Chapter 17. Simulation of Supply/Demand Balance

17.1. Options for Power Development Plan up to 2030

In order to examine supply reliability and supply-demand balance based on the Lao PDR's development situation, and considering the development status of the country's power supply facilities and transmission facilities, a simulation is conducted for 2030. Laos's power system is examined up to 2030 considering the demand situation in the domestic system and the expansion plans for transmission lines. The northern and central 1 areas are put together to form a Laos NC system, the central 2 a Laos C system, and the southern part an S system.

Based on the results of the supply/demand balance simulations, we make recommendations for power plant expansion plans and transmission lines, and for interconnections with neighboring countries.

17.1.1. Power Development Plan for Laos' domestic system up to 2030

1. Power plants for analysis of supply/demand balance in Laos

In examining the supply/demand balance for domestic demand in Laos up to 2030, we use the power plan approved by the MEM Minister (see Table 17.1-1).

Table 17.1-1 Power Development Plan approved by minister of MEM, including existing plants

No	Power Plant	MW	Type	COD	Province	Region
1	Nam Dong	1.00	Run of river	1970	Luangprabang	NC
2	Nam Ngum 1	155.00	Reservoir	1971	Vientiane Pro	NC
3	Nam Ko	1.50	Run of river	1996	Oudomxay	NC
4	Nam Luek	60.00	Reservoir	2000	Saysomboun	NC
5	Nam Mang 3	40.00	Reservoir	2004	Vientiane Pro	NC
6	Nam Tha 3	1.30	Run of river	2010	Luangnamtha	NC
7	Nam lik 1/2	100.00	Reservoir	2010	Vientiane Pro	NC
8	Nam Nhon	2.40	Run of river	2011	Borkeo	NC
9	Nam Song	6.00	Reservoir	2011	Vientiane Pro	NC
10	Nam Ngum 5	120.00	Reservoir	2012	Vientiane Pro	NC
11	Nam Long	5.00	Run of river	2013	Luangnamtha	NC
12	Nam Sien Tad Lang	5.00	Run of river	2014	Xieng Khuang	NC
13	Nam Sana	14.00	Run of river	2014	Vientiane Pro	NC
14	Nam Khan 2	130.00	Reservoir	2015	Luangprabang	NC
15	Nam Ou 2	120.00	Reservoir	2015	Luangprabang	NC
16	Hongsa Lignite (T) (d)	100.00	Coal	2015	Xayaboury	NC
17	Nam Ngiep 2	180.00	Reservoir	2015	Xieng khuang	NC
18	Nam Ngipe 3A	44.00	Reservoir	2015	Xieng Khuang	NC
19	Nam San 3B	45.00	Reservoir	2015	Saysomboun	NC
20	Nam Beng	36.00	Reservoir	2016	Oudomxay	NC
21	Nam Khan 3	60.00	Reservoir	2016	Luangprabang	NC
22	Nam San 3A	69.00	Reservoir	2016	Saysomboun	NC
23	Nam Sor	7.38	Run of river	2016	Saysomboun	NC
24	Nam Nga 2	14.50	Run of river	2017	Oudomxay	NC
25	Nam Peun 2	12.00	Run of river	2017	Houaphanh	NC
26	Nam Ngipe 2C	15.00	Run of river	2017	Xieng Khuang	NC
27	Nam Phai	86.00	Reservoir	2017	Saysomboun	NC
28	Naxaythong Solar Farm (S)	32.00	Renewable	2017	Vientiane Capital	NC
29	Nam Peun 1	15.00	Run of river	2019	Houaphanh	NC
30	Nam Tha 1	168.00	Reservoir	2018	Borkeo	NC

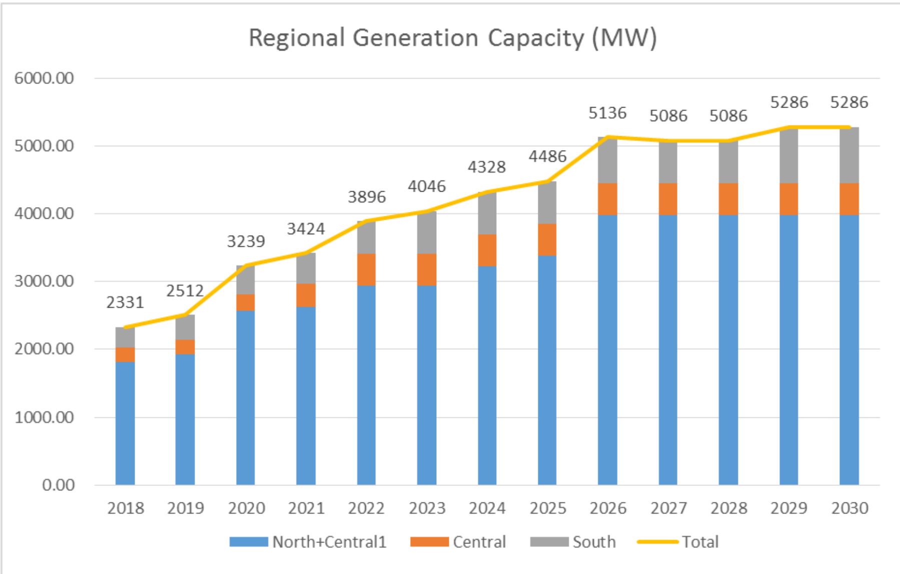
No	Power Plant	MW	Type	COD	Province	Region
31	Nam Chiene	104.00	Reservoir	2018	Saysomboun	NC
32	Nam Ngum Keng Kaun	1.00	Run of river	2018	Xieng Khuang	NC
33	Nam Ngum 1 (Extension Phase 1)	80.00	Reservoir	2018	Vientiane Pro	NC
34	Nam Lik 1	64.00	Run of river	2019	Vientiane Pro	NC
35	Nam Ngipe 2A	12.55	Run of river	2019	Xieng Khuang	NC
36	Nam Ngipe 2B	9.44	Run of river	2019	Xieng Khuang	NC
37	Nam Chee 1	15.00	Run of river	2019	Saysomboun	NC
38	Nam Ou 1	180.00	Run of river	2020	Luangprabang	NC
39	Nam Ou 3	210.00	Run of river	2020	Luangprabang	NC
40	Nam Ou 4	132.00	Reservoir	2020	Phongsaly	NC
41	Nam Sim	8.40	Run of river	2020	Houaphanh	NC
42	Nam Aow (Nam Pot)	15.00	Reservoir	2020	Xieng Khuang	NC
43	MK. Xayaboury (d)	60.00	Run of river	2020	Xayaboury	NC
44	Nam PhaGnai	19.20	Reservoir	2020	Saysomboun	NC
45	Nam The	15.00	Run of river	2020	Xieng Khuang	NC
46	Nam Mon 1	10.00	Run of river	2021	Houaphanh	NC
47	Nam Ngum 1 (Extension Phase 2)	40.00	Reservoir	2021	Vientiane Pro	NC
48	Nam Samoi	5.00	Run of river	2021	Vientiane Pro	NC
49	Nam Hao	15.00	Run of river	2022	Houaphanh	NC
50	Nam Dick 1	15.00	Run of river	2022	Houaphanh	NC
51	Nam Ngao	15.00	Reservoir	2022	Borkeo	NC
52	Nam Houng Down	15.00	Run of river	2022	Xayaboury	NC
53	Nam Ngum 4	240.00	Reservoir	2022	Xieng Khuang	NC
54	Nam Krap	12.00	Run of river	2022	Saysomboun	NC
55	Nam Pha	180.00	Reservoir	2024	Luangnamtha	NC
56	Nam Phouan	102.30	Reservoir	2024	Saysomboun	NC
57	Nam Tha 2 (B. Hat Mouak)	37.50	Run of river	2025	Borkeo	NC
58	Nam Bak 2	120.00	Reservoir	2025	Saysomboun	NC
59	Huaphan (Lignite) Unit1 (T)	300.00	Coal	2026	Houaphanh	NC
60	Huaphan (Lignite) Unit2 (T)	300.00	Coal	2026	Houaphanh	NC
NC-Total		**3635.47**	**MW**			
61	Nam Theun 2 (d)	75.00	Reservoir	2009	Khammouan	C
62	Nam Gnoug 8	60.00	Reservoir	2012	Borikhamxai	C
63	Nam Phao	1.60	Run of river	2012	Borikhamxai	C
64	Sugar Mitlao Factory (T)	3.00	Biomass	2012	Savannakhet	C
65	Tadsalen	3.20	Run of river	2013	Savannakhet	C
66	Nam Mang 1	64.00	Reservoir	2016	Borikhamxai	C
67	Nam Ngeip Regulation	20.00	Run of river	2020	Borikhamxai	C
68	Nam Hinboun (Down)	15.00	Run of river	2020	Khammouan	C
69	Nam Sor (Borikhamxai)	4.20	Run of river	2020	Borikhamxai	C
70	Nam Hinboun	30.00	Reservoir	2021	Khammouan	C
71	Xelanong 1	70.00	Reservoir	2021	Savannakhet	C
72	Nam Theun 1 (d)	130.00	Reservoir	2022	Borikhamxai	C
C-Total		**476.00**	**MW**			
73	Xelabam	5.00	Run of river	1970	Champasak	S
74	Xeset 1	45.00	Run of river	1990	Saravan	S
75	Houay Ho (d)	2.10	Reservoir	1999	Attapeu	S
76	Xeset 2	76.00	Run of river	2009	Saravan	S

No	Power Plant	MW	Type	COD	Province	Region
77	Sugar Factory Attapeu (T)	15.00	Biomass	2013	Attapeu	S
78	Xenamnoy 1	15.00	Run of river	2014	Sekong	S
79	Houaylamphanh Gnai	88.00	Reservoir	2015	Sekong	S
80	Xenamnoy 6	5.00	Run of river	2016	Champasak	S
81	Xeset 3	23.00	Reservoir	2016	Champasak	S
82	Xenamnoy 2 - Xekatam 1	20.10	Run of river	2017	Champasak	S
83	Houay por	15.00	Run of river	2017	Saravan	S
84	MK. Donsahong (d)	65.00	Run of river	2019	Champasak	S
85	Houay Chiae	8.00	Run of river	2020	Champasak	S
86	Xepien - Xenamnoy (d)	40.00	Reservoir	2020	Champasak	S
87	Houay Yoi - Houaykod	15.00	Run of river	2021	Champasak	S
88	Houaylamphan Gai (Downstream)	15.00	Run of river	2021	Sekong	S
89	Houay palai	30.00	Reservoir	2022	Champasak	S
90	Nam Phak	150.00	Reservoir	2023	Champasak	S
91	Xekong (Downstream) A	50.00	Run of river	2026	Attapeu	S
92	Houay Ho (e)	150.00	Reservoir	2029	Attapeu	S
S-Total		**832.20**	**MW**			
Total		**4943.67**	**MW**			

Source: MEM

2. Power plants for Laos' domestic system in each region

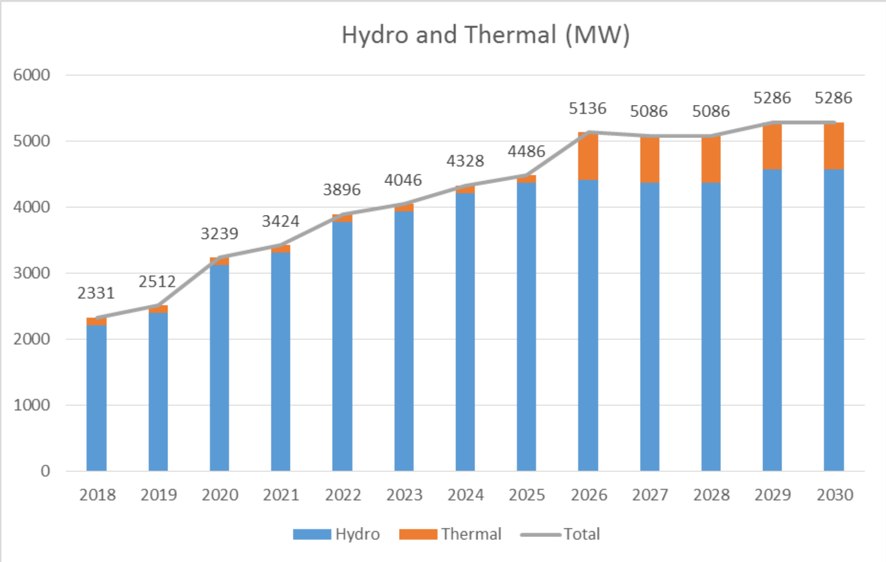
The power supply capacity for the domestic system in Laos will be 5,286 MW in 2030. The power supply capacity in each region is 3,978 MW for the NC system, 476 MW for the C system, and 832 MW for the S system. The power supply capacity ratio in each region is 75% for the NC system, 9% for the C system, and 16% for the S system.



Source: JICA study team based on MEM documents

Figure 17.1-1 Changes in Laos domestic power plant capacity

As of 2018, during the rainy season, the amount of power supply that has already exceeded power demand has already been secured. However, power supply shortages during the dry season after 2026 will require the development of thermal power or power imports from neighboring Thailand. From an energy security point of view, it is desirable to cover the supply capacity within the Laos system. Therefore, it is recommended to develop thermal power in Laos for dry season supply capacity while paying attention to its economy.



Source: JICA study team based on MEM documents

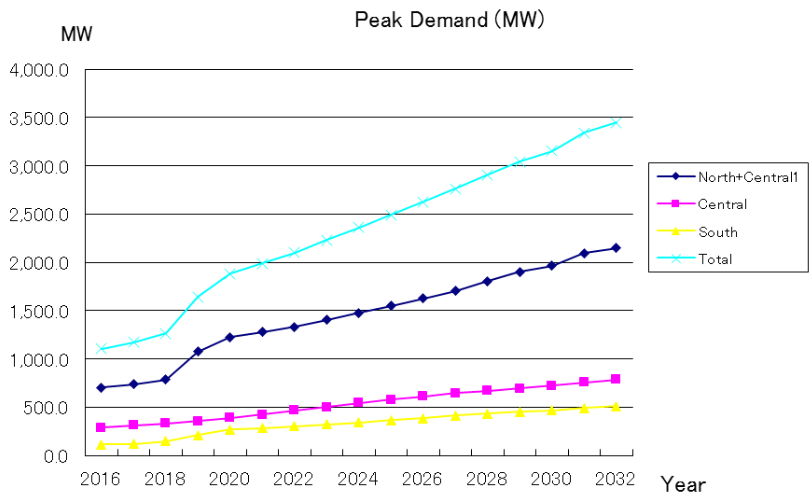
Figure 17.1-2 Changes in hydro/thermal ratio of Power supply facilities for Laos system

17.1.2. Domestic demand forecast in Laos by 2030

1. Peak demand (MW) forecast

The Laos NC system, consisting of the north and central 1 areas, is expected to export 100 MW of power to Myanmar from 2020, and 240 MW from a data center in Luang Pragang from the end of 2019. The Laos S system is expected to export 70 MW of electricity to Cambodia in 2019 and 120 MW in 2020.

The peak demand forecast in 2030 is a total of 3,152 MW, consisting of 1,965 MW for the Laos NC system, 720 MW for the Laos C system, and 466 MW for the Laos S system. Annual growth rates of peak demands are, NC system 8% C strain of 7%, S-system 11%.



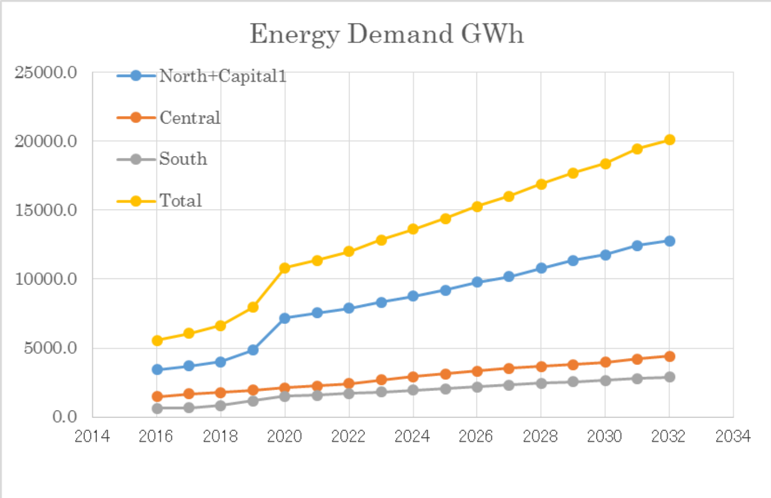
Source: JICA study team based on EDL documents

Figure 17.1-3 Peak demand forecast by region (MW)

2. Electric power forecast (GWh)

The peak demand forecast for 2030 is 18,396 GWh for the whole Laos system, consisting of 11,780 GWh for the Laos NC system, 3,969 GWh for the Laos C system, and 2,647 GWh for the Laos S system. In this power demand forecast, the Laos NC system includes power exports to Myanmar, and the Laos S system includes Cambodia's power exports.

The annual average growth rates are 7%/year for the NC system, 6%/year for the C system, 10%/year for the S system, and 8%/year for all Lao systems.



Source: JICA study team based on EDL documents

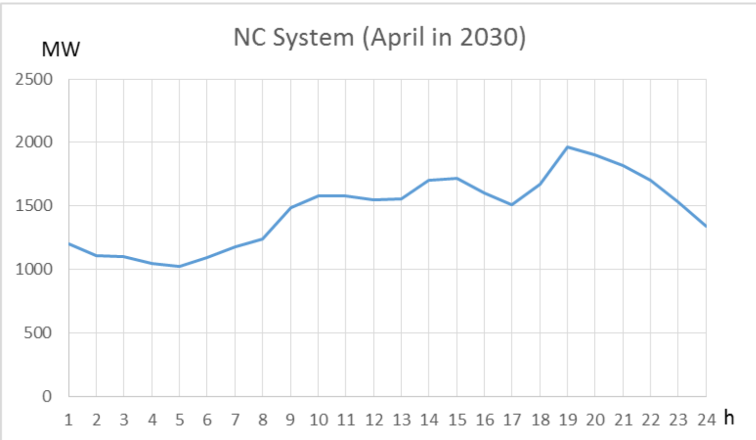
Figure 17.1-4 Electric power forecast (GWh) by region

3. Daily load curve forecast by region

Using the average of the actual values from 2012 to 2016, a daily load curve for each power system in 2030 has been assumed. The assumed daily load curves are shown below.

a) Laos NC system

From the average of the actual values from 2012 to 2016, the peak demand is at 19:00 in April 2030.

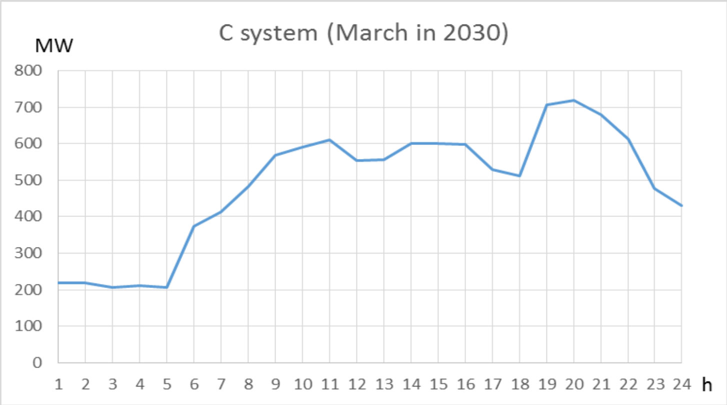


Source: JICA study team based on EDL documents

Figure 17.1-5 Estimated daily load curve in the Laos NC system (at peak demand in 2030)

b) Laos C system

From the average of the actual values from 2012 to 2016, the peak demand is at 20:00 in March 2030.

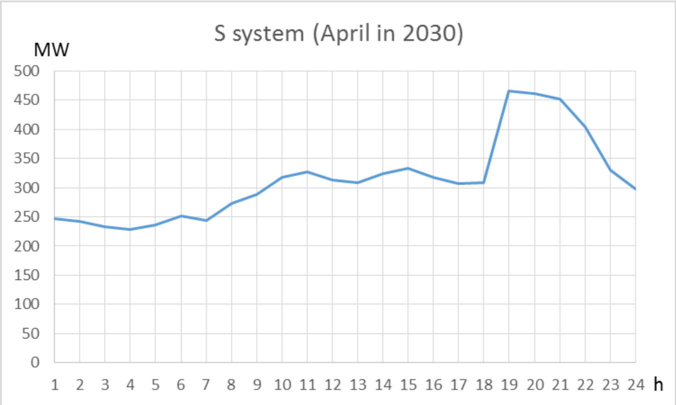


Source: JICA study team based on EDL documents

Figure 17.1-6 Estimated daily load curve in the Laos C system (at peak demand in 2030)

c) Laos S system

From the average of the actual values from 2012 to 2016, the peak demand is at 19:00 in April 2030.



Source: JICA study team based on EDL documents

Figure 17.1-7 Estimated daily load curve in the Laos S system (at peak demand in 2030)

17.2. Power Supply/Demand balance simulation conditions

17.2.1. System configuration for Supply/Demand balance simulation in Laos

Currently, the EDL system is synchronized with the EGAT system at 115 kV via AC interconnections. Therefore, the simulation is performed considering this interconnection between the EDL and EGAT systems.

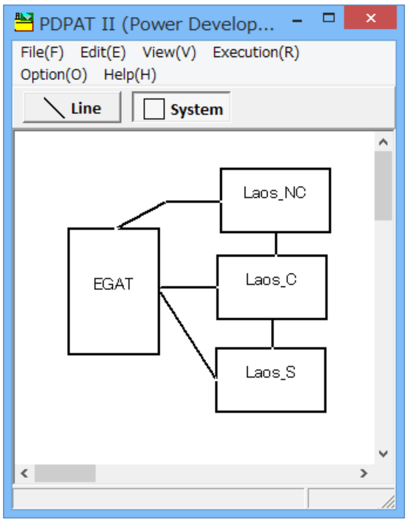


Figure 17.2-1 Current interconnections between EDL and EGAT

The following two benefits can generally be considered in performing grid interconnection.

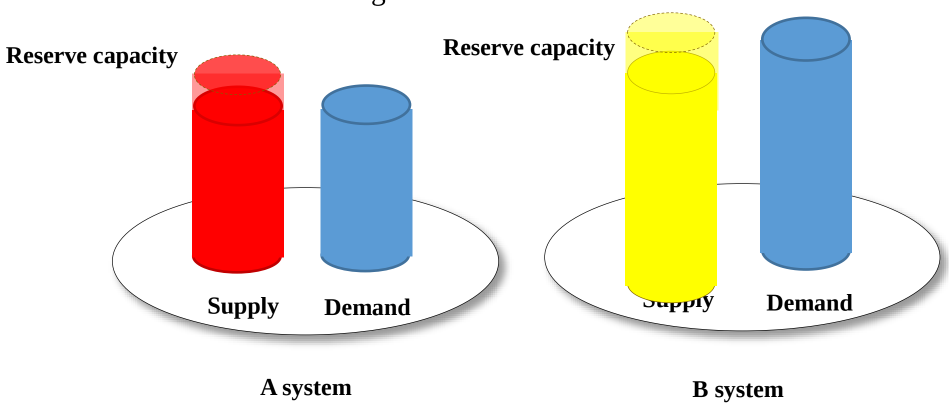
① Increase the possible mutual usage amount of the peak supply facilities due to there being unequal times for peak demand among interconnected systems[2], thereby reducing the amount of peak supply facilities required to secure the reliability criteria.

② Fuel costs can be reduced through rational operation (economical operation) of power supply facilities, utilizing the differences in supply and demand structures.

The Lao domestic system can be divided into three parts - northern and central part 1, central part 2, and southern part - based on the power demand forecast and the transmission equipment installation situation. The benefits of the interconnection between these three systems are evaluated via a demand/supply balance simulation. After that, the benefits of interconnection with neighboring countries are evaluated via a supply/demand balance simulation, and compared with grid interconnection plans in the GMS, by the World Bank, in ASEAN, etc., and recommendations are made for interconnection plans with neighboring countries.

The illustration below shows the effect of reducing reserve capacities by utilizing unequal times of peak demand.

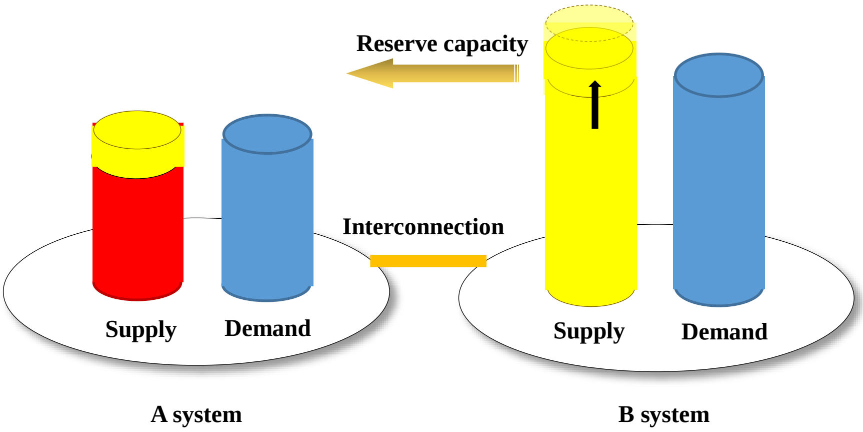
① When there is no grid connection: It is necessary to develop supply capacity sufficient to cover the demand within the local grid.



[2] The probability of a simultaneous occurrence of peak demand in different power systems is low due to geographical differences (time differences, etc.), weather differences, demand structure differences, and the like. This is called unequal time. Due to unequal times of demand, when peak demand occurs on one side the other power system frequently has peak supply facilities as reserve capacity. By utilizing this reserve margin among interconnected systems, it is possible to reduce the necessary reserve capacity to secure the supply reliability criteria in each system.

② When there is a grid connection: Generally, the time when the peak demand is generated differs between each system (unequal time).

Since the reserve capacity can be mutually utilized among interconnected systems via the interconnection line, the amount of necessary reserve can be reduced.

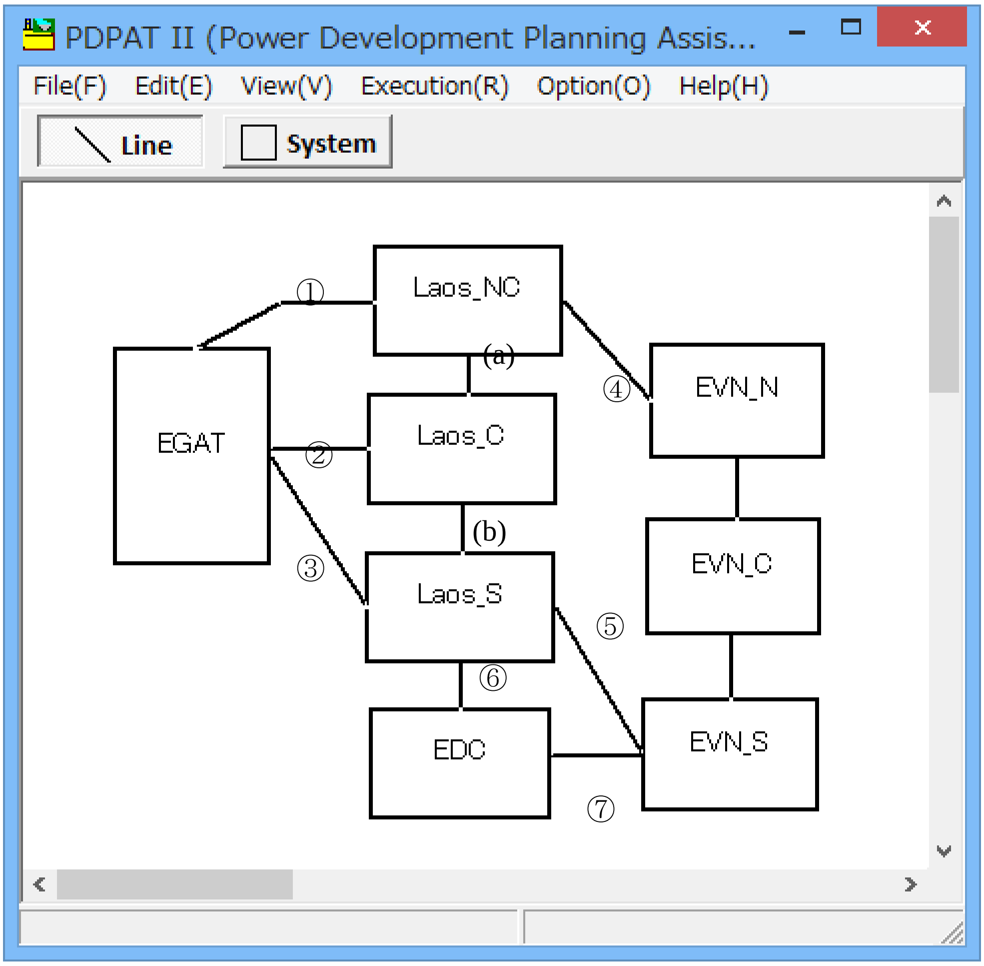


Taking into account the supply/demand balance situation in Laos, the improvement of grid operation capacity, and the status of interconnection plans with neighboring countries, a supply/demand balance simulation is conducted with the grid configuration shown in the following section, assuming that the interconnections with neighboring countries will progress from 2030 onwards. We then evaluate the interconnection benefits.

17.2.2. Interconnections among the Laos domestic system and neighboring country systems in 2030

The power system in Laos is categorized according to the Laos NC system in the north and central 1, Laos C system in the central part 2, and Laos S system in the south in consideration of the demand situation in Laos's domestic systems and the plans to expand transmission lines up to 2030.

The status of the interconnections between Laos's domestic system and surrounding countries' systems in 2030 is shown below, based on interviews with Thailand's EGAT, Vietnam's MOIT, and Cambodia's EDC. The interconnection benefits are confirmed via a supply/demand balance simulation, and an effective interconnection method (capacity, interconnection point, etc.) is proposed.



Source: JICA study team

Figure 17.2-2 Interconnection among Laos's system and neighboring countries' systems in 2030

Table 17.2-1 Interconnections among Laos and surrounding countries' systems in 2030

No.	Interconnection	Voltage (kV)	Capacity (MW)
(a)	Laos NC – Laos C	230	300
(b)	Laos C – Laos S	115	200
①	Laos NC – Thai EGAT	500, 230	1000
②	Laos C – Thai EGAT	115	200
③	Laos S – Thai EGAT	115	100
④	Laos NC – Vietnam N	Generator to system (G to S)	
⑤	Laos S – Vietnam N	Generator to system (G to S)	
⑥	Laos S – Cambodia	500	500
⑦	Vietnam S – Cambodia	220	200

Source: JICA study team

Breakdown of each interconnection capacity in 2030 is as follows.

1. Interconnection between Laos system – Thai system

① Capacity of interconnection between Laos NC system – Thai EGAT system

i) New 500 kV (rooms of transmission line from Pak Beng HPP) 400 MW

ii) Existing 115 kV Vientiane capital area transmission line 300 MW

iii) New 115 kV transmission line in Vientiane capital area 300 MW

② Capacity of interconnection between Laos C system – Thai EGAT system

i) Existing 115 kV transmission line at Paksan, Thakhek area 200 MW

③ Capacity of interconnection between Laos S – Thai EGAT

i) Existing 115 kV transmission line at Pakse area 100 MW

ii) 500 kV transmission line from Xe Pian – Xe Nam Noi HPP is not considered as an interconnection.

2. Interconnection between Laos – Vietnam systems

Interconnections between Laos and Vietnam ④ and ⑤ have no system-to-system connections up to 2030. Therefore, these are not included in interconnection base cases in 2030.

3. Interconnection between Laos and Cambodia systems

Interconnection between Laos's south system and Phnom Penh in the Cambodian system is a G-to-System connection as per the policy of EDC. Therefore, the interconnection between the Laos S system and Phnom Penh system will not be a synchronous connection. However, when connecting at 500 kV in some cases, there is a possibility that synchronized parts may occur, so the interconnection capacity of 500 MW is considered.

17.3. Economic evaluation of power supply operations via supply/demand balance simulation

The benefits of connection between the Lao NC system and Thai EGAT system in 2030 are verified via a supply/demand balance simulation.

The Laos NC system includes a data center load (240 MW) and a partial load in Myanmar (about 500 MW).

17.3.1. Fuel cost assumptions and capacity settings

The study team made estimations on thermal power plants in Laos from the data provided by MEM. For the fuel costs of thermal power plants in Thailand, the study team uses oil, gas and coal prices in Southeast Asia based on the most probable stated policy from the World Energy Outlook 2019 (WEO 2019), issued by the IEA.

Table 17.3-1 Fuel prices (WEO 2019)

		2018	2025	2030	2035	2040
Oil	$/boe	68	81	88	96	103
Natural Gas	$/MBtu	8.2	9.1	9	9.3	9.8
Coal	$/tce	106	88	89	91	92

*boe (barrel of Oil equivalent), tce (ton of Coal equivalent)

Source: WEO2019, IEA

Table 17.3-2 Fuel costs at Laos' thermal plants

Site	Kcal/kg	USD/t
Hongsa Lignite	2430	9.1
Huaphan	5500	63.54
Kalum	3040	33.44
Lamam	3300	33

Source: JICA study team based on MEM documents

The connection capacity between the Lao NC system and the Thai EGAT system has been studied with the following settings.

Table 17.3-3 Interconnection Scenarios

Conditions	Interconnection capacity between Laos NC system and Thai EGAT system (MW)
Scenario 1: Existing 115 kV interconnection	300
Scenario 2: Existing 115 kV interconnection + new 230 kV interconnection	600
Scenario 3: Existing 115 kV interconnection + new 230 kV interconnection + new 500 kV transmission line from Pak Beng	1000

Source: JICA study team

17.3.2. Change in the amount of power transactions for each scenario

The simulation results for each scenario are shown in below.

1. Power transuction in Scenario 1

The following table shows the power transuction amount for the Laos NC system and the Thai EGAT system when the interconnection capacity is the same as the existing 300 MW.

Table 17.3-4 Amount of power transaction in Scenario 1 (300 MW of interconnection capacity)

Source: JICA study team

Scenario 1	GWh
Laos NC ⇒ Thai EGAT	2116.7
Thai EGAT ⇒ Laos NC	12.9
Laos C ⇒ Thai EGAT	927.0
Thai EGAT ⇒ Laos C	0.0
Laos S ⇒ Thai EGAT	383.4
Thai EGAT ⇒ Laos S	3.7
Laos ⇒ Thailand	3427.1
Thailand ⇒ Laos	16.6

2. Power transaction in Scenario 2

The following table shows the power transaction amount for the Laos NC system and the Thai EGAT system when the interconnection capacity is the same as the existing 600 MW.

Table 17.3-5Amount of power transaction in Scenario 2 (600 MW of interconnection capacity)

Source: JICA study team

Scenario 2	GWh
Laos NC ⇒ Thai EGAT	3112.8
Thai EGAT ⇒ Laos NC	12.9
Laos C ⇒ Thai EGAT	751.0
Thai EGAT ⇒ Laos C	0.0
Laos S ⇒ Thai EGAT	376.3
Thai EGAT ⇒ Laos S	3.7
Laos ⇒ Thailand	4240.1
Thailand ⇒ Laos	16.6

3. Power transaction in Scenario 3

The following table shows the 1000 MW interconnection capacity utilizing the surplus room in the 500 kV transmission line from Pak Beng Hydro power plant, planned on the Mekong main stream.

Compared to the 300 MW interconnection capacity in scenario 1, 1845.4 GWh of surplus power in Laos will be used to reduce fossil fuel consumption in EGAT's system. If the electric power trading price were 5 c/kWh, the additional annual income would be 92M USD.

Table 17.3-6 Power transaction with 1000 MW interconnection

Source: JICA study team

Scenario 3	GWh
Laos NC ⇒ Thai EGAT	4189.1
Thai EGAT ⇒ Laos NC	12.9
Laos C ⇒ Thai EGAT	708.8
Thai EGAT ⇒ Laos C	0.0
Laos S ⇒ Thai EGAT	374.6
Thai EGAT ⇒ Laos S	3.7
Laos ⇒ Thailand	5272.5
Thailand ⇒ Laos	16.6

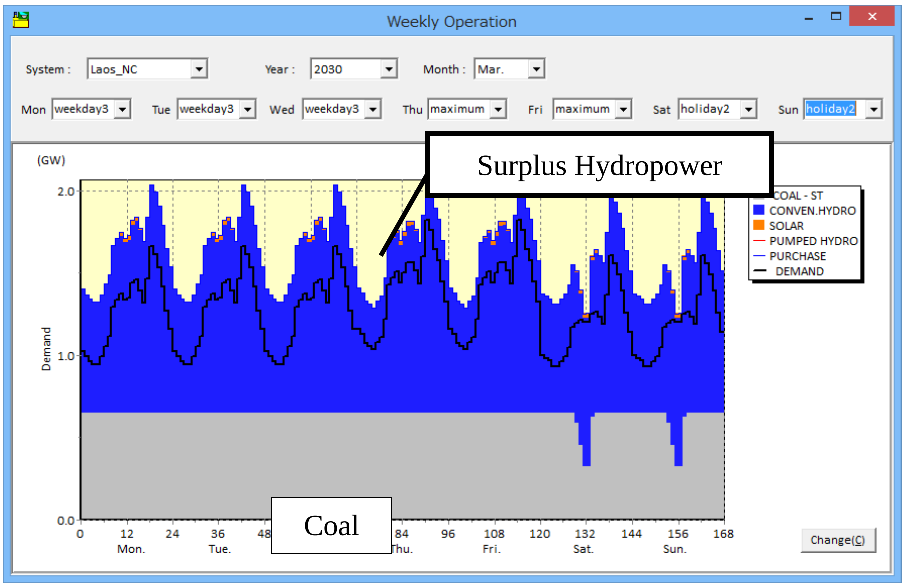
17.3.3. Supply/demand balance in each scenario

1. Supply/demand balance in Scenario 1

In the rainy season, the surplus outputs from Lao hydropower can be utilized in the Thai system. Since the interconnection capacity is limited, the amount of power transuction is limited. The amount of power transuction has been calculated to be 3,427 GWh/year.

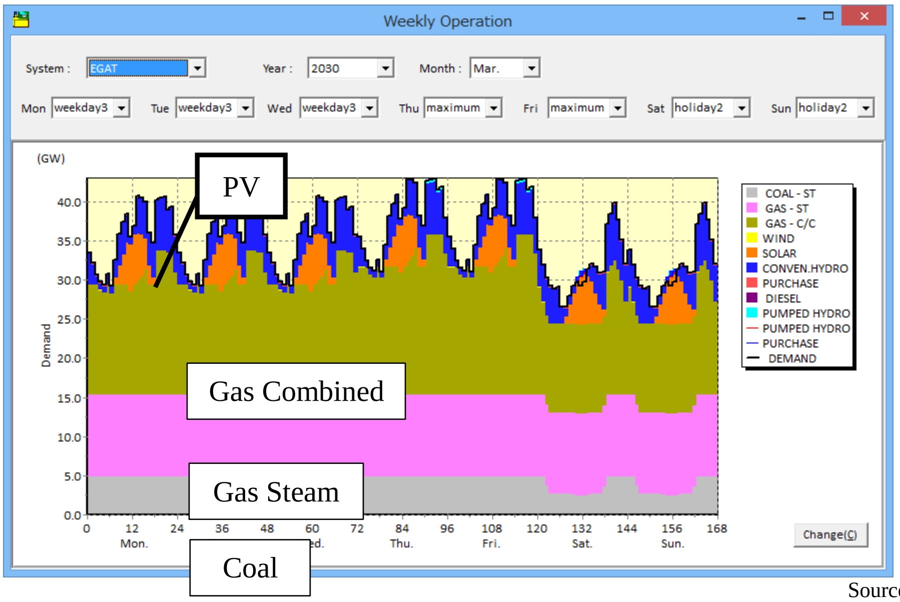
a) Supply/demand balance in dry season

In the dry season, half of the power trade amount in the rainy season (around 100 GWh/month) is provided to the Thai system.



Source: JICA study team

Figure 17.3-1 Supply/demand balance in Laos NC system (March 2030)



Source: JICA study team

Figure 17.3-2 Supply/demand balance in EGAT system (March 2030)

b) Supply/demand balance in rainy season

The surplus power from Laos hydropower during the rainy season (200 GWh/month) can be utilized to reduce thermal power fuel consumption in the Thai system. However, the surplus power from hydropower plants still remains.

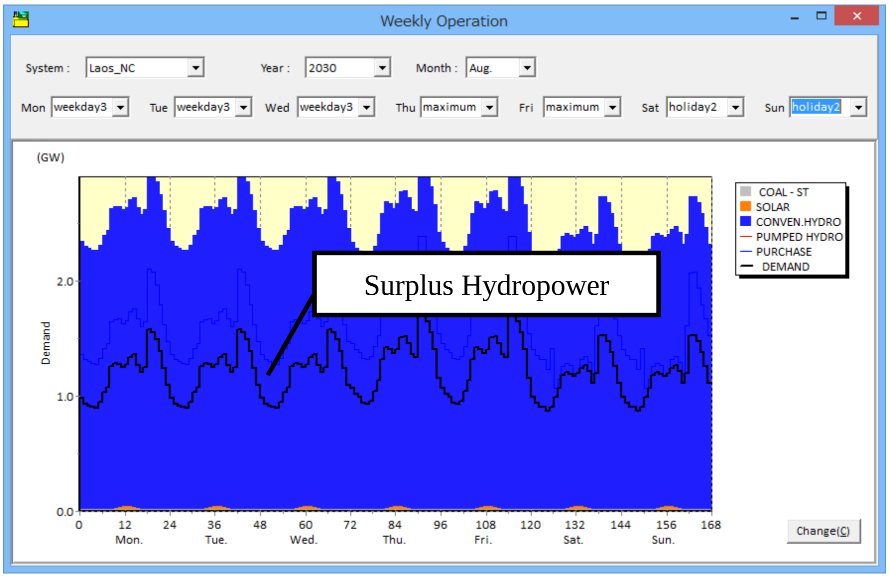


Figure 17.3-3 Supply/demand balance in Laos NC system (Aug. 2030)

Source: JICA study team

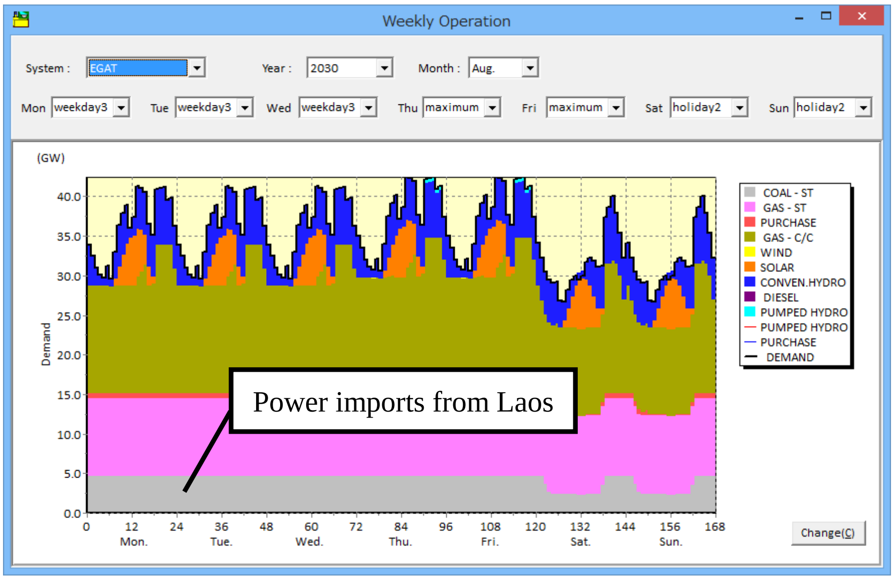


Figure 17.3-4 Supply/demand balance in EGAT system (Aug. 2030)

Source: JICA study team

2. Supply/demand balance in Scenario 2

Compared to Scenario 1, the interconnection capacity is doubled to 600 MW. The amount of power transuction is 1.2 times, at 4,2040 GWh/year.

a) Supply/demand balance in dry season

Compared to Scenario 1, the amount of power transuction has a slight increase, to 110

GWh/month.

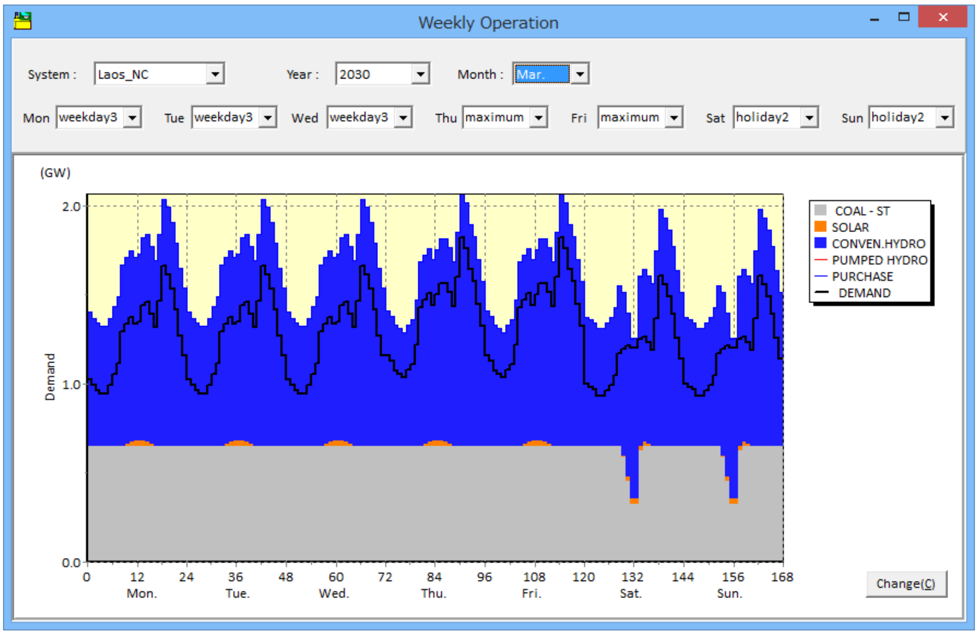


Figure 17.3-5 Supply/demand balance in Laos NC system (March 2030) Source: JICA study team

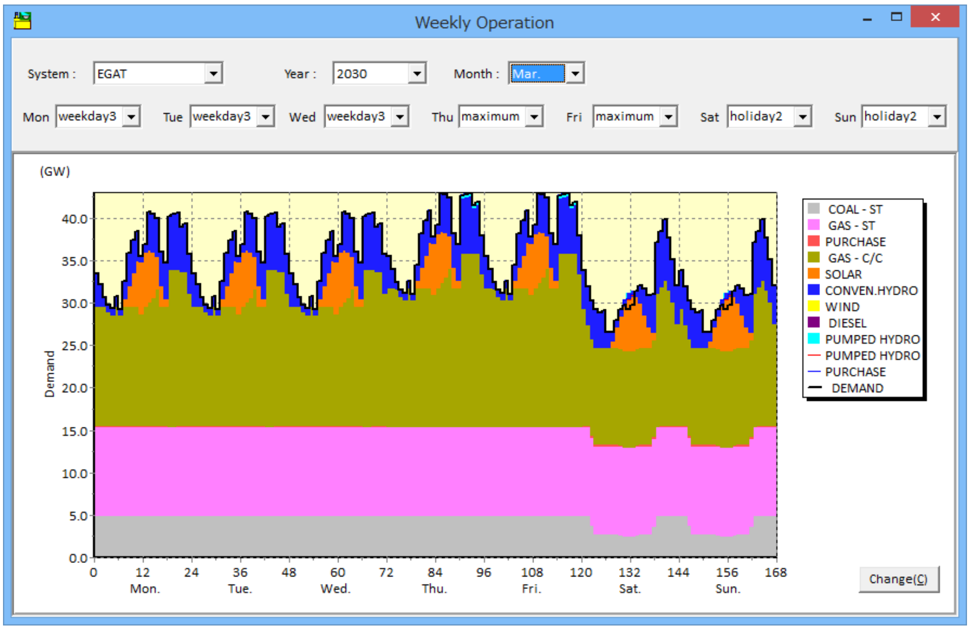


Figure 17.3-6 Supply/demand balance in EGAT system (March 2030)

Source: JICA study team

b) Supply/demand balance in rainy season

Since the interconnection capacity was doubled compared to Scenario 1, the amount of power transuction is doubled during the rainy season to 400 GWh/month. However, the surplus power from hydropower plants still remains in the rainy season.

