	0	20	1,969	0	436	0	24

Table 10.3-6: Unit Price for Cost Estimate

Equipment (CIF Prices)

	FC (US$)	Installation LC (US$)
Main Power Transformers		
230/115 kV, 100 MVA	1,200,000.00	90,000.00
230/115 kV, 200 MVA	1,800,000.00	115,000.00
115/22 kV, 10 MVA	450,000.00	20,000.00
115/22 kV, 20 MVA	550,000.00	25,000.00
115/22 kV, 30 MVA	650,000.00	30,000.00
Station Service TR, 100 kVA	20,000.00	3,000.00
230 kV Switchgears		
one-and-half CB system		
Circuit breakers	72,300.00	6,400.00
Disconnectors w/o ES	11,500.00	800.00
Disconnectors with ES	14,000.00	1,000.00
Current transformers	32,000.00	2,400.00
Capacitor voltage transformers	35,000.00	2,100.00
Surge arresters	11,800.00	900.00
Post insulators	8,000.00	200.00
Tubular busbar with structures	108,000.00	5,000.00
Gantries, 12 towers & 9 beams	167,000.00	15,000.00
Accessories, connectors, insulator	135,000.00	4,000.00
115 kV Switchgears		
Main and Transfer Bus system		
Three phase busbar	10,000.00	3,000.00
Circuit breakers 3po	43,000.00	4,800.00
Circuit breakers 1po	50,000.00	4,800.00
Disconnectors w/o ES	8,000.00	800.00
Disconnectors with ES	10,000.00	900.00
Current transformers	24,000.00	1,800.00
Voltage transformers	28,500.00	1,500.00
Gantries	12,000.00	3,000.00
Accessories, insulators	10,000.00	1,000.00
Post insulators	900.00	100.00
22 kV Outdoor Switchgears		
Gantory and busbars	30,000.00	30,000.00
Line bay	35,000.00	35,000.00
TR bay	35,000.00	35,000.00
Busbar section	25,000.00	25,000.00
Aux TR bay	10,000.00	10,000.00
Static Capacitor 2.5 Mvar	37,000.00	37,000.00
Static Capacitor 5 Mvar	45,000.00	45,000.00
Control & Protection		
230 kV TR Control & Protection	120,000.00	120,000.00
230 kV TL Control & Protection	115,000.00	115,000.00
230 kV Bus Control & Protection	85,000.00	85,000.00
115 kV TR Control & Protection	105,000.00	105,000.00
115 kV TL Control & Protection	95,000.00	95,000.00
115 kV Bus Control & Protection	79,000.00	79,000.00
Control & Protection Panel (22 kV	47,000.00	47,000.00
DCS for 230 kV SS	500,000.00	500,000.00
DCS for 115 kV SS	365,000.00	365,000.00
Communications System		
SDH, MPX & ODB	100,000.00	100,000.00
Digital PABX	20,000.00	20,000.00
Telephone system	15,000.00	15,000.00
VHF system	20,000.00	20,000.00
Optical fiber cable (36 cores)	3,200.00	3,200.00
OPGW joint boxes	3,400.00	3,400.00
Others		
Earthing system	150,000.00	150,000.00
Lightning protection	20,000.00	20,000.00
Station lighting system	50,000.00	50,000.00
110 V DC system with battery	100,000.00	100,000.00
48 V DC system with battery	40,000.00	40,000.00
MV, LV, and control cables	150,000.00	150,000.00
Spare parts & Tools	200,000.00	200,000.00
Documentation	10,000.00	10,000.00

Civil and Erection

		FC (US$)	LC (US$)
	230 kV Substation		
1	**Preliminary Works**		
1	Site survey	4,000.00	2,000.00
2	Sub-soil investigation	6,500.00	6,000.00
3	Civil engineering works	120,000.00	0.00
4	Temporary works, site office		150,000.00
2	**Site Cleaning & Formation Works**		
1	Cutting and removing trees & shrubs		20,000.00
2	Demolishing existing structures		25,000.00
3	Cutting, filling and compacting earth		45,000.00
4	Earth retaing structure		23,100.00
3	**Civil Works**		
1	Cable trenches & ducts		78,000.00
2	Foundations		250,000.00
3	Water supply and drainage		40,000.00
4	Servise roads		35,000.00
5	Chainlink fences		48,000.00
6	Gravelling		37,200.00
4	**Building Works**		
1	Control building & guard house		400,000.00
	115 kV Substation		
1	**Preliminary Works**		
1	Site survey	3,000.00	1,000.00
2	Sub-soil investigation	5,000.00	2,000.00
3	Civil engineering works	80,000.00	0.00
4	Temporary works, site office		100,000.00
2	**Site Cleaning & Formation Works**		