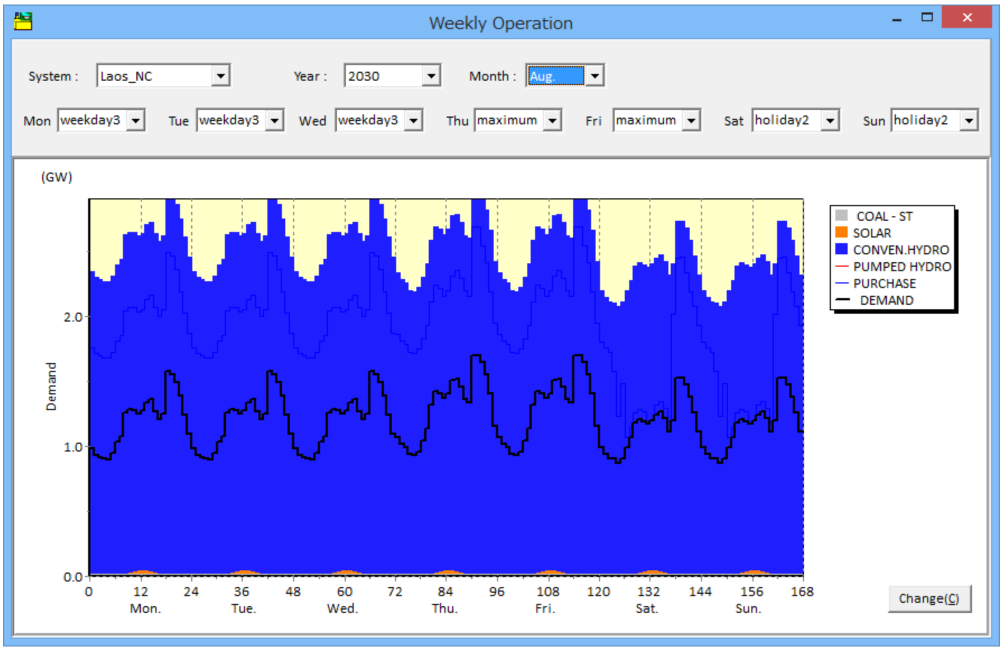


Figure 17.3-7 Supply/demand balance in Laos NC system (Aug. 2030) Source: JICA study team

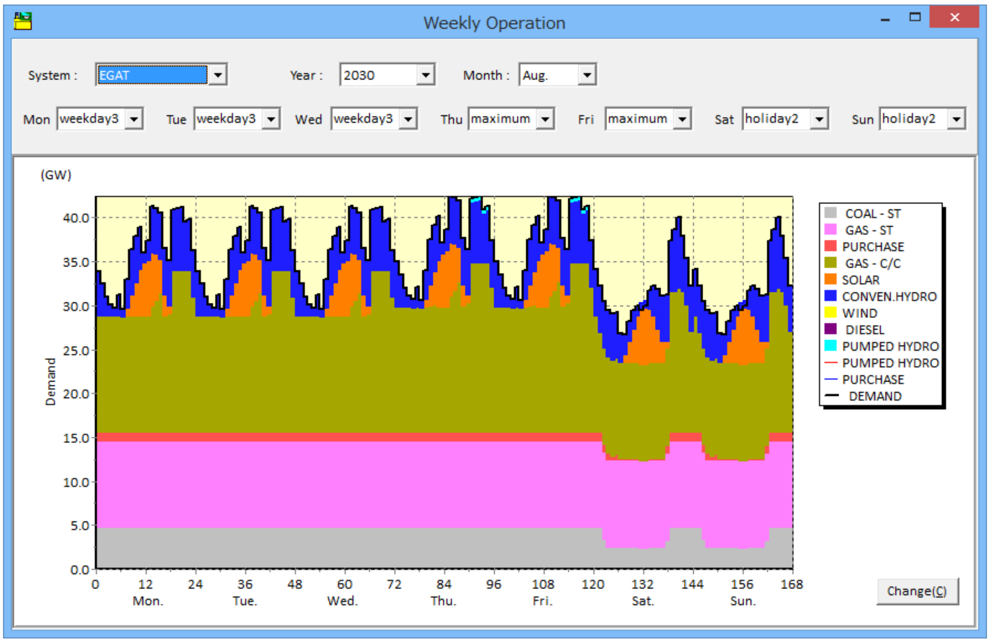


Figure 17.3-8 Supply/demand balance in EGAT system (Aug. 2030)

Source: JICA study team

3. Supply/demand balance in Scenario 3

Compared to Scenario 1, the interconnection capacity is more than tripled to 1000 MW. The amount of power transuction is 1.5 times, increasing to 5,272 GWh/year.

a) Supply/demand balance in dry season

Although the interconnection capacity is more than tripled compared to Scenario 1, the amount of power transuction during the dry season remains at 110 GWh/month, similar to Scenario 2.

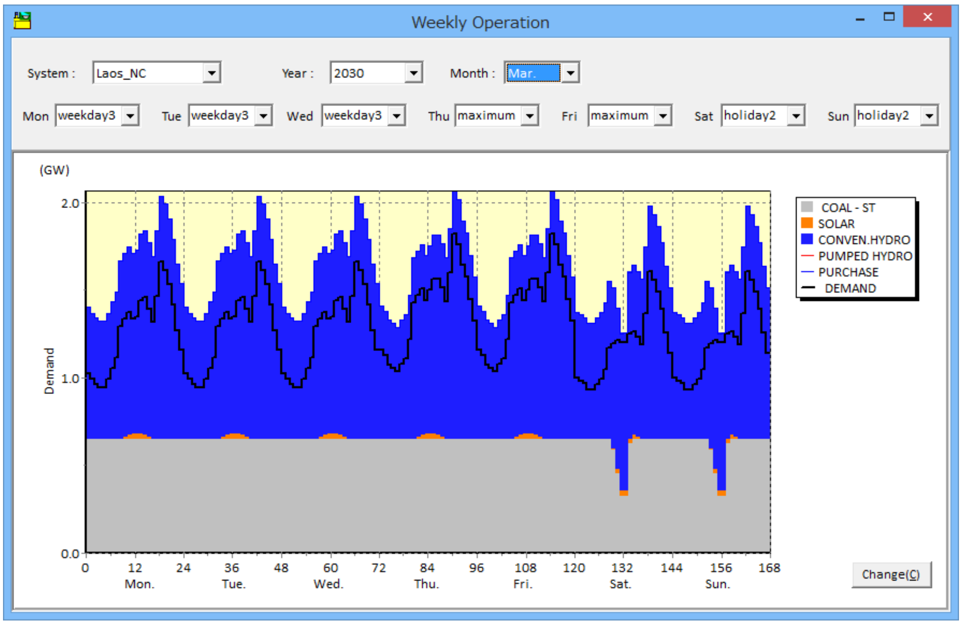


Figure 17.3-9 Supply/demand balance in Laos NC system (March 2030)

Source: JICA study team

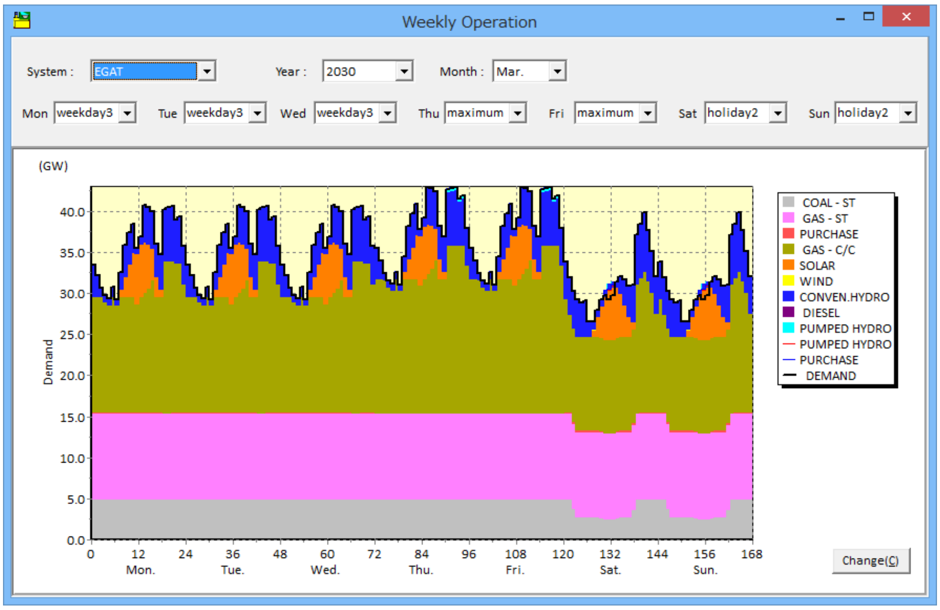


Figure 17.3-10 Supply/demand balance in EGAT system (March 2030)

Source: JICA study team

b) Supply/demand balance in rainy season

The amount of power transuction in rainy season increases to 680-700 GWh/month. Surplus power from hydropower at peak times is eliminated, but surplus power still remains at off-peak times. In the off-peak Thai system, the increase in PV will reduce the capacity from thermal power, which limits the acceptance of surplus power from Laos' hydropower plants. In the Lao system, it is necessary to adjust the hydropower output during off-peak times.

According to PDP 2018, in the Thai system after 2030, contracts for large-scale thermal IPPs will decrease. The controllable capacity is expected to increase, in following increment of the thermal power plants owned by EGAT. Then, the amount of surplus power from Laos' hydropower plants utilized in the Thai system is expected to increase.

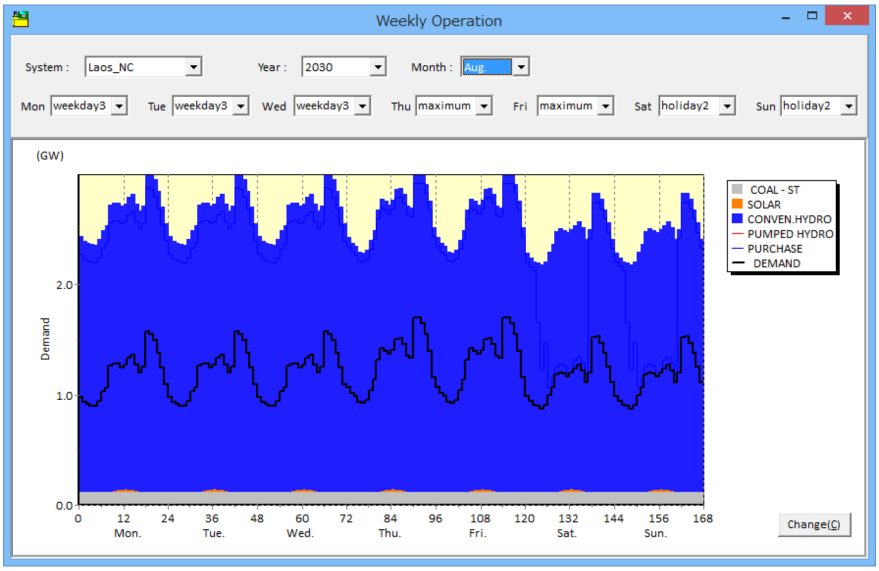


Figure 17.3-11 Supply/demand balance in Laos NC system (Aug. 2030) Source: JICA study team

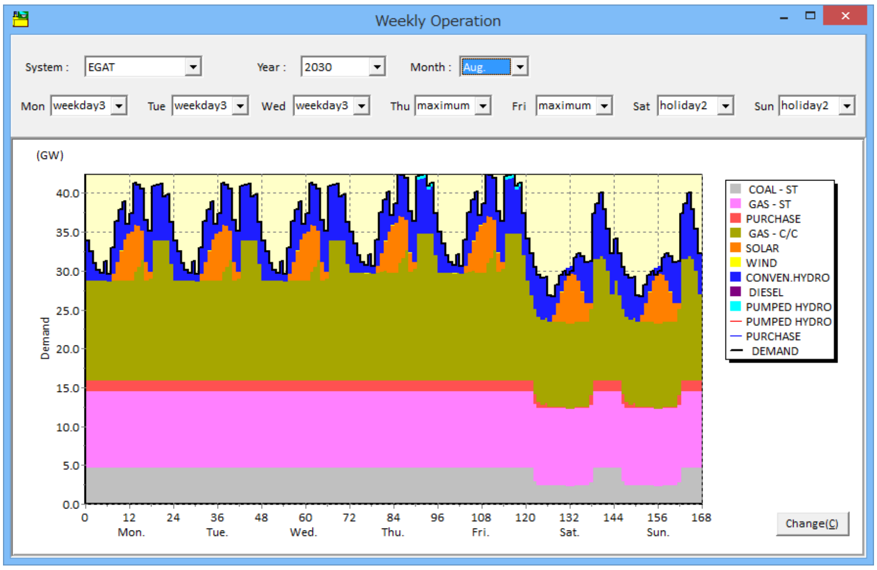


Figure 17.3-12 Supply/demand balance in EGAT system (Aug. 2030) Source: JICA study team

17.3.4. Summarization of Supply/Demand balance simulation

1. Interconnections between neighboring countries

Considering the current power developments in the Laos system, there is a large amount of surplus power from hydropower plants in the Laos NC system in 2030. It is unlikely that the surplus power from hydropower plants will be eliminated through Laos' domestic demand. In the Thai system, the output from the northern coal-fired power plants will decrease due to aging and a decrease in Lignite reserves. As a result, the transmission capacity of the 500 kV transmission line used for power evacuation from the coal-fired power plants will have some room. Given this, it is expected that interconnection between the Laos NC system and the 500 kV system in the northern part of the Thai system will help improve the power generation efficiency of both systems.

2. Interconnection between Laos NC system and northern Thai system

At an interconnection capacity of 1000 MW, the surplus power from hydropower in the Laos NC system would be eliminated during peak times and on weekdays in the rainy season. However, during the off-peak daytime, the capacity of thermal power plants for curtailment in fuel consumption is reduced due to the increase in PV output in the Thai system, meaning that the amount of power transuction utilizing surplus power in the Laos system is reduced.

Thermal power IPP contracts for the Thai system will decrease from 2030 onward, and the number of thermal power plants owned by EGAT will increase, so it is expected that the adjustment capacity for the curtailment of fuel consumption would increase. For this reason, it can be expected that the surplus hydropower in the Laos system would be used to reduce fuel consumption at thermal power plants in the Thai system even after 2030.

17.3.5. Recommendations for facilitating power transuction among neighboring countries

1. Development of Supply power in Laos system during dry season

The current hydropower-oriented development will not solve the issue of power shortages during the dry season. In addition, there is a concern that oversupply in the rainy season will increase the problem of overpayment with take-or-pay contract IPPs. Therefore, it is necessary to study the supply power during the dry season in the Laos system. The following dry season supply is considered based on the current situation in the Laos and Thai systems.

- Development of a Lignite-fired thermal power plant, Lignite being mined in Laos (since only dry season supply is required, it is developed as middle supply generation at around 50% of the capacity factor)
- Reservoir-type hydropower operation regulated in utilizing PV during the dry season. In particular, it is important to utilize Houay Ho (126 MW, to expire 2029) and Nam Thuen 2 (948 MW, to expire 2031) after their PPA has expired
- Power imports from the Thai system

The most economical dry season supply should be examined.

2. Capacity building in Power development planning

MEM and EDL can carry out studies on economical supply in the dry season considering power imports from neighboring countries and generator operation in their system by themselves. It is necessary to establish a power development plan based on the study.

Chapter 18. Power System Operational Challenges for GMS-wide Power Trading

18.1. Challenges in Adjusting Grid Codes in Each Country to comply with the GMS Regional Grid Code in order to Promote GMS-wide Power Trading

Thailand & Vietnam already have detailed grid codes, and their actual operations are based on them. Domestic Grid Codes still have some issues to be improved from the aspect of consistency with the GMS Regional Grid Code and international cooperation. Nevertheless, there are no problems with the autonomous revision procedure being implemented.

Laos, Myanmar and Cambodia have big issues in this matter, especially in terms of international coordination. Table 18.1-1 shows the results of gap analyses between fundamental policies, important rules in the GMS Regional Grid Code and the current status of domestic grid codes in Laos, Myanmar and Cambodia.

Laos has its own domestic grid code, but it has not been officially approved or operated. It is undergoing revision work. The rules are too general and abstract, the relevant parties and penalties are not clear, and its effectiveness is poor.

Cambodia also has a domestic grid code which is currently being revised. No detailed research has been conducted on its effectiveness, but it is objectively similar to the status in Laos.

Myanmar does not have its own grid code.

Connection Code

	Cambodia	Laos	Myanmar (No Grid Code)
The Connection Code contains a set of connection conditions for **power-generator facilities, HVDC systems including DC connected power modules and Demand facilities.**	No HVDC	No HVDC	
The Connection Code specifies **the acceptable technical design, and operational criteria**, which must be complied with by any Party connected to the GMS Interconnected Network.	Generally Yes, but poor	Generally Yes, but poor	
The objective of the connection conditions is to ensure that, by specifying minimum technical, design and operational criteria, the basic rules for connection to the Interconnected System are **similar for all participants of an equivalent category.**	Generally Yes, but poor	Generally Yes, but poor	
This will enable **the maintenance, preservation and restoration of system security** in order to facilitate proper functioning of the internal electricity market within and between synchronous areas, and to achieve cost efficiencies.	Generally Yes	Generally Yes	
All power-generating facilities shall **be capable of remaining connected to the network and operate** within the frequency ranges and time periods specified in the Connection Code.	Chapter 3 3.3.3 47.0-47.5Hz, 20sec. 47.5-52.0Hz, Unlimited??	Chapter 3 3.5.5.1 47.0Hz ≥5sec. 52.0Hz ≥5sec.	
Type B, C and D power-generating facilities shall **be capable of continuous operation, at up to 100% active power output, within a frequency range of 49.0 to 51.0 Hz and voltage range of 0.05 pu** either side of nominal voltage.	Chapter 3 3.3.3 (3.3.1b, 3.3.2a) 49.5 - 50.5Hz 230kV: +245kV -207kV 115kV: +123kV -103.5kV 22kV: +24kV -19.8kV	Chapter 3 3.5.4.1(a)(b) 49.5 - 50.5Hz 0.95-1.05pu	
Type B, C and D power-generating facilities shall **be capable of continuous operation at any point between the limits of 0.85 power factor leading and 0.95 power factor lagging**, when supplying 100% active power output.	Chapter 3 3.3.3 0.95 leading - 0.85 lagging	Chapter 3 3.5.4.1(c) 0.9 leading - 0.85 lagging	
The active power output from Type B, C and D power-generating facilities **shall not decrease by more than a proportionate decrease in frequency** when the frequency varies within the range of 47.5 to 49.0 Hz.	Chapter 3 3.3.3 Pro-rata with frequency 47.0 - 49.5Hz	Non	
All power-generating facilities shall be designed to **be capable to provide power-frequency response** in order to stabilise the grid frequency.	Chapter 3 3.3.3 Speed Governor	Chapter 3 3.5.7.2, 3.5.7.5 Speed Governor	
Type C and D power-generating facilities shall be equipped with appropriate plant controllers **enabling the Automatic Generation Control functions** to provide the required Secondary Reserve for the Control Area.	Non	Chapter 3 3.5.7.3(b) AGC	
Power-generating facilities contracted for **black start** shall have the capabilities specified in the Connection Code.	Non	Chapter 3 3.5.9.2 Blackstart	
The power-generating facility owner shall demonstrate to the relevant system operator that it has complied with the requirements set out in this code by successfully completing the **operational notification procedure** for connection of each power-generating module as specified in the Connection Code.	Chapter 3 3.5.1d.	Chapter 5 5.11.1 Test Requirements	
Power-generating facility owners shall undertake the response **compliance tests**, frequency restoration control tests, black start tests, tripping to house-load tests, reactive power capability tests when required and as specified in the connection Code	Chapter 7 7.3 Black start	Chapter 5 5.11.2 Tests to be performed	
All Demand facilities shall **be capable of remaining connected to the network and operate** within the frequency ranges and time periods specified in the Connection Code.	Non	Non	
Tripping times for when frequency goes outside of the normal operating range of 49.0 to 51.0 Hz shall be agreed with the relevant TSO. **The TSO shall co-ordinate such settings** to minimise the risk of cascade tripping and network collapse.	Non	Chapter 3 3.6.2.1 Connection Agreement	
All Demand facilities shall fulfil the requirements related to **low frequency demand disconnection functional capabilities** as specified in the Connection Code.	Chapter 3 3.3.4a Only general provision	Chapter 3 3.6.2.2-3.6.2.4 UFLS specification	

Operational Security Code

	Cambodia	Laos	Myanmar (No Grid Code)
To determine the System State, each TSO shall **at least every 30 minutes perform Contingency Analysis in real-time**	Non	Non	
Each TSO shall **monitor in real-time** the following parameters (active-reactive power flows, busbar voltages, frequency, active-reactive reserves, generation - consumption) within its **Responsibility Area** based on real-time telemetry and measurements from its Observability Area.	Chapter 9 9.3 Reportable Events ?	Chapter 5 5.2.1 Operating States 5.2.2.1 Maintaining Normal States	
Each TSO shall use all available economically efficient and feasible means under its control **to maintain in real-time its Transmission System in a Normal State**.		Chapter 5 5.7 Frequency & Voltage Control	
For each element of its Transmission System, each TSO shall define before its use in operation **the Operational Security Limits**	Chapter 3 3.3 Technical Design and Operational Criteria	Chapter 2 Performance Standards Chapter 4 4.5 Planning Studies Load Flow, Short Circuit, Transient Stability, Steady-state Stability, Voltage Stability, Supply Reliability	
For each Interconnector, each **TSO shall coordinate with the interconnected TSO**, the common definition of Operational Security Limits.	Non	Non	
Each TSO shall design its systems in order to ensure **the availability, reliability and redundancy of the following critical tools and facilities,** which are required for system operation: (i) Facilities for monitoring the System State, including State Estimation applications; (ii) Means for controlling switching; (iii) Means of communication with control centres of other TSOs; (iv) Tools for Operational Security Analysis.	Chapter 11 Metering, Communication and Data Acquisition No rules related to tools for system analysis	Chapter 3 3.7 Communication and SCADA Equipment Requirements No rules related to tools for system analysis	
Each TSO shall **contribute to the Load-Frequency Control Structure** according to the requirements for frequency quality defining parameters and **provisions for Active Power Reserves** as defined in the Load Frequency Control and Reserves Code.	Chapter 3 3.3.1a. Nominal : 50Hz Deviation : +/-0.5Hz in normal state 47-52Hz in exceptional circumstances To be coordinated with Vietnam	Chapter 2 2.2.1Frequency Variation Nominal : 50Hz Deviation : +/-0.5Hz, 99.5% time of a yr 47-52Hz, 100% time of a yr To be coordinated with Thailand	
In the case where the frequency is beyond the Maximum Steady-state Frequency Deviation, but within the range 49 -51 Hz, all TSOs of the Synchronous Area shall apply commonly agreed **Remedial Actions** following coordinated procedures agreed among all TSOs of that Synchronous Area in order to recover frequency back within the range of Maximum Steady-state Frequency Deviation	Chapter 6 6.3 Methods of Frequency control	Chapter 5 5.7.1 Reserve 5.7.3 5.7.4 Primary/Secondary control To describe specific remedial actions	
In the case where the frequency is outside of the range 49 -51 Hz, all TSOs of the Synchronous Area shall apply commonly agreed measures of **the System Defence Plan** following coordinated procedures agreed among all TSOs of that Synchronous Area in order to recover and restore frequency within the time ranges specified in the Connection Code	Chapter 6 6.5 Load Reduction	Chapter 5 5.7.5, 5.7.6 Automatic/Manual Load Shedding 5.7.7 Demand Reduction 5.8 Emergency Procedures	
Each TSO shall use all available economically efficient and feasible means under its control to maintain the Transmission System steady-state **voltage at the connection Points** within the ranges of Operational Security Limits	Chapter 3 3.3.1b. Chapter 6 6.6 - 6.8	Chapter 2 2.2.2 Voltage Variation Chapter 5 5.7.2 Voltage Control	
Each TSO shall ensure **Reactive Power reserve**, with adequate volume and time response, in order to keep the voltages within its Responsibility Area within the Operational Security Limits ranges	Non	Chapter 3 3.5.8 Excitation Control	
Each TSO shall **coordinate Operational Security Analysis with other TSOs** in accordance with the multi-party agreements in order to ensure the respect of the Operational Security Limits for voltage ranges in its Responsibility Area and within the Responsibility Areas of these TSOs	Non	Non	
Each TSO shall perform **Operational Security analysis** based on the forecast and real-time operational parameters from its Observability Area.	Non	Non	
Each TSO shall define **the Contingency List**, including Internal and External Contingencies within its Observability Area	Non	Non	

Operational Security Code [Continued]

	Cambodia	Laos	Myanmar (No Grid Code)
Each TSO shall **perform Contingency Analysis** in its Observability Area in real-time operation and in operational planning	Partly Yes No rules for real-time	Partly Yes No rules for real-time	
Each TSO shall **coordinate its Contingency Analysis in terms of coherent Contingency Lists at least with the TSOs** from its Observability Area and in accordance with the concluded multi-party agreements	Non	Non	
Each TSO shall at least every five years review and analyse **the protection strategy and concepts** and when necessary adapt the protection functions to ensure the correct functioning of the protection and the maintaining of Operational Security	Non	Non	
Each TSO shall **coordinate with interconnected TSOs the protection Set-Points for the Interconnectors** and inform and coordinate with those TSOs before changing the settings	Non (Chapter 10 10.4 To be coordinated between Users)	Non	
Each TSO shall **monitor the dynamic state of the Transmission System** in terms of Voltage, Frequency and Rotor Angle Stability by off-line studies, wide area measurements, or other approaches	Non	Real-time monitoring is not specified In the Planning Phase; Chapter 3 3.4.5 Grid Impact Studies Chapter 4 4.5 Planning Studies	
Each TSO shall perform **Dynamic Stability Assessment (DSA) studies** in order to identify the Stability Limits and potential stability problems in its Transmission System	Non	In the Planning Phase; Chapter 3 3.4.5 Grid Impact Studies Chapter 4 4.5.3 Transient Stability 4.5.4 Steady-state Stability	
Each TSO shall be entitled to **gather the information**, which is required for the Operational Security Analysis and related to the following items: (a) Generation; (b) Consumption; (c) Schedules; (d) Balance positions; (e) Planned outages and substation topologies; and (f)Own forecasts	Chapter 2 2.7 Historical Demand Data 2.8 Forecast Demand Data 2.9 Standard Plannng Data 2.10 Detailed Planning Data Chapter 4 4.3 Outage Planning Process Chapter 5 5.4 Scheduling & Dispatch Data	Chapter 4 4.6 Standard Planning Data 4.7 Detailed Planning Data Chapter 5 5.5 Operating & Maintenence Program 5.6 Scheduling & Dispatch	
Obligations among the **TSOs to communicate without undue delay to all neighbouring TSOs any changes** in the protection settings, thermal limits and technical capacities at the Interconnectors between their Responsibility Areas	Non	Non	
Obligations of the **DSOs directly connected to the Transmission System to inform within the agreed timescales their TSOs of any changes** in the data and information scope and contents	Non	Non	
Neighbouring TSOs shall **exchange the structural information** related to the Observability Area	Non	Non	
Neighbouring TSOs shall **exchange the protection Set-Points of the lines** included as external Contingencies in neighbouring TSOs Contingency Lists to allow protection coordination between the different Transmission Systems	Non	Non	
In order to support coordinated Dynamic Stability Assessment (DSA), each TSO shall **exchange with other TSOs within the relevant part of the Synchronous Area the necessary data for DSA**, informing the affected Power Generating Facility Owner	Non	Non	

Operational Planning and Scheduling Code

	Cambodia	Laos	Myanmar (No Grid Code)
All TSOs shall establish **Individual Grid Models** for merging into Common Grid Models consistent with the objectives of the OPS Code for each of the following timeframes: Year-ahead, Month-ahead, Week-ahead, Day-ahead, and Intraday	Non	Chapter 5 5.5.1.1 except "Intraday"	
Each TSO shall establish a Year-Ahead Individual **Grid Model for each of the defined scenarios**, and make it available through the RPCC	Non	Non	
Each TSO shall **create and deliver**, via the RPCC, **its Day-ahead and Intraday Individual Grid Models** in accordance with the provisions defined pursuant to the OPS Code and with the Market Code	Non	Non	
Each TSO shall perform **coordinated Operational Security Analyses** at least at the following **time horizons**: Year-ahead, Month-ahead, Week-ahead, Day-ahead and Intraday	Non	Chapter 5 5.5.1.1 except "Intraday"	
TSOs shall **coordinate between them their Operational Security Analyses** in accordance with the OS Code and in accordance with the OPS Code in order to verify that Operational Security Limits affecting their own Responsibility Areas are not exceeded.	Non	Non	

Load-frequency Control & Reserves Code

	Cambodia	Laos	Myanmar (No Grid Code)
All TSOs of each Synchronous Area shall establish a **Synchronous Area Operational Agreement** that shall at least cover all requirements listed in the LFCR Code.	Non	Non	
All TSOs of each LFC Block shall establish a **LFC Block Operational Agreement** that shall at least cover all requirements listed in the LFCR Code.	Non	Non	
All TSOs of each LFC Area shall establish a **LFC Area Operational Agreement** that shall at least cover all requirements listed in the LFC Code.to the OPS Code and with the Market Code	Non	Non	
All TSOs of each Monitoring Area shall establish a **Monitoring Area Operational Agreement** that shall at least include the specific allocation of responsibilities between TSOs within the Monitoring Area according to the LFCR Code	Non	Non	
All TSOs participating in the same Imbalance Netting Process shall establish an **Imbalance Netting Agreement** that shall at least include the roles and responsibilities of the TSOs according to the LFCR Code.	Non	Non	
All TSOs participating in the same Cross-Border FRR Activation Process shall establish a **Cross-Border FRR Activation Agreement** that shall at least include the roles and responsibilities of the TSOs according to the LFCR Code.	Non	Non	
All TSOs participating in the same Cross-Border RR Activation Process shall establish a **Cross-Border RR Activation Agreement** that shall at least include the roles and responsibilities of the TSOs	Non	Non	
All TSOs participating in the same **Sharing of FCR, FRR or RR** shall establish a **Sharing Agreement** that shall at least cover all requirements listed in the LFCR Code.	Non	Non	
All TSOs participating in the same **Exchange of FCR, FRR or RR** shall establish an **Exchange Agreement** that shall at least cover all requirements listed in Section 2.9 of the LFCR Code.	Non	Non	
All TSOs of a Synchronous Area shall define, in the Synchronous Area Operational Agreement, the **Load-Frequency-Control Structure** for the Synchronous Area.	Non	Non	
Each TSO is **responsible for implementing and operating according to the Load-Frequency Control Structure** of its Synchronous Area	Non	Non	
All TSOs of a Synchronous Area shall **establish a real-time data exchange**	Non	Non	

Emergency Restoration Code

	Cambodia	Laos	Myanmar (No Grid Code)
Each TSO shall design a **System Defence Plan** in consultation with relevant DSOs, Significant Grid Users, neighbouring TSOs and the other TSOs in that Synchronous Area	Chapter 7 Contingency Planning	Chapter 5 5.7.5 5.7.6 Load Shedding 5.8 Emergency Procedures	
Each TSO shall design a **Restoration Plan** in consultation with relevant DSOs, Significant Grid Users, neighbouring TSOs and the other TSOs in that Synchronous Area, to return its system to Normal State as fast as possible	Chapter 7 Contingency Planning	Chapter 5 5.8 Emergency Procedures	

Table 18.1-1 Comparison between the GMS grid code and each domestic code

18.2. Action Plan and Roadmap for Future System-to-system Operation

In this Master Plan, installation of the following two transmission lines is proposed for the future system-to-system:

- A new 500 kV transmission line + back-to-back between the Thai and Laos power grids to export Firm-energy power from MK. Pakbeng or other facilities; and
- A 230 kV Thabok-Pakxan-Bungkan (EGAT) transmission line to enhance synchronous interconnection and generator stability.

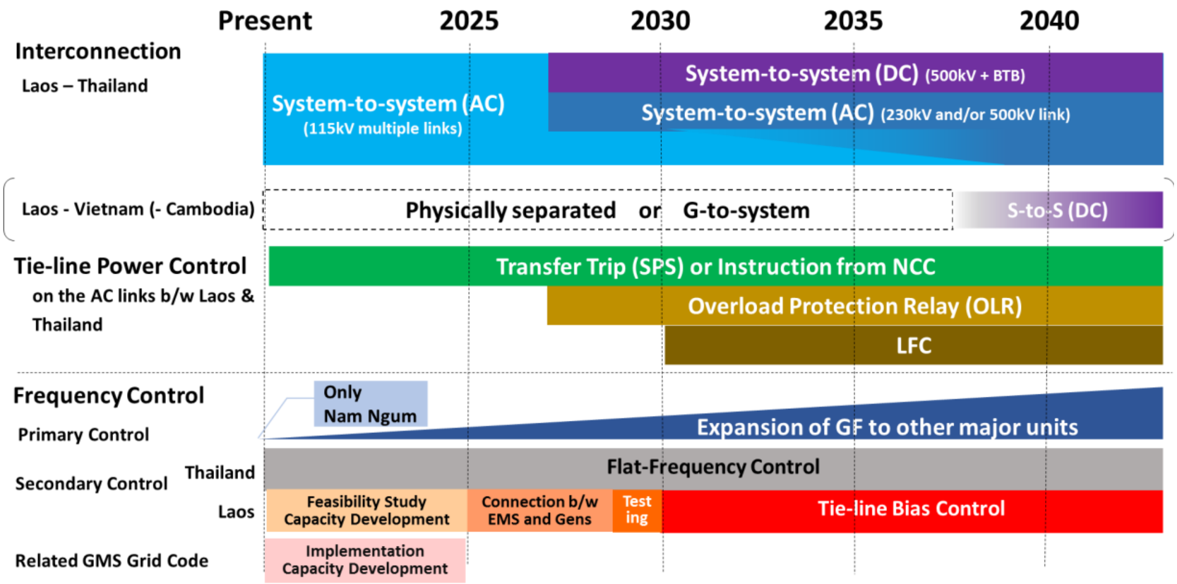


Figure 18.2-1 Roadmap for International Grid Connection Operation Plan

At present, the power systems in both countries are synchronized with each other via multipoint interconnections with 115 kV transmission lines. Thanks to operation and control by EGAT (Thailand), frequency quality is totally maintained, though, in Laos, frequency control (primary control) is not performed except for governor-free operation of the Nam Ngum hydropower generator. In addition, since there is no “secondary control” function to control the power flow on the 115 kV international tie-lines and properly maintain the supply-demand balance in the Lao power system itself, some operational issues, such as overloading of transmission lines near borders and power swings due to the steady state stability limit, have occurred.

Interconnection	with Thailand (EGAT)	synchronized via 115kV lines (multiple points)
	with Vietnam (EVN)	physically separated
GF		Only at Nam Ngum P/S
LFC		FFC by EGAT in total. Tie-line power flow control is not performed

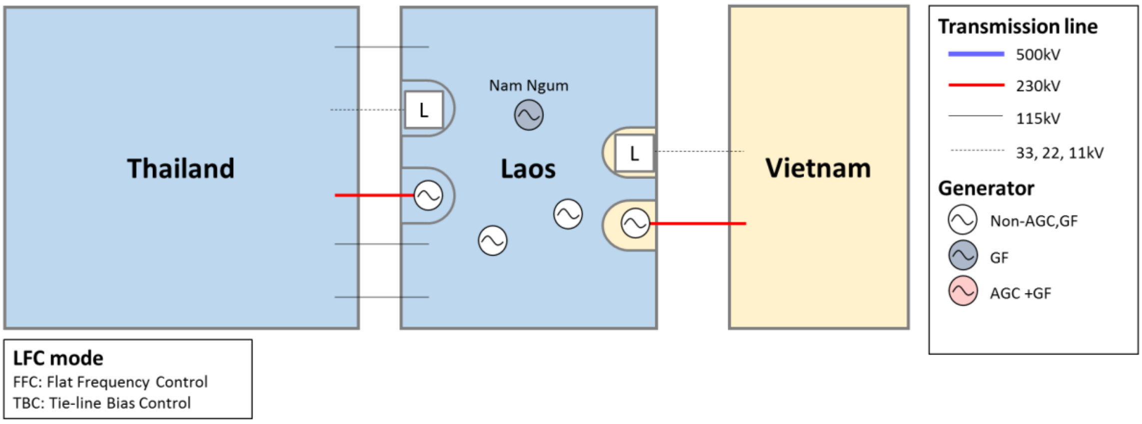


Figure 18.2-2 Current Status of Synchronization between Thai and Lao Grids

As a countermeasure for transmission line overloading, a special protection scheme is applied which issues a transfer trip signal to some generators, or manual control or operational instructions are conducted from EGAT NCC operators to regulate power output from generators. In addition, currently the only countermeasure for power swings is limitation of generator output in advance. In any event, generating power stations must be forced into uneconomical operation due to insufficient generator utilization rates.

After the new 500 kV and 230 kV interconnections have been established (assuming around 2027), the problem of power swings is likely to be mitigated. However, the situation regarding power flows around the interconnection lines will drastically change. In particular, there are concerns about reverse power flow (Loop Flow) from Thailand to Laos via the 230 kV and 115 kV AC interconnection lines once the power trade based on the firm contract via the 500 kV interconnection line begins, unless the necessary amount of supply capacity is procured within the Lao side. This problem can be solved by implementing load frequency control (LFC). However, since it may take a long time to apply the control, it is necessary to consider a tentative measure to control power flow by installing an Overload Protection Relaying System (OLR).

Interconnection	with Thailand (EGAT)	synchronized via **230** and 115kV lines (multiple points)
	with Vietnam (EVN)	physically separated
GF		**Increase GF P/Ss**
LFC		FFC by EGAT in total. **Over load on AC tie-line is mitigated by OLR**

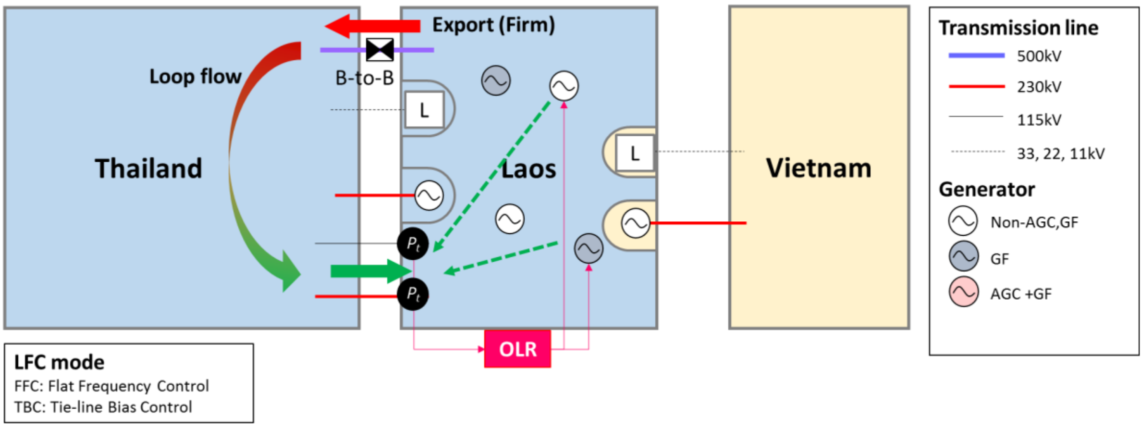


Figure 18.2-3 Application of OLR as a tentative countermeasure for overloading

After this tentative phase, as early as possible after 2030, load frequency control (LFC - TBC: Tie-line Bias Control mode) that comprehensively controls the frequency of the power system and the import/export of power flow on the international interconnection in real time should be performed. This technology is necessary for the establishment of wide-area power trading in the GMS region. Especially for countries that are synchronized with each other, it is vital to establish an “LFC Responsibility Structure” and “LFC Control Structure” according to the GMS Regional Grid Code, which is currently being established, in order to trade electric power equally based on each country’s own supply-demand balancing plans and to help maintain frequency quality across the entire synchronous system. By around 2025, it is desirable to complete the GMS Grid Code, revise and adjust the domestic Grid Code in each country, then implement these in actual work (planning and operation), and establish a mechanism for compliance with these rules.

LFC (TBC) is generally a centralized control method using the EMS (Energy Management System) in an NCC (National Control Center). In EMS, an AGC (Automatic Generation Control) function, which controls the output of the generator according to the system frequency and power flow situation, is generally installed as a standard package. However, at present, data setting and channels of communication with power plants have not been realized and so are not operated. It is also necessary to investigate whether the generators are equipped with a receiving terminal for control signals from the EMS. Therefore, technical requirements should be defined in the domestic grid code so that, at least, newly planned generator units in the future are equipped with communication terminals and are mechanically designed for appropriate control according to control signals.

Interconnection	with Thailand (EGAT)	synchronized via 230 and **500kV** lines (multiple points)
	with Vietnam (EVN)	physically separated
GF		**All generators**
LFC		**TBC by both EDL and EGAT AGC is imposed to gens. of 40MW or more**

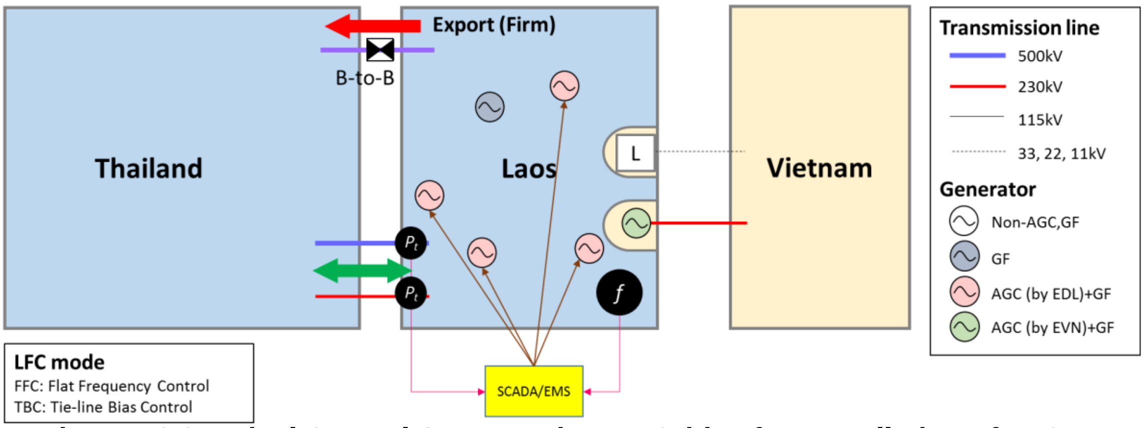


Figure 18.2-4 Ideal Control Structure in Lao Grids after Installation of LFC

Therefore, the JICA Study Team recommends the following steps:

- First, the feasibility study on the system construction described above is to be completed by around 2025.
- After that, some pilot generators that implement AGC functions to communicate with EMS in EDL-NCC will be selected and interconnected via data communication channels.
- By around 2030, verification tests will be completed and LFC will be commissioned.

After 2030, once LFC (TBC) has been performed stably by Laos EDL, there will be the following two ways for EGAT in Thailand to control Secondary Control:

- Continuously maintain the position to control the entire synchronous system via FFC (Flat Frequency Control mode).
  - **Advantage**: Even when the supply-demand balance in Laos is disrupted, a generator in Thailand can help maintain the total balance as a last resort.
  - **Disadvantage**: As electricity demand in Laos increases, backup using only Thai generators may not be economically feasible. Therefore, establishment of an economic reimbursement mechanism, such as applying an ancillary service fee, is necessary.

- Thailand also transitions to TBC and Thailand and Laos will be equally responsible for independent supply-demand control.
  - **Advantage**: Interconnected countries can achieve independent and equal system operation.
  - **Disadvantage**: In principle, the TBC control system automatically restores the balance with the generators in the grid when a supply-demand imbalance has occurred. Therefore, it is necessary for each interconnecting country to operate the system with appropriate responsibilities, and it is essential to build a trusting relationship.

The method should be decided according to the degree of maturity in independent grid operations after Laos has realized LFC and the difference in demand scale between the two countries.

Chapter 19. Challenges in Expanding GMS Power Interchanges

19.1. Reasons for Lack of Progress in GMS Wide-Area Interconnections

19.1.1. Difficulties in Connecting Thailand and Vietnam

Many donors have already conducted many studies on the benefits of GMS wide-area interconnections and the effects on the economy of the entire region, and have recognized the common interests of each country. In addition, the necessity of future wide-area interconnections within the GMS region and plans for this are shared at HAPUA and ADB meetings.

However, although some interconnections between the two countries that use electricity generated in neighboring countries have been constructed, the GMS wide-area interconnection system envisioned since the early 1990s has not yet been realized.

Power demand in the GMS region is concentrated in Thailand and Vietnam. Thailand's maximum power demand is 40,000 MW, about 40 times that of Laos, and Vietnam's maximum power demand is 30,000 MW, about 20 times that of Cambodia. GMS wide-area interconnections are expected to take the form of expanding interconnections from Thailand and Vietnam to neighboring countries.

Thailand, which has little potential for hydropower development, has traditionally imported abundant hydropower from Laos. In this supply method, a Lao power supply is directly connected to a Thai power system and used as a Thai power source. Thailand's PDP uses hydropower from neighboring countries such as Laos to ensure the best mix of energy. Laos has maintained a certain level of stable power supply by linking its power system for domestic supply to Thailand, which has a larger system scale.

In Cambodia, the development of a power system sufficient to meet the recent increase in demand has not progressed. A synchronous interconnection with Vietnam has been selected, and supply for the rapidly increasing power demand has relied on the large-scale Vietnamese power system.

Vietnam expects to use Laos's inexpensive hydropower, which is cost competitive, as a source of power for its country.

Although limited interconnections between GMS countries have been realized as mentioned above, multilateral interconnections have not yet been realized. One of the reasons for this is that Laos and Cambodia, situated between Thailand and Vietnam, have weak power infrastructures. The figure below shows the current range of synchronous interconnection. In order to expand the amount of interconnections from Thailand and Vietnam, it is necessary to construct transmission lines in Laos or Cambodia to realize wide-area interconnections for large-scale power transmission, and to carry out appropriate operations. However, there are barriers to this realization, as described below. Similar difficulties arise when incorporating Myanmar into the GMS interconnection scheme.

Figure 19.1-1 Range of current GMS synchronous interconnection

19.1.2. Power System Operations in Laos, Cambodia and Myanmar

Thailand and Vietnam may be cautious about expanding synchronous interconnection with Laos and Cambodia due to the low supply reliability of the power system in Laos and Cambodia and inadequate grid operation.

Frequency adjustment in Laos and management of the power flow in the interconnection line with Thailand are currently being implemented per instructions from the power dispatching center in Thailand, and frequency adjustment in Cambodia is also being implemented according to Vietnamese power dispatching orders.

In recent years, Laos and Cambodia have each expanded their domestic power grids in response to increasing power demand. However, the capacity of the transmission lines and the operation of the grid are not sufficient for the development of power sources in Laos and Cambodia. In Thailand, power oscillations due to stability problems at distant hydropower stations in Laos have been observed on interconnections. Similarly, in Vietnam, power fluctuations through interconnections due to a decrease in transmission stability at a recently installed hydropower plant in Cambodia have been confirmed. (If the stability declines, the generator may lose synchronization when the power flow increases or in the event of an accident, and may fall out of the grid, causing a large supply interruption.) The increase in the output of hydropower plants during the rainy season cannot be adequately controlled, and transmission lines around Vientiane in Laos have been overloaded and system blackouts have occurred due to protection device operation. Laos and Cambodia have a small demand scale and power dispatching centers have been installed in recent years, but they do not have sufficient system operation functions to cope with the recent expansion of the system. For this reason, technical issues such as insufficient capacity of the power system in Laos and Cambodia, and inadequate system operation functions have become apparent. At present, Lao PDR and Cambodia have not been able to properly upgrade their grids, formulate grid plans, or operate grids. Thailand and Vietnam should expand direct connections to grids with low technical reliability. This may be one of the barriers to expanding GMS interconnections.

There are grid codes in Thailand and Vietnam and they are compliant to some extent, but there are no Grid Codes in Cambodia or Myanmar. In Laos, a Grid Code has been established at EDL, but their compliance is inadequate. The imbalance of Grid Code development and compliance, as well as the lack of Grid Codes, is also one of the reasons why interconnections have not progressed. For interconnections, it is necessary to indicate to the neighboring countries the degree of system tolerance and recovery methods in the event of an accident in the country. However, in Laos, Cambodia, and Myanmar, the status of the domestic power system cannot be properly ascertained via system analysis. In addition, it is necessary to carefully consider the operation form of the interconnection system, such as how to operate Laos or Cambodia in the synchronous interconnection block of either Thailand or Vietnam in the future.

19.1.3. Investment in Large Transmission Lines

Laos and Cambodia are financially vulnerable, making it difficult to raise funds and consider planning for the construction of larger transmission lines to export or import energy.

Power transmission to Thailand or Vietnam, where power demand is large, is a significant area of electric power business in Laos and Cambodia, where power demand is small, and the scale of interconnection lines is too large for the power utilities and the national finances of Laos and Cambodia. Investment in transmission lines in Laos and Cambodia used for interconnection cannot be covered via the normal operations of the electric utilities in either country.

In addition, if there are any uncertainties about the need for interconnection, such as fluctuations in power demand assumptions or fluctuations in power demand in partner countries, the risk of recovering the costs increases, making funding difficult. Risk assessment can be difficult in a single country in the first place. This is also considered to be a reason why interconnections between Thailand and Vietnam through Laos and Cambodia have not progressed.

19.1.4. Effective Measures for Accelerating the Wide Area Power Trading Scheme

1. Institutional Aspects

- The concept of interconnection, which has been examined from the viewpoint of GMS, aggregating the needs of and information on each country, has been formulated and authorized at HAPUA and other venues. MPs, FSs, etc. are conducted by donors as a single country or bilateral survey. However, if the plans are larger than a certain scale, they may relate to future GMS interconnections. For such projects, it is desirable to share the results of studies with other countries. Alternatively, the function can be added to an existing organization such as HAPUA.
- Attract private capital for investment in interconnections. Set up multilateral government guarantees (by financially sound countries) within GMS. Improve business risk assessment functions in each country.
- Establishment of a GMS interconnection operation organization that coordinates grid operation with the participation of grid operators from each country. (However, the need for this organization arises when actually implementing intra-regional power interchanges; initially, its function should be considered.)

2. Technical Aspects

- Properly estimate power demand. Improve planning ability.
- Establishment of GMS Grid Code, establishment and revision of Grid Codes in each country, and enhancement of grid operation capabilities and facility functions required to comply with the Codes.
- In particular, Cambodia, Laos and Myanmar do not have their own Grid Codes or their compliance is not sufficient, so it is necessary to establish Grid Codes and strengthen grid operation capabilities. In addition, it is necessary to invest in the addition of power dispatching functions, which are necessary for compliance, and to cooperate with private power producers such as IPPs in grid operation.
- Furthermore, in the GMS, a multilateral Grid Code that defines the protocol with other countries in the event of a failure in a country's own grid, an evaluation of the impact of a system accident on multiple countries via system analysis, rules for establishing the specifications of electric power equipment, etc. are required.

3. Management Aspects

- Multilateral power market design and setting of consignment charges

19.1.5. Situation in each country, and the requirements regarding interconnection lines and their conditions

The situation in each country, the requirements regarding interconnections, and the expected utilization methods and conditions are described below.

1. Thailand

Current and future status

- Increasing solar power generation in local communities, changing load curves
- Slowdown of domestic demand growth
- Other countries dependent on hydropower

Requirements regarding interconnections and expected utilization method

- Ensuring the supply capacity of economically viable hydropower from neighboring countries (for this purpose, Thailand has already incorporated it into the PDP)
- Thermal fuel reduction through hydropower generation in economically viable neighboring countries
- Ensuring supply/demand and frequency adjustment through hydropower generation in neighboring countries
- Expansion of power wheeling/transmissions to neighboring countries (currently 100 MW of consignment to Malaysia)

Conditions

- Strengthening of domestic power system for imports and exports
- Institutional design in the case of power wheeling. (Hydropower in the Indochina Peninsula has large fluctuations in the amount of power generated during the rainy and dry seasons. Power wheeling is not limited to simultaneous power wheeling - power wheeling of the same amount of energy with time differences, utilizing thermal power output adjustment, can also be considered.)

2. Vietnam

Current and future status

- Coal-fired power plant development delay
- Rapid increase in mega solar and capacity constraints of regional transmission lines

Requirements regarding interconnections and expected utilization method

- Ensuring the supply capacity of economically viable hydropower from neighboring countries (for this purpose, Vietnam has already incorporated it into the PDP)
- Thermal fuel reduction through hydropower generation in economically viable neighboring countries
- Ensuring supply/demand and frequency adjustment through hydropower generation in neighboring countries

Conditions

- Strengthening of domestic power system for imports and exports
- When importing power into the Vietnam electricity market, how to incorporate this into the system

3. Laos

Current and future status

- Surplus power in domestic power supply system (especially in rainy season)
- Low power supply reliability

Requirements regarding interconnections and expected utilization method

- Exports of surplus power
- Exports from export-dedicated hydro power plants

Conditions

- Strengthening of domestic power system for imports and exports

- Develop Grid Code and compliance system
- Develop appropriate power demand forecasting, planning and power system operation capabilities
- Interconnection plan evaluation and financing

4. Cambodia

Current and future status

- Rapid increase in domestic power demand
- Delay in development of power generation facilities
- Lack of power supply in dry season
- Low power supply reliability

Requirements regarding interconnections and expected utilization method

- Secure power supply with farm-like economic power

Conditions

- Strengthening of domestic power system for imports and exports
- Develop Grid Code and compliance system
- Improve appropriate power demand forecasting, planning and power system operation capabilities
- Interconnection plan evaluation and financing

5. Myanmar

Current and future status

- Rapid increase in domestic power demand
- Delay in development of power generation
- Low power supply reliability
- Large frequency fluctuations

Requirements regarding interconnections and expected utilization method

- Secure power supply with farm-like economic power
- Exports from export-dedicated hydro power plants

Conditions

- Strengthening of domestic power system for imports and exports
- Develop Grid Code and compliance system
- Develop appropriate power demand forecasting, planning and power system operation capabilities

19.2. Roadmap for expanding GMS wide-area power trading

19.2.1. Items to be improved

Items to be improved in order to expand GMS interconnection are listed below, together with the above-mentioned conditions for each country.

1. Institutional System

- Establishment of an in-region organization to share the results of studies (projects of a certain size or larger) or its ad hoc establishment
- Establishment of risk assessment method for multilateral interconnection projects
- Establishment of wide-area interconnection operation organization on GMS standard

2. Power system improvement

- Strengthening of domestic power system

3. Power System Operation

- Establishment of GMS grid code and establishment and revision of Grid Codes in each country
- Enhancement of grid operation capabilities and facility functions required to comply with the grid code (particularly Laos, Myanmar, and Cambodia)

4. Power Market Design, and Setting of Power Wheeling Charges

5. Development of interconnections (including export-dedicated transmission lines)

Table 19.2-1 and Figure 19.2-1 show the interconnections of 230 kV or more to be developed/considered. Power source transmission is of a form in which a specific power supply (all IPPs) is disconnected from the power supply system in Laos and transmitted to the neighboring countries. Grid interconnections are of the form of connecting the power system for domestic supply in Laos with a power system in a neighboring country. All existing interconnections with a voltage of 230 kV or more are for power source transmission.

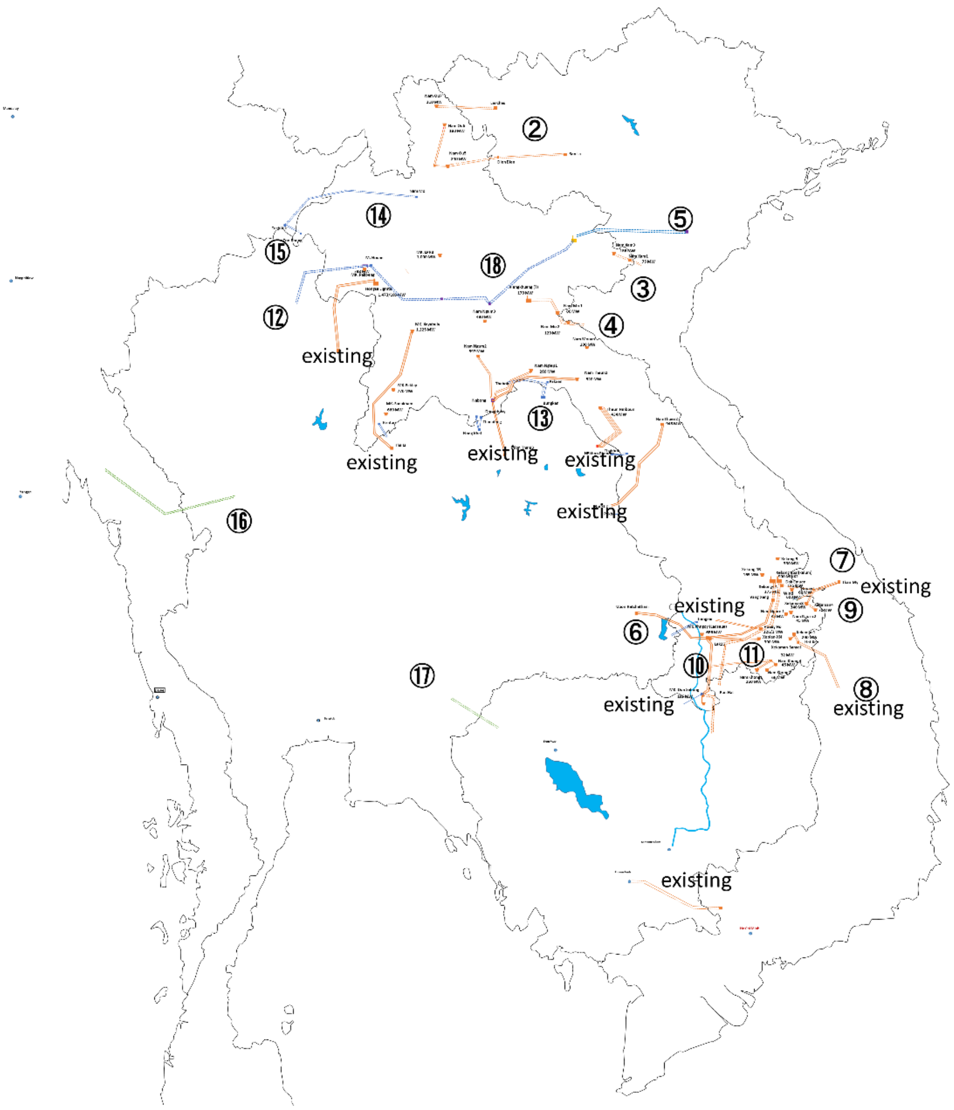
Nam Xam 1, 2 and 3 and Nam Mo 1 and 2 hydropower in northern Laos have been designated for export to Vietnam and will be transmitted via 230 kV transmission lines. Negotiations on exports from Nam Ngum 3 to Thailand through the Nabon substation are currently under way and this is a priority export project in Laos. (Construction was initially started for domestic supply.) Nam Ou was built and operated for domestic supply, and some units are still under construction. Later, due to the lack of domestic transmission lines, the location near the border to Vietnam, and the generation of surplus power in the country, a plan was drafted for Nam Ou to export via 230 kV power transmission lines. The proposal for implementation of a FS was submitted to MOIT, but this has not currently been accepted by EVN in Vietnam.

Transmission lines from southern Laos to Cambodia are under consideration by China, and some 500 kV transmission lines in Laos are under construction. There are several power sources for export from southern Laos to Cambodia, including Dongsahong Hydropower, Xekong Thermal and Nam Kong Hydropower, and the total transmission power has reached 3,000 MW. Transmission methods are under consideration.

As a candidate for future Thai-Vietnam interconnections, it is assumed that the Northern Laos-Thailand interconnection (⑮) and Northern Laos-Vietnam interconnection (⑤) will be interconnected.

Table 19.2-1 Interconnection Lines to be Constructed/Considered (230 kV or More)

No.	Area	Voltage	From	To	Type	Status	Implementation /Financing
①	Existing IPP Transmission Lines	230 KV	Theun-Hinboun	Thailand	Power Source Lines	Existing	—
		230 KV	Nam Theun 2	Thailand	Power Source Lines	Existing	—
		230 KV	Houay Ho	Thailand	Power Source Lines	Existing	—
		500 kV	Nabon	Thailand	Power Source Lines	Existing	—
		230 KV	Nam Ngum 2	Nabon	Power Source Lines	Existing	—
		230 KV	Nam Ngum 3	Nabon	Power Source Lines	Under study	—
		230 KV	Nam Ngiep 1 (Off take)	Nabon	Power Source Lines	Existing	—
		500 kV	Nam Theun 1	Nabon	Power Source Lines	Under construction	—
		500 kV	Hongsa Lignite	Thailand	Power Source Lines	Existing	—
		500 kV	MK. Xayaboury	Thailand	Power Source Lines	Existing	—
		230 KV	Xekaman 3	Vietnam	Power Source Lines	Existing	—
		230 KV	Xekaman 1	Vietnam	Power Source Lines	Existing	—
		230 KV	Xekaman - Xanxai	Xekaman 1	Power Source Lines	Existing	—
②	North of Laos - Vietnam	230 KV	Nam Ou	Vietnam	Power Source Lines	Unclear	Vietnam
③	North of Laos - Vietnam	230 KV	Nam Xam	Vietnam	Power Source Lines	To be constructed	Vietnam
④	North of Laos - Vietnam	230 KV	Nam Mo	Vietnam	Power Source Lines	To be constructed	Vietnam
⑤	North of Laos - Vietnam	500 kV		Vietnam	(System Interconnection)	Future idea	
⑥	South of Laos - Thailand	230 kV 500 kV	Xepian – Xenamnoi	Thailand	Power Source Lines	Under construction	IPP
			Xekong Hydropower	Lak 25	Power Source Lines	Future idea	
⑦	South of Laos - Vietnam	230 KV	Hydropower in Laos	Xekaman 3	Power Source Lines	Under study	Vietnam
⑧	South of Laos - Vietnam	230 KV	Hydropower in Laos	Xekaman 1	Power Source Lines	Under study	Vietnam
⑨	South of Laos - Vietnam	500 kV	Monsoon Wind	Vietnam	Power Source Lines	Under study	Vietnam
		500 kV	EDL System	Vietnam	(System Interconnection)	Future idea	
⑩	South of Laos - Cambodia	500 kV	Xekong	Ban Hat	Power Source Lines	Under construction	China
		500 kV	Ban Hat	Cambodia	Power Source Lines	Under construction	China
⑪	South of Laos - Cambodia	230 kV	Nam Kong Hydropower	Ban Na	Power Source Lines	Under study	China
		500 kV	Xekong Thermal	Cambodia	Power Source Lines	Under study	China?
⑫	North of Laos - Thailand	500 kV	M. Houan	Thailand	(System Interconnection)	Future idea	
		500 kV	MK. Pakbeng Hydropower	Thailand	Power Source Lines	Future idea	
⑬	Center of Laos - Thailand	230 kV	Vientiane	Thailand	(System Interconnection)	Future idea	
⑭	North of Laos - Myanmar	230 kV	NamMo	Myanmar	(System Interconnection)	Under study	ADB
⑮	North of Thailand - Myanmar	230 kV	North of Thailand	Myanmar	(System Interconnection)	Under study	ADB
⑯	North Central of Thailand - Myanmar	230 kV or 500 kV	North Central of Thailand	Myanmar	(System Interconnection)	Future idea	
⑰	Thailand - Cambodia	230 kV	East of Thailand	Cambodia	(System Interconnection)	Future idea	



1

Figure 19.2-1 Interconnection Lines to be Constructed/Considered (230 kV or More)

19.3. Transitional Steps

Initially, as described in the below frame, the interconnections in the region will be constructed as power supply lines from power plants in neighboring countries or as interconnections to transmit power from an area where power is available to an area where power is insufficient. In the case of multilateral interconnections, it is considered that in the future the use of bilateral transmission lines will be changed into multilateral interconnections in some cases.

The following two transitional steps will be taken, and it is expected that interconnections will be expanded in the future according to need.

1. Bilateral power transmission lines or bilateral interconnection system (one is load; the other is power)

2. Interconnections between other countries

Current interconnection lines have the following forms.

A. Single power generation company – Power Utility in neighboring country
There are many examples of this pattern, such as Houay Ho, Theun Hin Bouan and Nam Theun 2. In general, the investment in the interconnection is made by the power generation company or the electric power company in the neighboring country.

B. Multiple power generation companies - Power Utility in neighboring country
In this pattern, since the development times for multiple power generation companies differ, it is necessary to formulate a plan in advance, design a transmission line, and promote investment. In some cases, three or four power plants are connected to the Nabon 500 kV substation. The power line for the Xepian-Xenamnoi power plant, which is under construction, will have a 500 kV design from a substation in Laos so other IPPs will be connected in the future. In addition, several 230 kV power lines from Laos to Vietnam will be connected to multiple power plants.

C. Power Utility-Neighboring Power Utility
System-to-System interconnection. There are the following examples.

- Synchronous interconnection between Thailand and Laos

This was originally built to transmit power from the Nam Ngum hydropower plant in Laos to Thailand. Later, with the increase in demand in Laos, and the construction of new hydroelectric power plants and substations the system in Laos expanded, making Laos a relatively large single system consisting of multiple lines.

- Synchronous interconnection between Vietnam and Cambodia

Due to the weakness of Cambodia's domestic power grid, a 230 kV interconnection was constructed to supply Phnom Penh from neighboring Vietnam. Power is imported from Vietnam.

It is anticipated that newly established interconnection lines will be constructed based on such relative needs at first, and then a shift to a multilateral scheme is expected.

In the future, it is necessary to set specifications considering the operation of sections that are expected to be used as multilateral interconnection lines at the construction stage.

19.4. Roadmap for Expansion of Cross-border Interconnections

19.4.1. Roadmap for Enhancement of Cross-border Transmission Lines

Table 19.6 1 shows a roadmap for enhancement of cross-border transmission lines.

The table is divided into 4 categories: infeed lines dedicated for the IPPs (G-to-S), interconnection lines between China and GMS countries and interconnection lines between GMS countries (S-to-S, or cross-border supply to the loads of neighboring countries: S-to-L).

230 kV Thailand-Laos, 500 kV Thailand-Laos, and 500 kV Thailand-Myanmar (Myawaddy) are considered priority projects and are described in the next chapter. It is planned for MK. Pakbeng Hydropower to share the 500 kV Thai-Northern Lao interconnection with exports from the Lao domestic grid.

The ⑱ (500 kV Thailand-Northern Laos)-(500 kV Northern Laos-Vietnam) on the map indicates the establishment of an interconnection between Thailand and Vietnam by connecting the 500 kV infeed lines for Huaphan thermal power plant (Thailand － Laos) and the 500 kV Napia - M. Houn transmission line (Vietnam – Laos) in the Lao grid. In order to avoid synchronous interconnection between Vietnam and Thailand, DC facilities such as Back-to-back will be required.

Table 19.6 1 Roadmap for Enhancement of Cross-border Interconnections

		Current Situations		2030			2035		
			No. in Map		Expected Donors	No. in Map		Expected Donors	No. in Map
IPP	IPP-Neighboring Countries	Thailand-Laos IPP (Five points)	existing	Thailand-Laos IPP (Five points)	IPP	existing	Thailand-Laos IPP (Five points)	IPP	existing
G-to-S				Thailand-Laos IPP (Xepian-Xenamnoi)	IPP	⑥	Thailand-Laos IPP (Xepian-Xenamnoi)	IPP	⑥
							Thailand-Laos IPP (Others)	IPP	
			existing	Laos IPP-Vietnam (Two Points)	IPP/EVN	existing	Laos IPP-Vietnam (Two Points)	IPP/EVN	existing
				Connection of surrounding hydropower to the abovementioned interconnections	IPP/EVN	⑦, ⑧	Connection of surrounding hydropower to the abovementioned interconnections	IPP/EVN	⑦, ⑧
				Laos IPP-Vietnam (Two Points)	IPP/EVN	③, ④	Laos IPP-Vietnam (Two Points)	IPP/EVN	③、④
				Laos IPP-Vietnam (Wind)	IPP/EVN	⑨	Laos IPP-Vietnam (Wind)	IPP/EVN	⑨
							Laos IPP-Vietnam (Others)	IPP/EVN	
				Laos IPP-Cambodia (4 to 6 points)	IPP/China	⑩, ⑪	Laos IPP-Cambodia (4 to 6 points)	IPP/China	⑩, ⑪
							Myanmar IPP - Thailand	-	
China	China			500 kV China - Myanmar	China		500 kV China - Myanmar	China	
S-to-S(B2B)							500 kV China - North of Laos	China	
							500 kV China - Vietnam	China	
S-to-S	Laos –Thailand	115 kV Thailand - Laos	existing	115 kV Thailand - Laos	Existing	existing	115 kV Thailand - Laos	Existing	existing
				230 kV Thailand - Laos	-	⑬	230 kV Thailand - Laos	-	⑬
				500 kV Thailand - North of Laos	-	⑫	500 kV Thailand - North of Laos	-	⑫
				Connection of MK. Pakbeng to the abovementioned interconnections	IPP	⑫	Connection of MK. Pakbeng to the abovementioned interconnections	IPP	⑫
				230 kV Northernmost of Laos - Thailand	ADB	⑮	230 kV Northernmost of Laos - Thailand	ADB	⑮
							500 kV North of Laos - Vietnam	-	⑤
							(500 kV Thailand – North of Laos)–(500 kV Thailand – Vietnam) Interconnection	China	⑱
	Laos – Vietnam						500 kV South of Laos - Vietnam	-(IFC)	
	Thailand – Myanmar			500 kV Thailand - Myanmar (Myawaddy)	-	⑯	500 kV Thailand - Myanmar (Myawaddy)	-	⑯
	Vietnam – Cambodia	230 kV Vietnam - Cambodia	existing	230 kV Vietnam - Cambodia	Existing	existing	230 kV Vietnam - Cambodia	Existing	existing
	Thailand – Cambodia	(115 kV Thailand - Cambodia)	existing	(115 kV Thailand - Cambodia)	Existing	existing	(115 kV Thailand - Cambodia)	Existing	existing
							230 kV Thailand - Cambodia	-	⑰
S-to-L	Laos – Cambodia	115 kV Laos - Cambodia	existing	115 kV Laos - Cambodia	Existing	existing	115 kV Laos - Cambodia	Existing	existing
	Laos – Myanmar			230 kV North of of Laos - Myanmar	ADB	⑭	230 kV North of of Laos - Myanmar	ADB	⑭

The Roadmap for Enhancement of Cross-border Transmission Lines is shown in Table 19.6 2.

Table 19.6 2 Roadmap for Enhancement of Cross-border Transmission Lines

		Current Situations	2030	2035
Types of Interconnections		G-to-S	G-to-S	G-to-S
		S-to-S (Small scale)	S-to-S (500 kV, 230kV Bilateral)	S-to-S (500 kV, 230kV Trilateral)
System development			Domestic System	Domestic System
			Cross-Border	Cross-Border
System development			Financial Support	
			(Laos, Myanmar, Cambodia)	
			Private BOT, Support for private	Private BOT, Support for private
			Support for F/S, Risk assessment	
			Preparation for Interregional Organization	Preparation for Interregional Organization
				(Plan, Funding, Institutional Management)
Grid Codes	Thailand, Vietnam	established	established	established
System Operation	Laos, Cambodia, Myanmar	not yet established	established	established
			Adjustment of protocol to neighboring countries	Adjustment of protocol to neighboring countries
Market		IPP Tariff Setting	IPP Tariff Setting	IPP Tariff Setting
		S-to-S Tariff Setting	S-to-S Tariff Setting	S-to-S Tariff Setting
			EGAT Wheeling Tariff System Design	EGAT Wheeling Tariff System Design
				Interregional Tariff System Design
Contract	IPP	Domestic IPP- Utilities	Domestic IPP- Utilities	Revision of IPP Tariff System
		Export IPP-EGAT	Export IPP-EGAT	
		Export IPP-EVN	Export IPP-EVN	
	S-to-S	EDL-EGAT	EDL-EGAT	Liberalization
		EDC-EVN	EDC-EVN	
			EDL-DPTSC	
		(EDL-TNB)+EGAT Power Wheeling	(EDL-TNB)+EGAT Power Wheeling	
			EGAT-MOEE	
		CSG-MOEE	CSG-MOEE	

19.4.2. Issues in the Current Tariff Setting

The following issues exist in the current tariff setting in the region, so they should be considered in the design of the electricity market. In addition, full liberalization increases the risk to power producers' return on investment, which may hinder investment in power generation business, so it should be carefully considered.

1. Reconciliation between contracts with domestic IPPs and power companies in neighboring countries (S-to-S)

The benefits of applying hydropower plants can be measured through reduction of the capital costs (fixed costs) and fuel costs (variable costs) at thermal power plants by replacing them with hydropower plants. However, if there is a large difference in the amount of power generated by hydropower between the rainy season and the dry season, the capital costs for a thermal power plant cannot be saved by using hydropower because, during the dry season, the amount of hydropower decreases, so construction of thermal power plants becomes inevitable, and even if the amount of hydropower generation increases in the rainy season, only the effect of reducing the fuel costs of thermal power plants is gained.

Therefore, the following two pricing methods are conceivable for a contract between hydropower companies and electricity utilities.

1. For buyers of electricity from hydropower plants, the value and price of electricity differ between the rainy and dry season because the benefits obtained in the rainy season and the dry season differ for buyers. Therefore, different prices should be set between the rainy season and the dry season.
2. When purchasing electricity from hydropower throughout the rainy and dry seasons, the price should be set in consideration of the unit price averaged by the annual generated power.

The IPPs in Laos set the selling price on the assumption of ②. For this reason, when electricity purchased by the EDL from domestic IPPs is used to supply domestic demand and for exports to neighboring countries, EDL is trying to set the same price regardless of the rainy season or dry season.

However, EGAT is considering setting the purchase price on the premise of a so-called “firm contract”, which is based on a constant power contract regardless of the season. In this case, the selling price is generally high during the dry season and low during the rainy season, and the price averaged across the year is somewhere in the middle. Therefore, during the rainy season, the price offered by EDL to EGAT will be high, and negotiations between EGAT and EDL may not proceed well. (In actual fact, the JICA Study Team heard the same opinion from the EGAT side.)

For this reason, even if a purchase is made from the IPPs with the price set in ②, EDL should understand the trading method based on the selling price divided into the rainy season and the dry season. EDL should consider a strategy to obtain profits on an annual basis via contracts for domestic sales and exports to neighboring countries.

As a prerequisite, it is necessary that 100% of the annual power generated by the hydropower stations is fully purchased.

2. Revision of Take or Pay contracts for thermal power IPPs

In order to make full use of the economic benefits of surplus hydropower throughout the region, it is necessary to reduce fuel consumption. However, for thermal IPPs based on Take or Pay contracts, this incentive does not work, so EDL should consider revising the contracts.

19.4.3. Relationships with China

China has surplus electricity and plans to export it to the GMS region. According to the interim results from the ADB GMS Master Plan (Manitoba), 500 kV or DC transmission interconnections from China to Myanmar, northern Laos and Vietnam are to be constructed. However, the political decisions of Vietnam, Thailand and Laos on whether to rely on Chinese power for domestic power supply are unknown at present, and the demand for Chinese power in each country is uncertain. Hence, it is assumed that 500 kV interconnection lines from China to northern Laos and Vietnam are to be constructed in 2030 or later, along with the China-Myanmar interconnection also by 2030, in accordance with Myanmar’s request that China should be ready to supply electricity after conducting a feasibility study.

In addition, there are plans to strengthen interconnection lines like the (500 kV Thailand-Northern Laos)-(500 kV Northern Laos-Vietnam) interconnection and to promote the multilateral interconnection of Thailand, Laos, Vietnam and Cambodia by using electricity provided by China and Laos.

As mentioned above, in a Chinese initiative EDL-T is to be established to assist in formulating a Lao grid plan concerning the intra-regional interconnection concept centered on China-Laos, and to realize transmission line investments and constructions. EDL-T is a company for constructing backbone transmission lines and interconnected lines in Laos, exporting power from power plants in Laos and China to neighboring countries, and conducting business based on revenues from consignment fees.

The following table shows the key points of the feasibility study conducted by EDL-T in January 2020, as described by China Southern Power Grid Company.

<Key points of EDL-T's Feasibility study>

The forecast of transmission volume through the EDL-T grid (domestic demand in Laos and export volume to neighboring countries) is shown as the basis for the effectiveness of the project. The plan is to balance the surplus of domestic power during the rainy season and the shortage during the dry season with power imports from China Southern Power Grid, and increase the price of power exports from Laos to neighboring countries by maintaining a constant supply capacity throughout the year. However, the amount of such surplus which China purchases from Laos will be reduced after five years, so Laos has to increase sales to Thailand, Vietnam and Cambodia via this new interconnection. The PIRR for this construction is calculated at 6%, which is not a great return, but its funds will rise considerably.

Therefore, one of the conditions for the sound operation of EDL-T projects is that neighboring countries Thailand, Vietnam, and Cambodia import from Laos as expected, and demand in Laos increases as expected. Hence, it is desirable to start by taking the following steps.

First, PPAs with Thailand, Vietnam and Cambodia should be concluded, including an agreement to establish EDL-T.

Then, EDL-T should start with an organization that builds and operates transmission lines according to the demand scale in Laos and the status of PPA conclusions with neighboring countries.

Table 19.4-1 Assumption of domestic demand and export volume from Laos by China Southern Grid Company(Unit: GWh)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic	10,367	10,943	11,570	12,239	12,910	13,572	14,281	15,048	15,831	16,655
LA-CN	3,808	3,808	3,808	3,808	3,808	2,500	2,000	1,000	1,000	1,000
LA-KH	1,918	2,368	2,368	3,018	3,018	3,018	6,018	6,018	6,018	6,018
LA-TH						4,000	4,000	4,000	4,000	4,000
LA-VN							7,500	7,500	7,500	7,500
Total	16,093	17,119	17,746	19,065	19,736	23,090	33,799	33,566	34,349	35,173
	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Domestic	16,988	17,327	17,674	18,027	18,388	18,756	19,131	19,514	19,904	20,302
LA-CN	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
LA-KH	6,018	6,018	6,018	6,018	6,018	6,018	6,018	6,018	6,018	6,018
LA-TH	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
LA-VN	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Total	35,506	35,845	36,192	36,545	36,906	37,274	37,649	38,032	38,422	38,820

(Source: Key Points of Establishing EDL-T Feasibility Study, Jan,2020)

19.4.4. Strategies for expanding regional interconnection and candidate projects for cooperation

In order to expand the wide area interconnection, it is necessary for countries to cooperate in the planning, construction, operation, and maintenance of interconnection transmission lines in an appropriate manner. There may be differences in scale and the state of transmission system development, making it difficult for some countries to procure necessary and sufficient financing and to operate the grid properly after interconnection, which may not be effective. The expansion of wide-area interconnection is expected to progress mainly due to the needs of Thailand and Vietnam, where the power demand is large and the power grid is relatively well developed. It is essential to support the planning, construction and operation of national and interconnected grids in Laos and Cambodia.

In order to properly operate the interconnected system, cooperate with other countries in consideration of the impact on the systems of other countries, such as measures to prevent the spread to neighboring countries in the event of a system accident and the method of sharing the frequency adjustment of each country in the interconnected system. It is necessary to realize the operation of the interconnected grid with good balance. In addition, it is necessary to maintain the power quality of the national grid high.

Laos is located at the center of the GMS interconnection system and currently supplies power to its country through a system synchronized with Thailand at 115 kV. However, at present, frequency adjustment, generator output control, and the like are practically implemented according to instructions from the EGAT, and autonomous system operation in their own country is not performed. In order to expand GMS wide area interconnection in the future, it is necessary to construct a highly reliable system in Laos located at the center of the system and to operate the system in Laos, which is autonomous and cooperates with other countries.

Therefore, in order to strengthen the operation capacity of the power system of Laos, which is located in the center of the future GMS wide-area interconnection system, adjacent to Thailand, Vietnam, China, Cambodia, and Myanmar, it is recommended to strengthen Lao PDR's practical capacity in grid operation, improve grid code, and conduct basic research on infrastructure to improve grid operation functions such as LFC function and GF function.

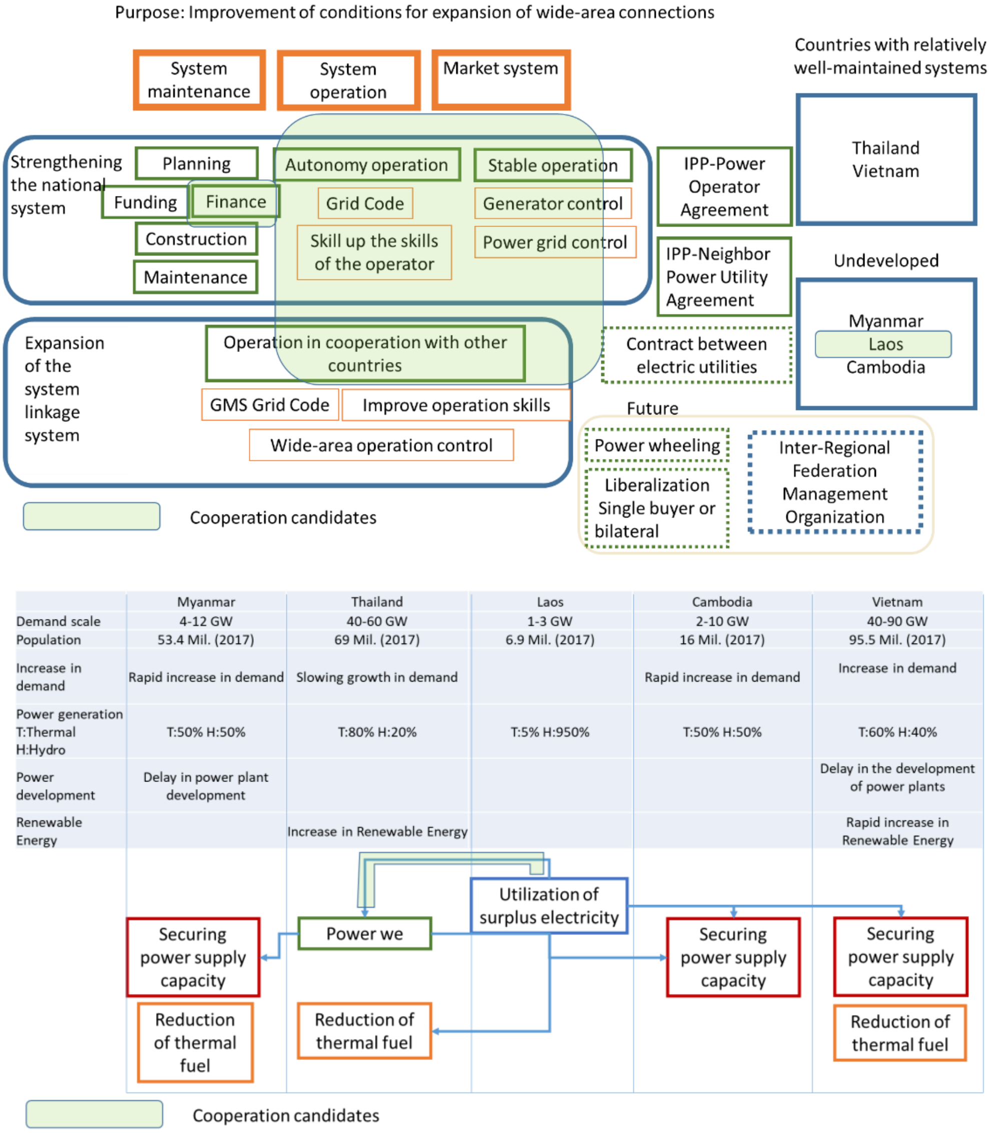


Figure 19.4-1 Improvement of conditions for expanding GMS wide area interconnection

Chapter 20. Proposal of Candidate Projects for Cooperation

The following are proposed as candidate projects for cooperation.

20.1. Capacity Development for Power System Operational Planning, Monitoring and Control

- Adjustment of the Lao Grid Code to comply with GMS Regional Grid Code
  - Establishment of rules for cooperation between GSM countries, generation companies and EDL operators
  - Establishment of compliance system and PDCA cycle system
- Investigation of details regarding system operational work processes in EDL and Seminar for Capacity Development
  - Supply-demand balance planning/scheduling/grid monitoring and control
  - Process for outage planning
  - Skills for emergency restoration
  - Skill-certification system/operator training
  - Strategy, planning and management for protection relay/stabilizing system, etc.

20.2. Development of power supply infrastructure (from the aspect of grid operation)

- Fundamental research to realize LFC control
  - NCC system functions, data installation and maintenance
  - Communication infrastructure
  - Generator specifications/requirements
  - Measurement of electrical quantities of interconnection lines
  - Selection of generators for demonstration
- Fundamental research to realize GF control
  - Generator specifications/requirements
  - Selection of generators for demonstration
- Studies for countermeasures to improve steady state stability (power swing)
  - Power system analysis and tuning of PSSs
- Studies for mitigating overload via installation of OLR systems

20.3. Expansion of Interconnections between Northern Laos and Thailand

New 500 kV and 230 kV interconnection lines will be established between the Laos system and the Thai system in order to meet the needs regarding expanding power interchanges from Laos to Thailand in the future.

Laos's hydropower development has significantly exceeded domestic power and energy demand, and this trend will continue. Surplus energy cannot be consumed domestically, but can be consumed in neighboring countries, contributing to the economy of the entire region. By transmitting the surplus in domestic power to Thailand, it is possible to reduce the usage of thermal fuel in Thailand and realize efficient power supply operations in the region.

In Myanmar and Cambodia, neighboring countries of Thailand, demand for power is expected to increase greatly in the future. In Cambodia, there are plans to increase imports from Thailand to several hundred MW, for example by increasing the interconnection to Thailand to 230 kV. In Myanmar, there are plans to construct a new 500 kV transmission line from around Yangon to around Myawaddy, a candidate site for high-voltage interconnection with Thailand. In addition, Malaysia is considering expanding the current LTMS scheme. In this way, the need for power transmission to neighboring countries in Thailand is high, and by increasing the capacity of the interconnection from Laos to Thailand, and exporting surplus energy from Laos to neighboring countries via Thailand, it can contribute to economic development in the region.

Hydropower generators generally respond faster to frequency fluctuations than thermal power generators, and have a wider range of response to fluctuations. Further, the ability to follow fluctuations in the power load is high. On the other hand, frequency adjustment by a thermal power plant involves an increase or decrease in fuel, which imposes a heavy burden on the plant, and is slow and uneconomical, and many power plants do not perform primary adjustment. For this reason, it is desirable to secure a fixed amount of hydropower plants with high frequency and supply/demand adjustment capabilities in the power system. The number of hydropower plants in Thailand's power system was as small as about 15% of the installed capacity in 2014, of which about 40% is in Laos. In the future, with the increase in the amount of renewable energy generation, such as solar power in the Thai system, it will be necessary to expand the range of frequency adjustment functions that absorb system load fluctuations and balance supply and demand. Therefore, the Lao PDR's hydropower is directly linked to the Thai system, aiding supply and demand adjustment and frequency adjustment operations.

- Advantages of expanding power interchanges from Laos to Thailand
  - 1. Economic effects of reducing thermal power generation in Thailand using surplus power from Laos
  - 2. Combined effects of solar power in Thailand and reservoir type hydropower in Laos (can be used at night by storing water)
  - 3. Exports from Laos to neighboring countries via Thailand

- Why interconnections between northern Laos and Thailand are a priority
  - Laos has a large surplus of hydropower in the north.
  - Thailand considers the establishment of a new interconnection from northern Laos to Thailand a priority.
  - Need for export to Myanmar
  - Myanmar lacks supply capacity. The development of hydropower in Myanmar is not progressing, and the country is looking for emergency power gas turbines. There are several plans for thermal power, but there is a possibility that the export via Thailand will be acceptable for Myammar.
  - There are plans for a 230 kV interconnection line between Thailand and the southeastern part of Yangon City (Myawaddy).

In Laos, surplus power is generated during the rainy season, and the power exported through the interconnection will increase during the rainy season. On the other hand, neighboring countries may need a certain amount of power regardless of the season. In this case, it is conceivable that the amount of energy from Laos can be leveled during the rainy and dry seasons by operating thermal power plants in Thailand and transferred to neighboring countries.

- Candidates for Lao-Thai interconnection
  - 500 kV M. Houn (Laos) - Nan (Thailand) interconnection
  - 230 kV Thabok (Laos) - Pakxan (Laos) -Bungkan (Thailand) interconnection line

It is proposed to conduct an FS survey for the northern Laos-Thailand interconnection. In the case of transfer from Thailand to Myanmar, it is necessary to construct a 500 kV transmission line between the Thai-Myanmar interconnection line and the Phayargyi substation in Myanmar.

- Proposed content of FS
  - Survey on supply and demand balance in Laos and neighboring countries, and power supply composition
  - Identify new system installation points, generator operation method during interconnection, and assumed power flow, and perform system analysis
  - Power transmission method (whether to install Back-to-Back, etc.)
  - Schematic design for transmission and substation facilities, project cost estimation
  - Environmental and social considerations

- Economic and financial analysis, and analysis of effects of interconnection

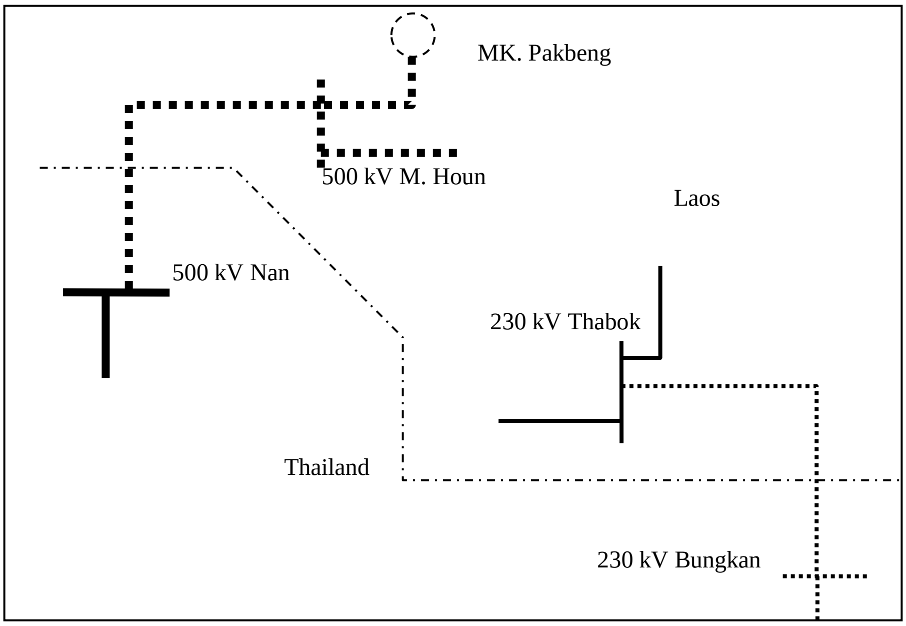


Figure 20.3-1 500 kV M. Houn-Nan and 230 kV Thabok-Pakxan-Bungkan Interconnection

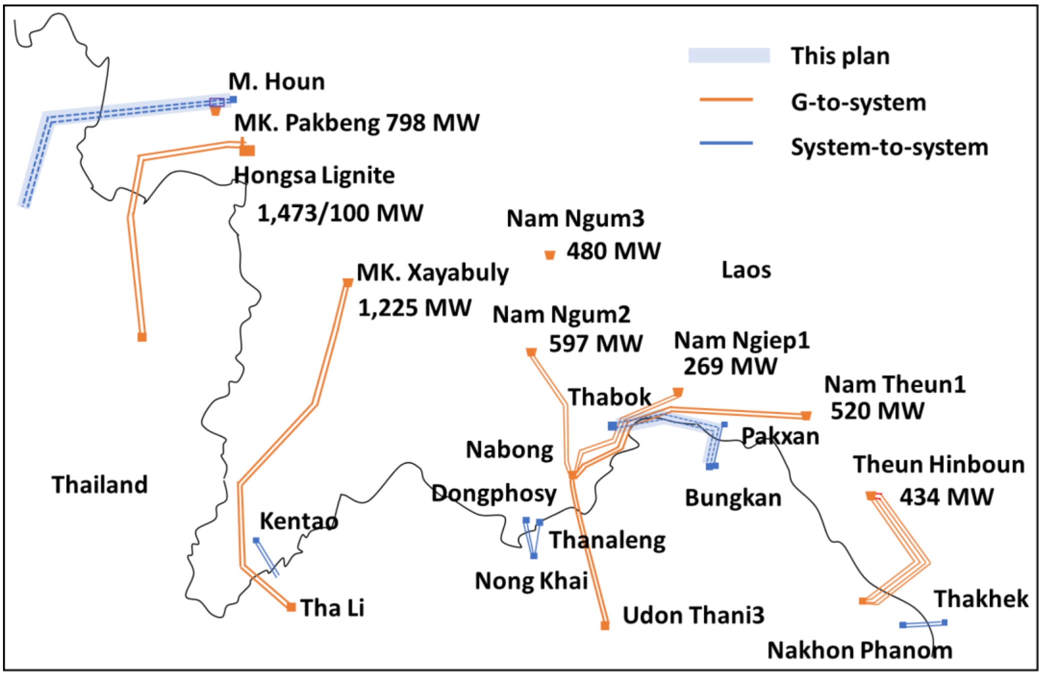


Figure 20.3-2 Locations of 500 kV M. Houn-Nan and 230 kV Thabok-Pakxan-Bungkan Interconnection

20.4. Cooperation in Financial Management

As stated above, EDL's financial status is not good and continues to deteriorate currently, and has been financially insolvent if EDL is a private company. In nature, it is necessary to make positive cash flow from operating activities, and mobilize that into investment activities in order to generate additional cash flow from operating activities. However, currently EDL continues to invest by borrowings with the business & financial structures which cannot generate cash flow from operating activities. Hence, EDL continues to be caught in a vicious cycle financialy.

EDL should conduct financial management as a public institution, and at the same time, operate business including development of business strategy and investing activities etc as a private company. Considering those characteristics and above financial situation, it will be beneficial to support more inclusive business improvement including financial management, as a cooperation to contribute to solve financial issues. Types of cooperation are shown selectively as follows:

- Coopreation in development of business strategy (refer to examples of privatized electric power companies in other countries)
- Cooperation in introduction of financial management system with optimization of financial management operations and capacity development of financial management (apply the cooperation done in public financial management to EDL)
- Cooperation in improvement of cash flow from operating activities
  - Coopreation in improvement of working capital (apply the methods done in private companies to EDL which has issues in working capital)
  - Cooperation in development of new revenue resources (consider the possibility of new revenue resources for EDL, such as consulting services which generate service fees)

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

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

Final Report

Appendix

February 2020

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Holdings Company, Inc.
TEPCO Power Grid, Inc.
NIPPON KOEI CO., LTD.
Tokyo Electric Power Services Co., Ltd.

IL
JR
20-006

Appendix 1-1_Report_on_Domestic_Power_System_20190627_(e)

The Study on Power Network System Master Plan in Lao PDR

Draft Report on Domestic Power Supply System Plan

JICA Study Team
June 27, 2019

Table of Contents

1. Classification of Power Systems for Domestic Power Supply and Export Dedicated Transmission Lines

Until 2030, export dedicated transmission lines and domestic power supply system will be separated. The existing system-to-system interconnections between Laos and Thailand will be maintained.

Figure 1-1 Export Dedicated Transmission Lines in 2030 shows the Export Dedicated Transmission Lines in 2030, Figure 1-2 Plan of Domestic Power Supply System in 2030 (North and Central 1) and Figure 1-3 Power Network System Plan for Domestic Power Supply in 2030 (Central 2 and South) shows the Domestic Power Supply System in 2030.
Many plans for export dedicated transmission lines are not yet determined due to uncertainty or no-progress in contract process between power producers and neighboring electric power utilities.