1	Cutting and removing trees & shrubs		15,000.00
2	Demolishing existing structures		12,000.00
3	Cutting, filling and compacting earth		30,000.00
4	Earth retaing structure		15,000.00
3	**Civil Works**		
1	Cable trenches & ducts		40,000.00
2	Foundations		150,000.00
3	Water supply and drainage		30,000.00
4	Servise roads		25,000.00
5	Chainlink fences		30,000.00
6	Gravelling		25,000.00
4	**Building Works**		
1	Control building & guard house		354,000.00

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Northern																													
Phongsaly Province																													
1	Boun Neua SS	115 kV	2012	New Construction	1x10 MVA TR, 4xTL bays (including 2xprivate)	5,400.0	FC	4,295.8	429.6	3,436.6	429.6																		
							LC	1,104.2	110.4	883.4	110.4																		
		115 kV	2017	add TL bay	2 TL bays for Nam Ou 6	872.0	FC	753.9							377.0	377.0													
							LC	118.1							59.0	59.0													
Luang Namtha Province																													
1	Luang Namtha SS	115 kV	2010	add TL bay	1 TL bay for Cu mining (P)	449.0	FC	382.4	382.4																				
							LC	66.6	66.6																				
		115 kV	2012	add TL bay	2 TL bays for Houayxai SS & Nam Tha 1 HPS	872.0	FC	753.9		377.0	377.0																		
							LC	118.1		59.0	59.0																		
		115 kV	2022	add TR	additional 1x20 MVA TR	981.0	FC	876.7												438.4	438.4								
							LC	104.3												52.1	52.1								
		115 kV	2030	add TR	additional 1x20 MVA TR	981.0	FC	876.7																				438.4	438.4
							LC	104.3																				52.1	52.1
Oudomxai Province																													
1	Oudomxai SS	115 kV	2012	add TL bay	1 TL bay for THL-C mining (P)	449.0	FC	382.4		191.2	191.2																		
							LC	66.6		33.3	33.3																		
		115 kV	2013	add TL bay	2 TL bays for Na Mo SS & Lunang Prabang-2 (Pakson) SS	872.0	FC	753.9			377.0	377.0																	
							LC	118.1			59.0	59.0																	
2	Namo SS	115 kV	2012	New Construction	1x10 MVA TR, 8xTL bays (including 2xprivate)	6,854.0	FC	5,669.4	566.9	4,535.5	566.9																		
							LC	1,184.6	118.5	947.7	118.5																		
3	New SwS for Nam Beng HPS	115 kV	2020	New Construction	5 TL bays	4,014.0	FC	3,066.5									306.7	2,453.2	306.7										
							LC	947.5									94.7	758.0	94.7										
Bokeo Province																													
1	Huayxai SS	115 kV	2012	New Construction	1x30 MVA TR, 1xTL bays	3,936.0	FC	3,197.7	319.8	2,558.2	319.8																		
							LC	738.3	73.8	590.6	73.8																		
		115 kV	2024	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0														545.5	545.5						
							LC	115.0														57.5	57.5						
2	Nam Thoung SwS	115 kV	2015	New Construction	5 TL bays for Nam Tha 1(2), Luang Namtha (2) & Huaixai (1	4,014.0	FC	3,066.5				306.7	2,453.2	306.7															
							LC	947.5				94.7	758.0	94.7															
Houaphanh Province																													
1	Xam Neua SS	115 kV	2011	New Construction	1x10 MVA TR, 2xTL bays	4,817.0	FC	3,745.7	1,872.8	1,872.8																			
							LC	1,071.3	535.7	535.7																			
		115 kV	2016	add TL bay	2 TL bays for Nam Ma-1 HPS	872.0	FC	753.9						377.0	377.0														
							LC	118.1						59.0	59.0														
Luang Prabang Province																													
1	Luang Prabang-1 SS	115 kV	2013	add TL bay	2 TL bays for LP-2 SS & LP-3 SS	872.0	FC	753.9			377.0	377.0																	
							LC	118.1			59.0	59.0																	
2	Luang Prabang-2 (Pakson) SS	115 kV	2010	add TL bay	2 TL bays for Cement Factory (P) & United (P)	872.0	FC	753.9	753.9																				
							LC	118.1	118.1																				