This report describes the plan of the domestic power supply system in 2030.

This report is a draft and will be revised after review.

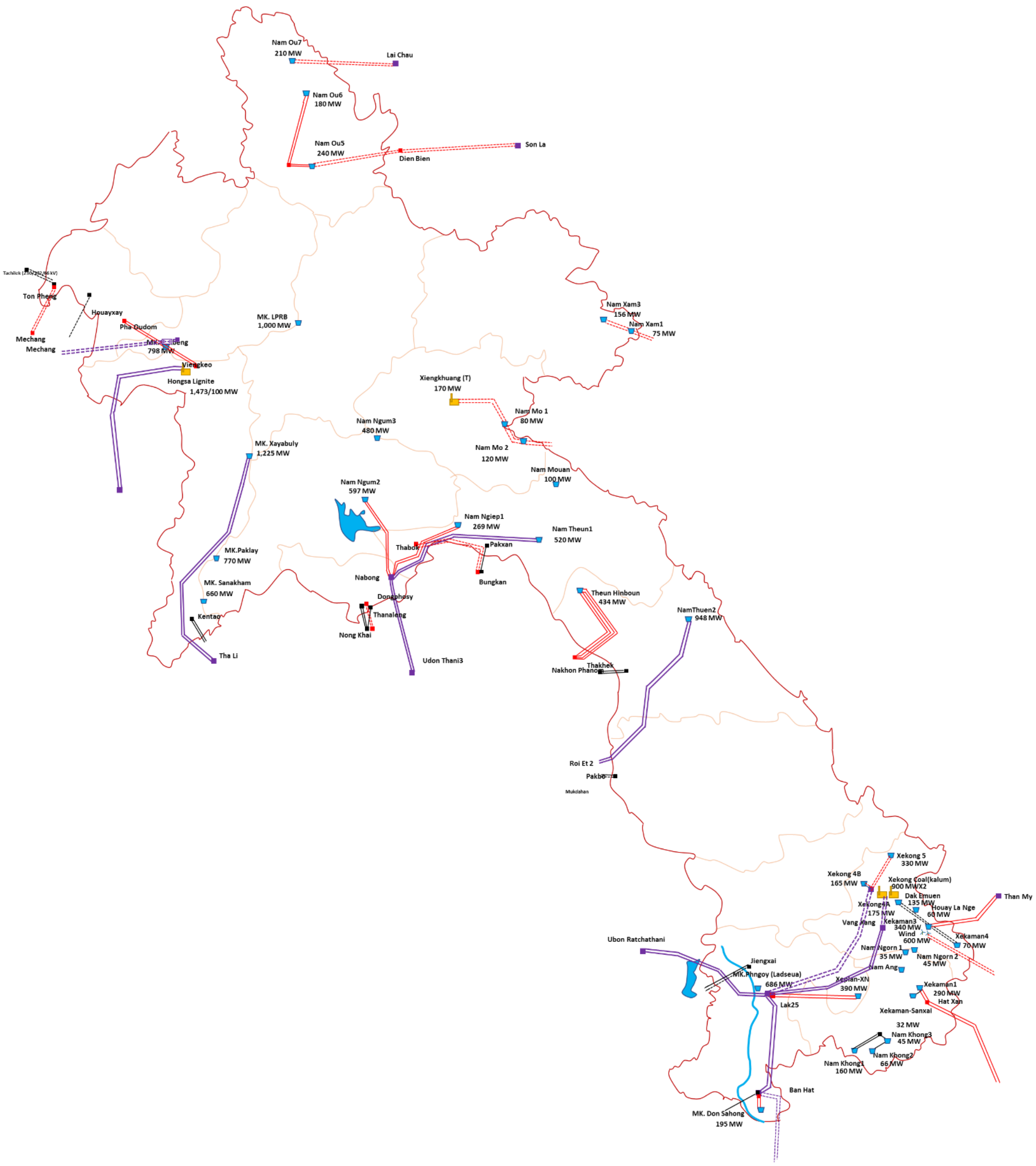


Figure 1-1 Export Dedicated Transmission Lines in 2030

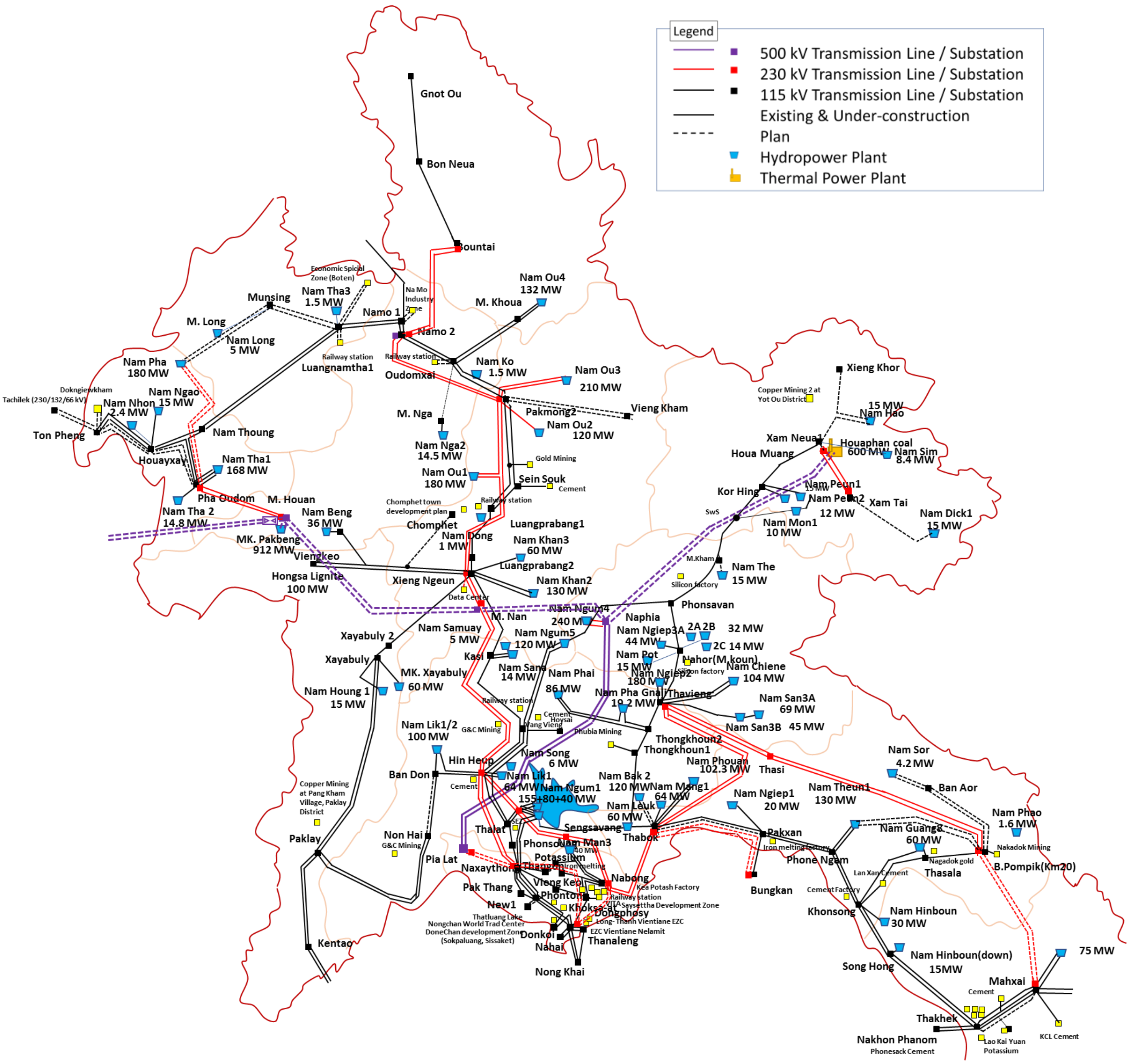


Figure 1-2 Plan of Domestic Power Supply System in 2030 (North and Central 1)

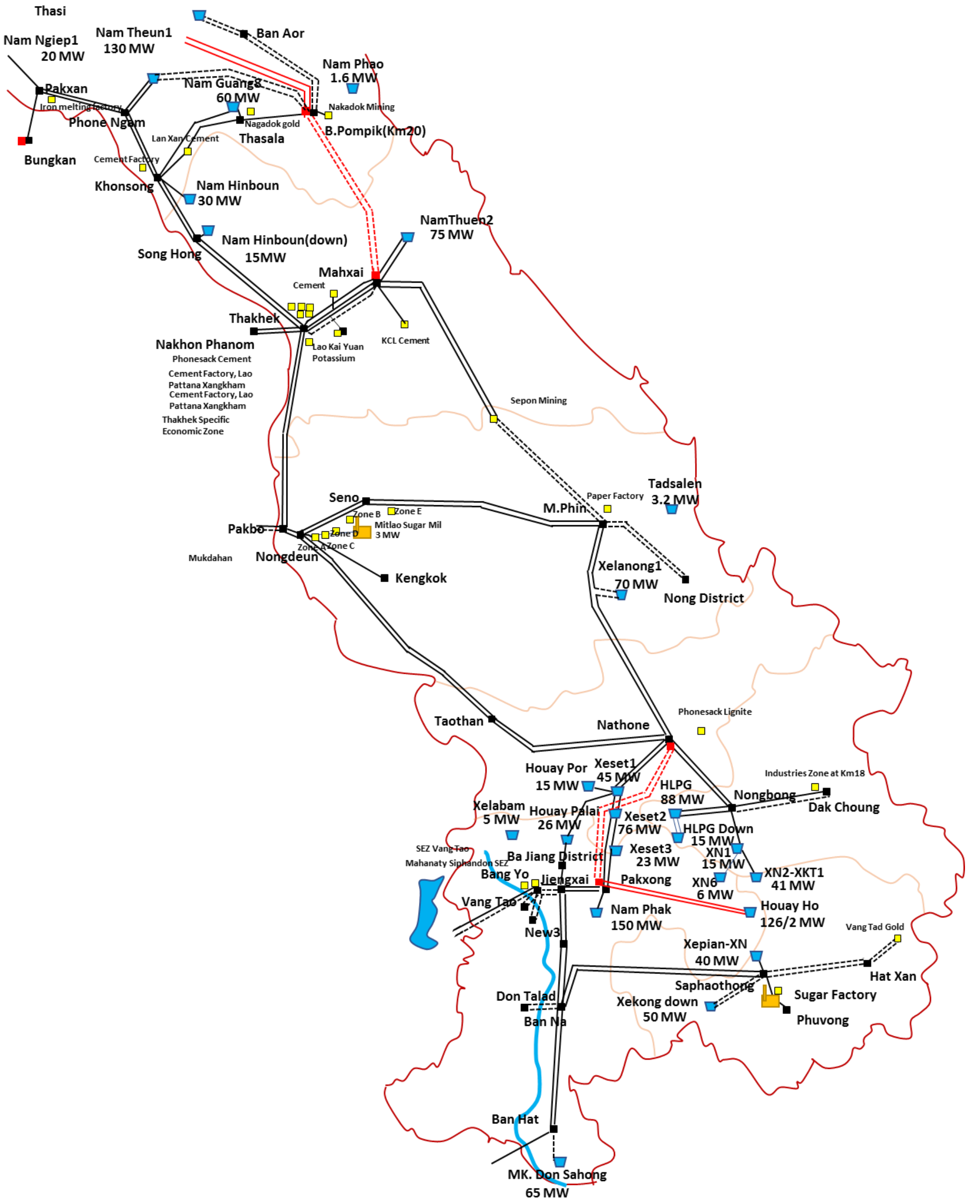


Figure 1-3 Power Network System Plan for Domestic Power Supply in 2030 (Central 2 and South)

2. Existing and Under-construction Power Plants in Domestic Power Supply System

2.1. Power Supply / Demand Balance for Existing and Under-construction Power Plants

In the domestic power supply system, the capacity of power generation facilities is excessive compared with the capacity required for domestic power supply, and the situation of over-generation continues. The following figures show the capacity and amount of generated power at existing and under-construction power plants connected to the domestic power supply system from 2018 to 2030, as well as the trend of maximum domestic power demand and energy demand.

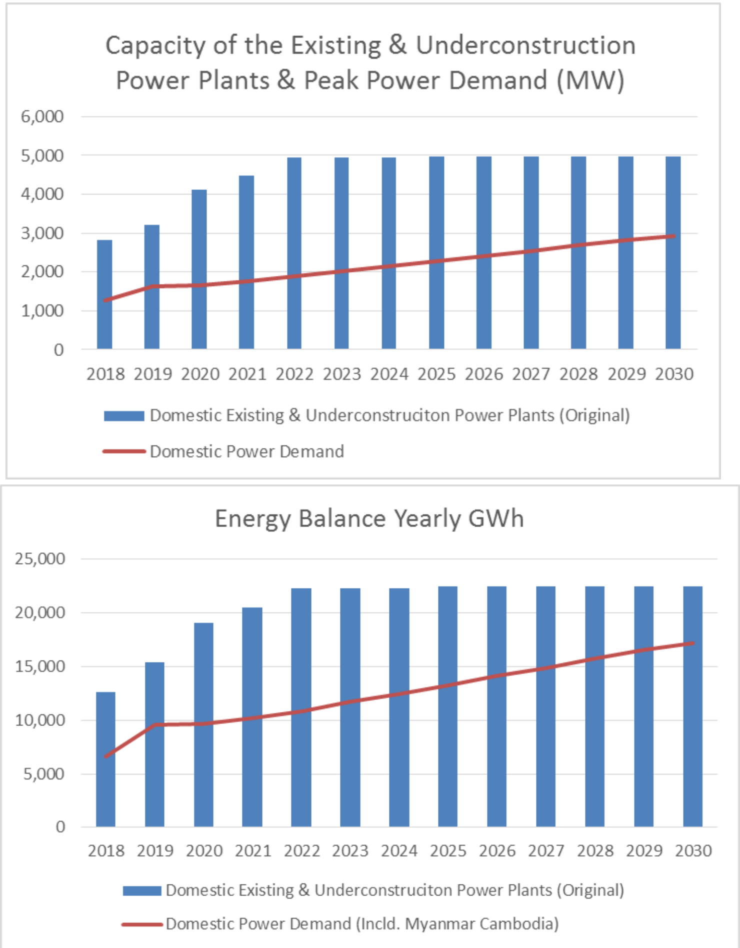


Figure 2-1 Capacities of Existing and Under-construction Power Plants in Domestic Power Supply System and Maximum Domestic Power Demand

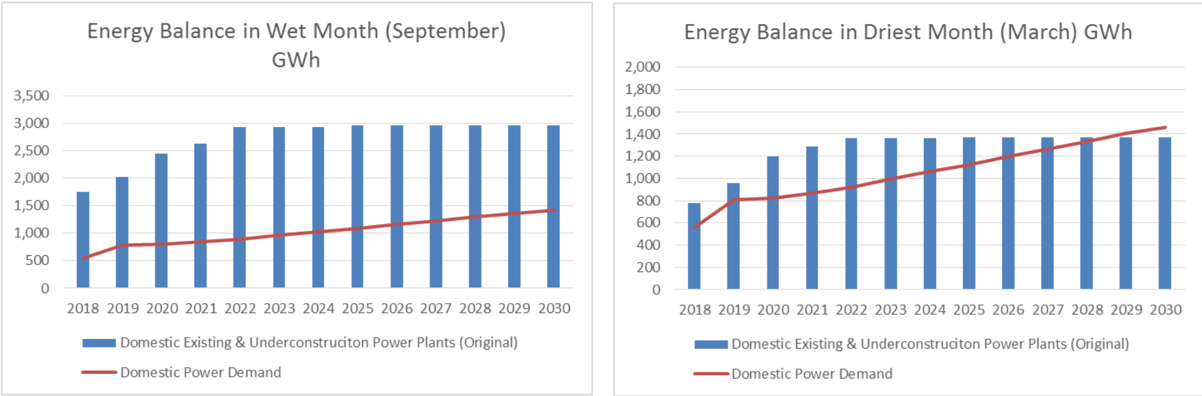


Figure 2-2 Power Generation Energy of Existing and Under-construction Power Plants in Domestic Power Supply System and Domestic Power Demand Energy (Yearly)

The figures below show the amount of the power demand energy and the generated power energy in September in the rainy season and in March in the dry season from 2018 to 2030 at existing and under construction power plants in the domestic power supply system.

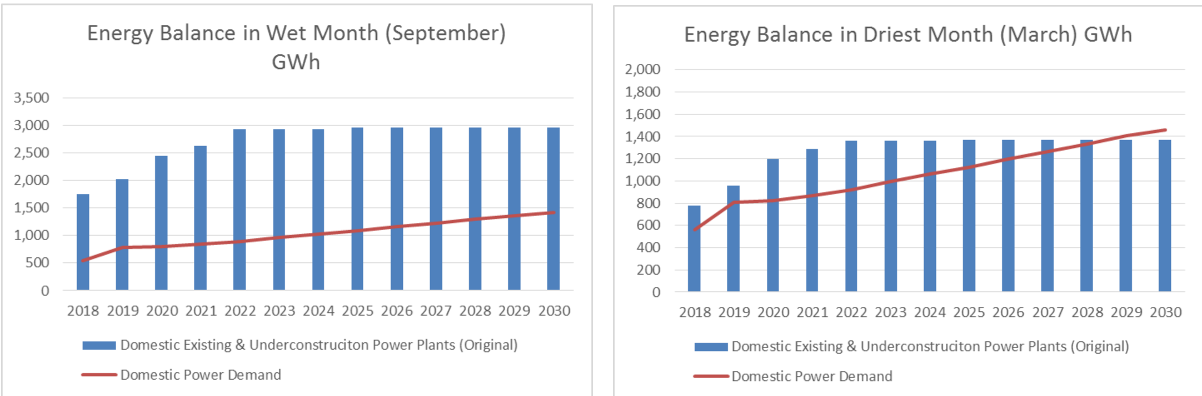


Figure 2-3 Amount of Generated Power by Existing and Under-construction Power Plants in the Domestic Power Supply System and Power Demand (September rainy season and March dry season)

The amount of power generation energy by existing and under-construction power plants will exceed the power demand until 2027 even in the dry seasons of March, when the amount of power generation energy is the smallest. Unused power generation capacity and power generation energy throughout the year is putting pressure on the finances of EDL, which has many feed-in contracts. The following measures can be taken to reduce surplus energy and to utilize the generated energy of power plants.

*Increase domestic power demand.

*Increase the amount of exports from the domestic power system.

*The power generation for domestic power supply is converted into the power generation for export

2.2. Regional Power Supply / Demand Balance for Existing and Under-construction Power Plants

Many of the existing and under-construction power plants in the domestic power supply system are located far from Vientiane, where large power demand is concentrated. The power generation capacity of existing and under-construction power plants connected to the domestic power supply system by prefecture and the distribution of maximum power demand in 2030 are shown in Figure 2-4 Distribution of Power Generation Capacity and Maximum Domestic Power Demand in 2030 by Prefecture for Existing and Under-construction Power Plants connected to the Domestic Power Supply System for details. Phongsaly and Luangprabang provinces in the north have large generation capacity. However, Vientiane is 400 -500 km away from those prefectures, and there is only 1 route of 230 kV transmission line. Therefore, the generated power cannot be transmitted to the demand center due to the restriction of power transmission stability. On the other hand, although the Xieng Khuang and Vientiane Province have large capacity to meet demand, they are close to Vientiane, so power transmission is possible. Many power plants for domestic power supply are located far from Vientiane Capital, which is a power demand center, and the domestic power system is insufficient to make full use of the generated power.

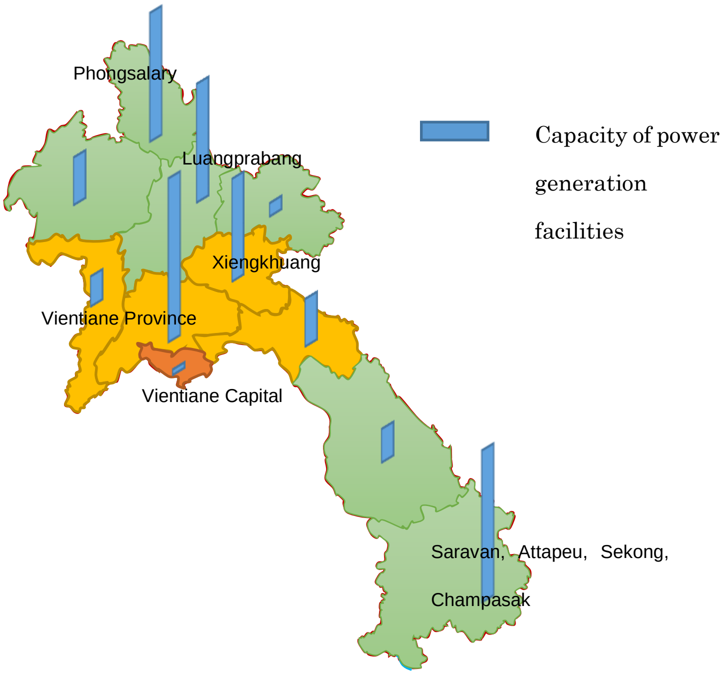


Figure 2-4 Distribution of Power Generation Capacity and Maximum Domestic Power Demand in 2030 by Prefecture for Existing and Under-construction Power Plants connected to the Domestic Power Supply System

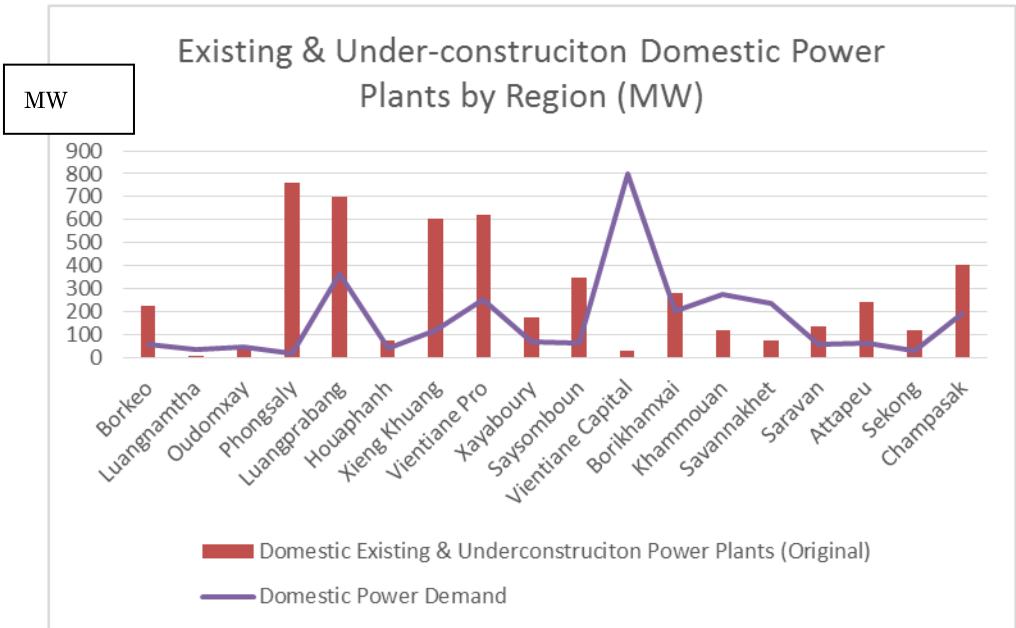


Figure 2-5 Distribution of Power Generation Capacity by Prefecture for Existing and Under construction Power Plants connected to the Domestic Power Supply System

2.1. Limits of Hydropower Transmission in the Northern Region

It is difficult to transfer hydroelectric power plants in the Nam Ou river system to Vientiane Capital via existing transmission lines. The reason is not limited by the heat capacity of transmission lines but by the stability of transmission lines.

Nam Ou Hydropower is a group of power plants of the Nam Ou river system across Phongsaly and Luangprabang provinces, with a combined maximum output of 1,272 MW. The distance from the 230 kV Bountai substation, the origin of the transmission line to Nam Ou 5,6,7, to Vientiane Capital's Naxaithon substation is 484 km.

	Generation Capacity (MW)
Nam Ou 1	180.0
Nam Ou 2	120.0
Nam Ou3	210.0
Nam Ou4	132.0
Nam Ou5	240.0
Nam Ou 6	180.0
Nam Ou7	210.0

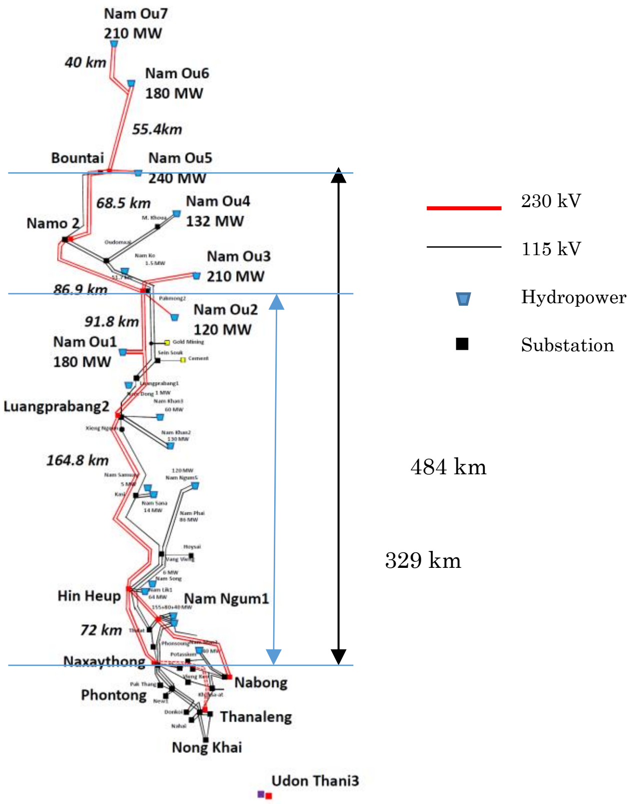


Figure 2-6 Power Transmission System of Hydroelectric Power Plants in Nam Ou River System

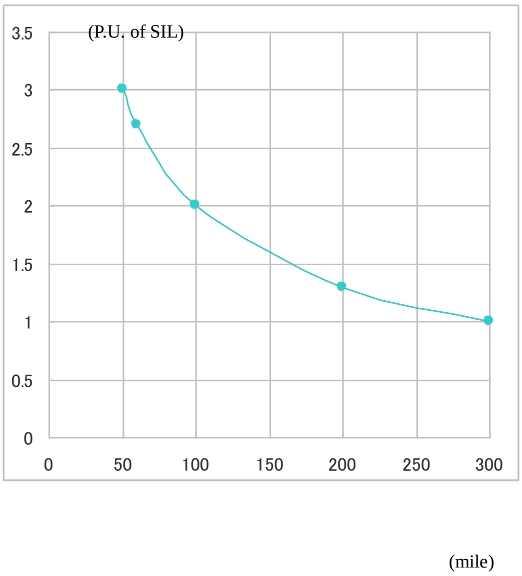
The amount of power which can be stably transmitted for this distance by 230 kV double circuits is estimated to be about 300 MW. Therefore, the current power transmission system cannot transmit all of the power generated in the Nam Ou river system to Vientiane Capital.

<Estimation of Available Power>

Method 1: The ability of power transmission is simply estimated from the voltage phase difference between the sending and the receiving ends and the impedance between them. The distance is 480

km in 230 kV double circuit lines. Assuming that the transient impedance of the generators are 0.4 p.u., the impedance of the step-up transformer is 10%, and the phase difference is 44 degrees ($\sin\theta = 0.7$), the amount of power that can be stably transmitted through the 230 kV double circuits is approximately 312 MW.

Method 2: The amount of power that can be transmitted through a certain distance can be estimated using the SIL value (Surge Impedance Load) unique to the transmission line as a guide. The SIL value is a current in which a voltage drop due to reactance of the transmission line balances a voltage rise due to capacitance. The relationship between transmission distance and transmission capacity is empirically obtained as a multiple of the SIL value and used as a guide. The graph below shows the relationship between transmission distance and transmission capacity.



(Source: Analytical Development of Loadability Characteristics for EHV and UHV Transmission Lines, "R.D. Dunlop, R. Gutman and P.P. Marchenko, IEEE Transactions on Power Apparatus and Systems, Vol. PAS -98, No. 2, March/April 1979, or Power System Stability and Control, P 228, 6.1. 12 Loadability Characteristics, P. Kundur, 1993)

Figure 2-7 Indication of Available Power Flow of a AC Transmission Line

The SIL value of 230 kV transmission line is 136 MVA for a single circuit and 273 MW for double circuits. According to the graph, the approximate power flow that can be transmitted over a distance of 480 km (= 300 mile) is 1 times the SIL value. Therefore, the amount power that can be stably transmitted through a 230 kV double circuit transmission line is approximately 273 MW.

Method 3: Determine the amount of power that can be stably transmitted by power system analysis. Stability calculations were performed using PSS/E system analysis software in the following three cases where the output power of Nam Ou was changed.

- Case A: Nam Ou 7 105 MW, Nam Ou 6 60 MW, Nam Ou 5 120 MW
- Case B: Nam Ou 7 105 MW, Nam Ou 6 60 MW, Nam Ou 5 240 MW
- Case C Nam Ou 4 88 MW, Nam Ou 210 MW

The fault type was set as a three-phase short-circuit fault of the Nam Mo-Pakmon transmission line, and the fault clearing time was set at 100 ms. The results are shown below. As confirmed in Methods 1 and 2, the output of Nam Ou 5, 6 and 7 in case A is close to the stability limit of about 300 MW. Case B is above the stability limit.

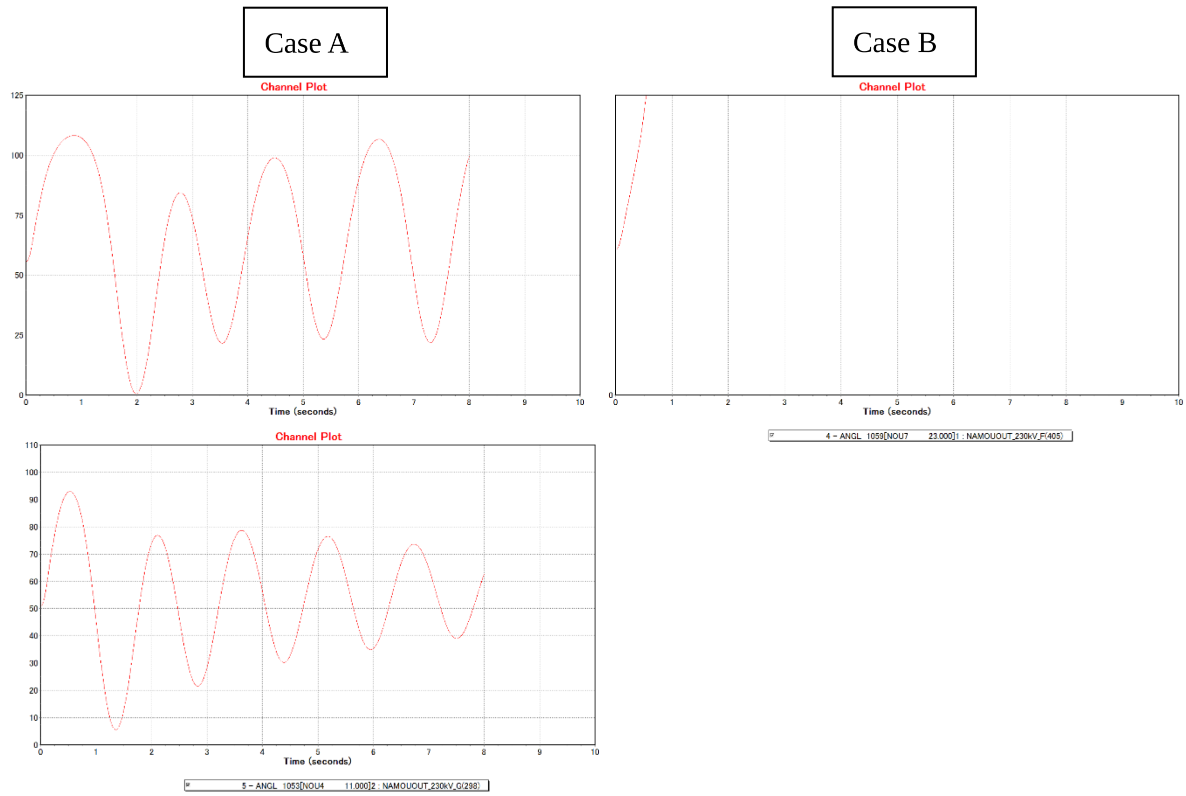


Figure 2-8 Results of stability calculations in each case with different Nam Ou outputs

<Conclusion>

Nam Ou 5, 6, 7 is over 480 km away from Vientiane, and its transmission capacity is estimated to be about 300 MW even with double circuits of 230 kV. Nam Ou 5, 6, and 7 cannot generate power to their full capacity because the total installed capacity is 630 MW. Since Nam Ou 1-7 has a total capacity of 1,272 MW and is distributed over a 300 km - 600 km radius from Vientiane, they cannot generate full power.

2.2. Conversion for Export of Power Plants Near the Border

Power plants located far from the domestic power demand-center and near the Lao border may be more effectively used for export to neighboring countries than to use them to domestic power supply, due to the needs to import electricity from Laos to neighboring countries. Specifically, among the existing power plants and those under construction that are connected to the domestic power supply system, power plants that are located far from the center of demand and close to neighboring countries will be converted for export in response to the needs of neighboring countries for power imports. The plants will be separated from the domestic supply system and will be sent to neighboring countries through an export dedicated lines.

Table 2-1 Existing and Under-construction Power Plants in Domestic Power Supply System to be Converted for Export

Name of Project	Location	Region	Inst.Cap	Energy (GWh)	COD
Nam Ou 5 (H)	Phongsalary	North	240 MW	1049	2016
Nam Ou 6 (H)	Phongsalary	North	180 MW	739	2016
Nam Kong 2 (H)	Attapeu	South	66 MW	263.11	2018
MK DonSahong (H)*	Champasack	South	195 MW	1504.5	2019
Nam Ou 7 (H)	Phongsalary	North	210 MW	810	2020
Nam Kong 1 (H)	Attapeu	South	160 MW	649	2021

*MK DonSahong (H) will convert three of the four units for export.

2.3. Power Export from the Domestic Power Supply System

To take advantage of the surplus power generated in the domestic power supply system, it is also effective to increase exports from the domestic power supply system throgh the international interconnections. Interconnections from the domestic power supply system to neighboring countries by 2030 are assumed as follows.

Table.2-1 Interconnections from the Domestic Power Supply System to Neighboring Countries by 2030 (Draft)

interconnection line	Thailand	Myanmar	Cambodia
existing	115 kV interconnection line	-	115 kV Ban Hat (EDL)
Capacity	610 MW	-	120 MW
New 1	230 kV Thabok (EDL) - Bung Kan (EGAT)	132/110 kV Thonpeng (EDL) - 132 kV Tachilek (Myanmar	-
Capacity	300 MW (estimate)	100 MW	-
New 2	500 kV M. Houn (EDL) - Tha Wang Pha (EGAT)	-	-
Capacity	1,000 MW (estimate)	-	-

2.4. Current and Future Supply/Demand Balance

The output of hydroelectric power plants in Laos fluctuates from season to season. The amount of power generated in the rainy season is large, and the amount of power generated in the dry season is small. The figure below shows the total monthly electric power generation of existing and under-construction hydroelectric power plants for domestic supply in Laos. The amount of generated power is small in the dry season from November to May, and the rainy season from June to October is large.

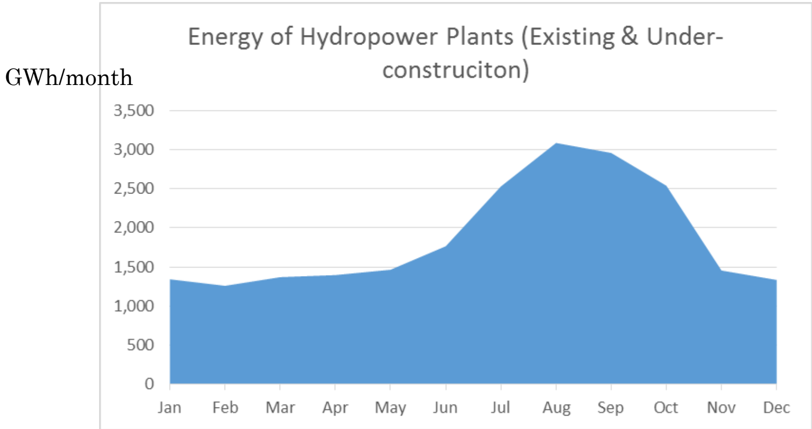


Figure 2-9 Total Monthly Power Generation Energy of Existing and Under-construction Hydropower Plants for Domestic Power Supply in Laos

On the other hand, domestic power demand in Laos fluctuates little between seasons. The following figure shows the current monthly supply-demand balance in Laos. The horizontal axis indicates the months, and the red line is the demand. The amount of generated energy throughout the year is larger than the demand, and the surplus power in the rainy season is particularly large.

Even if demand is expected to increase, it is possible to supply power without constructing new power sources for several years.

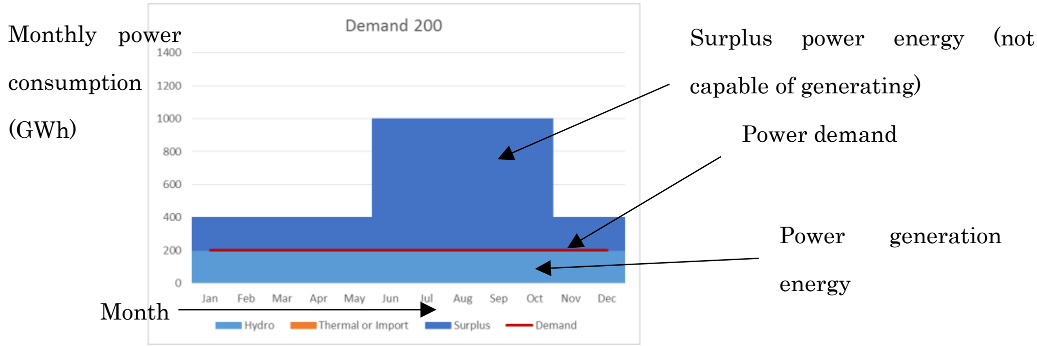


Figure 2-10 Current Monthly Power Supply / Demand Balance in Laos

In the future, when power demand increases and supply in the dry season becomes insufficient, new power sources will be required. That is, in the schematic diagram below, a new power supply is required to supply the difference between the demand in the dry season and the generated power. In the rainy season, there is a surplus of electric power generated by existing power sources, so new power sources do not need to generate electricity.

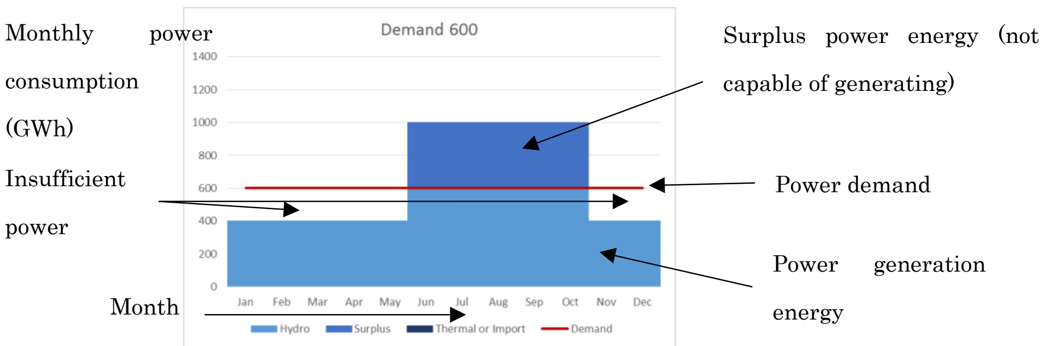


Figure 2-11 Schematic Diagram of the Power Supply / Demand Balance for Each Month in the Future in Laos (in case of NOT new power sources)

3. Power Generation Plan for Domestic Power Supply

3.1. New Power Supply

In the future, it is necessary to secure supply capacity in the dry seasons because supply capacity will be insufficient in the dry seasons. In the rainy season, surplus power continues to be generated, so there is no need to generate new power for a while. New power sources are generated only in the dry seasons.

3.2. Securing Supply Capacity by Hydroelectric Power Plants

Since hydropower has a low output in the dry seasons, it is necessary to install a considerably large capacity power plant in order to secure supply capacity in the dry seasons by newly installing hydropower. In addition, the annual capacity factor of newly constructed hydroelectric power plants is low because power generation is not required in the rainy season.

The average annual capacity factor of the existing hydropower plants currently under construction for domestic power supply system in Lao PDR is 51.3%. If power is generated only in January to May, November, and December in the dry season, but is shut down in other months, the capacity factor is only 22.1%. Therefore, it is feared that the cost per unit of generated power will increase.

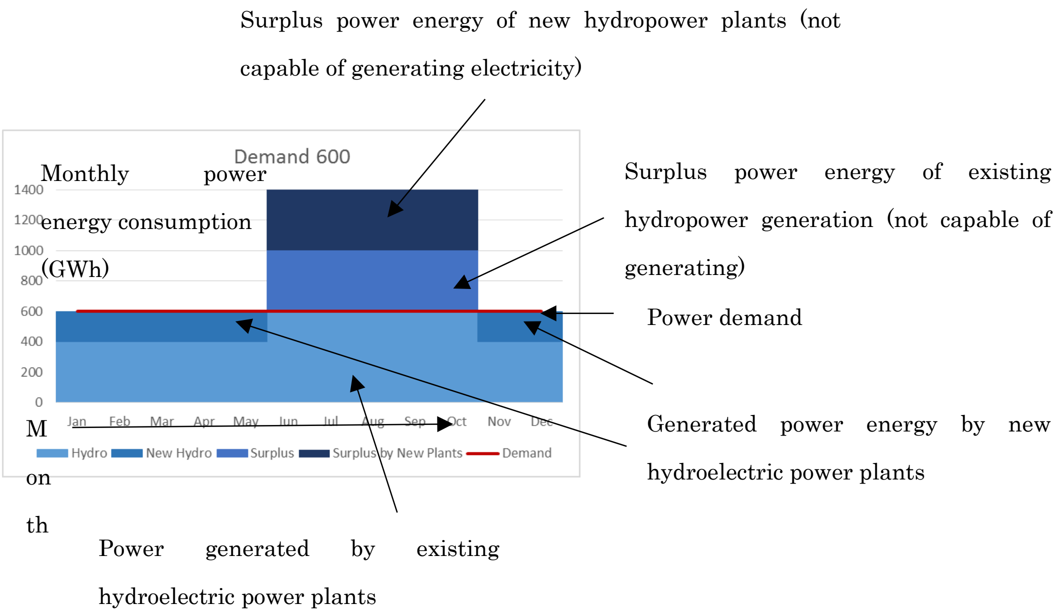


Figure 3-1 Securing Supply Capacity by Hydroelectric Power Plants

3.3. Securing Supply Capacity through Thermal Power Plants

If new thermal power plants are constructed to secure electricity during the dry seasons and shut down during the rainy seasons, the annual utilization rate of thermal power plants will be about 45%.

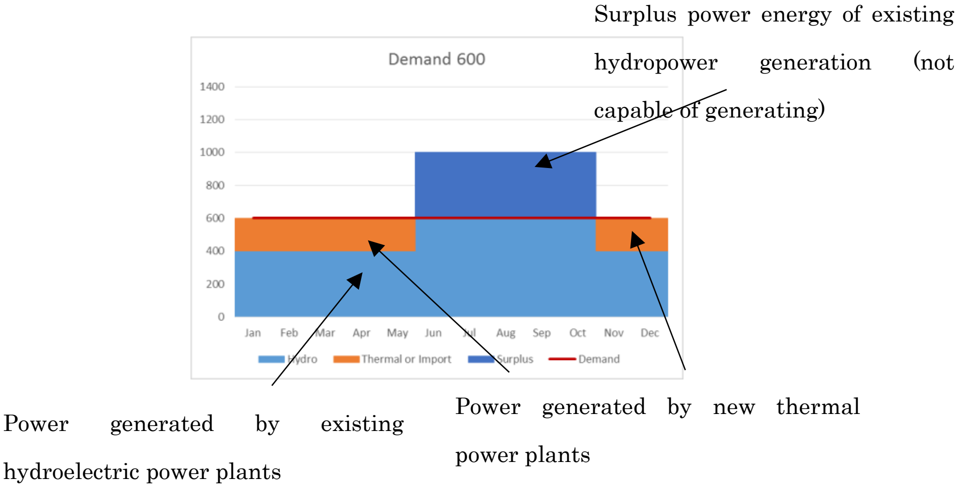


Figure 3-2 Securing Supply Capacity by Thermal Power Plants

3.4. Solar Power

If solar power is used to ensure supply capacity in the dry seasons, the annual capacity factor will be less than 10%.

3.5. Comparison of Costs of Various Types of Power Supplies

In order to secure supply capacity in the dry seasons, the cost of each new power source is compared.

The following figures show the utilization rates of facilities plotted on the horizontal axis and the annual cost and unit cost of power generation plotted on the vertical axis. In general, the cost of a solar power or hydroelectric power plant is the fixed cost of the power generation equipment, not the fuel cost. Therefore, the unit cost of power generation becomes lower as the annual power generation capacity utilization rate increases.

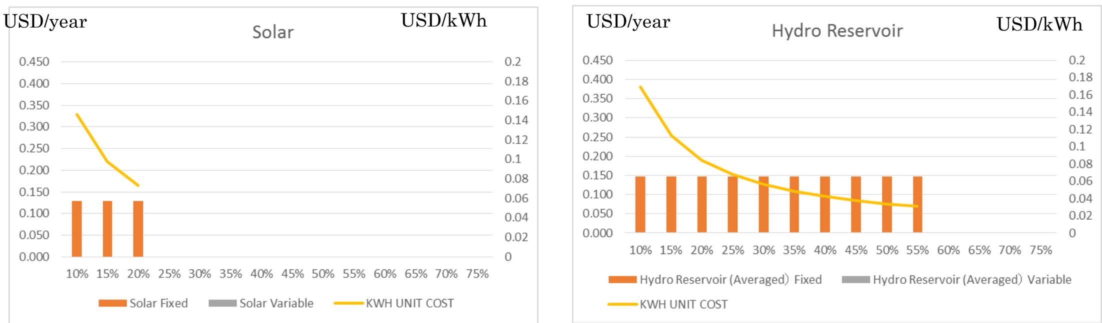


Figure 3-3 Solar and hydro costs (Power generation capacity 1 MW)

On the other hand, imports from EGAT do not have fixed costs, only variable costs (Unit price per KWH), and the unit cost of power generation does not depend on the annual utilization rate.

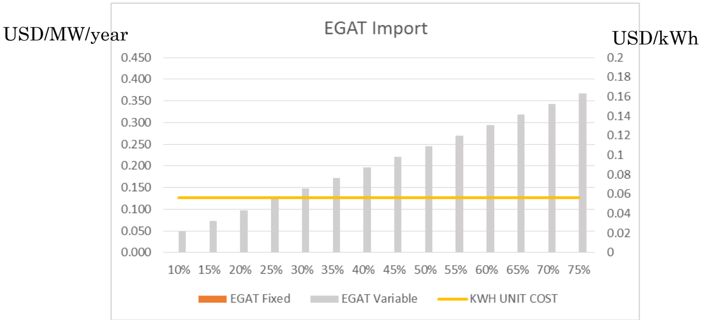


Figure 3-4 Cost of import from EGAT

There are fixed and variable costs (fuel cost) for thermal power plants, and as the annual amount of generated power energy increases, the unit price of generation decreases because the unit price of fixed costs decreases.

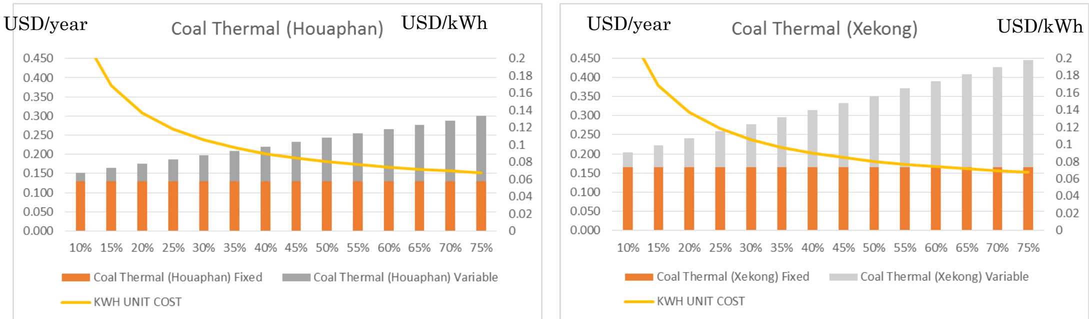


Figure 3-5 Cost of thermal power plants (Power generation capacity 1 MW)

Figure 3-6 Comparison of costs of various types of power supplies6 shows a comparison of the costs of power generation from solar, reservoir hydro, coal-fired (Houaphan Province), coal-fired (Xekong Province), and EGAT in relation to the annual capacity factor. The horizontal axis indicates the annual capacity factor, and the vertical axis indicates the cost per unit of generated power.

Based on the above analysis, the annual capacity factor for generating electricity only in the dry season in Lao PDR is 22% for hydropower, 45% for thermal power and 10% for solar power.

If the power generation facilities are operated at the capacity factor to ensure the amount of generated power only in the dry seasons, the cost becomes high in the order of;

- Solar
- Coal-fired (Xekong Province) 500 kV Transmission Line 300 km

- Reservoir type hydropower
- Coal-fired (Houaphan Province) 500 kV Transmission Line 200 km
- Imports from EGAT

Therefore, in order to secure supply capacity in the dry seasons in Laos, EGAT imports or the Houaphan thermal power plant are economically superior.

However, there is an upper limit to the amount imported from EGAT, so the Houaphan thermal power plant is planned as a new power source. The reason why EGAT became the cheapest is that the cost of power generation includes gas-fired thermal power, and when the capacity factor is lower than 50%, it becomes cheaper than the cost of hydroelectric and coal-fired thermal power.

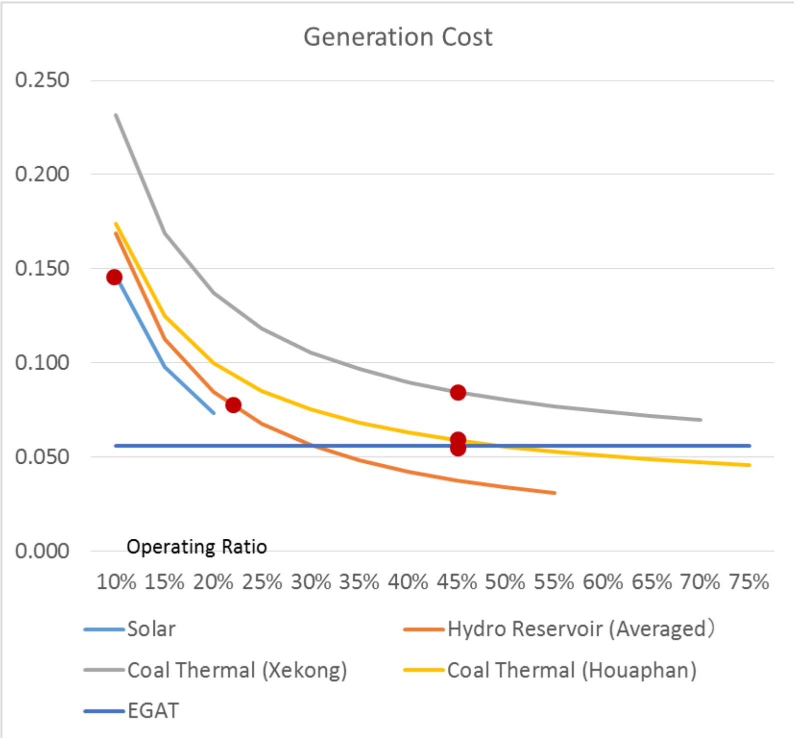


Figure 3-6 Comparison of costs of various types of power supplies

4. Plan for Domestic Power Supply

For domestic power supply plans Table. 4-1 Power Stations remained in Domestic Power Supply System (Existing)fromTable. 4-5 Convert for Exportfor details.

Table. 4-1 Power Stations remained in Domestic Power Supply System (Existing)

Provinces	Power Plant	MW	Type		Owner
Luangprabang	Nam Ou 2	120	Reservoir	2016	IPP.D
Luangnamtha	Nam Long	5	Run of river	2013	IPP.D
Luangprabang	Nam Khan 2	130	Reservoir	2015	EDL & EDL-G
Luangprabang	Nam Khan 3	60	Reservoir	2016	EDL & EDL-G
Luangprabang	Nam Dong	1	Run of river	1970	EDL
Oudomxay	Nam Ko	1.5	Run of river	1996	EDL
Luangnamtha	Nam Tha 3	1.3	Run of river	2010	IPP.D
Borkeo	Nam Nhon	2.4	Run of river	2011	IPP.D
Xayaboury	Hongsa Lignite (T) (d)	100	Thermal	2015	IPP.E
Oudomxay	Nam Beng	36	Reservoir	2016	IPP.D
Oudomxay	Nam Nga 2	14.5	Run of river	2017	IPP.D
Houaphanh	Nam Peun 2	12	Run of river	2017	IPP.D
Xieng Khuang	Nam Sien Tad Lang	5	Run of river	2014	IPP.D
Xieng Khuang	Nam Ngiep 2	180	Reservoir	2015	IPP.D
Xieng Khuang	Nam Ngiep 3A	44	Reservoir	2015	IPP.D
Xieng Khuang	Nam San 3A	69	Reservoir	2016	IPP.D
Xieng Khuang	Nam Ngiep 2C	15	Run of river	2017	IPP.D
Vientiane Pro	Nam Ngum 1	155	Reservoir	1971	EDL & EDL-G
Vientiane Pro	Nam Mang 3	40	Reservoir	2004	EDL & EDL-G
Vientiane Pro	Nam lik 1/2	100	Reservoir	2010	IPP.D
Vientiane Pro	Nam Song	6	Reservoir	2011	EDL & EDL-G
Vientiane Pro	Nam Ngum 5	120	Reservoir	2012	IPP.D
Vientiane Pro	Nam Sana	14	Run of river	2014	EDL & EDL-G
Vientiane Pro	Nam Ngum 1 (Extensien I	80	Reservoir	2018	EDL
Vientiane Pro	Nam Lik 1	64	Run of river	2019	IPP.D
Saysomboun	Nam Luek	60	Reservoir	2000	EDL & EDL-G
Saysomboun	Nam San 3B	45	Reservoir	2015	IPP.D
Saysomboun	Nam Sor	7.38	Run of river	2016	IPP.D
Saysomboun	Nam Phai	86	Reservoir	2017	IPP.D
Saysomboun	Nam Chiene	104	Reservoir	2017	EDL
Vientiane Capital	Naxaythong Solar Farm (S	32	Renewable	2017	EDL & EDL-G
Borikhamxai	Nam Gnoug 8	60	Reservoir	2012	IPP.D
Borikhamxai	Nam Phao	1.6	Run of river	2012	IPP.D
Borikhamxai	Nam Mang 1	64	Reservoir	2016	IPP.D
Khammouan	Nam Theun 2 (d)	75	Reservoir	2009	IPP.E
Savannakhet	Sugar Mitlao Factory (T)	3	Biomus	2012	IPP.D
Savannakhet	Tadsalen	3.2	Run of river	2013	IPP.D
Attapeu	Houay Ho (d)	2.1	Reservoir	1999	IPP.E
Champasak	Xelabam	5	Run of river	1970	EDL & EDL-G
Champasak	Xeset 3	23	Reservoir	2016	EDL
Champasak	Xenamnoy 2 - Xekatam 1	20.1	Run of river	2017	IPP.D
Saravan	Xeset 1	45	Run of river	1990	EDL & EDL-G
Saravan	Xeset 2	76	Run of river	2009	EDL & EDL-G
Saravan	Houay por	15	Run of river	2019	IPP.D
Attapeu	Sugar Factory Attapeu (T	15	Biomus	2013	IPP.D
Sekong	Xenamnoy 1	15	Run of river	2014	IPP.D
Sekong	Houaylamphanh Gnai	88	Reservoir	2015	EDL
Champasak	Xenamnoy 6	5	Run of river	2016	IPP.D

Table. 4-2 Power Stations remained in Domestic Power Supply System (Under construction)

Provinces	Power Plant	MW	Type		Owner
Luangprabang	Nam Ou 1	180	Run of river	2020	IPP.D
Borkeo	Nam Tha 1	168	Reservoir	2018	IPP.D
Houaphanh	Nam Peun 1	15	Run of river	2018	IPP.D
Houaphanh	Nam Sim	8.4	Run of river	2018	IPP.D
Houaphanh	Nam Hao	15	Run of river	2019	IPP.D
Houaphanh	Nam Mon 1	10	Run of river	2019	IPP.D
Borkeo	Nam Ngao	15	Reservoir	2020	EDL
Borkeo	Nam Tha 2 (B. Hat Mouak	37.5	Run of river	2020	IPP.D
Houaphanh	Nam Dick 1	15	Run of river	2020	IPP.D
Xieng Khuang	Nam Aow (Nam Pot)	15	Reservoir	2018	IPP.D
Xieng Khuang	Nam Ngiep 2A	12.55	Run of river	2019	IPP.D
Xieng Khuang	Nam Ngiep 2B	9.44	Run of river	2019	IPP.D
Xieng Khuang	Nam The	15	Run of river	2019	IPP.D
Xieng Khuang	Nam Ngum 4	240	Reservoir	2021	IPP.D
Xieng Khuang	Nam Ngum Keng Kaun	1	Run of river	2022	NA
Vientiane Pro	Nam Samoi	5	Run of river	2020	NA
Vientiane Pro	Nam Ngum 1 (Extensien I	40	Reservoir	2020	EDL
Xayaboury	MK. Xayaboury (d)	60	Run of river	2019	IPP.E
Xayaboury	Nam Houng Down	15	Run of river	2019	IPP.D
Saysomboun	Nam PhaGnai	19.2	Reservoir	2018	IPP.D
Saysomboun	Nam Chee 1	15	Run of river	2021	IPP.D
Borikhamxai	Nam Ngiep Regulation	20	Run of river	2019	IPP.D
Borikhamxai	Nam Theun 1 (d)	130	Reservoir	2022	IPP.E
Borikhamxai	Nam Sor (Borikhamxai)	4.2	Run of river	2022	IPP.D
Khammouan	Nam Hinboun	30	Reservoir	2018	EDL
Khammouan	Nam Hinboun (Down)	15	Run of river	2020	IPP.D
Savannakhet	Xelanong 1	70	Reservoir	2021	IPP.D
Champasak	Houay Chiae	8	Run of river	2020	IPP.D
Champasak	Houay palai	30	Reservoir	2021	EDL
Champasak	Houay Yoi - Houaykod	15	Run of river	2021	SPP.D
Champasak	MK. Donsahong(d)	65	Run of river	2019	IPP.D
Champasak	Xepien - Xenamnoy (d)	40	Reservoir	2019	IPP.E
Sekong	Houaylamphan Gai (Dowr	15	Run of river	2025	IPP.D
Saysomboun	Nam Karp	12	Run of river	2019	0

Table 4-3 Remaining Power Sources in Domestic Power Supply System (New)

Provinces	Power Plant	MW	Type		Owner
Houaphanh	Huaphan Coal Power Plar	600	Thermal	2021	IPP.D
Luangnamtha	Nam Pha	180	Reservoir	2022	IPP.D
Saysomboun	Nam Phouan	102.3	Reservoir	2023	IPP.D
Champasak	Nam Phak	150	Reservoir	2021	IPP.D
Attapeu	Xekong (Downstream)A	50	Run of river	2020	IPP.D
Saysomboun	Nam Bak 2	120	Reservoir	2028	

Table. 4-4 Convert for Domestic Power Supply from Export

Provinces	Power Plant	MW	Type		Owner
Attapeu	Houay Ho (e)	150	Reservoir	1999	IPP.E

Table. 4-5 Convert for Export

Existing

Provinces	Power Plant	MW	Type		Owner
Phongsaly	Nam Ou 5	240	Reservoir	2016	IPP.D
Phongsaly	Nam Ou 6	180	Reservoir	2016	IPP.D
Attapeu	Nam Kong 2	66	Reservoir	2017	IPP.D

Under construction

Provinces	Power Plant	MW	Type		Owner
Phongsaly	Nam Ou 7	210	Reservoir	2020	IPP.D
Phongsaly	Nam Ou 4	132	Reservoir	2020	IPP.D
Luangprabang	Nam Ou 3	210	Run of river	2020	IPP.D
Champasak	MK. Donsahong (e)	195	Run of river	2019	IPP.D
Attapeu	Nam Kong 3	45	Reservoir	2021	IPP.D
Attapeu	Nam Kong 1	160	Reservoir	2021	IPP.D

(Export dedicated power stations are developed through contracts between private companies and neighboring countries, taking into account the supply-demand balance and the concept of securing supply capacity in neighboring countries. As a result, the direction of some plans is unclear at present. The further investigations and study will be conducted about this matter.)

5. Formulation of a New Power System Development Plan (Domestic Power Supply System)

5.1. Applicable Standards for Power System Improvement Plans

Standards for power transmission and transformation facility planning in Lao Grid Code, June 2013 are as follows.

System Reliability

- Load is less than the heat capacity of equipment during normal operation (normal condition).
- Normal operation possible in case of a single accident (N -1)

Bus Voltage

	Voltage
normal time	95% - 105%
abnormal condition	90% - 110%

Maximum Fault Current

It is evaluated for the following maximum accident current.

Voltage (KV Rating)	Accidental Current Liability (Short Circuit Duties)
500 kV	50 kA
230 kV	50 kA
115 kV	40 kA

Transient Stability

Stable after the following fault clearing time

Voltage (KV Rating)	Accident removal time (Fault Clearing Time)
500 kV	50 kA, 4 cycles, 80 ms
230 kV	50 kA, 5 cycles, 100 ms
115 kV	40 kA, 7 cycles, 140 ms

5.2. Needs for Individual Projects

Connection of 230 kV Pia Lat – Dongphosy Transmission Line to Naxaythong

In 2030, the power flow and transmission loss are compared between Case (A) and Case (B) shown in Figure 5-1.

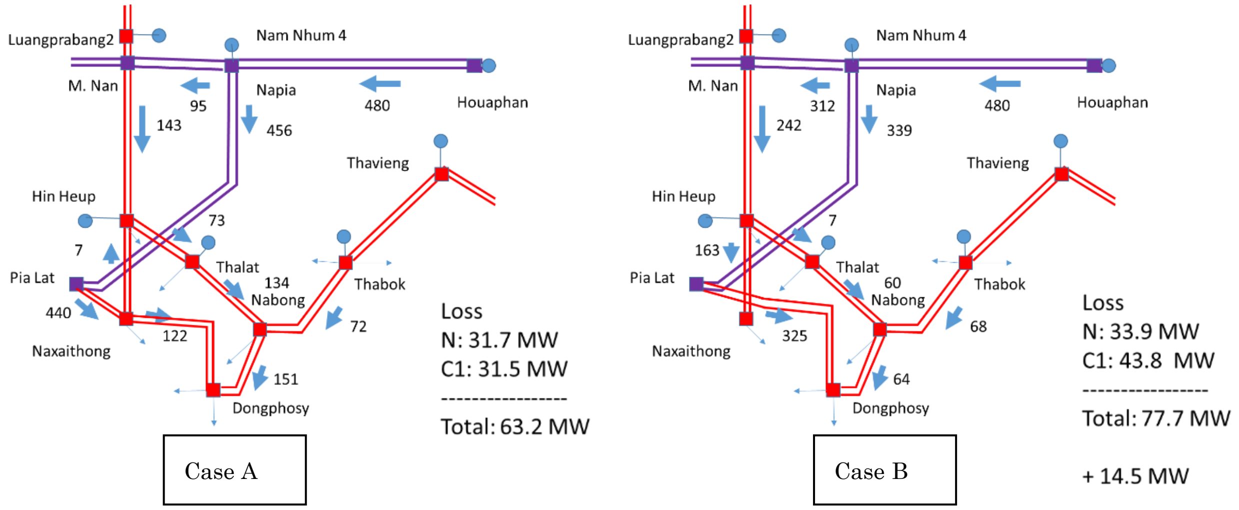


Figure 5-1 Power flow and power transmission losses of the 230 kV Pia Lat – Dongphosy transmission line with the case of connecting Naxaythong and not conecting Naxaythong at the peak power demand during dry season in 2030

Pulling the 230 kV Pia Lat – Dongphosy transmission line to Naxaythong reduces transmission losses by 14.5 MW. This loss reduction will increase exports to EGAT and decrease imports. This amount is at least 1 million USD per year, while the bays of 230 kV 4 circuits take costs at about 5 million USD. Therefore, in 5 years, the increase in the cost for bays can be recovered through loss reduction, and after that, the cost reduction can be expected.

In addition, power supply reliability of Naxaythong can be improved, because more than one power supply sources can be secured by pulling the transmission line into Naxaythong.

Therefore, it is recommended to pull the 230 kV Pia Lat – Dongphosy transmission line to Naxaythong.

5.3. Case of Power Export to Thailand from Nam Ou 5-7

In the base case, Nam Ou 5-7 is to be exported to Vietnam because it is close to Vietnam and far from Vientiane. However, there is also the possibility of exporting to Thailand. When exporting Nam Ou 5-7 to Thailand, a 500 kV transmission line is required between Namo and M. Houan. Between 500 kV M.Houan-Thailand, 1,500 MW can be secured during the rainy season and 1,000 MW during the dry season with other power stations.

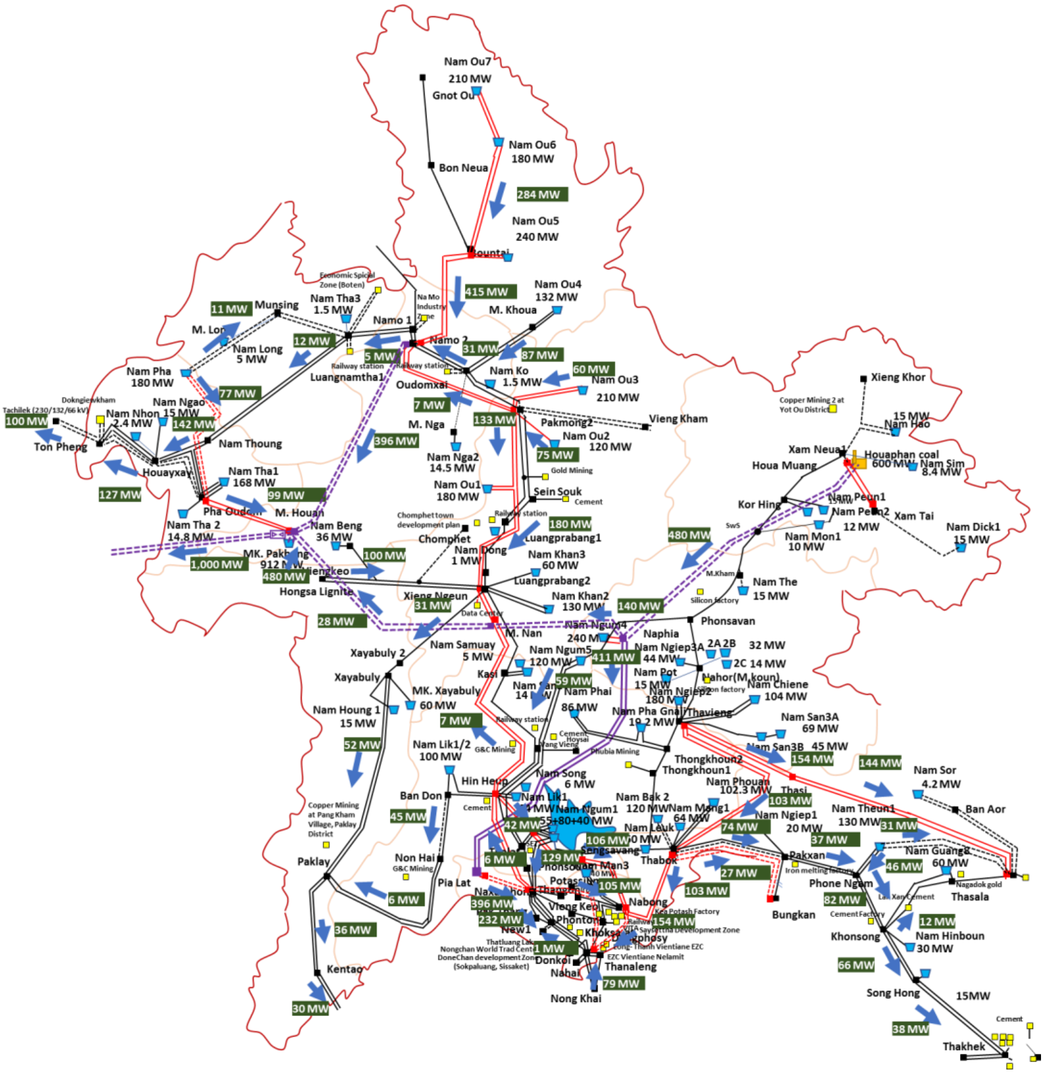


Figure 5-2 Power Flow in Case of Exporting Nam Ou 5-7 to Thailand (Dry Season)

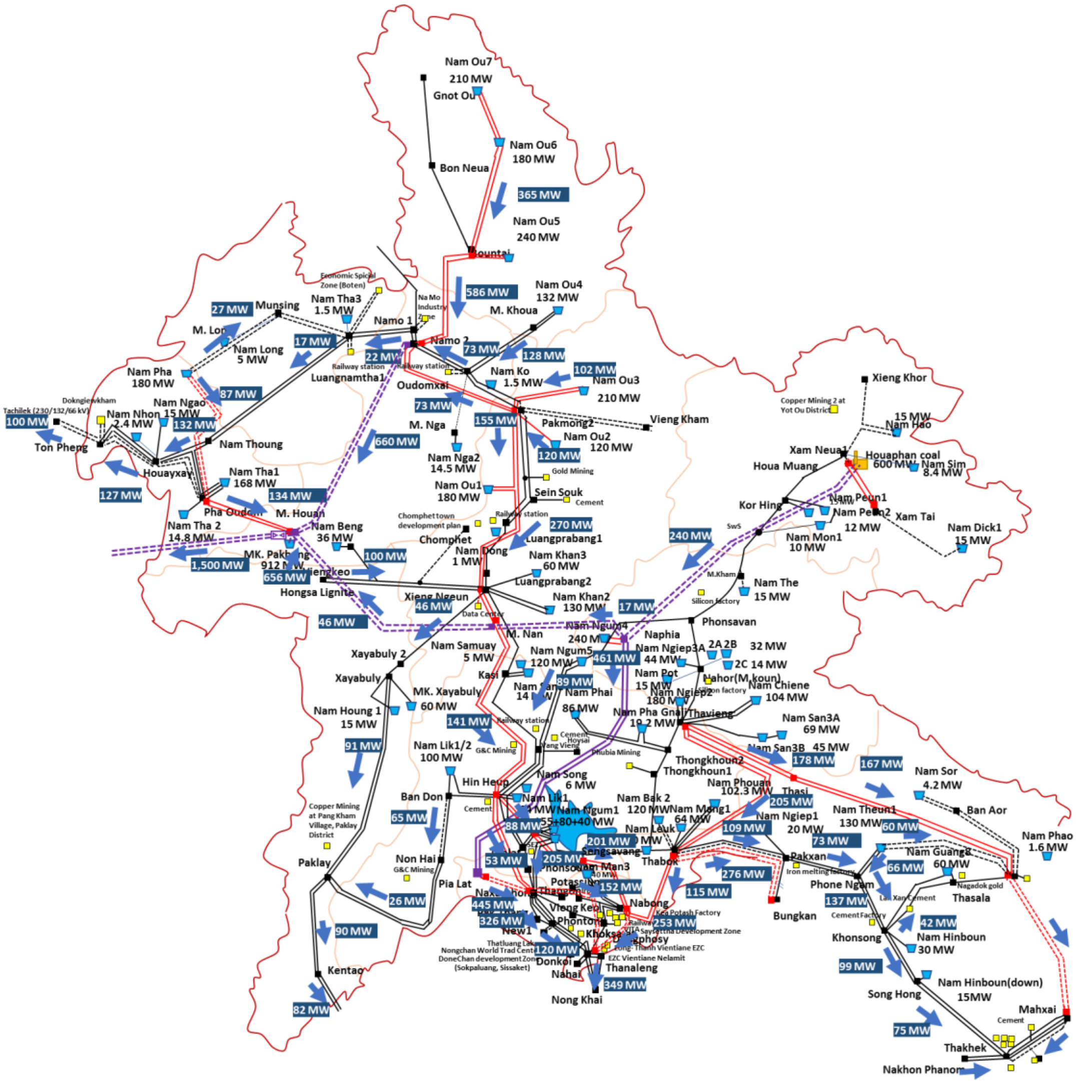


Figure 5-3 Power Flow in Case of Exporting Nam Ou 5-7 to Thailand (Wet Season)

(The needs for other individual projects will be described in later reports.)

5.4. Power System Analysis

Based on the PSS/E data provided by the EDL, the analytical data of the Lao system in 2030 are prepared. Power flow calculation and fault current calculation are carried out by PSS/E ver 33.4. (Stability will be described in a later report.)

The system analyzed here have the maximum demand in the dry season (March) and the maximum demand in the rainy season (September) in 2030.

Load

Maximum power demands of substations and large customers were used. The power factor was assumed 85%.

Power Outputs of Power Plants

The average power outputs of the hydropower plants was calculated from the data on the amount of power generated in the corresponding month.

The reservoir type hydropower stations can follow the monthly demand curve excluding the power demand supplied by the run-of-river type hydropower, and the power output at the time of maximum demand was estimated from the data of electric power generation in the corresponding month.

Voltage Regulation

In order to compensate the line charging capacity, shunt reactors for line compensation of 500 kV transmission line was assumed. (A 500 kV transmission line has a charging capacity of about 1 MVA per 1 km.)

As the distance increases, reactive power of several hundred MVA is generated and the system voltage increases.

Results of Power Flow Calculation

Power flow calculation results at maximum demand (Maximum load of each substation) are shown in Figure 5-1 Power Flow during Dry Seasons in the North and Central 1~ Figure 5-4 for details. In both cases, when a single circuit in the system fails, the power flow is within the capacity of the remaining lines.

Results of Fault Current Calculations

Three - phase short - circuit fault currents are calculated at each bus. The result was below the permissible maximum fault current.

5.5. Plan of Transmission Lines and Substations for Domestic Power Supply System

(A list of transmission lines and substations is given in a later report.)

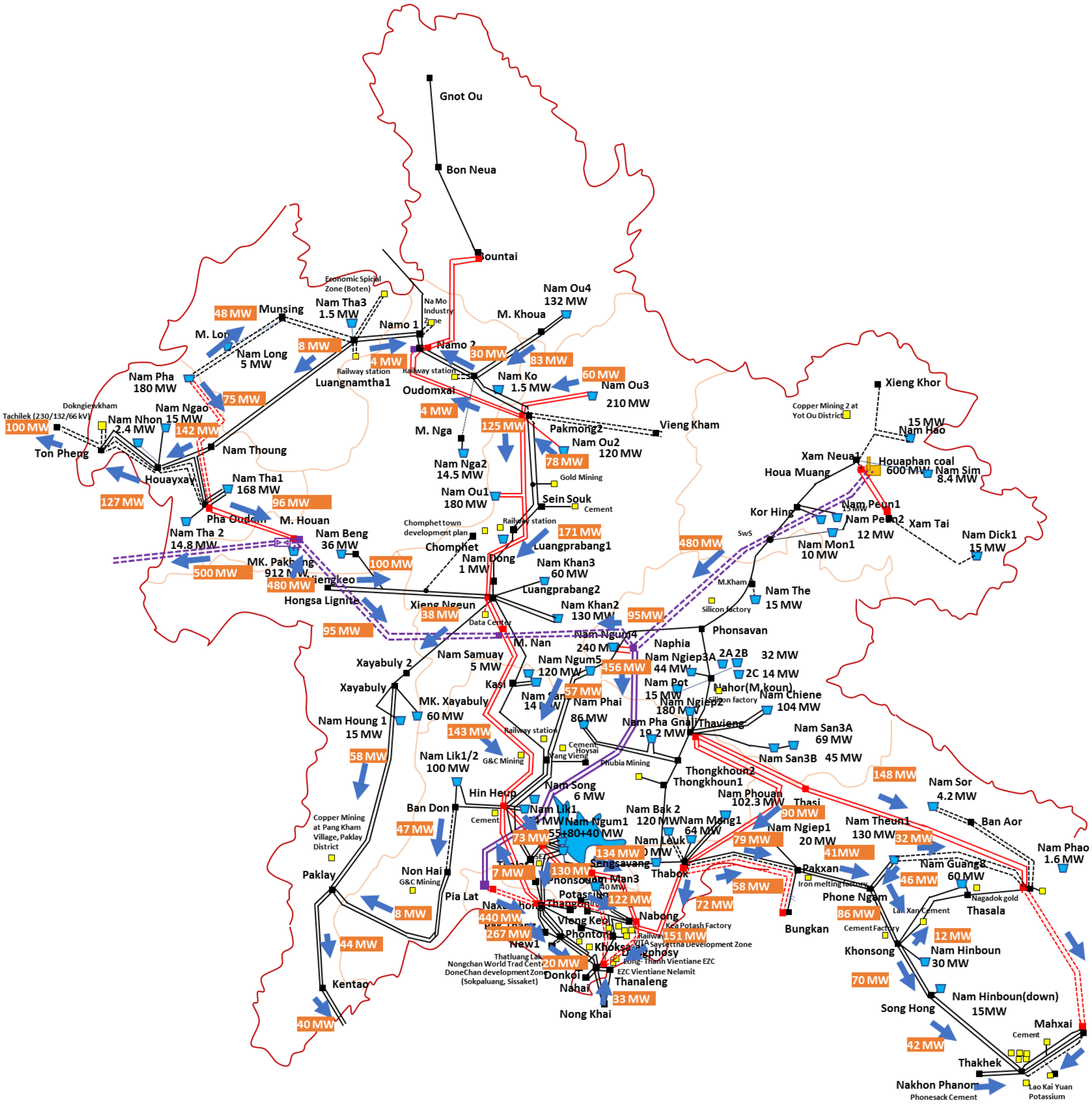


Figure 5-1 Power Flow during Dry Seasons in the North and Central 1 (Base Case)

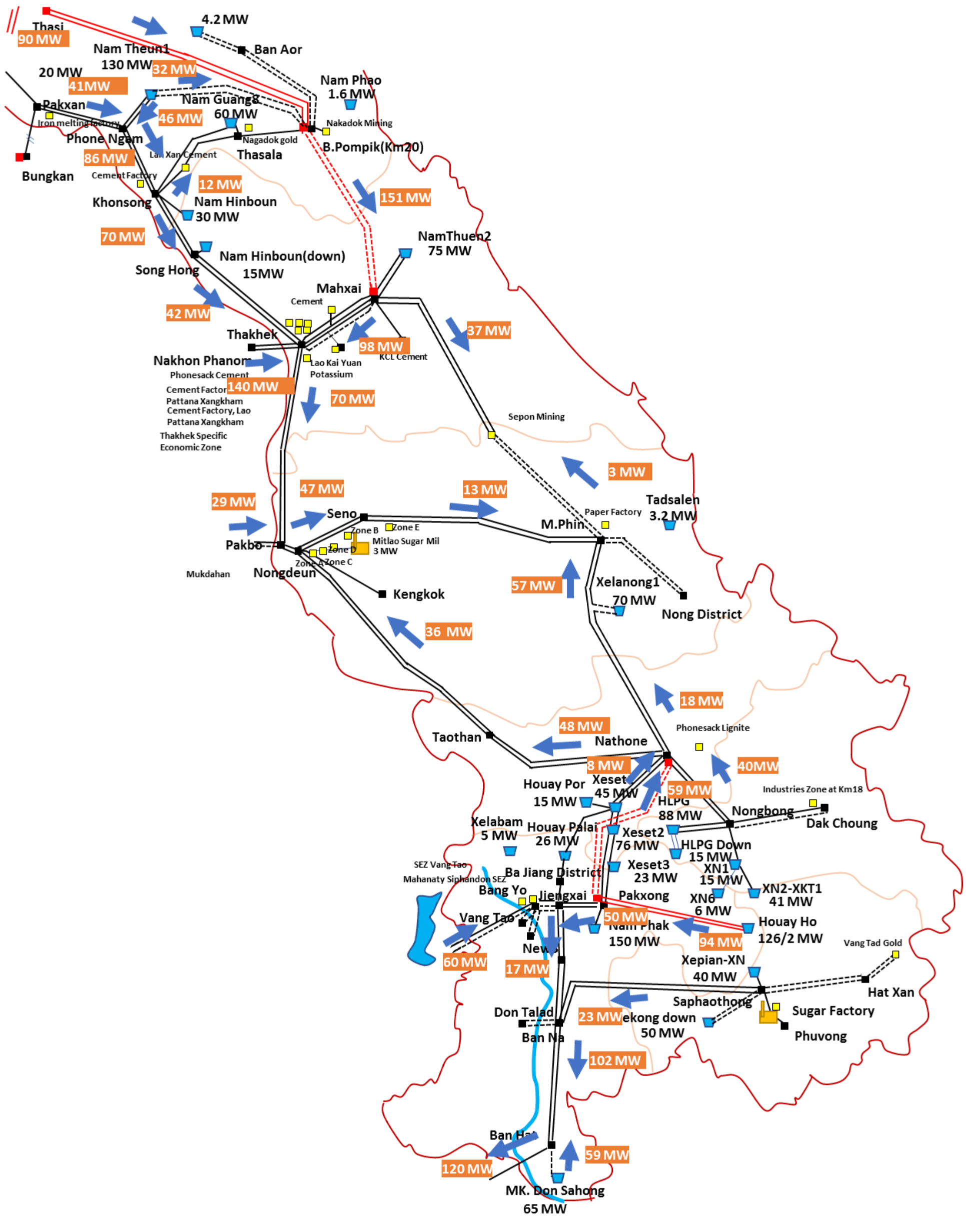


Figure 5-2 Power Flow during Dry Seasons in the Central 2 and South (Base Case)

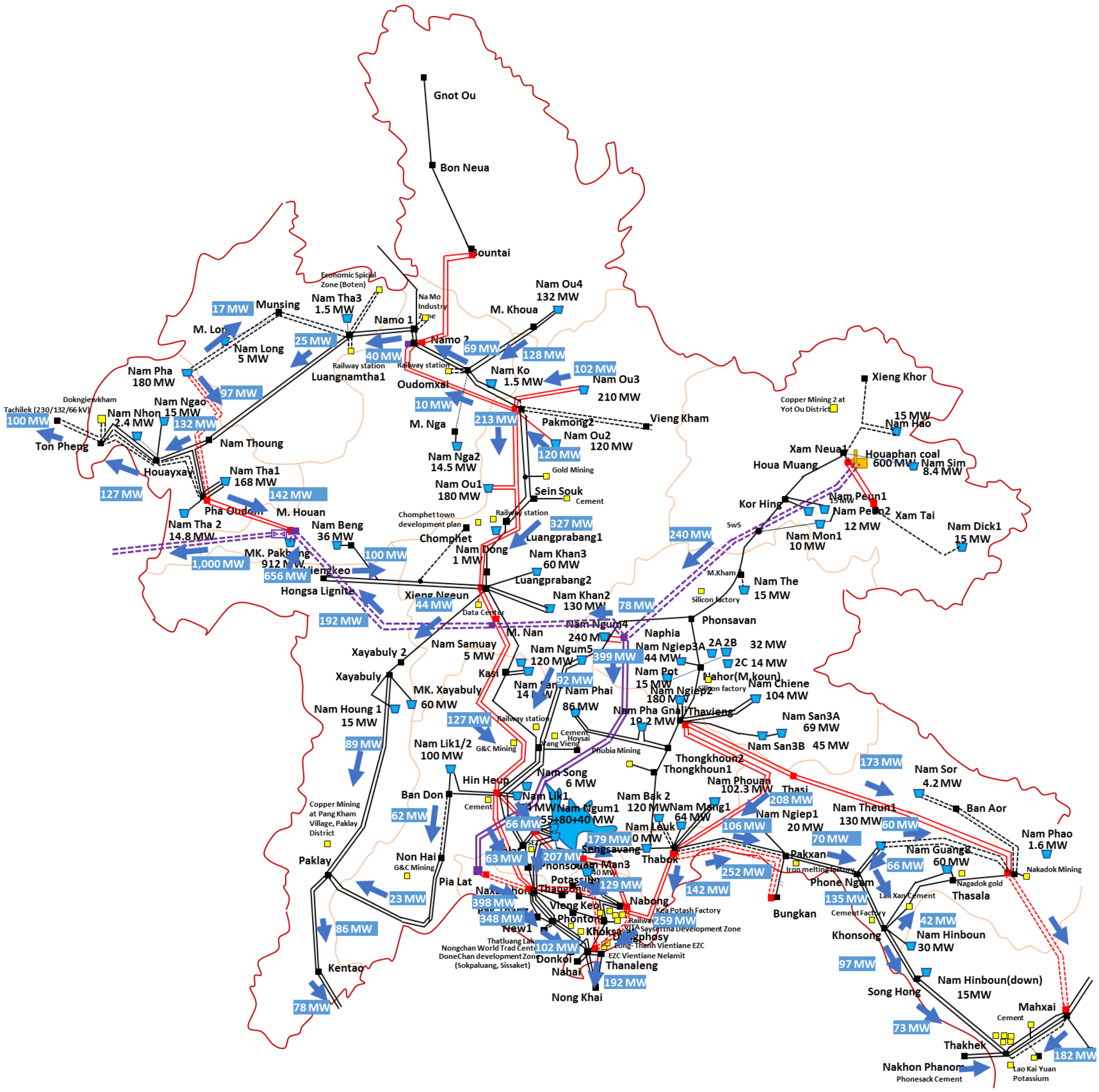


Figure 5-3 Power Flow during Rainy Seasons in the North and Central 1 (Base Case)

5

Figure 5-4 Power Flow during Rainy Seasons in the Central 2 and South (Base Case)

Appendix 1-2_Progress Report until 8th mission on May 2019

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

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

- Kick off Meeting

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Holdings, Inc.

TEPCO Power Grid, Inc.

NIPPON KOEI CO., LTD.

Tokyo Electric Power Services Co., Ltd.

Vientiane

May 20, 2019

Todays Agenda

1. Domestic Power Generation Plan 2030
2. Domestic Power Transmission Plan 2030
3. Export Power Generation Plan & Export Dedicated Power Transmission Lines up to 2030
4. Issues regarding system operation for interconnection
5. Current Limitation of Power Transmission Ability from Nam Ou
6. Future Study Topics

1. Domestic Power Generation Plan 2030

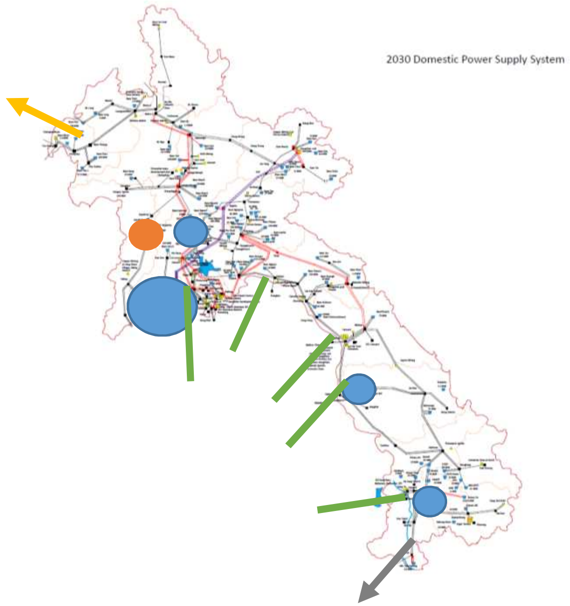
Power Demand Forecast in "Domestic Power System" up to 2030

Power Demand Forecast in Domestic Power System made in 2018

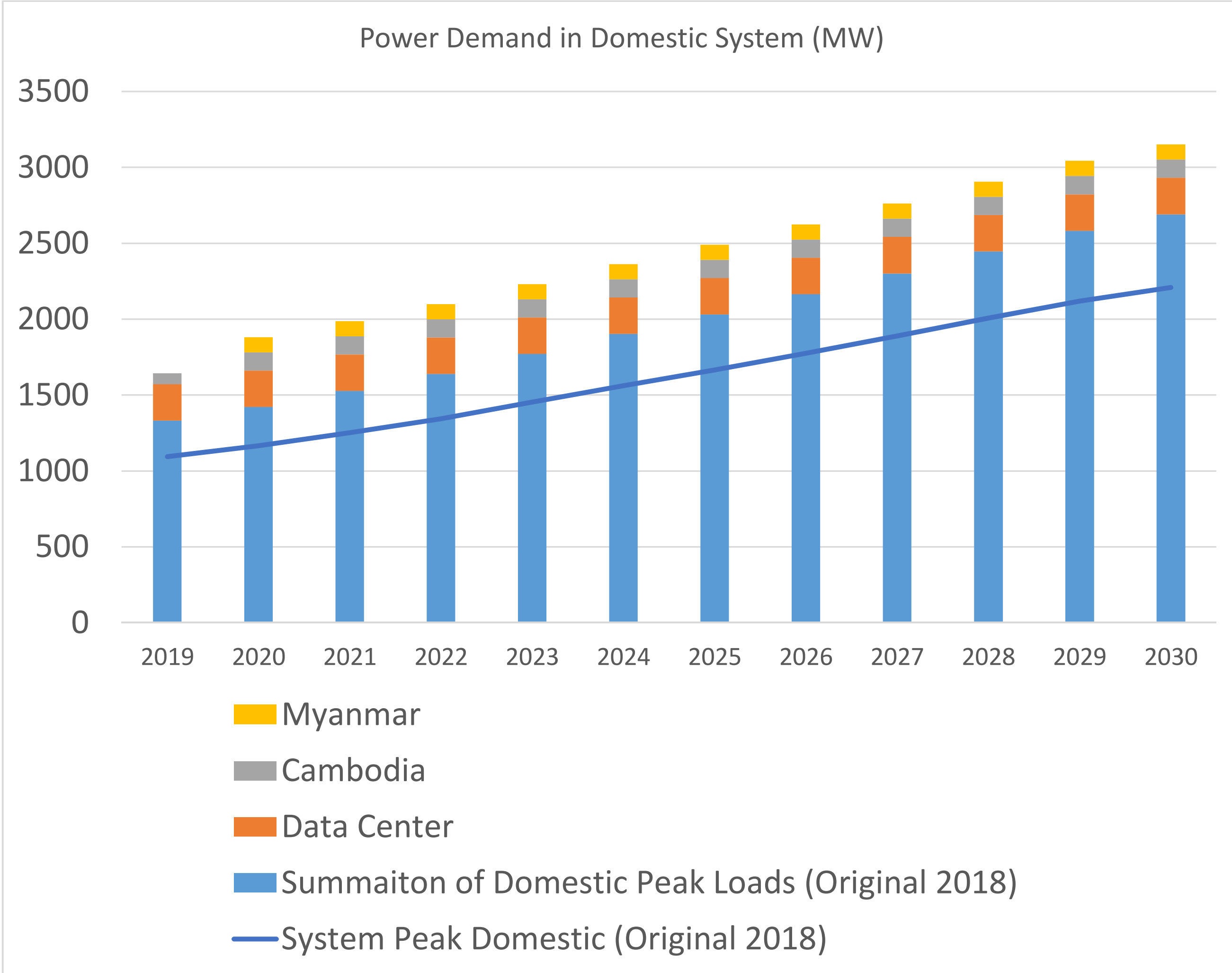
+Data Center Luang Prabang (240 MW)

+Cambodia (120 MW)

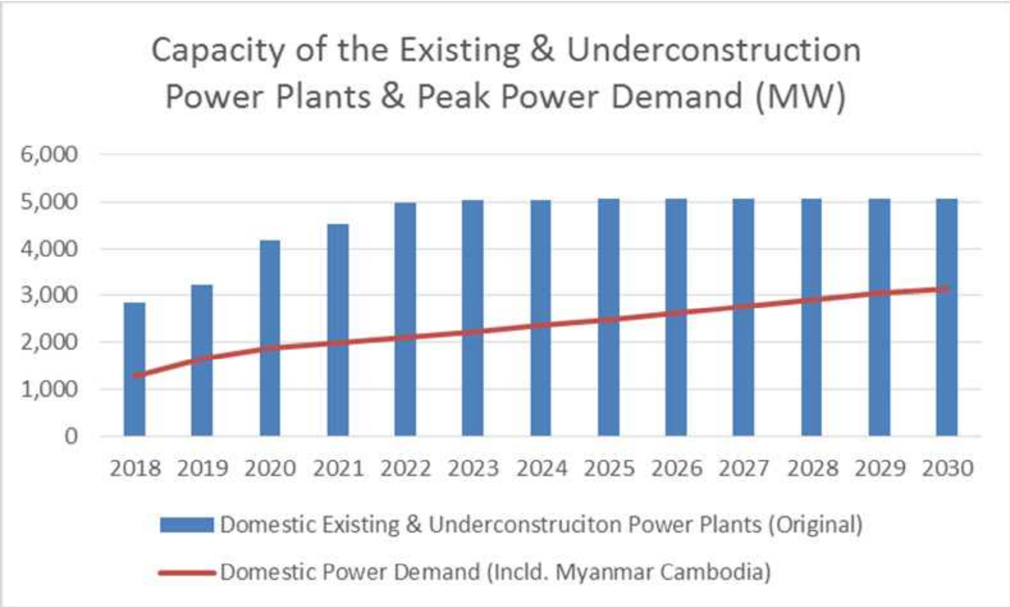
+Myanmar (100 MW)

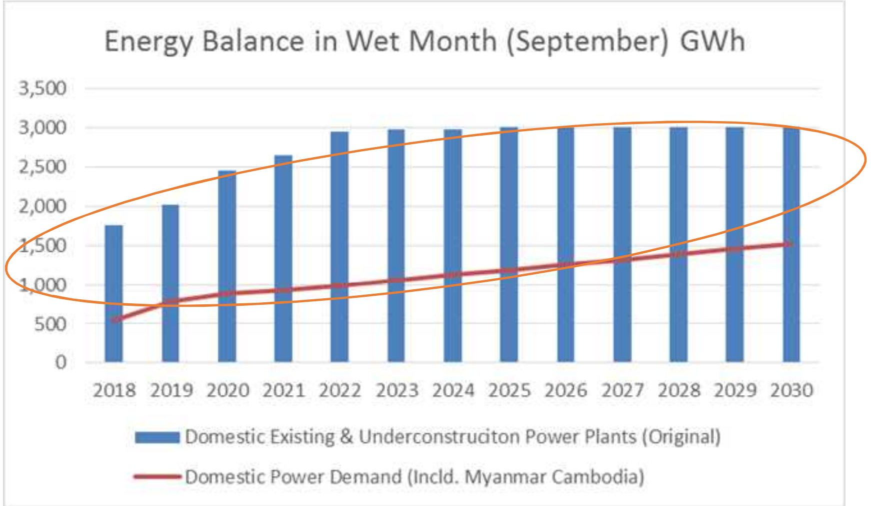


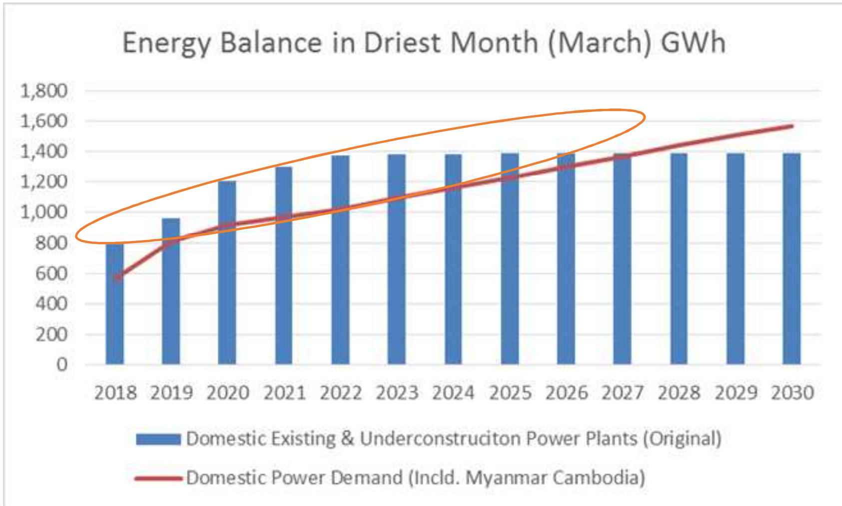
Power trade with EGAT through 115 kV interconnections is still continued.