		115 kV	2013	add TL bay	2 TL bays for LP-1 SS & Oudomxai SS	872.0	FC	753.9			377.0	377.0																	
							LC	118.1			59.0	59.0																	
		115 kV	2020	add TL bay	1 TL bay for Nam Nga HPS	449.0	FC	382.4										191.2	191.2										
							LC	66.6										33.3	33.3										
3	Luang Prabang-3 SS	230/115 kV	2013	New Construction	2x200 MVA 230kV TR, 20 MVA 115kV TR, 2x230 kV & 2x11	12,706.0	FC	10,978.1		1,097.8	8,782.5	1,097.8																	
							LC	1,727.9		172.8	1,382.3	172.8																	
		115 kV	2015	add TL bay	2x115 kV TL bays for Hongsa SS	872.0	FC	753.9					377.0	377.0															
							LC	118.1					59.0	59.0															
		115 kV	2016	add TL bay	2x115 kV TL bays for Mekong Lunag Praban HPS	872.0	FC	753.9						377.0	377.0														
							LC	118.1						59.0	59.0														
		230 kV	2018	add TL bay	2x230 kV TL bays for Nam Khan-2 HPS	1,216.0	FC	1,051.8								525.9	525.9												
							LC	164.2								82.1	82.1												
		115 kV	2022	add TR	additional 1x20 MVA 115/22 kV TR	1,094.0	FC	984.3												492.2	492.2								
							LC	109.7												54.8	54.8								
Xayaboury Province																													
1	Hongsa SS	115 kV	2013	New Construction	1x20 MVA TR, 4xTL bays	5,518.0	FC	4,408.4		440.8	3,526.7	440.8																	
							LC	1,109.6		111.0	887.7	111.0																	
		115 kV	2022	add TR	additional 1x20 MVA TR	1,094.0	FC	984.3												492.2	492.2								
							LC	109.7												54.8	54.8								
2	Xayaboury SS	115 kV	2014	add TL bay	2 TL bays for Paklay SS	872.0	FC	753.9				377.0	377.0																
							LC	118.1				59.0	59.0																
		115 kV	2019	add TR	additional 1x16 MVA TR from Phonesavan SS	479.0	FC	390.6									195.3	195.3											

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							LC	88.4									44.2	44.2											
		115 kV	2026	add TL bay	1 TL bay for Nam Feung-3 HPS	449.0	FC	382.4																191.2	191.2				
							LC	66.6																33.3	33.3				
		115 kV	2027	add TR	additional 1x16 MVA TR from Vangvieng SS	479.0	FC	390.6																	195.3	195.3			
							LC	88.4																	44.2	44.2			
3	Paklay SS	115 kV	2014	New Construction	1x20 MVA TR, 5xTL bays (including 2xprivate)	5,857.0	FC	4,727.1			472.7	3,781.7	472.7																
							LC	1,129.9			113.0	903.9	113.0																
		115 kV	2028	add TR	additional 1x20 MVA TR	1,094.0	FC	984.3																		492.2	492.2		
							LC	109.7																		54.8	54.8		
Xiengkouang Province																													
1	Phonesavan SS	115 kV	2011	add TL bay	5 TL bays for NN-5 (2), MK (2) & Cu mine (P)	2,245.0	FC	1,912.0	956.0	956.0																			
							LC	333.0	166.5	166.5																			
		115 kV	2017	add TL bay	2 TL bays for Nam Ngiep 2	872.0	FC	753.9							377.0	377.0													
							LC	118.1							59.0	59.0													
		115 kV	2019	add TR	replacement of 1x16 MVA TR to 1x30 MVA	1,206.0	FC	1,091.0									545.5	545.5											
							LC	115.0									57.5	57.5											
		115 kV	2025	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0															545.5	545.5					
							LC	115.0															57.5	57.5					
2	Moung Kham	115 kV	2011	New Construction	1x10 MVA TR, 5xTL bays (including 1xprivate)	5,740.0	FC	4,615.3	2,307.7	2,307.7																			
							LC	1,124.7	562.3	562.3																			
		115 kV	2020	add TL bay	1 TL bay for Nam Mo-1 HPP	449.0	FC	382.4										191.2	191.2										
							LC	66.6										33.3	33.3										
		230/115 kV	2022	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays	6,788.0	FC	5,496.6											549.7	4,397.3	549.7								
							LC	1,291.4											129.1	1,033.1	129.1								