Power Supply by "Existing & Under-Construction" Power Stations in Domestic Power System





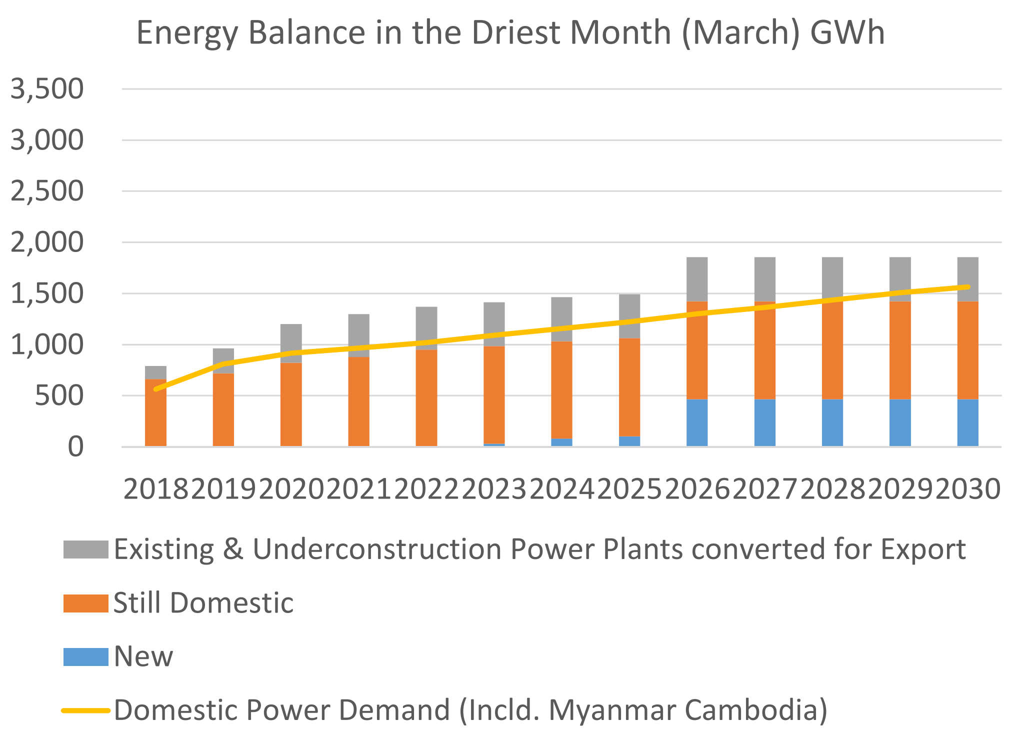


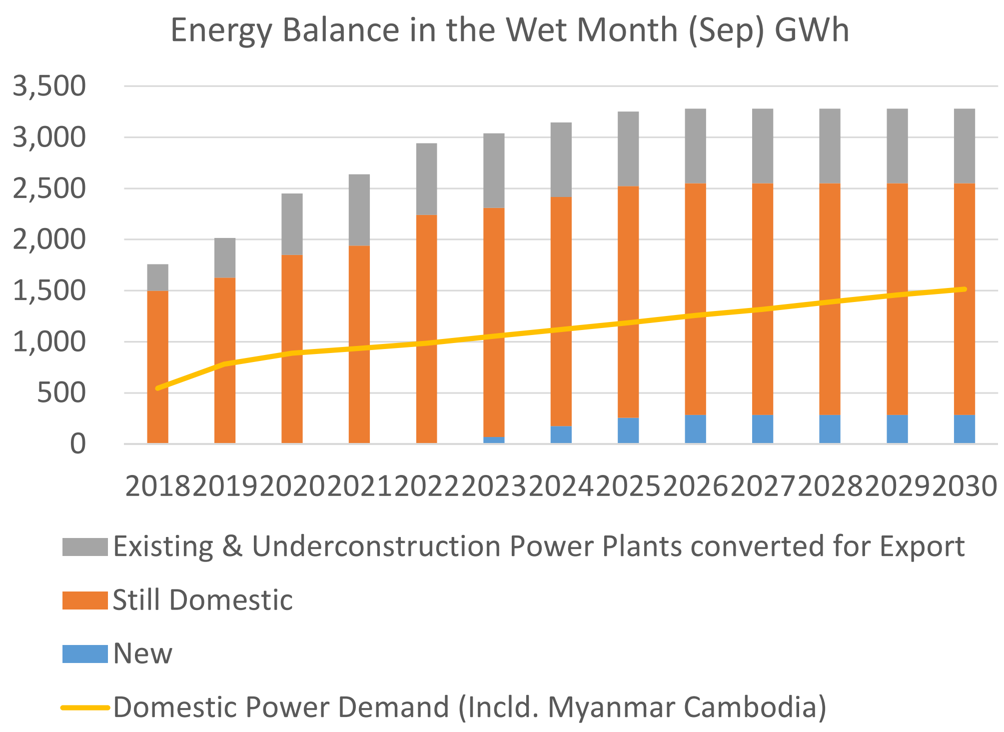
“Existing and Under-Construction” Power Stations to be Converted to Export

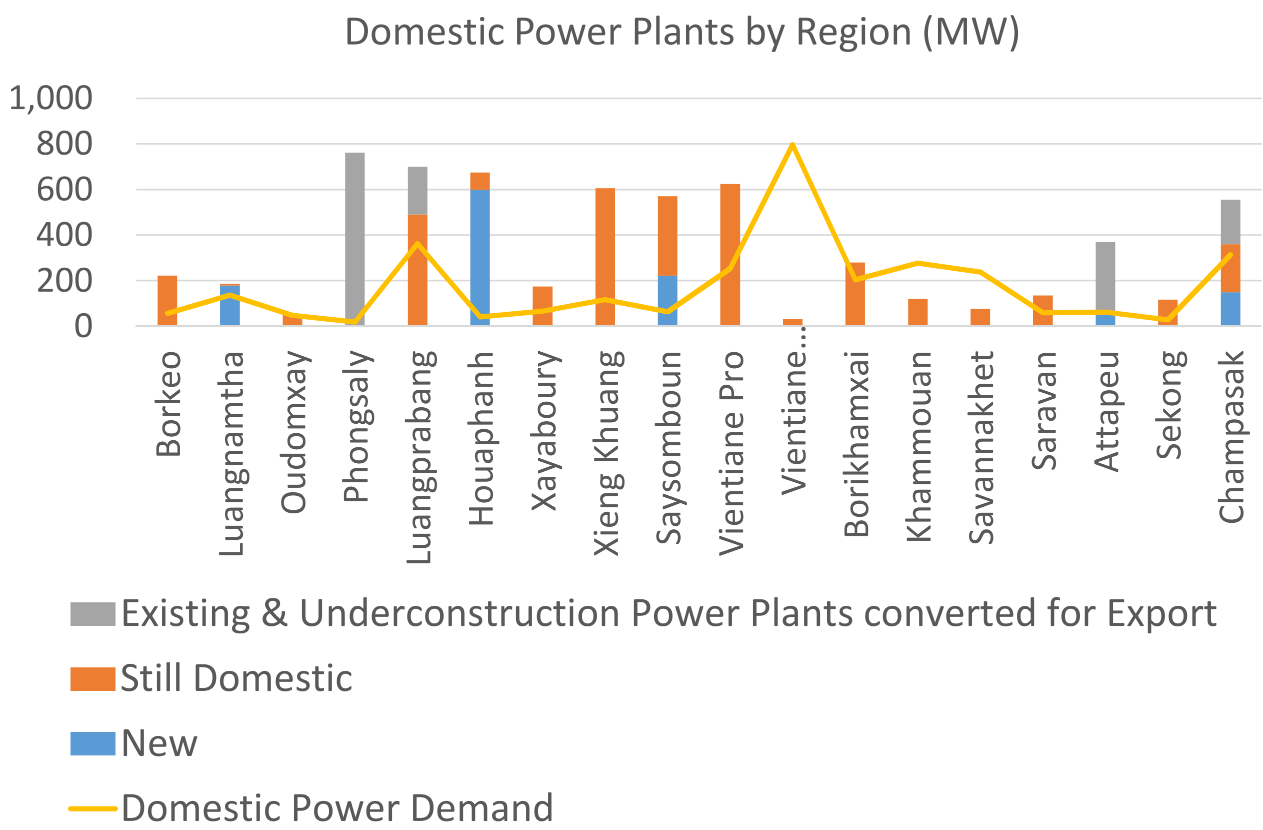
Name of Project	Location	Region	Inst.Cap	Energy(GWh)	COD
Nam Ou 5 (H)	Phongsaly	North	240 MW	1049	2016
Nam Ou 6 (H)	Phongsaly	North	180 MW	739	2016
Nam Kong 2 (H)	Attapeu	South	66 MW	263.11	2018
MK DonSahong (H)*	Champasack	South	195 MW	1504.5	2019
Nam Ou 3 (H)	Luangprabang	North	210 MW	684	2020
Nam Ou 4 (H)	Phongsaly	North	132 MW	523	2020
Nam Ou 7 (H)	Phongsaly	North	210 MW	810	2020
Nam Kong 1 (H)	Attapeu	South	160 MW	649	2021

*Three units among four units of MK DonSahong (H) are converted to export.
Nam Xam 3, Nam Mo2 and Xekamn-Xanxai are not included in the above list because they have been already converted to export.

Energy Balance between Power Supply and Demand





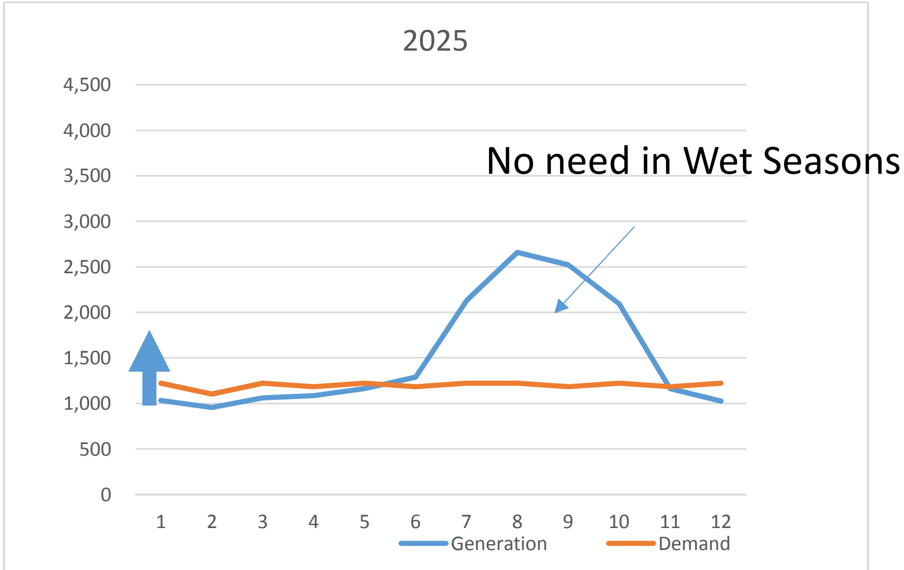

Domestic Power Plants by Region (MW)
1,000
800
600
400
200
0
Borkeo
Luangnamtha
Oudomxay
Phongsaly
Luangprabang
Houaphanh
Xayaboury
Xieng Khuang
Saysomboun
Vientiane Pro
Vientiane...
Borikhamxai
Khammouan
Savannakhet
Saravan
Attapeu
Sekong
Champasak
Existing & Underconstruction Power Plants converted for Export
Still Domestic
New
Domestic Power Demand

Thermal Power Plants

Thermal power plants are effective as a new power source for dry seasons.
Now, consider the case where power is generated only during the dry seasons 1 to 6, 11 and 12 Month.
The cost for generating 1 GWh in the dry season in one year was converted to annual cost and estimated.
Solar power, reservoir-type hydropower, EGAT, and coal-fired power plants were in descending order of their costs.

Comparison of Costs for Dry Season Power Production

		Solar	Hydro Reservoir (Averaged)	Import from EGAT	Coal Thermal
Capacity	MW	32	3246.6		600.0
Fixed Cost	million USD	32	6168.54		702.3
Life Time		10	40		20.0
Expense Rate		0.128	0.063		0.082
Annual Expense for Fixed Cost	million USD/y	4.1	386.8		57.8
Transmission Line	million USD	0	616.854		250.0
Life Time		35	35		35.0
Expense Rate		0.065	0.065		0.065
Annual Expense for Fixed Cost	million USD/y	0.0	40.1		16.3
1-6,11,12 Month	GWh	28.9	6,433.3		2,489.8
Load Factor during Dry Seasons		18%	39%		82%
Fuel Cost for (1-5,11,12 Month)	million USD/y	0.0	0.0		64.4
Annual Expense	million USD/y	4.1	426.9	0.0	138.5
	million USD/GWh/y	**0.142**	**0.0664**	**0.0560**	**0.0556**



New Power Stations for Domestic Power System up to 2030

Province	Name	MW	Type	COD
Champasak	Nam Phak	150.0	Reservoir	2023
Luangnamtha	Nam Pha	180.0	Reservoir	2024
Saysomboun	Nam Phouan	102.3	Reservoir	2024
Saysomboun	Nam Bak 2	120.0	Reservoir	2025
Attapeu	Xekong (Downstream)A	50.0	Run of river	2026
Houaphanh	Huaphan Coal Power Plan (Lignite) (T)	600.0	Thermal	2026
Attapeu	Houay Ho (e)	150.0	Reservoir	2029

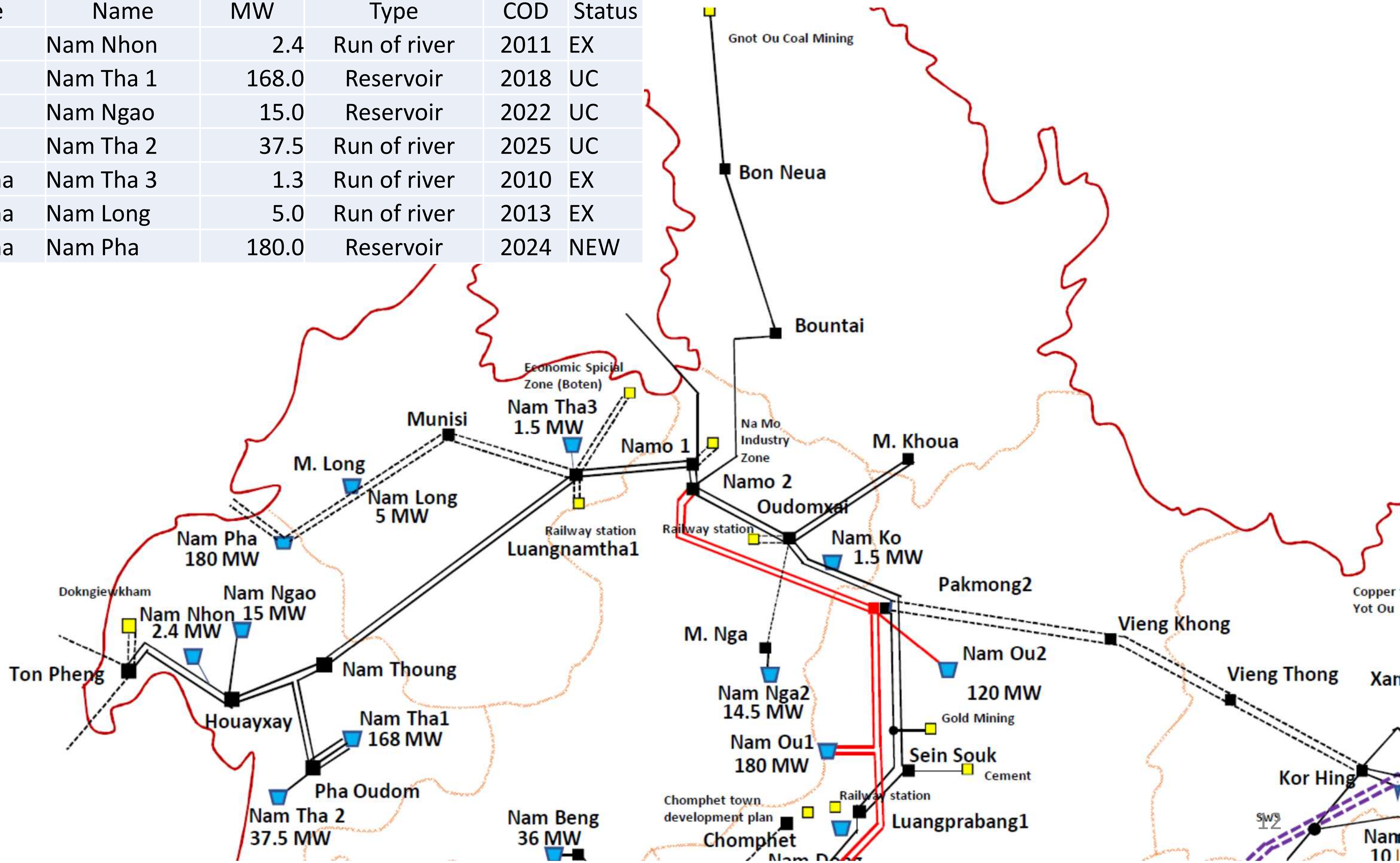
Return back

Another option of Xekong thermal may be possible and should be studied.

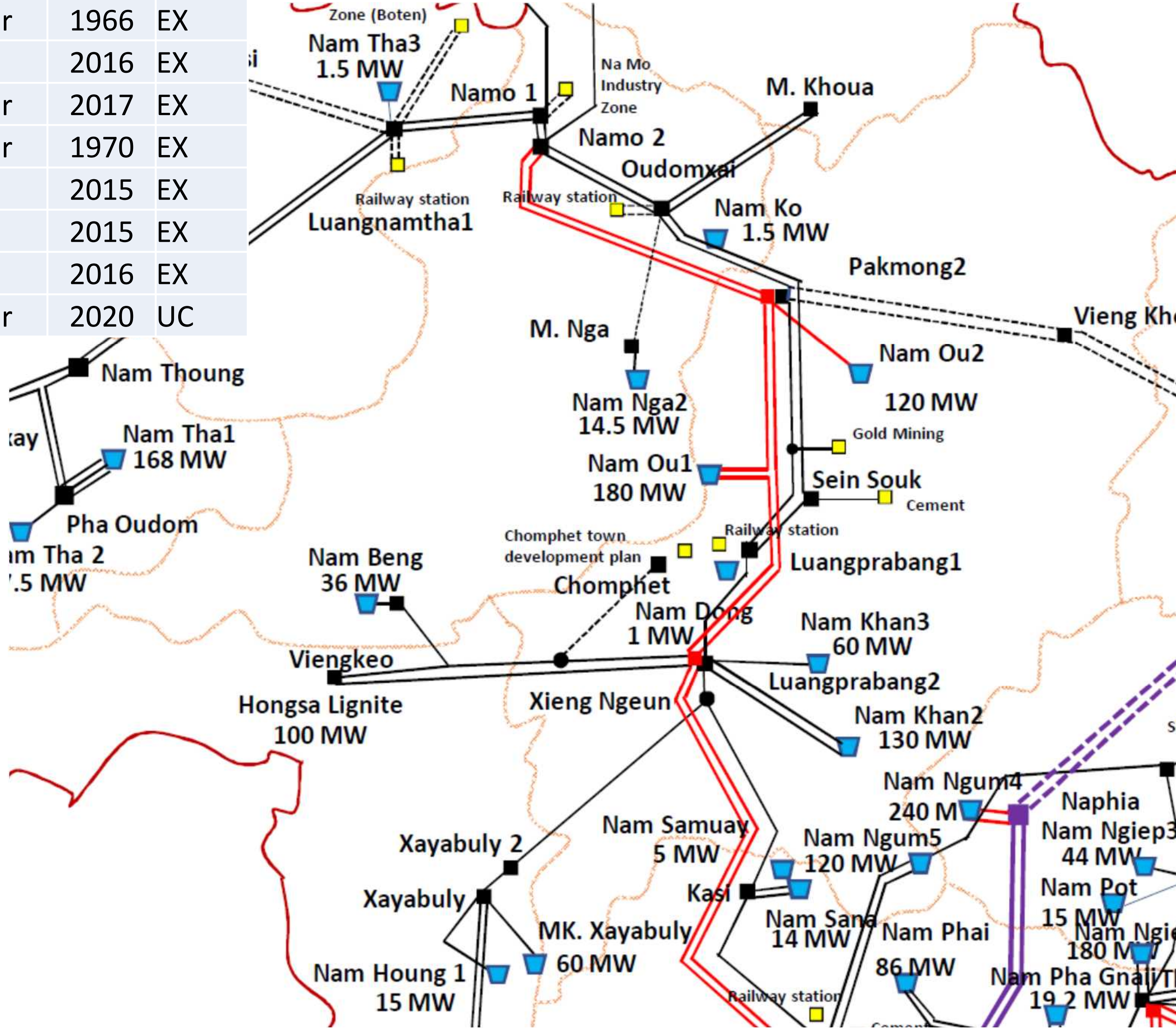
2. Domestic Power Transmission Plan 2030

Power Flow will be shown later.

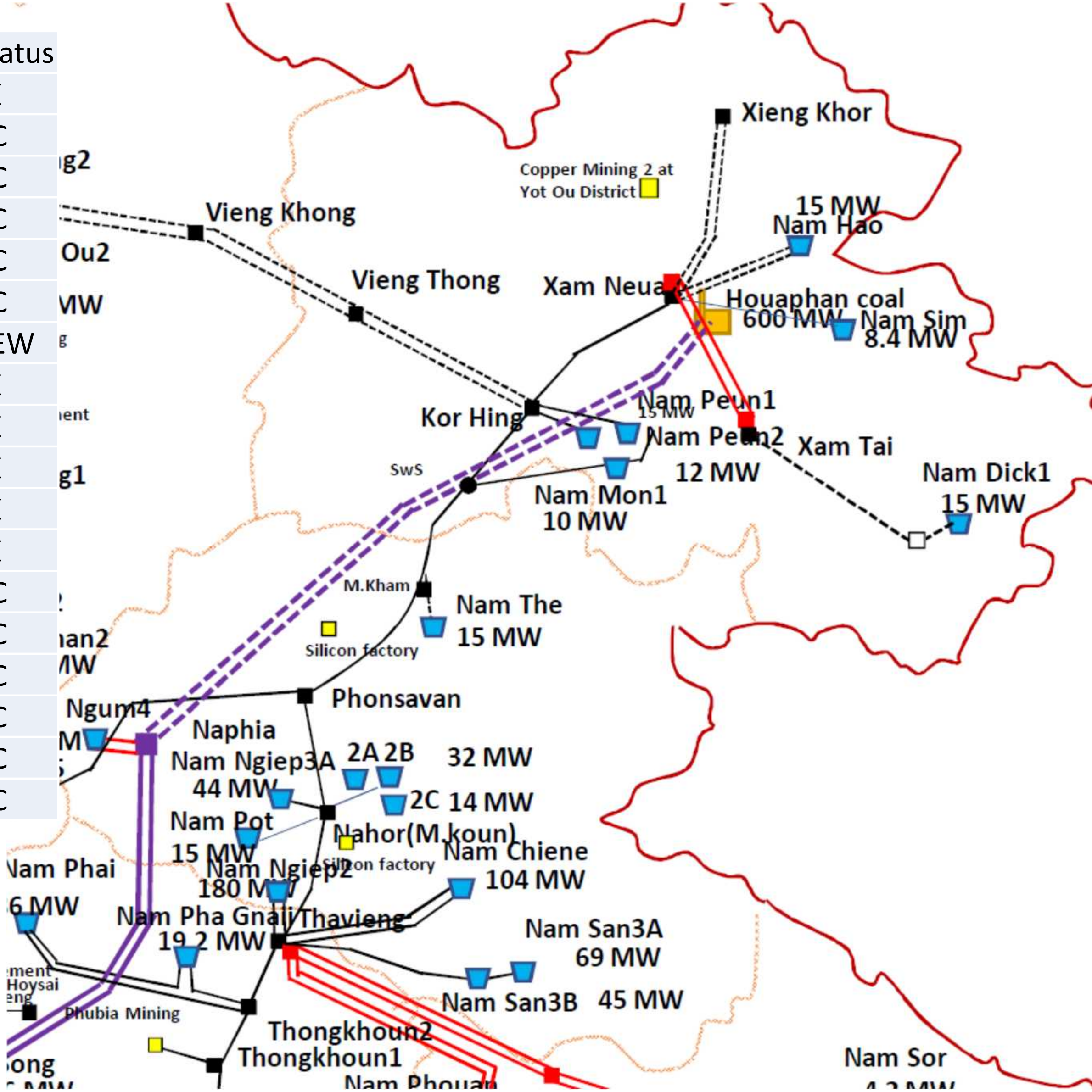
Province	Name	MW	Type	COD	Status
Borkeo	Nam Nhon	2.4	Run of river	2011	EX
Borkeo	Nam Tha 1	168.0	Reservoir	2018	UC
Borkeo	Nam Ngao	15.0	Reservoir	2022	UC
Borkeo	Nam Tha 2	37.5	Run of river	2025	UC
Luangnamtha	Nam Tha 3	1.3	Run of river	2010	EX
Luangnamtha	Nam Long	5.0	Run of river	2013	EX
Luangnamtha	Nam Pha	180.0	Reservoir	2024	NEW



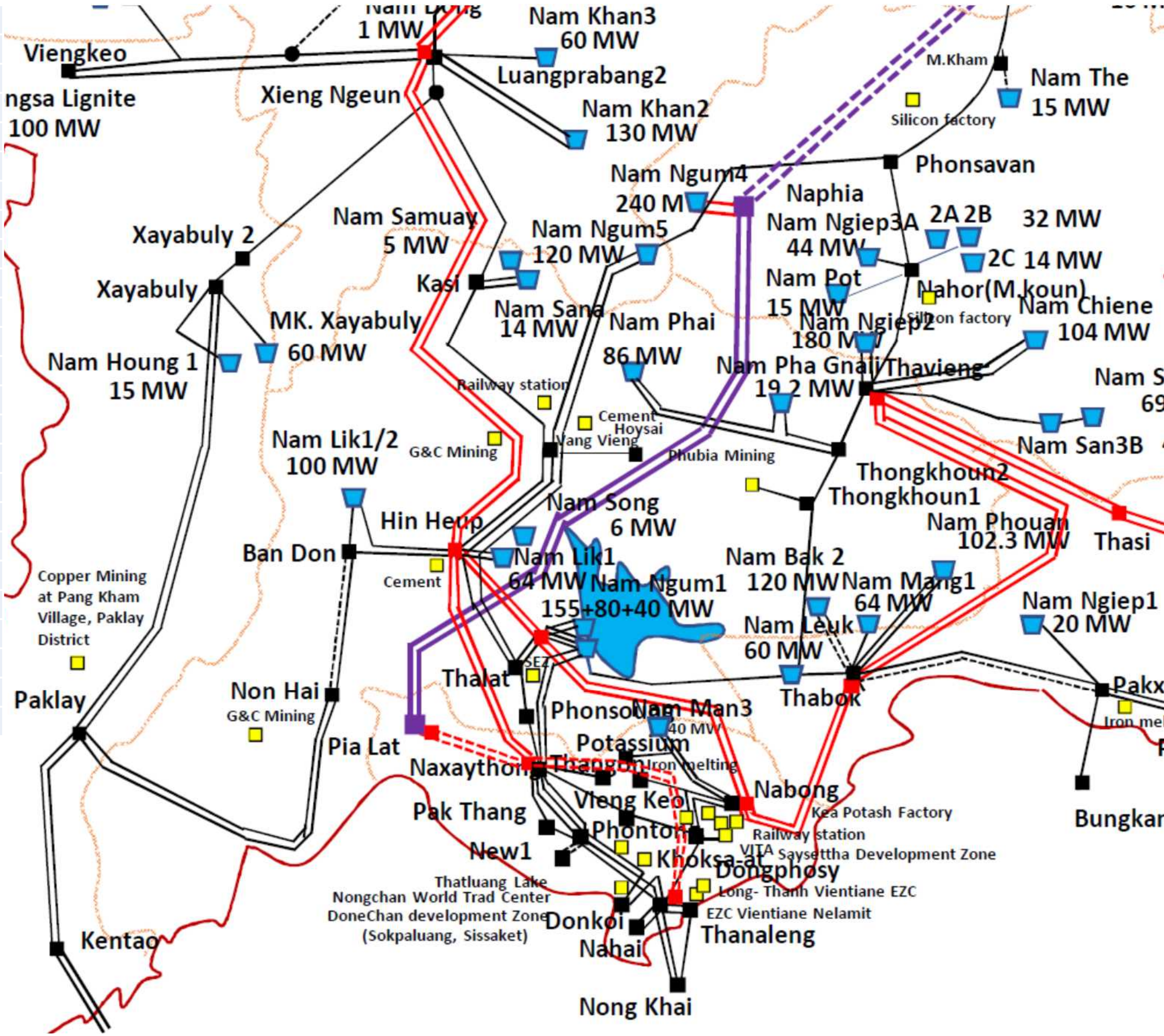
Province	Name	MW	Type	COD	Status
Oudomxay	Nam Ko	1.5	Run of river	1966	EX
Oudomxay	Nam Beng	36.0	Reservoir	2016	EX
Oudomxay	Nam Nga 2	14.5	Run of river	2017	EX
Luangprabang	Nam Dong	1.0	Run of river	1970	EX
Luangprabang	Nam Ou 2	120.0	Reservoir	2015	EX
Luangprabang	Nam Khan 2	130.0	Reservoir	2015	EX
Luangprabang	Nam Khan 3	60.0	Reservoir	2016	EX
Luangprabang	Nam Ou 1	180.0	Run of river	2020	UC

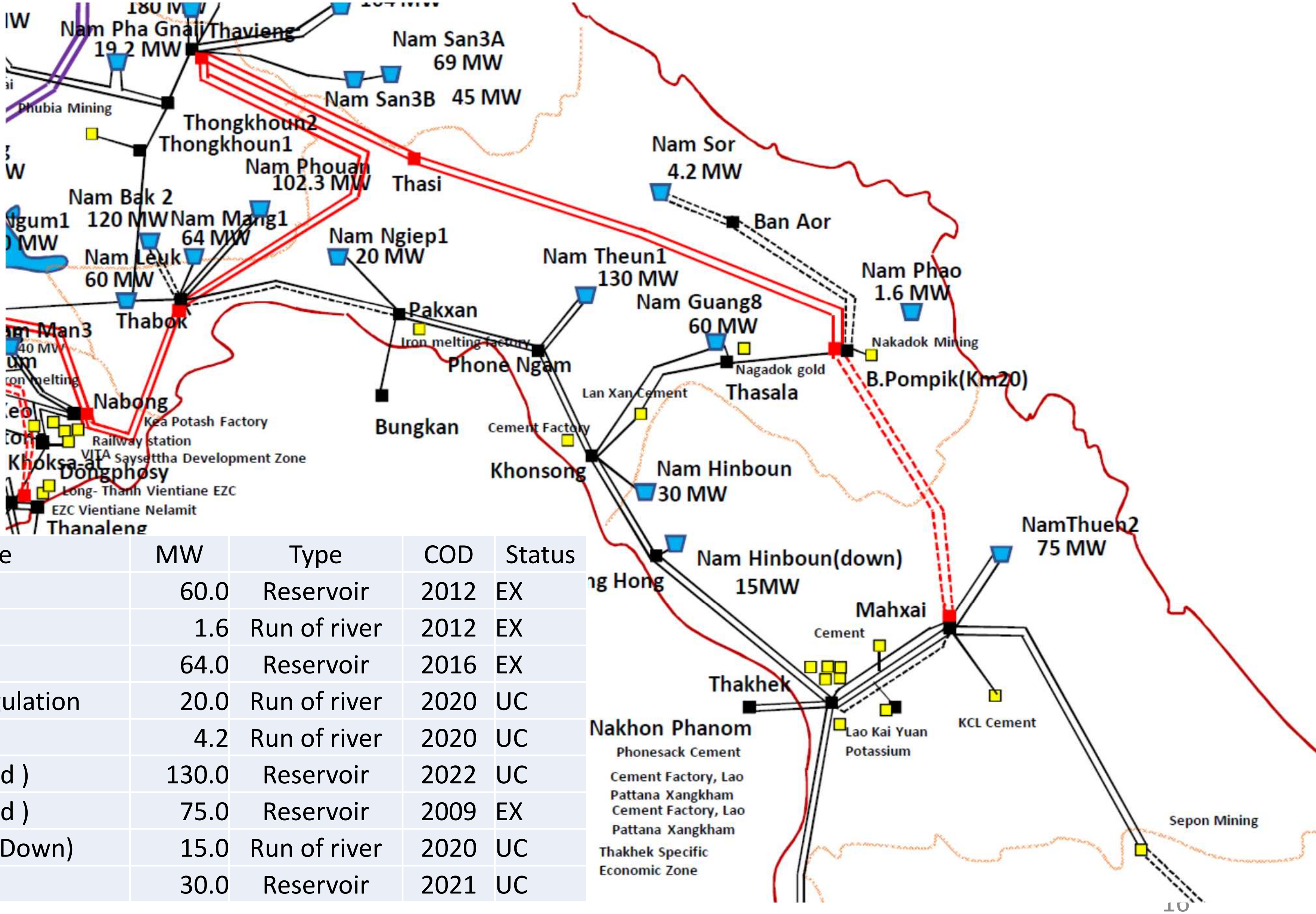


Province	Name	MW	Type	COD	Status
Houaphanh	Nam Peun 2	12.0	Run of river	2017	EX
Houaphanh	Nam Peun 1	15.0	Run of river	2019	UC
Houaphanh	Nam Sim	8.4	Run of river	2020	UC
Houaphanh	Nam Mon 1	10.0	Run of river	2021	UC
Houaphanh	Nam Hao	15.0	Run of river	2022	UC
Houaphanh	Nam Dick 1	15.0	Run of river	2022	UC
Houaphanh	Huaphan Lignite	600.0	Thermal	2026	NEW
Xieng Khuang	Nam Sien Tad Lang	5.0	Run of river	2014	EX
Xieng Khuang	Nam Ngiep 2	180.0	Reservoir	2015	EX
Xieng Khuang	Nam Ngiep 3A	44.0	Reservoir	2015	EX
Xieng Khuang	Nam San 3A	69.0	Reservoir	2016	EX
Xieng Khuang	Nam Ngiep 2C	15.0	Run of river	2017	EX
Xieng Khuang	Nam Ngum Keng Kaun	1.0	Run of river	2018	UC
Xieng Khuang	Nam Ngiep 2A	12.6	Run of river	2019	UC
Xieng Khuang	Nam Ngiep 2B	9.4	Run of river	2019	UC
Xieng Khuang	Nam Aow (Nam Pot)	15.0	Reservoir	2020	UC
Xieng Khuang	Nam The	15.0	Run of river	2020	UC
Xieng Khuang	Nam Ngum 4	240.0	Reservoir	2022	UC

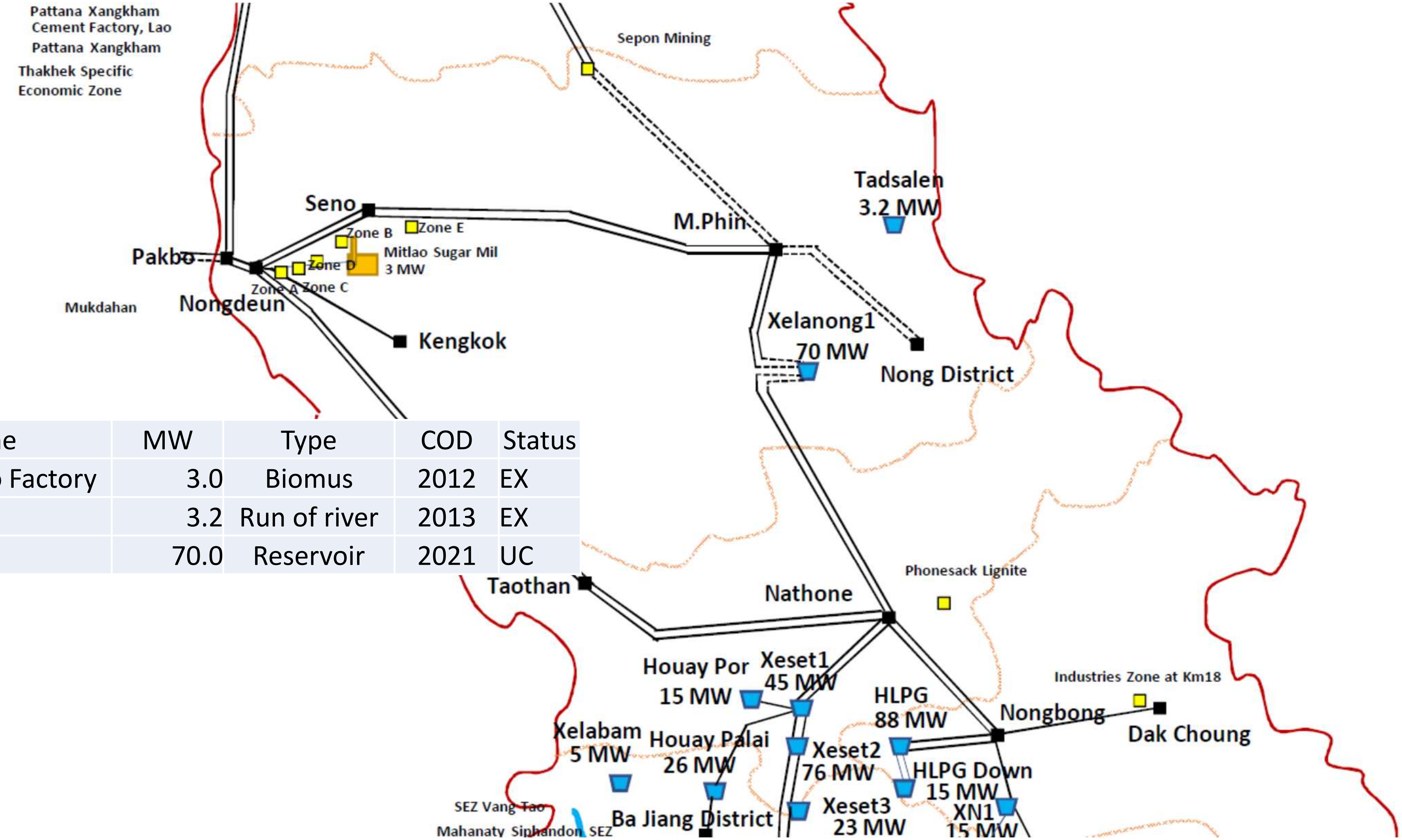


Province	Name	MW	Type	COD	Status
Vientiane Pro.	Nam Ngum 1	155.0	Reservoir	1971	EX
Vientiane Pro.	Nam Mang 3	40.0	Reservoir	2004	EX
Vientiane Pro.	Nam lik 1/2	100.0	Reservoir	2010	EX
Vientiane Pro.	Nam Song	6.0	Reservoir	2011	EX
Vientiane Pro.	Nam Ngum 5	120.0	Reservoir	2012	EX
Vientiane Pro.	Nam Sana	14.0	Run of river	2014	EX
Vientiane Pro.	Nam Ngum 1 (Ext.1)	80.0	Reservoir	2018	EX
Vientiane Pro.	Nam Lik 1	64.0	Run of river	2019	EX
Vientiane Pro.	Nam Samoi	5.0	Run of river	2021	UC
Vientiane Pro.	Nam Ngum 1 (Ext.2)	40.0	Reservoir	2021	UC
Xayaboury	Hongsa Lignite(d)	100.0	Thermal	2015	EX
Xayaboury	MK. Xayaboury (d)	60.0	Run of river	2020	UC
Xayaboury	Nam Houng Down	15.0	Run of river	2022	UC
Saysomboun	Nam Luek	60.0	Reservoir	2000	EX
Saysomboun	Nam San 3B	45.0	Reservoir	2015	EX
Saysomboun	Nam Sor	7.4	Run of river	2016	EX
Saysomboun	Nam Phai	86.0	Reservoir	2017	EX
Saysomboun	Nam Chiene	104.0	Reservoir	2018	EX
Saysomboun	Nam Chee 1	15.0	Run of river	2019	UC
Saysomboun	Nam PhaGnai	19.2	Reservoir	2020	UC
Saysomboun	Nam Karp	12.0	Run of river	2022	UC
Saysomboun	Nam Phouan	102.3	Reservoir	2024	NEW
Saysomboun	Nam Bak 2	120.0	Reservoir	2025	NEW
Vientiane Cap.	Naxaythong Solar	32.0	Renewable	2017	EX



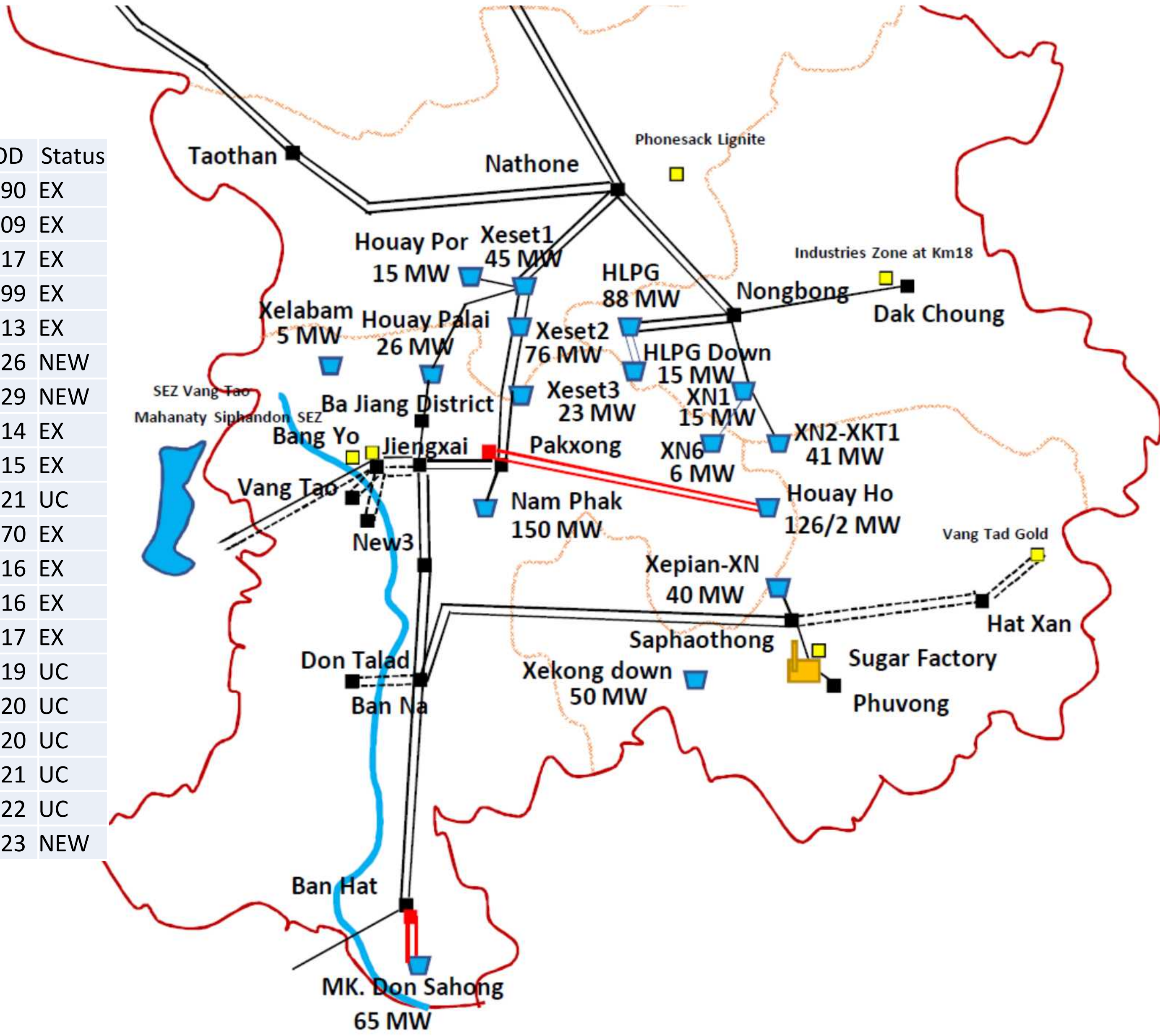


Province	Name	MW	Type	COD	Status
Borikhamxai	Nam Gnoug 8	60.0	Reservoir	2012	EX
Borikhamxai	Nam Phao	1.6	Run of river	2012	EX
Borikhamxai	Nam Mang 1	64.0	Reservoir	2016	EX
Borikhamxai	Nam Ngiep Regulation	20.0	Run of river	2020	UC
Borikhamxai	Nam Sor	4.2	Run of river	2020	UC
Borikhamxai	Nam Theun 1 (d)	130.0	Reservoir	2022	UC
Khammouan	Nam Theun 2 (d)	75.0	Reservoir	2009	EX
Khammouan	Nam Hinboun (Down)	15.0	Run of river	2020	UC
Khammouan	Nam Hinboun	30.0	Reservoir	2021	UC



Province	Name	MW	Type	COD	Status
Savannakhet	Sugar Mitlao Factory	3.0	Biomus	2012	EX
Savannakhet	Tadsalen	3.2	Run of river	2013	EX
Savannakhet	Xelanong 1	70.0	Reservoir	2021	UC

Province	Name	MW	Type	COD	Status
Saravan	Xeset 1	45.0	Run of river	1990	EX
Saravan	Xeset 2	76.0	Run of river	2009	EX
Saravan	Houay por	15.0	Run of river	2017	EX
Attapeu	Houay Ho (d)	2.1	Reservoir	1999	EX
Attapeu	Sugar Factory Attapeu	15.0	Biomus	2013	EX
Attapeu	Xekong (Down)A	50.0	Run of river	2026	NEW
Attapeu	Houay Ho (e)	150.0	Reservoir	2029	NEW
Sekong	Xenamnoy 1	15.0	Run of river	2014	EX
Sekong	Houaylamphanh Gnai	88.0	Reservoir	2015	EX
Sekong	Houaylamphan Gai (Down)	15.0	Run of river	2021	UC
Champasak	Xelabam	5.0	Run of river	1970	EX
Champasak	Xeset 3	23.0	Reservoir	2016	EX
Champasak	Xenamnoy 6	5.0	Run of river	2016	EX
Champasak	Xenamnoy 2 - Xekatam 1	20.1	Run of river	2017	EX
Champasak	MK. Donsahong(d)	65.0	Run of river	2019	UC
Champasak	Houay Chiae	8.0	Run of river	2020	UC
Champasak	Xepien - Xenamnoy (d)	40.0	Reservoir	2020	UC
Champasak	Houay Yoi - Houaykod	15.0	Run of river	2021	UC
Champasak	Houay palai	30.0	Reservoir	2022	UC
Champasak	Nam Phak	150.0	Reservoir	2023	NEW



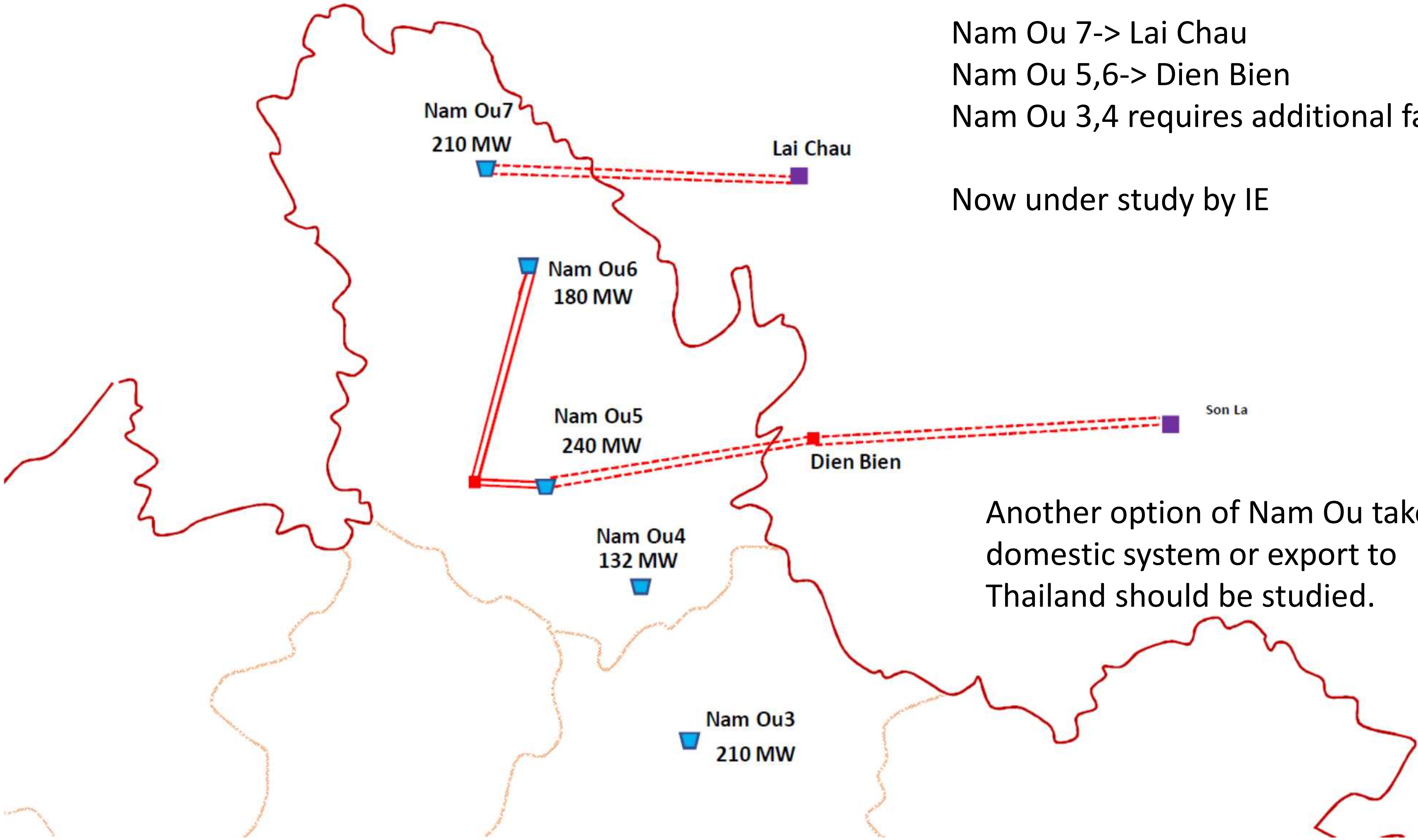
Main Required Transmission Lines up to 2030

- Construction of 500 kV transmission lines with double circuits from Houapan Thermal Power Plant to Naphia to evacuate the power from Houapan Thermal Power Plant
- Construction of 230 kV transmission lines with double circuits from Lak 20 to Mahaxai to send the power from north and central regions to Kammouan and Savanhakhet corresponding to the increase in power demand in those provinces
- Construction of 115 kV transmission lines with double circuits from Sepon Mining to M.Phin
- Construction of 230 kV transmission lines with double circuits from Pialat to Naxaithon (with large capacity)
- Construction of 230 kV transmission lines with double circuits from Naxaithon to Dongphosy
- Adding one circuit of 115 kV transmission lines to Tabok – Pakxan
- Etc.

- The 500 kV back-bone transmission lines is not needed until 2030 for domestic power supply.

- Power trade and power export from “Domestic Power System” is carried out through the following interconnections.
- 115 kV Nam Pha - (Myanmar) double circuit
- 115 kV Houayxay - (Thailand) double circuit
- 115 kV Kenthao – Tha Li (Thailand) double circuit
- 115 kV Vientiane – Nong Khai (Thailand) three circuits
- 115 kV Pakxan – Bung Kan (Thailand) single circuits
- 115 kV Thakhek-Nakhon Phanom (Thailand) double circuits
- 115 kV Pakbo - Mukdahan (Thailand) double circuits
- 115 kV Bang Yo – Sirindhorn (Thailand) double circuits
- Banhat – (Cambodia) double circuits

3. Export Power Generation Plan & Export Dedicated Power Transmission Lines up to 2030

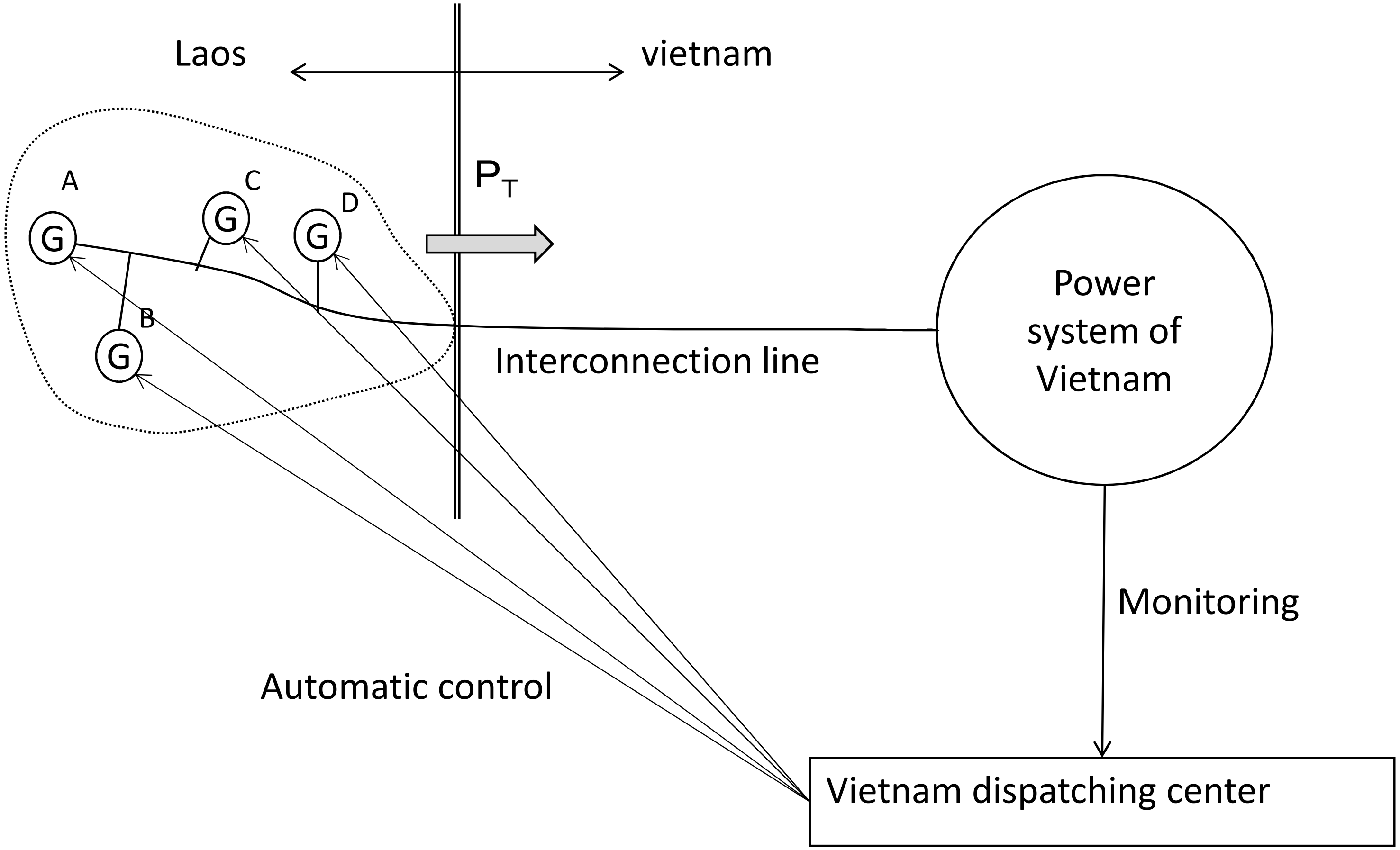


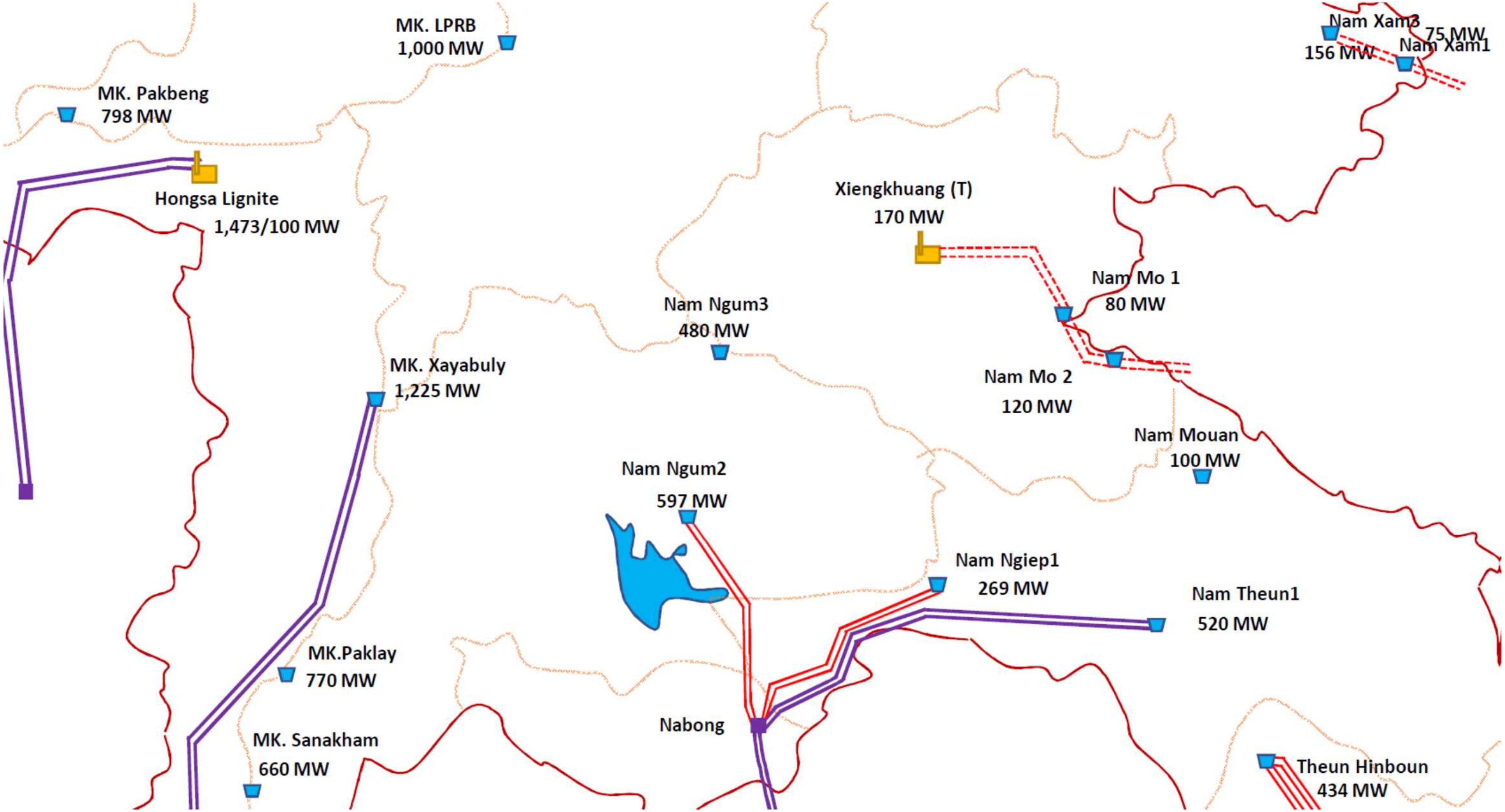
Nam Ou 7-> Lai Chau
Nam Ou 5,6-> Dien Bien
Nam Ou 3,4 requires additional facilities

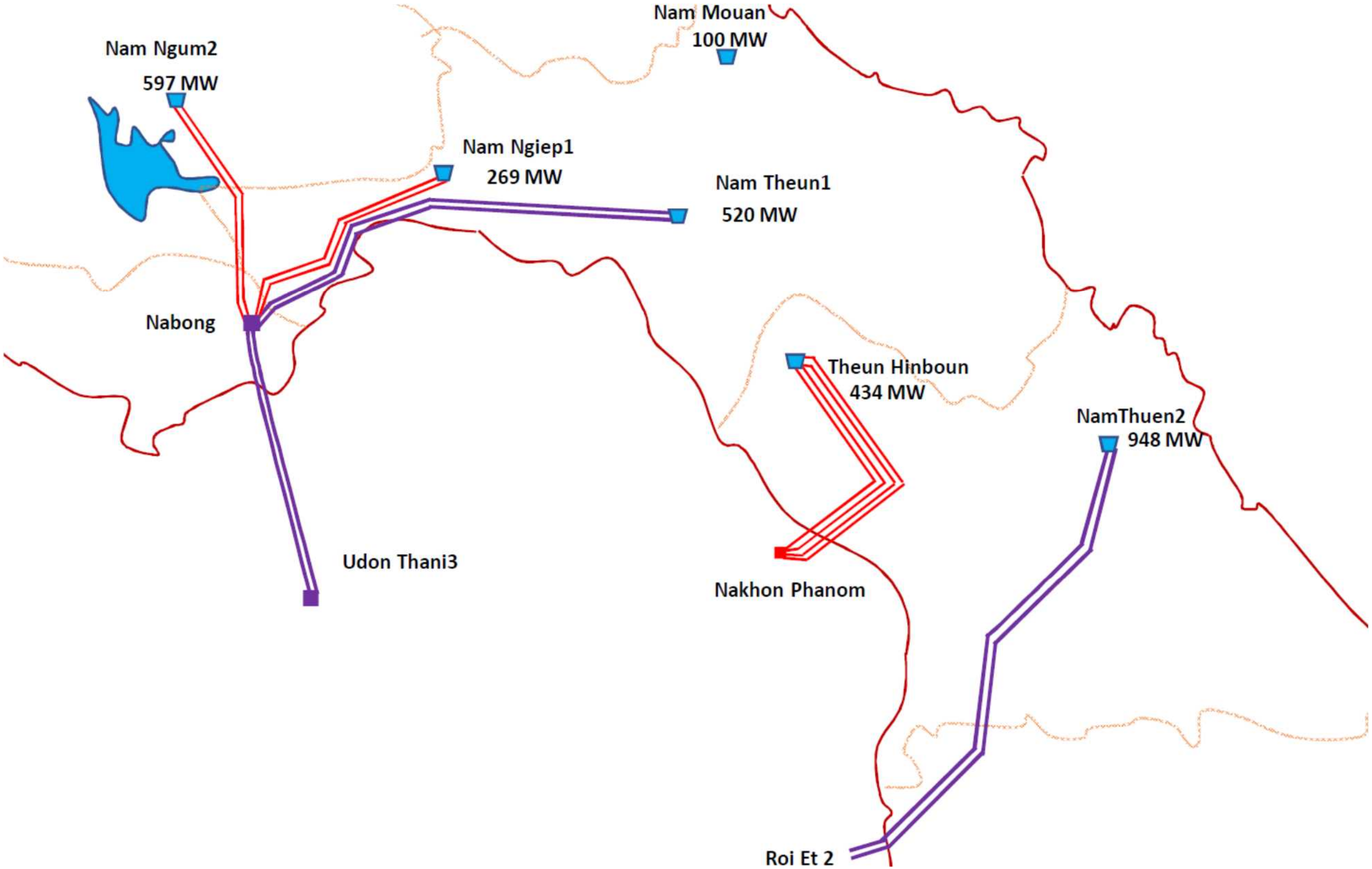
Now under study by IE

Another option of Nam Ou taken to domestic system or export to Thailand should be studied.

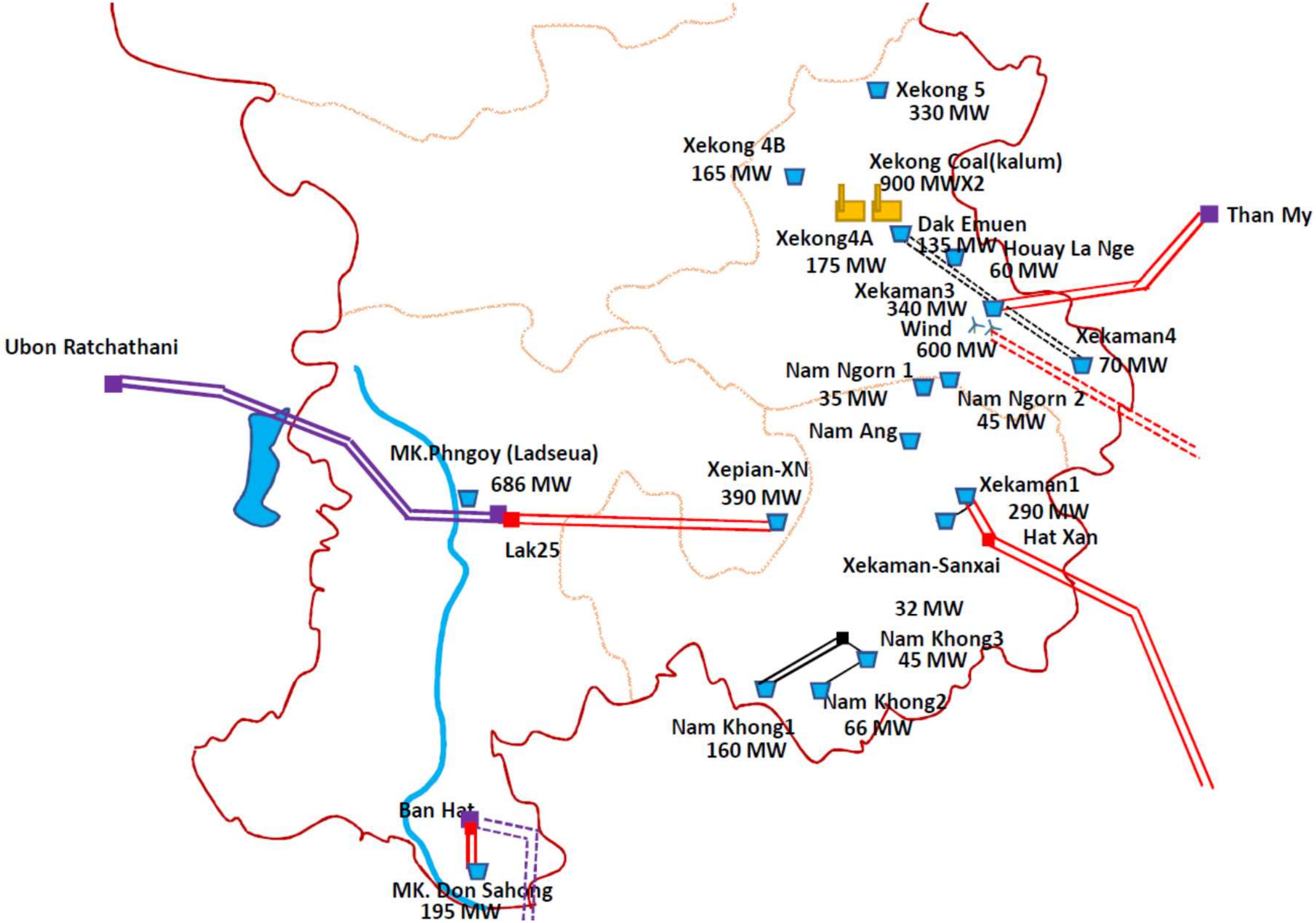
Control Method of Generators Connected to Vietnam




MK. LPRB
1,000 MW
MK. Pakbeng
798 MW
Hongsa Lignite
1,473/100 MW
Nam Xam3
156 MW
75 MW
Nam Xam1
Xiengkhuang (T)
170 MW
Nam Mo 1
80 MW
Nam Ngum3
480 MW
MK. Xayabuly
1,225 MW
Nam Mo 2
120 MW
Nam Mouan
100 MW
Nam Ngum2
597 MW
Nam Ngiep1
269 MW
Nam Theun1
520 MW
MK.Paklay
770 MW
Nabong
MK. Sanakham
660 MW
Theun Hinboun
434 MW



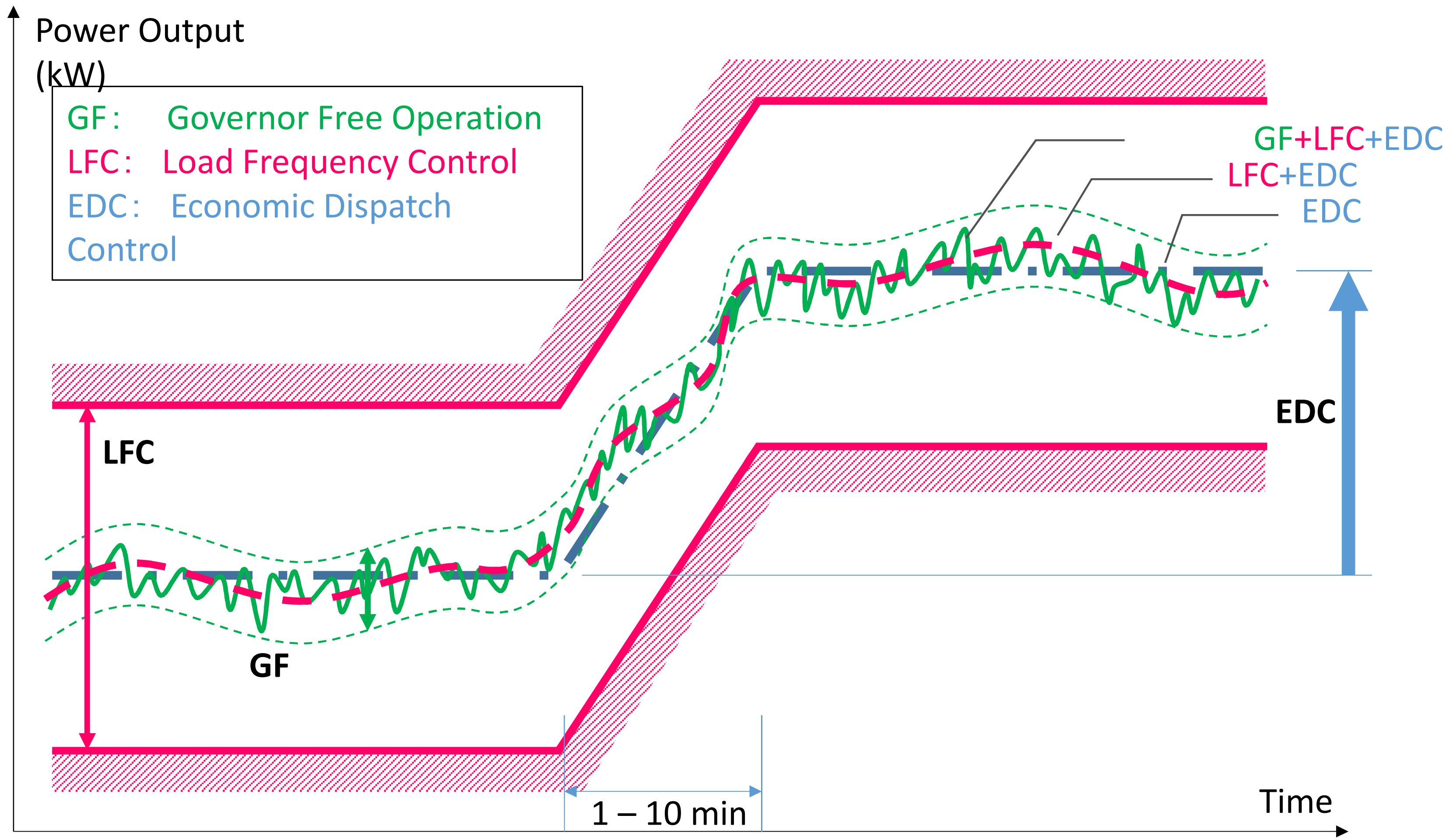
Nam Mouan
100 MW
Nam Ngum2
597 MW
Nam Ngiep1
269 MW
Nam Theun1
520 MW
Nabong
Theun Hinboun
434 MW
NamThuen2
948 MW
Udon Thani3
Nakhon Phanom
Roi Et 2



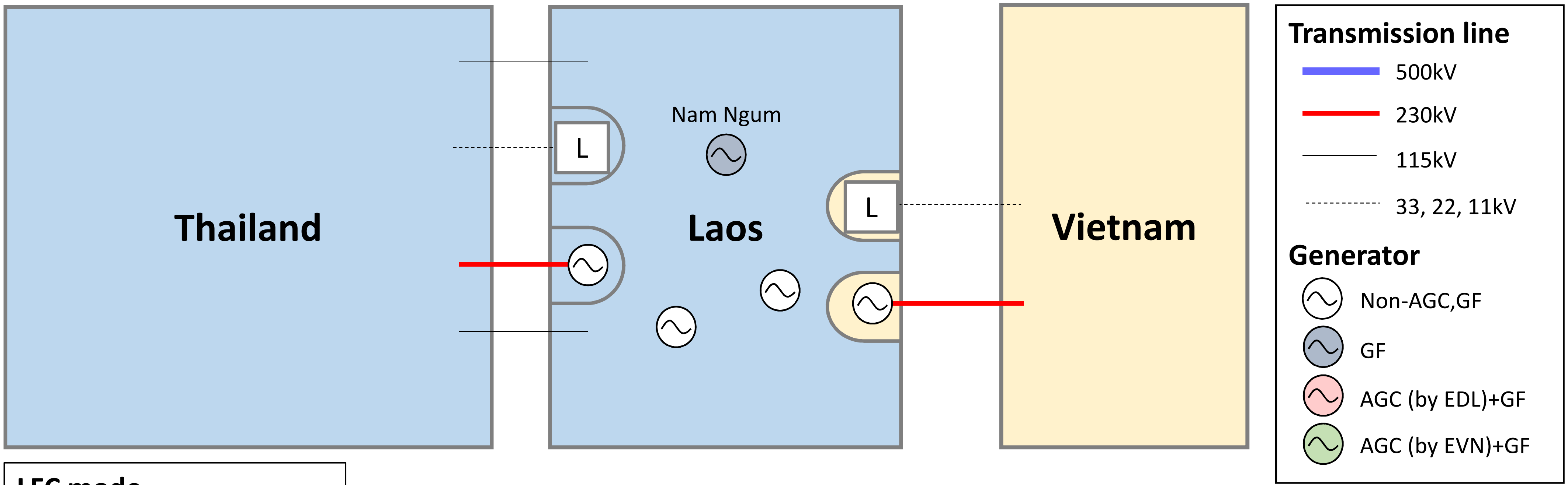
Xekong 5
330 MW
Xekong 4B
165 MW
Xekong Coal(kalum)
900 MWX2
Than My
Dak Emuen
135 MW
Xekong4A
175 MW
Houay La Nge
60 MW
Xekaman3
340 MW
Wind
600 MW
Xekaman4
70 MW
Ubon Ratchathani
Nam Ngorn 1
35 MW
Nam Ngorn 2
45 MW
Nam Ang
MK.Phngoy (Ladseua)
686 MW
Xepian-XN
390 MW
Xekaman1
290 MW
Hat Xan
Lak25
Xekaman-Sanxai
32 MW
Nam Khong3
45 MW
Nam Khong2
66 MW
Nam Khong1
160 MW
Ban Hat
MK. Don Sahong
195 MW

4. Issues Regarding System Operation for Interconnection

Concept for Frequency Control

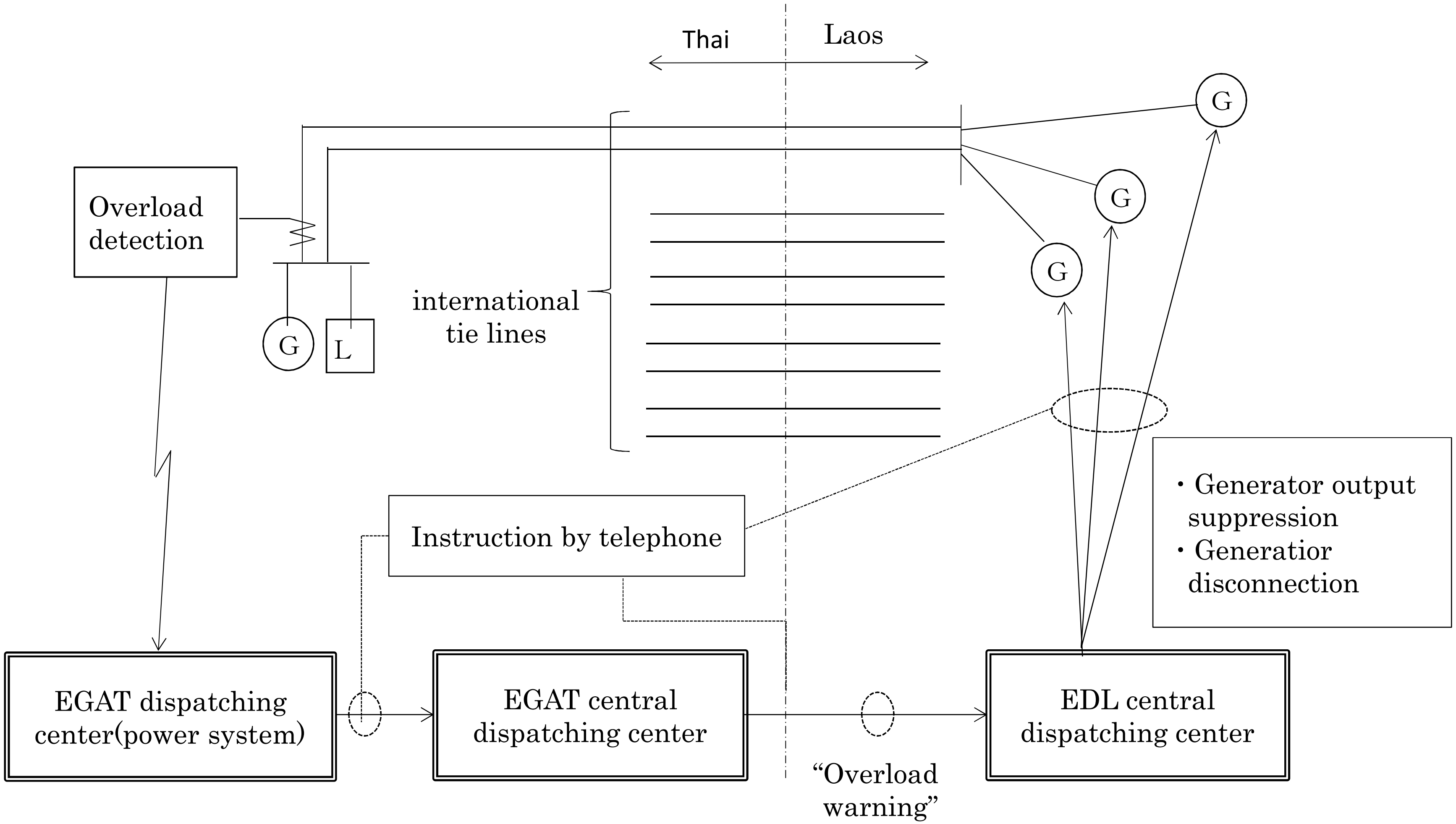


Current Power System

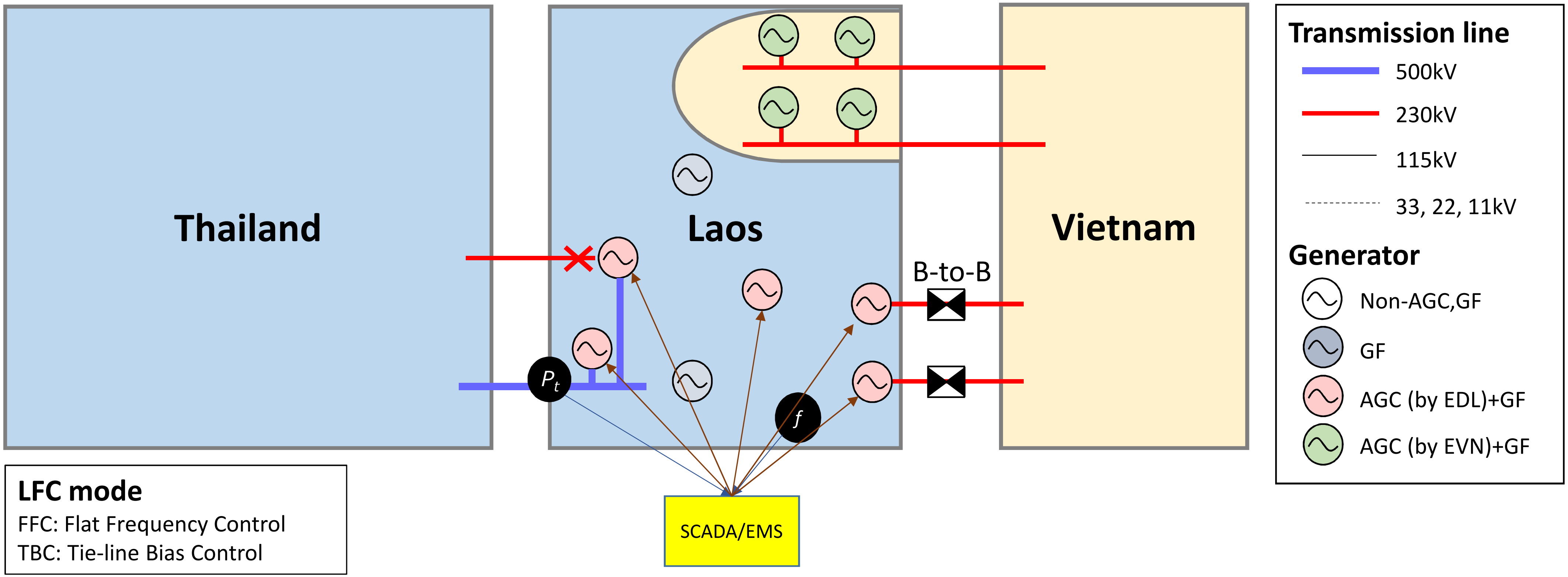


LFC mode
FFC: Flat Frequency Control
TBC: Tie-line Bias Control

Power Flow Control – Overload Protection System



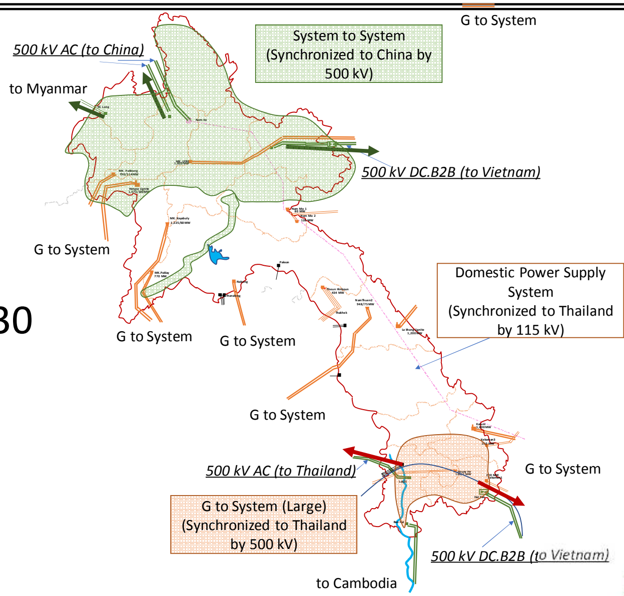
Up to 2040

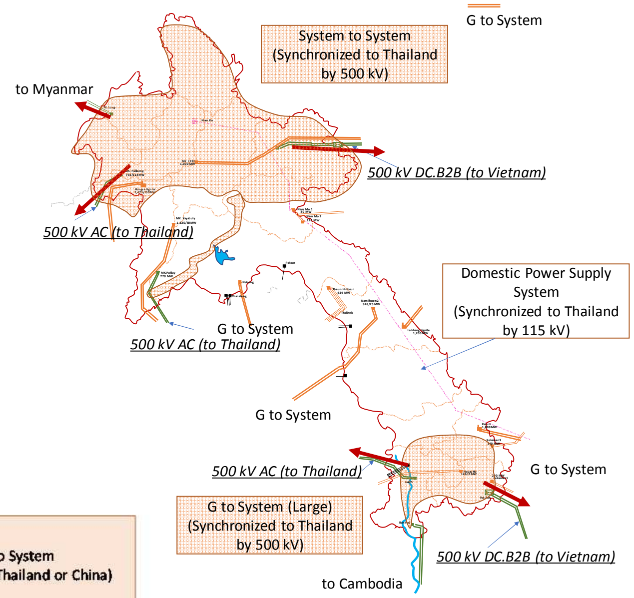


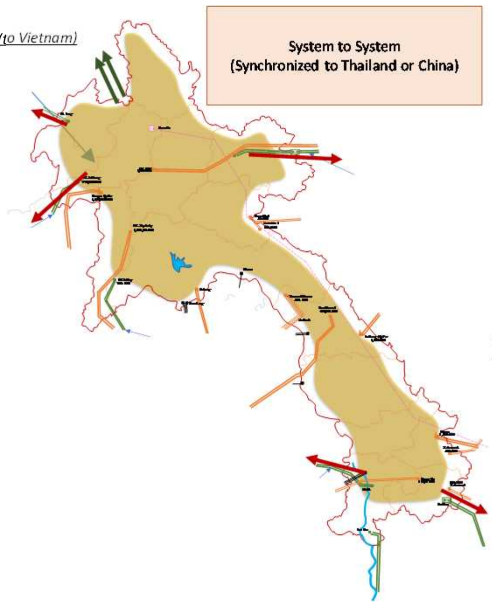
LFC mode
FFC: Flat Frequency Control
TBC: Tie-line Bias Control

Far Future System

After 2030







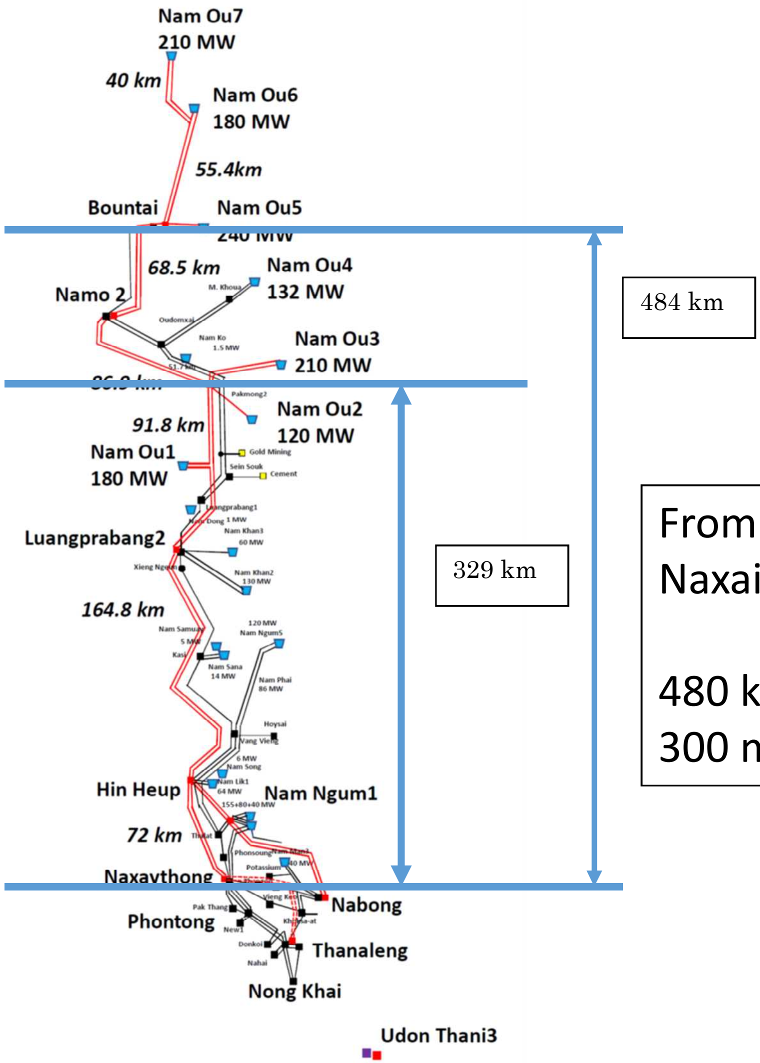
System contributing to GMS Power Trade

5. Current Limitation of Power Transmission Ability from Nam Ou

Nam Ou System

- It is difficult to take all the power from Nam Ou to Vientiane because of limitation of stable power transmission.