		115 kV	2028	add TR	additional 1x10 MVA TR	981.0	FC	876.7																		438.4	438.4		
							LC	104.3																		52.1	52.1		
3	New SwS for Nam Sam-3 HPS	115 kV	2016	New Construction	3 TL bays	3,210.0	FC	2,428.7					242.9	1,943.0	242.9														
							LC	781.3					78.1	625.0	78.1														
					Northern Total	**94,953.0**	FC	**78,502.3**	7,589.1	17,773.7	15,797.3	7,134.9	3,922.7	3,380.5	1,750.7	1,279.8	1,573.4	3,576.4	1,238.7	5,820.0	1,972.3	545.5	1,091.0	736.7	386.5	1,125.8	930.5	438.4	438.4
							LC	**16,450.7**	1,751.9	4,062.2	2,955.1	1,518.5	1,067.2	896.9	314.3	200.2	278.5	926.3	290.5	1,194.9	291.0	57.5	115.0	90.8	77.5	151.2	107.0	52.1	52.1
Central-1																													
Vientiane Province																													
1	Phonsoung SS	115 kV	2011	replace TR	replacement of 1x22 MVA TR to 1x30 MVA	981.0	FC	876.7	438.4	438.4																			
							LC	104.3	52.1	52.1																			
		115 kV	2020	add TR	additional 1x30 MVA TR	981.0	FC	876.7										438.4	438.4										
							LC	104.3										52.1	52.1										
		115 kV	2030	add TR	additional 1x30 MVA TR	981.0	FC	876.7																				438.4	438.4
							LC	104.3																				52.1	52.1
2	Vangvieng SS	115 kV	2010	add TL bay	1 TL bay for Iron/Coal Mine (P)	449.0	FC	382.4	382.4																				
							LC	66.6	66.6																				
		115 kV	2011	add TL bay	3 TL bays for Nam Ngum-5 (2) & Hin Huep	1,347.0	FC	1,147.2	573.6	573.6																			
							LC	199.8	99.9	99.9																			
		115 kV	2015	replace TR	replacement of 2x16 MVA TR to 2x30 MVA	1,962.0	FC	1,753.4					876.7	876.7															
							LC	208.6					104.3	104.3															
3	New Vangvieng SS	115 kV	2024	New Construction	2x30 MVA TR, 4xTL bays	7,526.0	FC	6,272.6													627.3	5,018.0	627.3						
							LC	1,253.4													125.3	1,002.8	125.3						
4	Thalat SS	115 kV	2022	add TR	additional 1x30 MVA TR	981.0	FC	876.7												438.4	438.4								
							LC	104.3												52.1	52.1								
5	Ban Don SS	115 kV	2010	add TL bay (U/C)	1 TL bay for Nam Lik 1-2 HPS	contract signed	FC																						
							LC																						
		115 kV	2012	add TL bay	1 TL bay for Non Hai SS	449.0	FC	382.4		191.2	191.2																		
							LC	66.6		33.3	33.3																		
6	Hin Heup SS	115 kV	2010	add TL bay (U/C)	1 TL bay for Nam Lik 1-2 HPS	contract signed	FC																						
							LC																						
		115 kV	2011	add TL bay	2 TL bays for Nam Lik-1 & Vangvieng	872.0	FC	753.9	377.0	377.0																			
							LC	118.1	59.0	59.0																			
		230/115 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 1x 10 MVA 115/22 kV TR, 4x23	9,142.0	FC	7,632.9	763.3	6,106.4	763.3																		
							LC	1,509.1	150.9	1,207.2	150.9																		
7	Non Hai SS	115 kV	2012	add TL bay	3 TL bays for Ban Don (1) & Sanakham Mine (2 cct, P)	1,347.0	FC	1,147.2		573.6	573.6																		
							LC	199.8		99.9	99.9																		
		115 kV	2026	add TR	additional 1x16 MVA TR from Vangvieng SS	479.0	FC	390.6																195.3	195.3				

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							LC	88.4																44.2	44.2				
8	Thongkun SwS	115 kV	2012	add TL bay	1 TL bay for Iron Pressing Factory (P)	449.0	FC	382.4		191.2	191.2																		
							LC	66.6		33.3	33.3																		
		115 kV	2030	add TL bay	2 TL bays for Nam Phouan HPS	872.0	FC	753.9																				377.0	377.0
							LC	118.1																				59.0	59.0
9	Nam Leuk HPS	115 kV	2011	add TL bay	2 TL bays for Nam Mang-3 HPS	872.0	FC	753.9	377.0	377.0																			
							LC	118.1	59.0	59.0																			
10	Nam Mang-3 HPS	115 kV	2011	add TL bay	3 TL bays for Nam Leuk (2) & Khaksaad SS (1)	1,347.0	FC	1,147.2	573.6	573.6																			
							LC	199.8	99.9	99.9																			
11	New SwS for Vangvien Mining Co.,	115 kV	2011	New Construction	3 TL bays for VVN, LP-3 & Vangvien Mine (P)	3,210.0	FC	2,428.7	1,214.3	1,214.3																			
							LC	781.3	390.7	390.7																			
Vientiane Captal																													
1	Phonetong SS	115 kV	2017	replace TR	replacement of old 1x30 MVA TR to new one	1,206.0	FC	1,091.0							545.5	545.5													
							LC	115.0							57.5	57.5													
		115 kV	2017	add TL bay	1 TL bay for Naxaythong SS	449.0	FC	382.4							191.2	191.2													
							LC	66.6							33.3	33.3													
2	Tanaleng SS	115 kV	2011	add TL bay	2 TL bays for Khaksaad SS & Nongkai	872.0	FC	753.9	377.0	377.0																			
							LC	118.1	59.0	59.0																			
		115 kV	2016	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0						545.5	545.5														
							LC	115.0						57.5	57.5														
3	Naxaythong SS	230/115 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 4x230kV & 2x115kV TL bays (fo	8,635.0	FC	7,227.7	722.8	5,782.1	722.8																		
							LC	1,407.3	140.7	1,125.9	140.7																		
		115 kV	2017	add TL bay	1 TL bay for Phonetong SS	449.0	FC	382.4							191.2	191.2													
							LC	66.6							33.3	33.3													
		115 kV	2020	add TL bay	2 TL bays for Nongteng (New-3)	1,347.0	FC	1,147.2										573.6	573.6										
							LC	199.8										99.9	99.9										
4	Khaksaad SS	115 kV	2011	add TL bay	3 TL bays for Nam Mang-3, Tanaleng & Iron Kaly Factory (P	1,347.0	FC	1,147.2	573.6	573.6																			
							LC	199.8	99.9	99.9																			
		230/115 kV	2012	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays	6,788.0	FC	5,496.6	549.7	4,397.3	549.7																		
							LC	1,291.4	129.1	1,033.1	129.1																		
		230 kV	2017	add TL bay	2x230 kV TL bays for Nam Ngiep 2 HPP	1,216.0	FC	1,051.8							525.9	525.9													
							LC	164.2							82.1	82.1													
		115 kV	2023	add TL bay	2 TL bays for New-4 SS	872.0	FC	753.9													377.0	377.0							
							LC	118.1													59.0	59.0							
		115 kV	2024	add TL bay	1 TL bay for New-5 SS	449.0	FC	382.4														191.2	191.2						
							LC	66.6														33.3	33.3						
5	Tha Ngon SS	115 kV	2011	replace TR	replacement of 1x22 MVA TR to 1x30 MVA	1,206.0	FC	1,091.0	545.5	545.5																			
							LC	115.0	57.5	57.5																			
		115 kV	2020	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0										545.5	545.5										
							LC	115.0										57.5	57.5										
6	Gnangsoum (New -1) SS	115 kV	2011	New Construction	2x30 MVA TR, 4xTL bays	7,698.0	FC	6,337.4	3,168.7	3,168.7																			
							LC	1,360.6	680.3	680.3																			
		115 kV	2026	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0																545.5	545.5				
							LC	115.0																57.5	57.5				
7	Nonkor (New-2) SS	115 kV	2013	New Construction	2x30 MVA TR, 3xTL bays	7,272.0	FC	6,006.8		600.7	4,805.4	600.7																	
							LC	1,265.2		126.5	1,012.2	126.5																	
8	Nongteng (New-3) SS	115 kV	2020	New Construction	2x30 MVA TR, 2xTL bays	6,910.0	FC	5,688.5									568.9	4,550.8	568.9										
							LC	1,221.5									122.1	977.2	122.1										
9	New 4 SS	115 kV	2023	New Construction	2x30 MVA TR, 2xTL bays	6,910.0	FC	5,688.5												568.9	4,550.8	568.9							
							LC	1,221.5												122.1	977.2	122.1							
10	New 5 SS	115 kV	2024	New Construction	2x30 MVA TR, 2xTL bays	6,910.0	FC	5,688.5													568.9	4,550.8	568.9						
							LC	1,221.5													122.1	977.2	122.1						
					Central-1 Total	**98,401.0**	FC	**82,426.0**	10,636.7	26,061.1	7,797.2	600.7	876.7	1,422.2	1,999.3	1,453.8	568.9	6,108.3	2,126.3	1,007.2	6,562.2	10,705.9	1,387.3	740.8	740.8	0.0	0.0	815.3	815.3
							LC	**15,975.0**	2,144.8	5,316.6	1,599.4	126.5	104.3	161.8	263.7	206.2	122.1	1,186.7	331.7	174.3	1,335.9	2,194.4	280.8	101.7	101.7	0.0	0.0	111.2	111.2
Central-2																													
Bolikhamxai Province																													
1	Pakxan SS	115 kV	2011	add TL bay (U/C)	2 TL bays for Thakhek SS	contract signed	FC																						
							LC																						
		115 kV	2017	add TL bay	2 TL bays for Nam Ngiep-1 HPS & Bungkan	872.0	FC	753.9							377.0	377.0													
							LC	118.1							59.0	59.0													
		115 kV	2021	replace TR	replacement of 2x16 MVA TR to 2x30 MVA	2,412.0	FC	2,182.0											1,091.0	1,091.0									

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							LC	230.0											115.0	115.0									
		115 kV	2028	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0																		545.5	545.5		
							LC	115.0																		57.5	57.5		
2	Khonsoung SS	115 kV	2012	New Construction	1x20 MVA TR, 6xTL bays (Nam Nguang-8(2) , Pakxan(2), TI	6,197.0	FC	5,046.7	504.7	4,037.4	504.7																		
							LC	1,150.3	115.0	920.2	115.0																		
3	Thabok SwS	115 kV	2015	New Construction	3 TL bays for Nam Mang-1 HPS, Nam Leuk HPS & Pakxan :	3,210.0	FC	2,428.7				242.9	1,943.0	242.9															
							LC	781.3				78.1	625.0	78.1															
Khammouan Province																													
1	Thakhek SS	115 kV	2010	add TL bay	2 TL bays for Cement Industry (P) & many companies (P)	872.0	FC	753.9	753.9																				
							LC	118.1	118.1																				
		115 kV	2011	add TL bay (U/C)	4 TL bays for Pakxan SS & Pakbo SS	contract signed	FC																						
							LC																						
		115 kV	2027	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0																	545.5	545.5			
							LC	115.0																	57.5	57.5			
2	Mahaxai SS	115 kV	2011	add TL bay	1 TL bay for Xepon Mine (P)	449.0	FC	382.4	191.2	191.2																			
							LC	66.6	33.3	33.3																			
3	New Thakhek SS	115 kV	2019	New Construction	2x30 MVA TR, 4xTL bays	7,526.0	FC	6,272.6								627.3	5,018.0	627.3											
							LC	1,253.4								125.3	1,002.8	125.3											
		115 kV	2027	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0																	545.5	545.5			
							LC	115.0																	57.5	57.5			
		230/115 kV	2028	Upgrade	1x200 MVA 230/115 kV TR, 2x230 kV TL bays	6,788.0	FC	5,496.6																	549.7	4,397.3	549.7		
							LC	1,291.4																	129.1	1,033.1	129.1		
Savannakhet Province																													
1	Pakbo SS	115 kV	2010	add TL bay	1 TL bay for Mukdahan	449.0	FC	382.4	382.4																				
							LC	66.6	66.6																				
		115 kV	2011	add TL bay (U/C)	2 TL bays for Thakhek SS	contract signed	FC																						
							LC																						
		115 kV	2013	replace TR	replacement of 2x20 MVA TR to 2x30 MVA	2,412.0	FC	2,182.0			1,091.0	1,091.0																	
							LC	230.0			115.0	115.0																	
		115 kV	2014	add TL bay	2 TL bays for Thaotan SS	1,124.9	FC	972.6				486.3	486.3																
							LC	152.3				76.2	76.2																
		115 kV	2019	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0									545.5	545.5											
							LC	115.0									57.5	57.5											
2	New Savannakhet SS	115 kV	2021	New Construction	2x30 MVA TR, 4xTL bays	7,526.0	FC	6,272.6										627.3	5,018.0	627.3									
							LC	1,253.4										125.3	1,002.8	125.3									
		115 kV	2028	add TL bay	1 TL bay for Kengkok SS	449.0	FC	382.4																		191.2	191.2		
							LC	66.6																		33.3	33.3		
3	Kengkok SS	115 kV	2013	replace TR	replacement of 2x10 MVA TR to 2x20 MVA	2,188.0	FC	1,968.6			984.3	984.3																	
							LC	219.4			109.7	109.7																	
		115 kV	2014	add TL bay	1 TL bay for Xepon SS	449.0	FC	382.4				191.2	191.2																
							LC	66.6				33.3	33.3																
		115 kV	2025	add TR	additional 1x20 MVA TR	1,094.0	FC	984.3															492.2	492.2					
							LC	109.7															54.8	54.8					
		115 kV	2025	add TL bay	1 TL bay for Xeban Hieng HPS	449.0	FC	382.4															191.2	191.2					
							LC	66.6															33.3	33.3					
		230/115 kV	2028	Upgrade	1x200 MVA 230/115 kV TR, 4x230 kV TL bays, 1x115 kV TL	8,111.0	FC	6,740.7																	674.1	5,392.6	674.1		
							LC	1,370.3																	137.0	1,096.2	137.0		
4	Xepon SS	115 kV	2014	New Construction	1x20 MVA TR, 3xTL bays	5,178.0	FC	4,088.8			408.9	3,271.1	408.9																
							LC	1,089.2			108.9	871.3	108.9																
		115 kV	2017	add TL bay	2 TL bay for Xepon-3 HPS	872.0	FC	753.9							377.0	377.0													
							LC	118.1							59.0	59.0													
		115 kV	2025	add TR	additional 1x20 MVA TR	1,094.0	FC	984.3															492.2	492.2					
							LC	109.7															54.8	54.8					
					Central-2 Total	64,545.9	FC	54,158.1	1,832.2	4,228.6	2,988.8	6,266.7	3,029.3	242.9	753.9	1,381.2	5,563.5	1,800.0	6,109.0	1,718.2	0.0	0.0	1,175.5	1,175.5	2,314.7	11,617.6	1,960.4	0.0	0.0
							LC	10,387.8	333.0	953.5	448.7	1,283.6	843.4	78.1	118.1	243.4	1,060.3	308.2	1,117.8	240.4	0.0	0.0	143.0	143.0	381.2	2,335.1	357.0	0.0	0.0
Southern																													
Saravan Province																													
1	Saravan SS	115 kV	2011	New Construction (U/C)	2x20 MVA TR, 2xTL bays	contract signed	FC																						
							LC																						
		115 kV	2011	add TL bay	1 TL bay for Cement Factory (P)	449.0	FC	382.4	191.2	191.2																			
							LC	66.6	33.3	33.3																			

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
		115 kV	2013	add TL bay	2 TL bays for Xekong SS	872.0	FC	753.9			377.0	377.0																	
							LC	118.1			59.0	59.0																	
		115 kV	2014	add TL bay	2 TL bays for Thaotan SS	872.0	FC	753.9				377.0	377.0																
							LC	118.1				59.0	59.0																
		115 kV	2016	add TL bay	2 TL bays for Xekong-4 HPS	872.0	FC	753.9						377.0	377.0														
							LC	118.1						59.0	59.0														
		115 kV	2028	add TL bay	2 TL bays for New Saravan Coal Thermal PS	872.0	FC	753.9																		377.0	377.0		
							LC	118.1																		59.0	59.0		
		115 kV	2029	add TR	additional 1x20 MVA TR	1,094.0	FC	984.3																			492.2	492.2	
							LC	109.7																			54.8	54.8	
2	Xeset-1 HPS	115 kV	2011	add TL bay (U/C)	2 TL bays for Saravan SS	contract signed	FC																						
							LC																						
3	Taothan SS	115 kV	2014	New Construction	2x10 MVA TR, 4xTL bays	6,343.0	FC	4,497.1			449.7	3,597.7	449.7																
							LC	1,845.9			184.6	1,476.7	184.6																
4	New SwS for Xedong-2 HPS	115 kV	2018	New Construction	3 TL bays	3,210.0	FC	2,428.7							242.9	1,943.0	242.9												
							LC	781.3							78.1	625.0	78.1												
		115 kV	2030	add TL bay	1 TL bay Xebangnouan-2 HPS	449.0	FC	382.4																				191.2	191.2
							LC	66.6																				33.3	33.3
Xekong Province																													
1	Xekong SS	115 kV	2013	New Construction	2x20 MVA TR, 3xTL bays (including Lao Aluminium Industry	7,046.0	FC	5,748.6		574.9	4,598.8	574.9																	
							LC	1,297.4		129.7	1,038.0	129.7																	
		115 kV	2016	add TL bay	3 TL bays for Houaylamphan (2) & Xekaman 3 (1)	1,347.0	FC	1,147.2						573.6	573.6														
							LC	199.8						99.9	99.9														
		115 kV	2017	add TL bay	2 TL bays for Xekong-3 (upper) HPS	872.0	FC	753.9							377.0	377.0													
							LC	118.1							59.0	59.0													
Attapeu Province																													
1	Saphaothong (Attapeu)	115 kV	2014	add TL bay	2 TL bays for Xekaman-1 HPS	872.0	FC	753.9				377.0	377.0																
							LC	118.1				59.0	59.0																
		115 kV	2020	add TL bay	1 TL bay for Nam Kong-3 HPS	449.0	FC	382.4										191.2	191.2										
							LC	66.6										33.3	33.3										
2	New SwS for SIMOA (P)	115 kV	2012	New Construction	5 TL bays	4,014.0	FC	3,066.5	306.7	2,453.2	306.7																		
							LC	947.5	94.7	758.0	94.7																		
Champasak Province																													
1	Bang Yo SS	115 kV	2016	add TL bay	4 TL bays for Jianxai SS & Siridhorn SS	1,744.0	FC	1,507.9						753.9	753.9														
							LC	236.1						118.1	118.1														
		115 kV	2022	replace TR	replacement of 2x25 MVA TR to 2x30 MVA	2,412.0	FC	2,182.0												1,091.0	1,091.0								
							LC	230.0												115.0	115.0								
2	Jianxai SS	115 kV	2010	add TL bay (U/C)	2 TL bays for Paksong SS	contract signed	FC																						
							LC																						
		115 kV	2010	add TR	add 1x30 MVA TR	603.0	FC	545.5	545.5																				
							LC	57.5	57.5																				
		115 kV	2016	add TL bay	2 TL bays for Bang Yo SS	872.0	FC	753.9						377.0	377.0														
							LC	118.1						59.0	59.0														
		115 kV	2022	add TR	additional 1x30 MVA TR	1,206.0	FC	1,091.0												545.5	545.5								
							LC	115.0												57.5	57.5								
3	Paksong SS	115 kV	2010	add TL bay (U/C)	2 TL bays for Jianxai SS	contract signed	FC																						
							LC																						
		115 kV	2012	add TL bay	2 TL bays for Xekatam HPS & SIMOA (P)	872.0	FC	753.9		377.0	377.0																		
							LC	118.1		59.0	59.0																		
		115 kV	2020	add TR	additional 1x10 MVA TR	981.0	FC	876.7										438.4	438.4										
							LC	104.3										52.1	52.1										
		230 kV	2023	connection	Connect to 230 kV Huay Ho Line (switchger is existing)	1,216.0	FC	1,051.8													525.9	525.9							
							LC	164.2													82.1	82.1							
4	Ban Na SS	115 kV	2015	add TL bay	1 TL bay for Nam Phak HPS	449.0	FC	382.4					191.2	191.2															
							LC	66.6					33.3	33.3															
5	Ban Hat SS	115 kV	2011	add TL bay	2 TL bays for Stung Treng	872.0	FC	753.9	377.0	377.0																			
							LC	118.1	59.0	59.0																			
		115 kV	2016	add TL bay	1 TL bay for Donsahong HPS	449.0	FC	382.4						191.2	191.2														
							LC	66.6						33.3	33.3														
6	New SwS for Xeset 3-4	115 kV	2015	New Construction	3 TL bays	3,210.0	FC	2,428.7				242.9	1,943.0	242.9															
							LC	781.3				78.1	625.0	78.1															
					Southern Total	44,519.0	FC	36,253.3	1,420.3	3,973.2	6,109.1	5,546.3	3,337.8	2,706.7	2,892.5	2,319.9	242.9	629.6	629.6	1,636.5	2,162.4	525.9	0.0	0.0	0.0	377.0	869.1	683.3	191.2

Table 10.4-3: Substation Development Plan & Disbursement Schedule 2010-2030

(unit: 1,000USD)

id	stations	voltage	year	status	scope	total		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						LC	8,265.7	244.6	1,039.1	1,435.4	1,861.7	961.0	480.8	506.5	684.1	78.1	85.4	85.4	172.5	254.6	82.1	0.0	0.0	0.0	59.0	113.9	88.2	33.3