	Capacity (MW)
Nam Ou 1	180.0
Nam Ou 2	120.0
Nam Ou 3	210.0
Nam Ou 4	132.0
Nam Ou 5	240.0
Nam Ou 6	180.0
Nam Ou 7	210.0

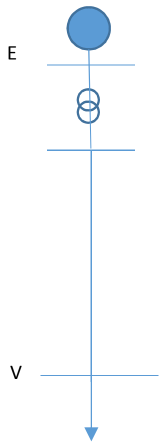


From Bountai to Naxaithong

480 km
300 miles

Method 1 –Rough Hand Calculation

$$P_{max} = \frac{EV}{X} \sin\theta$$



Generator Machine Base C [MVA]
Generator Impedance: Xd’= 0.4 [pu] Generator Machine Base
Step-up Transformer: XT = 0.1 [pu] Generator Machine Base
Transmission Line: XLine [pu] 100MVA Base

L=480 km
230 kV double circuits

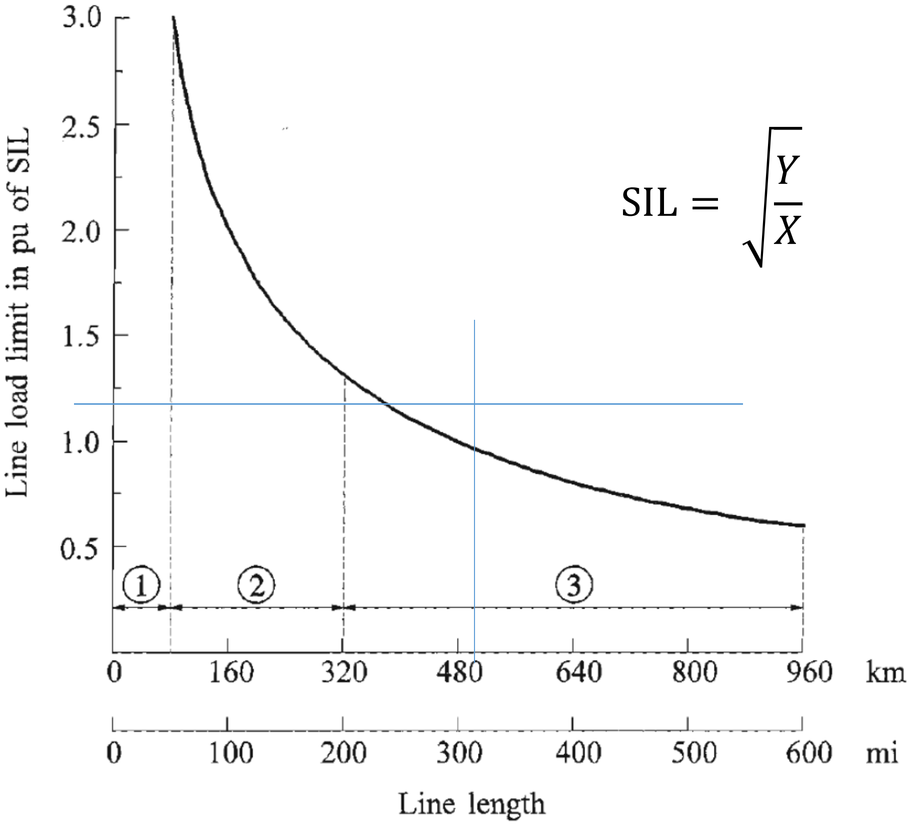
Line Parameters for 230 kV Transmission Line
Per circuit/km

	R	X	Y
230 kV	0.00016	0.00079	0.00146

$$P_{max} = \frac{EV}{X} \sin\theta = \frac{1.2 \times 1}{(0.5 + 0.1896 \times 630/100)} \times 630 \times 0.7$$
$$= 312[MW]$$

480 km 230 kV double circuits
Power Transmission Limitation is approximately 300 MW

Method 2 – Loadbility Curve



① 0–80 km: Region of thermal limitation
② 80–320 km: Region of voltage drop limitation
③ 320–960 km: Region of small-signal (steady-state) stability limitation

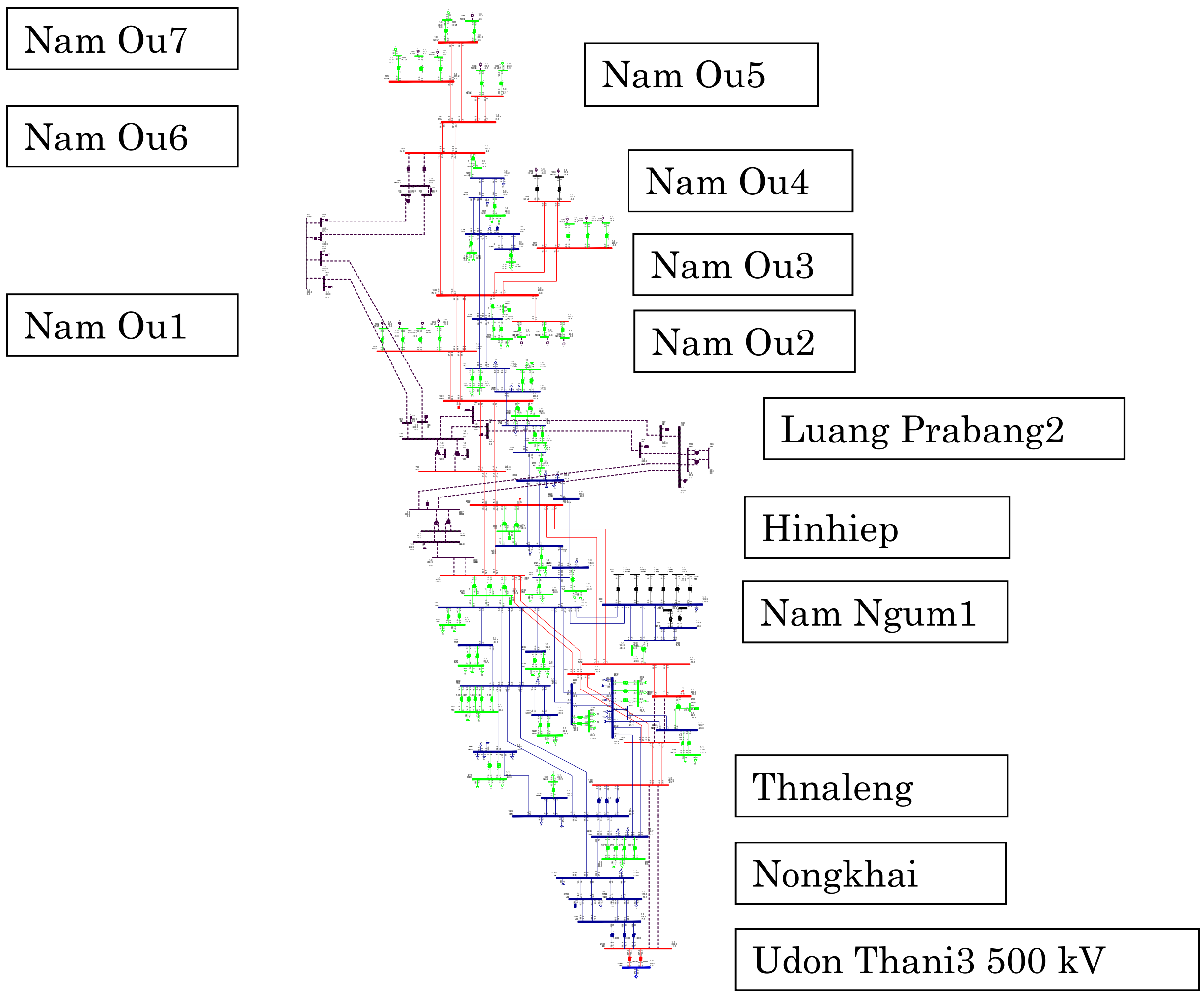
Figure 6.13 Transmission line loadability curve

230 kV SIL =136 MW
Double Circuits 273 MW

480 km 230 kV double circuits Power Transmission Limitation is approximately 270 MW

Source: P. Kundur, Power System Stability and Control, 1993
P228, 6.1.12 Loadability Characteristics

Method 3 –PSS/E Mini Model

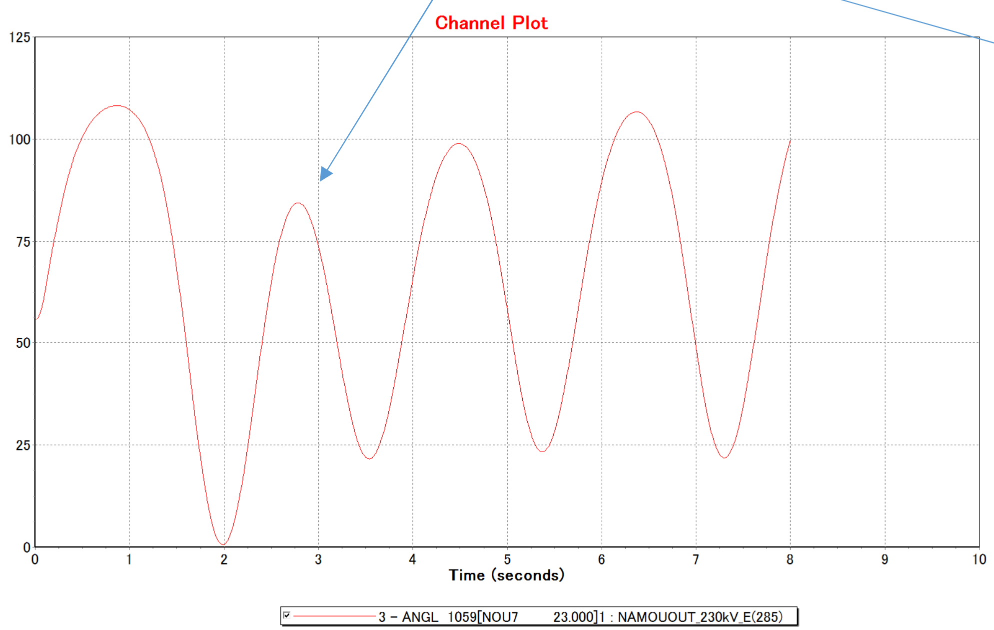


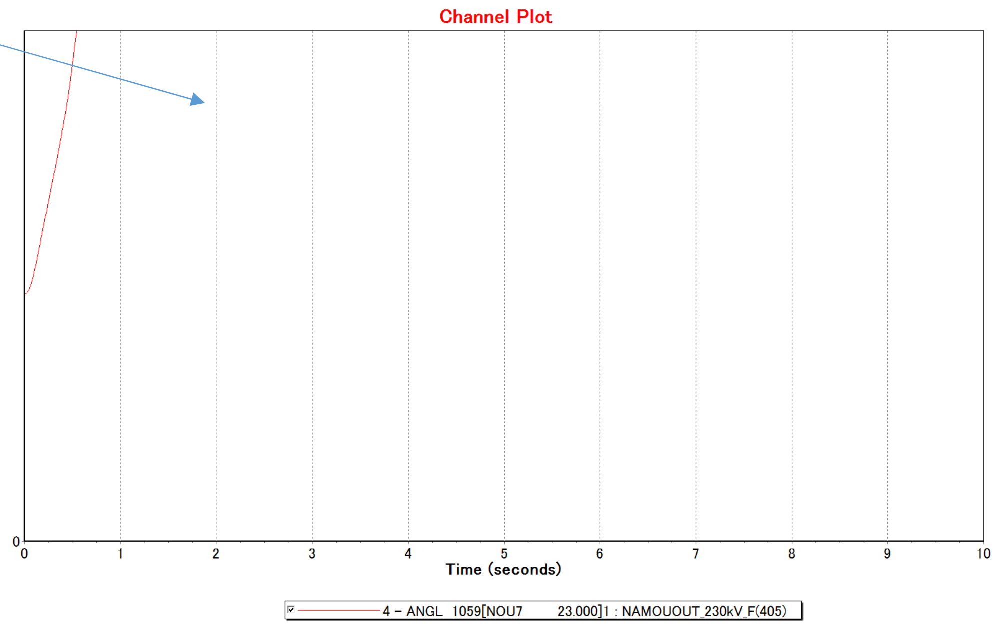
Only with generator exciters

Results of PSS/E Stability Analysis for Nam Ou 5,6,7

	Case A	Case B
NOU7	105	105
NOU6	60	60
NOU5	120	240
NOU4	0	0
NOU3	0	0
NOU2	0	0
NOU1	0	0
Total	285	405

From Nam Ou5,6,7 to UdonThani3 Power Transmission Limitation is less than 285 MW (power over 285 MW unstable)

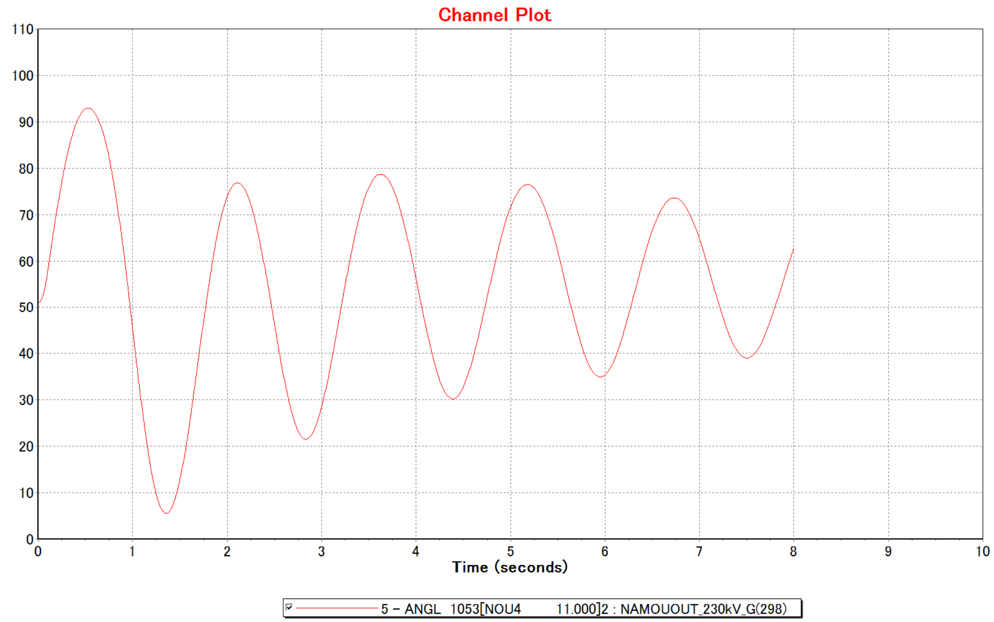




Results of PSS/E Stability Analysis for Nam Ou 3,4

Case with Nam Ou 3,4 to UdonThani3

	Case C
NOU7	0
NOU6	0
NOU5	0
NOU4	88
NOU3	210
NOU2	0
NOU1	0
Total	298



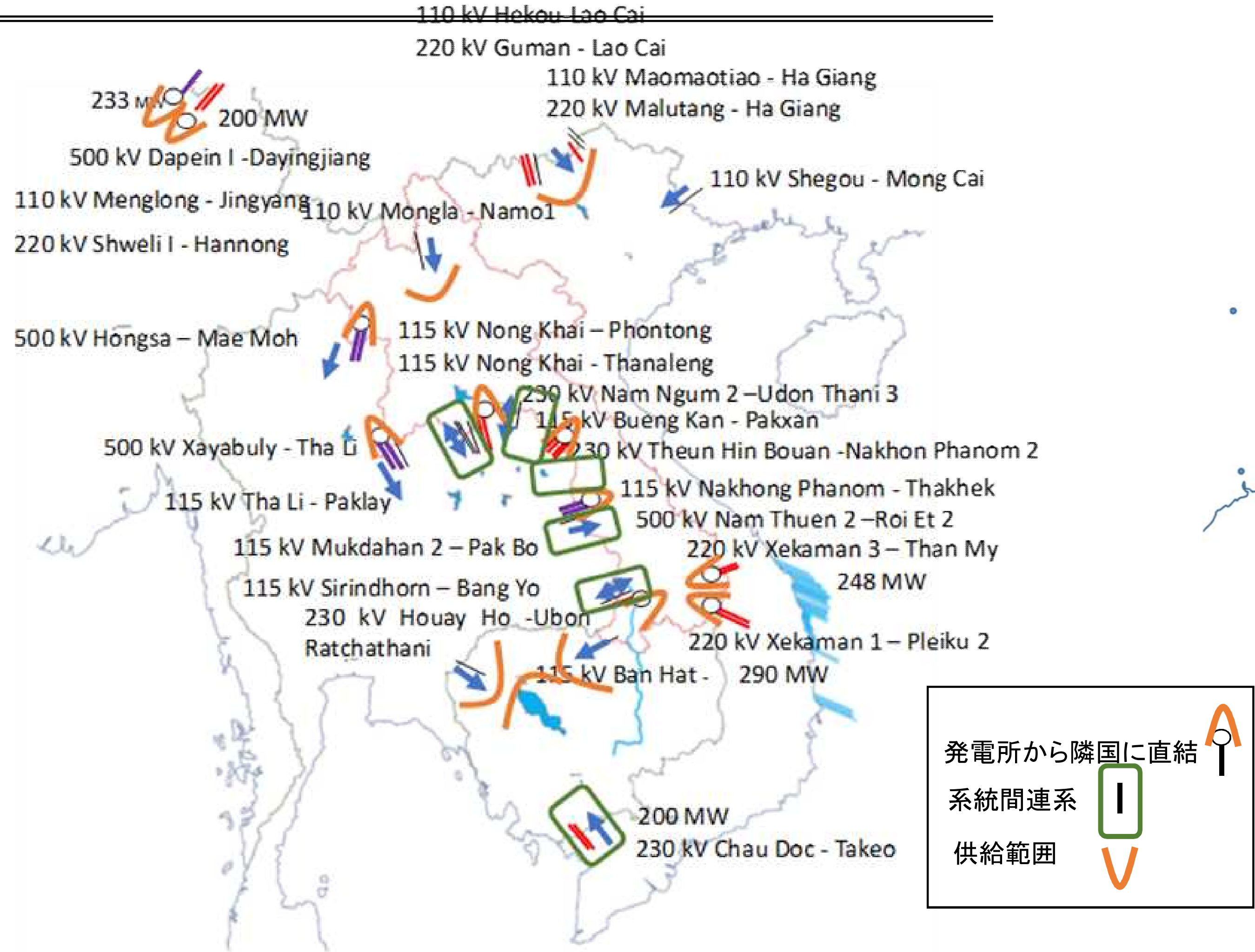
From Nam Ou3,4 to UdonThani3,
Around 300 MW power transmission is stable.

6. Future Study Topics

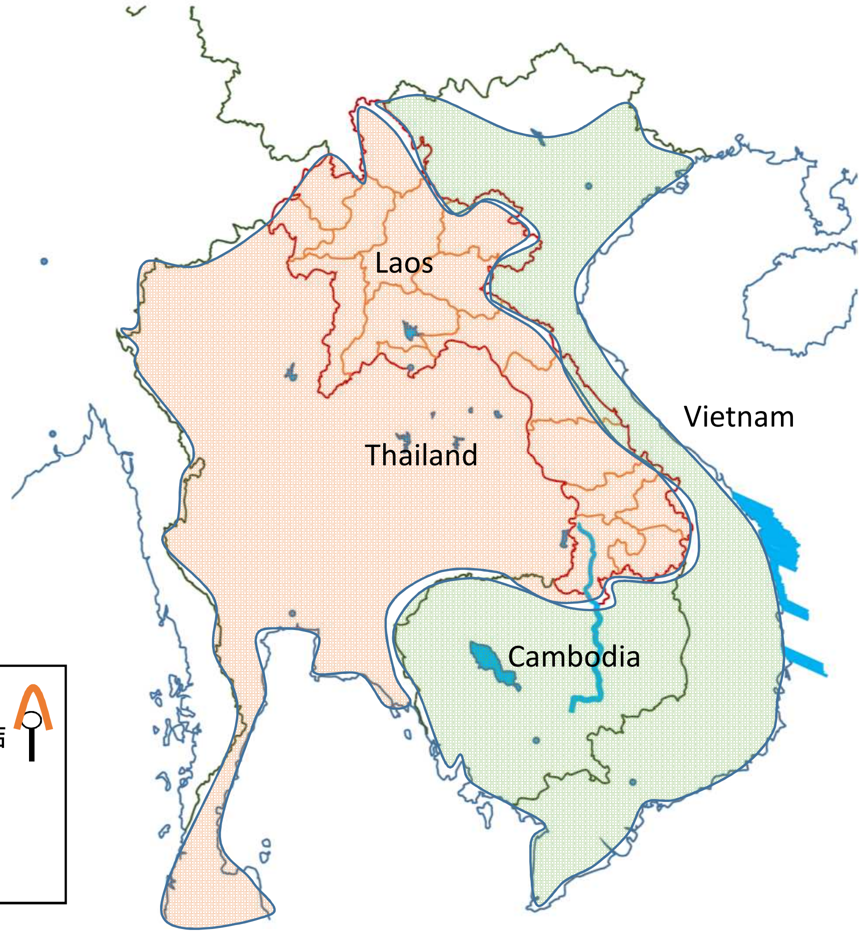
Future Study Topics

1. Power system analysis
2. Cost estimation of Transmission Lines & Substations
3. Financial Analysis of EDL
4. Option Plan
   - Nam Ou to Thailand
   - Comparison between Houapanh and Xekong (700 MW)
5. Issues about system operation for regional interconnection
6. Power Export Scenario
   - Situations of Neighboring Countries, Power Markets

Current Interconnections



Synchronized Areas



Current Power Export Conditions

- Thailand
  - MOU 9,000 MW 2030
  - EGAT PDP2015: 2026-2036 Hydropower from Neighboring Countries 7,700 MW
  - EGAT PDP2018: 2026-2036 Hydropower from Neighboring Countries 3,500 MW
- Vietnam
  - MOU -2020, minimum 1,000 MW, -2025, minimum 3,000 MW, -2030, minimum 5,000 MW
  - IE, MOIT are preparing New PDP
  - Nam Ou 5,6-> Dien Bien, Nam Ou 7-> Lai Chau, Nam Ou 3,4 requires additional lines
  - Xekaman 1 & 3 T/L: Under study supported by WB
  - 500 kV from South of Laos- Central to Vietnam by IFC
- China
  - Power is imported in case that the required power generation capacity is not enough to supply both maximum domestic power demand and power export for both wet and dry seasons.
- Cambodia
  - Already 20 MW through 115 kV, 120 MW in 2030, 195 MW from Dongsaphon, additional 300 MW expected
  - PDP not clear
- Myanmar
  - 300-500 MW in 2025 assumed. Study will be soon started under support by ADB between Laos and Myanmar.
  - PDP not clear

Thank you!

Appendix 4-1_Existing TL List

North

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		COD	Province	Owner-ship	Remarks
	From	To					Type	Size [sqmm]				
1	Luangprabang 2 (S)	Hinheup (S)	230	164.8	2	Twin	ACSR	630	2014	Luangprabang - Vientiane	EDL	
2	Pakmong 2 (S)	Luangprabang 2 (S)	230	91.8	2	Twin	ACSR	630	2015	Luangprabang	EDL	
3	Nam Ou 2 (H) IPP.D	Pakmong 2 (S)	230	22.9	1	Single	ACSR	630	2015	Luangprabang	EDL	
4	Namo 2 (S)	Pakmong 2 (S)	230	86.9	2	Twin	ACSR	630	2015	Oudomxai - Luangprabang	EDL	
5	Bountai (S)	Namo 2 (S)	230	68.5	2	Twin	ACSR	400	2015	Phongsaly - Oudomxai	EDL	
6	Nam Ou 5 (H) IPP.D	Bountai (S)	230	63.4	2	Single	ACSR	410	2015	Phongsaly	EDL	
7	Nam Ou 6 (H) IPP.D	Bountai (S)	230	55.4	2	Single	ACSR	410	2015	Phongsaly	EDL	
8	Luangprabang 1 (S)	Luangprabang 2 (Xieng Ngeun) (S)	115	16.5	1	Single	ACSR	240	1996	Luang Prabang	EDL	
9	Luangprabang 2 (Xieng Ngeun) (S)	Xieng Ngeun T-off (S)	115	0.8	1	Single	ACSR	117	2009	Luang Prabang	EDL	
	Xieng Ngeun T-off (S)	Kasi (S)	115	81.2	1	Single	ACSR	117	2009	Luang Prabang - Vientiane	EDL	
10	Xayabuly (S)	Xieng Ngeun T-off (S)	115	76.0	1	Single	ACSR	240	1996	Luang Prabang - Xayabuly	EDL	
11	Na Mo 1 (S)	M. La (Chica)	115	93.0	1	Single	ACSR	185	2009	Oudomxai - [China]	EDL	Interconnection Line with China
12	Na Mo 1 (S)	Luangnamtha 1 (S)	115	42.7	1	Single	ACSR	240	2009	Oudomxai - Luangnamtha	EDL	Line 1
	Na Mo 1 (S)	Luangnamtha 1 (S)	115	43.0	1	Single	ACSR	240	2017	Oudomxai - Luangnamtha	EDL	Line 2
13	Na Mo 1 (S)	Na Mo 2 (S)	115	5.6	2	Single	ACSR	240	2012	Oudomxai	EDL	
14	Na Mo 2 (S)	Oudomxai (S)	115	35.3	2	Single	ACSR	240	2012	Oudomxai	EDL	
15	Mekong Xayabuly (H) IPP.E	Xayabuly (S)	115	15.5	1	Single	ACSR	240	2014	Xayabuly	EDL	
16	Oudomxai (S)	Pakmong 2 (S)	115	51.7	1	Single	ACSR	240	2012	Oudomxai - Luangprabang	EDL	
17	Oudomxai (S)	Seinsouk (S)	115	124.5	1	Single	ACSR	240	2012	Oudomxai - Luangprabang	EDL	
18	Pakmong 2 (S)	Luangprabang 1 (S)	115	86.9	1	Single	ACSR	240	2009	Luangprabang	EDL	
19	Seinsouk (S)	Luangprabang 1 (S)	115	17.5	1	Single	ACSR	240	2009	Luangprabang	EDL	
20	Hongsa Lignite (T) IPP.E / Viengkeo (S)	Luangprabang 2 (S)	115	101.8	2	Single	ACSR	400	2014	Xayabuly - Luangprabang	EDL	
21	Nam Khan 2 (H) EDL	Luangprabang 2 (S)	115	23.8	2	Single	ACSR	400	2015	Luangprabang	EDL	
22	Nam Khan 3 (H) EDL	Luangprabang 2 (S)	115	6.9	1	Single	ACSR	400	2015	Luangprabang	EDL	
23	Pakmong 2 (S)	Pakmong 1 (S)	115	0.4	2	Single	ACSR	240	2015	Luangprabang	EDL	
24	Nam Beng (H) IPP.D	Nam Beng (S)	115	0.2	1	Single	ACSR	185	2016	Oudomxai	EDL	
25	Paklay (S)	Non Hai (S)	115	89.3	1	Single	ACSR	240	2016	Xayabuly - Vientiane	EDL	
	Paklay (S)	Non Hai (S)	115	104.0	1	Single	ACSR	240	2017	Xayabuly - Vientiane	EDL	
26	Pakmong 2 - Luangprabang 1 (T/L)	Gold Mining	115	8.2	1	Single	ACSR	240	2016	Luangprabang	Private	Operated by EDL.
27	Nam Nga 2 (H) IPP.D	Meuang Nga (S)	115	0.6	1	Single	ACSR	70	2017	Oudomxai	EDL	This "Meuang Nga" is temporary site.
28	Nam Thoung (Thafar) (S)	Luangnamta 1 (S)	115	85.0	2	Single	ACSR	240	2017	Bokeo - Luangnamtha	EDL	
		Total		1,663.9								
		Sub-total of 230 kV T/L		553.6								
		Sub-total of 115 kV T/L		1,110.3								

Central 1

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		COD	Province	Owner -ship	Remarks
	From	To					Type	Size [sqmm]				
1	Nam Ngum 2 (H) IPP.E	Nabong (S)	230	69.0	2	2	ACSR	400	2010	Xaysomboun - Vientiane Cap.	IPP.E	
2	Hinheup (S)	Naxaythong (S)	230	72.0	2	Single	ACSR	630	2012	Vientiane - Vientiane Cap.	EDL	
3	Nam Ngiep 2 (H) IPP.D	Thavieng (S)	230	12.5	2	Single	ACSR	630	2015	Xiengkhuang - Xaysomboun	EDL	
4	Thavieng (S)	Thabok (S)	230	154.8	2	Twin	ACSR	410	2017	Xaysomboun - bolikhamxai	EDL	T/L has been completed but not in operation.
5	Thabok (S)	Nabong (S)	230	54.0	2	Single	ACSR	630	2017	Borikhamxai - Vientiane Cap.	EDL	T/L has been completed but not in operation.
6	Nam Ngum 1 (H) EDL	Thalat (S)	115	5.1	1	Single	ACSR	240	1971	Vientiane	EDL	
	Nam Ngum 1 (H) EDL	Thalat (S)	115	4.8	1	Single	ACSR	240	1971	Vientiane	EDL	
7	Phontong (S)	Nong Khai (EGAT, Thailand)	115	25.7	2	Single	ACSR	240	1972	Vientiane Cap. - [Thailand]	EDL	Interconnection with Thailand (Import)
8	Thalat (S)	Phonsoung (S)	115	26.0	1	Single	ACSR	240	1972	Vientiane	EDL	
9	Thanaleng (S)	Nong Khai (EGAT, Thailand)	115	9.2	1	Single	ACSR	240	1996	Vientiane Cap. - [Thailand]	EDL	Interconnection with Thailand (Import)
10	Naxaythong (S)	Thangon (S)	115	12.0	1	Single	ACSR	240	1996	Vientiane Cap.	EDL	
11	Thalat (S)	Vang Vieng (S)	115	63.0	1	Single	ACSR	117	1996	Vientiane	EDL	
12	Nam Ngum 1 (H) EDL	Naxaythong (S)	115	61.0	2	Single	ACSR	240	2000	Vientiane - Vientiane Cap.	EDL	
13	Nam Ngum 1 (H) EDL	Nam Leuk (H) EDL	115	55.0	1	Single	ACSR	240	2000	Vientiane - Bolikhamxai	EDL	
14	Ban Don (S)	Non Hai (S)	115	54.0	1	Single	ACSR	240	2003	Vientiane	EDL	
15	Nam Mang 3 (H) EDL	Nabong (S)	115	29.0	2	Single	ACSR	240	2016	Vientiane - Vientiane Cap.	EDL	
16	Nabong (S)	Khoksaad (S)	115	34.5	2	Single	ACSR	240	2016	Vientiane - Vientiane Cap.	EDL	
17	Khoksaad (S)	Thanaleng (S)	115	16.0	1	Single	ACSR	240	2005	Vientiane Cap.	EDL	
18	Phonsoung (S)	Naxaythong (S)	115	30.0	1	Single	ACSR	240	2012	Vientiane - Vientiane Cap.	EDL	
19	Naxaythong (S)	Phontong (S)	115	13.0	3	Single	ACSR	240	2006	Vientiane Cap.	EDL	2-cct tower + One side of 2-cct tower
20	Phonsavan (S)	Na Hor (M. Koun) T-off (S)	115	34.0	1	Single	ACSR	240	2007	Xiengkhuang	EDL	
21	Thongkhoun 2 (S)	Nam Leuk (H) EDL	115	66.0	1	Single	ACSR	240	2007	Xaysomboun	EDL	
22	Thongkhoun 2 (S)	Thavieng (S)	115	51.0	1	Single	ACSR	240	2007	Xaysomboun	EDL	
23	Na Hor (M. Koun) T-off (S)	Thavieng (S)	115	29.0	1	Single	ACSR	240	2007	Xiengkhuang - Xaysomboun	EDL	
24	Thongkoun 1 T-off (S)	Phubia Mining (S)	115	13.0	1	Single	ACSR	240	2007	Xaysomboun	Private	Operated by EDL.
25	Hinheup (S)	Thalat (S)	115	29.2	1	Single	ACSR	240	2009	Vientiane	EDL	
26	Hinheup (S)	Ban Don (S)	115	20.0	1	Single	ACSR	240	2009	Vientiane	EDL	
27	Vang Vieng (S)	Nam Ngum 5 (H) IPP.D	115	55.7	2	Single	ACSR	240	2010	Vientiane - Luangprabang	EDL	
28	Nam Ngum 5 (H) IPP.D	Phonsavan (S)	115	68.8	1	Single	ACSR	240	2010	Luangprabang - Xiengkhuang	EDL	
29	Nam Lik 1/2 (H) IPP.D	Hinheup (S)	115	32.6	1	Single	ACSR	240	2010	Vientiane	EDL	
30	Nam Lik 1/2 (H) IPP.D	Ban Don (S)	115	13.6	1	Single	ACSR	240	2010	Vientiane	EDL	
31	Phonsavan (S)	Xamneua (S)	115	169.6	1	Single	ACSR	240	2013	Xiengkhuang - Huaphanh	EDL	
32	Vang Vieng (S)	Hinheup (S)	115	40.6	2	Single	ACSR	240	2012	Vientiane	EDL	
33	Naxaythong (S)	Pakthang (S)	115	11.0	1	Single	ACSR	240	2012	Vientiane Cap.	EDL	
34	Pakthang (S)	Phontong (S)	115	6.0	1	Single	ACSR	240	2012	Vientiane Cap.	EDL	
35	Phontong (S)	Donkoi (S)	115	14.0	1	Single	ACSR	95	2012	Vientiane Cap.	EDL	
36	Donkoi (S)	Thanaleng (S)	115	13.0	1	Single	ACSR	95	2012	Vientiane Cap.	EDL	
37	Naxaythong (S)	Viengkeo (S)	115	10.0	1	Single	ACSR	240	2012	Vientiane Cap.	EDL	
38	Viengkeo (S)	Khoksaad (S)	115	11.0	1	Single	ACSR	240	2012	Vientiane Cap.	EDL	
39	Nam Mang 3 - Nabong (T/L)	Kaly Protus (Potassium) (S)	115	3.0	1	Single	ACSR	185	2011	Vientiane	EDL	
40	Nam Mang 3 - Nabong (T/L)	Iron melting (Tha Ngon) (S)	115	15.0	1	Single	ACSR	240	2012	Vientiane	EDL	
41	Nam Ngiep 3A (H) IPP.D	Na Hor (M. Koun) T-off (S)	115	3.0	1	Single	ACSR	240	2015	Xiengkhuang	EDL	
42	Vang Vieng (S)	Hoysai (S)	115	38.0	1	Single	ACSR	240	2012	Vientiane	EDL	
43	Kasi (S)	Vang Vieng (S)	115	48.0	1	Single	ACSR	117	1996	Vientiane	EDL	
44	Nam San 3B (H) IPP.D	Thavieng (S)	115	25.0	1	Single	ACSR	410	2015	Xaysomboun	EDL	
45	Nam San 3A (H) IPP.D	Nam San 3B (H) IPP.D	115	10.0	1	Single	ACSR	150	2015	Xaysomboun	EDL	
46	Nam Phai (H) IPP.D	Thongkhoun 2 (S)	115	40.4	1	Single	ACSR	410	2017	Xaysomboun	EDL	
47	Nam Phai (H) IPP.D	Nam Pha Gnai (S) IPP.D	115	16.2	1	Single	ACSR	240	2017	Xaysomboun	EDL	T/L has been completed but not in operation.
48	Nam Pha Gnai (S) IPP.D	Thongkhoun 2 (S)	115	25.8	1	Single	ACSR	240	2017	Xaysomboun	EDL	T/L has been completed but not in operation.

49	Nam Peun 2 (H) IPP.D	Phonsavan - Xam Neua (T/L)	115	7.5	1	Single	ACSR	240	2017	Huaphanh	EDL	
50	Nam Ngiep 2C (H) IPP.D	Thavieng - Na Hor T-off (T/L)	115	0.2	1	Single	ACSR	240	2017	Xiengkhuang - Xaysomboun	EDL	
51	Khoksaad (S)	VITA Park	115	4.3	1	Single	ACSR	240	2015	Vientiane Cap.	Private	
52	Thavieng - Thabok (T/L)	Pakxan - Khonsong (T/L)	115		2					Blikhamxai	EDL	temporary detour line. cut after Thabok SS comple
		Total		1,656.2								
		Sub-total of 230 kV T/L		293.3								
		Sub-total of 115 kV T/L		1,362.9								

Central 2

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		COD	Province	Owner -ship	Remarks
	From	To					Type	Size [sqmm]				
1	Pakbo (S)	Nongdeun (S)	115	3.8	2	Single	ACSR	240	2012	Savannakhet	EDL	
2	Nongdeun (S)	Kengkok (S)	115	47.0	1	Single	ACSR	240	2012	Savannakhet	EDL	
3	Pakxan (S)	Bungkan (EGAT, Thailand)	115	11.0	1	Single	ACSR	240	2000	Bolikhamxai - [Thailand]	EDL	Interconnection with Thailand
4	Nam Leuk (H) EDL	Thabok (S)	115	39.0	1	Single	ACSR	240	2000	Bolikhamxai	EDL	
5	Pakxan (S)	Thabok (S)	115	47.0	1	Single	ACSR	240	2000	Bolikhamxai	EDL	
6	Thakhek (S)	Mahaxai (S)	115	47.0	2	Single	ACSR	240	2004	Khammouan	EDL	
7	Thakhek (S)	Cement factory (Mahaxai) (S)	115	27.0	1	Single	ACSR	240	2004	Khammouan	EDL	
8	Thakhek (S)	Nakhon Phanom (EGAT, Thailand)	115	14.7	2	Single	ACCC	325	2004	Khammouan - [Thailand]	EDL	Interconnection with Thailand/Conductor size was upgraded from ACSR to ACCC on 2016.
9	Pakbo (S)	Mukdahan 2 (EGAT,Thailand)	115	14.0	1	Single	ACSR	240	2004	Khammouan - [Thailand]	EDL	Interconnection with Thailand
10	Mahaxai (S)	Cement factory (Mahaxai) (S)	115	20.0	1	Single	ACSR	240	2009	Khammouan	EDL	
11	Nam Theun 2 (H) IPP.E	Mahaxai (S)	115	29.2	2	Single	ACSR	240	2009	Khammouan	EDL	
12	Mahaxai (S)	Sepon Mining (S)	115	117.1	1	Single	ACSR	240	2010	Khammouan - Savannakhet	EDL	Line 1
	Mahaxai (S)	Sepon Mining (S)	115	123.0	1	Single	ACSR	240	2010	Khammouan - Savannakhet	EDL	Line 2
13	Nam Gnuang 8 (H) EDL	Konsong (S)	115	52.0	1	Single	ACSR	240	2012	Bolikhamxai	EDL	
14	Thasala (S)	Cement factory (Lanxang) (S)	115	27.1	1	Single	ACSR	240	2012	Bolikhamxai	EDL	
15	Konsong (S)	Cement factory (Lanxang) (S)	115	26.0	1	Single	ACSR	240	2012	Bolikhamxai	EDL	
16	Pakxan (S)	Konsong (S)	115	90.0	2	Single	TACSR	240	2012	Bolikhamxai	EDL	
17	Thasala (S)	Lak 20 (Pompik) (S)	115	47.8	1	Single	ACSR	240	2014	Bolikhamxai	EDL	
18	Lak 20 (Pompik) (S)	Nakadok Mining (S)	115	5.0	1	Single	ACSR	240	2015	Bolikhamxai	EDL	
19	Konsong (S)	Thakhek (S)	115	105.0	2	Single	ACSR	240	2011	Bolikhamxai - Khammouan	EDL	
20	Thakhek (S)	Pakbo (S)	115	87.0	2	Single	TACSR	240	2010	Khammouan - Savannakhet	EDL	
21	Nam Mang 1 (H) IPP.D	Thabok (S)	115	6.3	1	Single	ACSR	240	2015	Bolikhamxai	EDL	
22	Nam Gnuang 8 (H) EDL	Thasala (S)	115	2.0	1	Single	ACSR	240	2015	Bolikhamxai	EDL	
23	Thakhek - Mahaxai (T/L)	MCS Factory	115	0.5	1	Single	ACSR	240	2016	Khammouan	Private	Operated by EDL.
24	Taothan (S)	Nongdeun (S)	115	154.3	2	Single	ACSR	240	2016	Savannakhet - Saravan	EDL	
25	Mahaxai (S)	Cement factory (KCL) (S)	115	11.0	1	Single	ACSR	240	2016	Khammouan	EDL	
26	Maeungphin (S)	Nathon (Saravan) (S)	115	117.0	2	Single	ACSR	240	2016	Savannakhet - Saravan	EDL	
27	Nongdeun (S)	Banmat (Seno) (S)	115	42.8	2	Single	ACSR	400	2016	Savannakhet	EDL	
28	Banmat (Seno) (S)	Maeungphin (S)	115	108.2	2	Single	ACSR	240	2016	Savannakhet	EDL	
		Total		1,421.8								
		Sub-total of 230 kV T/L		1,421.8								

South

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		COD	Province	Owner -ship	Remarks
	From	To					Type	Size [Sqmm]				
1	Bang Yo (S)	Sirindhorn (H) (EGAT, Thailand)	115	52.0	1	Single	ACSR	240	1996	Champasak - [Thailand]	EDL	Interconnection with Thailand
2	Jiengxai (S)	Bang Yo (S)	115	8.2	1	Single	ACSR	240	1996	Champasak	EDL	Line 1
	Jiengxai (S)	Bang Yo (S)	115	9.2	1	Single	ACSR	240	1996	Champasak	EDL	Line 2
3	Jiengxai (S)	Xeset 1 (H) EDL	115	63.2	1	Single	ACSR	240	2005	Champasak - Saravan	EDL	
4	Jiengxai (S)	Ban Na (S)	115	59.6	2	Single	ACSR	240	2005	Champasak	EDL	
5	Ban Na (S)	Ban Hat (S)	115	62.2	2	Single	ACSR	240	2005	Champasak	EDL	
6	Ban Na (S)	Saphaothong (S)	115	112.5	2	Single	ACSR	240	2005	Champasak - Attapeu	EDL	
7	Xeset 1 (H) EDL	Xeset 2 (H) EDL	115	3.1	2	Single	ACSR	240	2009	Saravan - Champasak	EDL	
8	Xeset 2 (H) EDL	Pakxong (S)	115	42.9	1	Single	ACSR	240	2009	Saravan - Champasak	EDL	
9	Pakxong (S)	Xeset 3 (H) EDL	115	21.0	1	Single	ACSR	240	2016	Champasak - Saravan	EDL	
10	Xeset 2 (H) EDL	Xeset 3 (H) EDL	115	20.8	1	Single	ACSR	240	2016	Saravan	EDL	
11	Pakxong (S)	Jiengxai (S)	115	43.2	2	Single	ACSR	240	2010	Champasak	EDL	
12	Xeset 1 (H) EDL	Nathon (Saravan) (S)	115	24.3	2	Single	ACSR	240	2011	Saravan	EDL	
13	Nathon (Saravan) (S)	Nongbong (S)	115	50.0	2	Single	ACSR	240	2012	Saravan - Sekong	EDL	
14	Nongbong (S)	Xekaman 3 (H) IPP.E	115	100.0	1	Single	ACSR	240	2012	Sekong	EDL	
15	Saphaothong (S)	Sugar Factory (T) IPP.D	115	23.0	1	Single	ACSR	240	2013	Attapeu	EDL	
16	Houylamphanyai (H) EDL	Nongbong (S)	115	11.0	2	Single	ACSR	240	2014	Sekong	EDL	
17	Xenamnoi 1 (H) IPP.D	Nongbong (S)	115	33.0	1	Single	ACSR	185	2014	Sekong	EDL	
18	Nathon (Saravan) (S)	Taothan (S)	115	68.7	2	Single	ACSR	240	2016	Saravan	EDL	
19	Xenamnoy 2 - Xekatam 1 (H) IPP.D	Xenamnoi 1 (H) IPP.D	115	10.0	1	Single	ACSR	240	2017	Sekong - Champasak	EDL	
20	Houay por (H) EDL	Xeset 1 (H)	115	11.0	1	Single	ACSR	240	2017	Saravan	EDL	
21	Nam Kong 2 (H) IPP.D	Sugar Factory (T) IPP.D	115	38.0	1	Single	ACSR	240	2017	Attapeu	IPP.D	Operated by EDL.
		Total		866.9								
		Sub-total of 115 kV T/L		866.9								

Appendix 4-2_Under Construction TL List

Under Construction

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		COD	Province	Owner -ship	Source of Fund
	From	To					Type	Size [sqmm]				
North												
1	Mekong Xayabuly (H) IPP.E	Tha Li (Thailand)	500	272.0	2	Quad	ACSR	795 MCM	2019	Xayabuly - Thailand	IPP.E	Unknown
2	Nam Ou 3 (H) IPP.D	Pakmong 2 (S)	230	35.0	2	Single	ACSR	410	2020	Luangprabang	IPP.D	EDL / YNPG, China
3	Nam Ou 7 (H) IPP.D	Nam Ou 6 - Bountai (T/L)	230	40.0	2	Single	ACSR	410	2020	Phongsaly	IPP.D	EDL / YNPG, China
4	500kV M. Nan (S)	Luangprabang 2 - Hinheup (T/L)	230	9.1	2	Single	ACSR	410	2020	Luangprabang	IPP.D	EDL / SCI, Koungthai Bank
5	Nam Ou 1 (H)	Pakmong 2 - Luang Prabang 2 (T/L)	230	1.0	2	Single	ACSR	410	2020	Luangprabang	IPP.D	EDL / YNPG, China
6	Nam Beng (H) IPP.D	T-off Hongsa - Luangprabang 2 (T/L)	115	40.0	1	Single	ACSR	240	2017	Oudomxai - Xayabuly	EDL	EDL
7	Xayabuly (S)	Paklay (S)	115	123.0	2	Single	ACSR	240	2018	Xayabuly	EDL	Korea EximBank & ADB
8	Nam Tha 1 (H) IPP.D	230 kV Pha Oudom (S)	115	4.0	3	Single	ACSR	300	2018	Bokeo	IPP.D	Nam Tha Company
9	Houayxay (S)	Nam Thoung (Thafar) (S)	115	57.0	2	Single	ACSR	300	2018	Bokeo	EDL	EDL/China
10	Pha Oudom (S)	Nam Thoung (Thafar) - Houayxay (T/L)	115	14.0	2	Single	ACSR	300	2018	Bokeo	EDL	Nam Tha Company
11	Houayxay (S)	Ton Pheung (S)	115	51.0	2	Single	ACSR	240	2018	Bokeo	EDL	Pinggao
12	Seinsouk (S)	Cement Factory Luangprabang (S)	115	18.0	1	Single	ACSR	240	2018	Luangprabang	IPP.D	Cond China
13	Paklay (S)	Kenthao (S)	115	67.0	2	Single	ACSR	240	2019	Xayabuly	EDL	Korea EximBank & ADB
14	Kenthao (S)	Tha Li (Thailand)	115	6.0	2	Single	ACSR	240	2019	Xayabuly - Thailand	EDL	Korea EximBank & ADB
15	Nam Ou 4 (H) IPP.D	M. Khoua (S)	115	7.0	2	Single	ACSR	410	2020	Phongsaly	IPP.D	EDL / YNPG, China
16	M. Khoua (S)	Oudomxai (S)	115	100.0	2	Single	ACSR	410	2020	Phongsaly	IPP.D	EDL / YNPG, China
17	Nam Tha 2 (B. Hat Mouak) (H) IPP.D	Pha Oudom (S)	115	18.0	1	Single	ACSR	240	2020	Bokeo	IPP.D	Mico Hydro Power Company
18	Nam Ngao (H) IPP.D	Houayxay (S)	115	21.0	1	Single	ACSR	240	2020	Bokeo	IPP.D	Houng Pa Seud Hydropower
19	Nam Houng Down (H) IPP.D	Xayabuly (S)	22	30.0	2	Single	ACSR	150	2019	Xayabuly	IPP.D	SiMeuang Group
Central 1												
1	Naphia (S)	Pia Lat (S)	500	210.0	2	Quad	ACSR	630	2020	Xieng Khuang - Vientiane Cap.	EDL	CWE
2	Nam Theun 1 (H) IPP.E	Nabong (S)	500	154.0	2	Quad	ACSR	630	2020	Bolikhamxai - Vientiane Cap.	IPP.E	Phonsac Group
3	Hinheup (S)	Thalat 2 (S)	230	58.0	2	Single	ACSR	410	2018	Vientiane - Vientiane Cap.	EDL	China
4	Thalat 2 (S)	Nabong (S)	230	32.0	2	Single	ACSR	410	2018	Vientiane - Vientiane Cap.	EDL	China
5	Nam Ngiep 1 (H) IPP.E	Nabong (S)	230	130.0	2	Twin	ACSR	410	2019	Bolikhamxai - Vientiane Cap.	IPP.E	Kansai
6	Xamtai (S)	Houa Muang (S)	230	88.0	2	Single	ACSR	410	2020	Houaphanh	EDL	CHMC
7	Nam Xam 3 (H) IPP.D	Xamtai (S)	230	18.0	2	Single	ACSR	410	2020	Houaphanh	IPP.D	Phongsapthavy Road and Bridge Construction
8	Houa Muang (S)	Kor Hing (S)	230	60.0	2	Twin	ACSR	410	2020	Huaphanh	EDL	CMEC (China)
9	Kor Hing (S)	Nonghet (S)	230	100.0	2	Twin	ACSR	410	2020	Huaphanh - Xieng Khuang	EDL	CMEC (China)
10	Nam Ngum 3 (H) EDL	Nabong (S)	230	100.0	2	Twin	ACSR	630	2020	Xieng Khuang	EDL	EDL and Sinohydro (China)
11	Nam Mo 2 (H) IPP.D	M. Mok Mai (S)	230	8.0	2	Twin	ACSR	410	2020	Xieng Khuang	EDL	CMEC (China)
12	M. Mok Mai (S)	Naphia (S)	230	120.0	2	Twin	ACSR	410	2020	Xieng Khuang	EDL	CMEC (China)
13	Nonghet (S)	M. Mok Mai (S)	230	70.0	2	Twin	ACSR	410	2020	Xieng Khuang	EDL	CMEC (China)
14	Nam Chiene 1 (H) EDL	Thavieng (S)	115	35.0	2	Single	ACSR	240	2017	Xaysomboun	EDL	EDL
15	Nam Peun 1 (H) IPP.D	Kor Hing (S)	115	22.0	1	Single	ACSR	240	2018	Xiengkhuang	IPP.D	Phongsapthavy Road and Bridge Construction Co.,Ltd
16	Nam Hao (H) IPP.D	Sopbao (S)	115	8.0	2	Single	ACSR	240	2019	Houaphanh	IPP.D	Duangchalern Road and Bridge Construction Co.,Ltd
17	Nam Lik 1 (H) IPP.D	Hinheup (S)	115	10.0	2	Single	ACSR	240	2019	Vientiane	IPP.D	Hydro Engineering 40%, EDL 10%, PTTI 40%, POSCO 10%
18	Nam Sim (H) IPP.D	22 kV TL Hanglong (S)	22	50.0	2	Single	ACSR	150	2020	Houaphanh	IPP.D	Energy Deverlopment as (Norway) 75%, ECI (Loas) 25%
Central 2												
1	Nam Hinboun (H) EDL	Khonsong (S)	115	15.0	1	Single	ACSR	240	2018	khammouan	EDL	EDL
2	Nam Hinboun (Down) (H) IPP.D	Song Hong	115	1.7	1	Single	TACSR	240	2018	khammouan	EDL	Lao Company
3	Nam Ngiep 1 (H) IPP.E	Pakxan (S)	115	35.0	1	Single	ACSR	240	2019	Bolikhamxai	EDL	EDL/China
4	Nam Theun 1 (H) IPP.E	Phone Ngam (S)	115	9.0	2	Single	ACSR	240	2020	Bolikhamxai	IPP.E	Phonsac Group

South												
1	Ban Lak 25Km (S)	Ubon Ratchathani 3 (Thailand)	500	60.0	2	Quad	ACSR	630	2019	Champasak	IPP.E	SK Engineering 265%, Korea Western Power 25%, Ratchaburi 25%, LHSE 24%, 40 MW / 178.8 GWh
2	Ban Lak 25Km (S)	Ban Hat (S)	500	109.0	2	Quad	ACSR	630	2019	Champasak	EDL	CGGC China
3	MK. Donsahong (H) IPP.D	Ban Hat (S)	230	30.0	2	Twin	ACSR	410	2019	Champasak	IPP.D	Maga Frist (Malaysia) 80%, GOL 20%,
4	Xepien-Xenamnoy (H) IPP.E	Ban Lak 25Km (S)	230	100.0	2	Twin	ACSR	410	2019	Champasak - Attapeu	IPP.E	SK Engineering 265%, Korea Western Power 25%, Ratchaburi 25%, LHSE 24%, 40 MW / 178.8 GWh
5	Xekaman -Xanxai (H) IPP.D	Xekaman 1 (H) IPP.E	115	10.0	1	Single	ACSR	240	2017	Attapeu	IPP.D	VLP (Vietnam) 85%, EDL 15%, 32 MW / 120 GWh
6	Xepien-Xenamnoy (H) IPP.E	Sapaothong (S)	115	7.7	1	Single	ACSR	240	2019	Champasak - Attapeu	IPP.E	SK Engineering 265%, Korea Western Power 25%, Ratchaburi 25%, LHSE 24%, 40 MW / 178.8 GWh

Appendix 4-3_International Interconnection TL List

Interconnection

No.	Section of Transmission Line		Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor		Province	Owner -ship	Remarks
	From	To					Type	Size [Sqmm]			
1	Hongsa Lignite (T) IPP.E	Mae Moh (Thailand)	500	265.0	2	Quad	ACSR	630	Xayabuly - [Thailand]	IPP.E	
2	Nabong (S)	Udon Thani 3 (Thailand)	500	99.0	2	Twin	ACSR	630	Vientiane Cap. - [Thailand]	IPP.E	500kV design/230kV operation
3	Nam Theun 2 (H) IPP.E	Roi Et (EGAT, Thailand)	500	282.0	2	Quad	ACSR	630	Khammouan	IPP.E	
4	Theun Hinboun (H) IPP.E	Sakhonakhon (EGAT, Thailand)	230	176.0	2	Single	ACSR	410	Bolikhamxai	IPP.E	
5	Houay Ho (H) IPP.E	Ubon Ratchathani 2 (Thailand)	230	230.0	2	Single	ACSR	410	Champasak - [Thailand]	IPP.E	
6	Xekaman 3 (H) IPP.E	Thanh My (EVN, Vietnam)	230	19.0	2	Single	ACSR	410	Sekong - [Vietnam]	IPP.E	
7	Xekaman 1 (H) IPP.E	Pleiku (EVN, Vietnam)	230	75.0	2	Twin	ACSR	630	Attapeu - [Vietnam]	IPP.E	
8	Phontong (S)	Nong Khai (EGAT, Thailand)	115	25.7	2	Single	ACSR	240	Vientiane Cap. - [Thailand]	EDL	Import
9	Thanaleng (S)	Nong Khai (EGAT, Thailand)	115	9.2	1	Single	ACSR	240	Vientiane Cap. - [Thailand]	EDL	Import
10	Pakxan (S)	Bungkan (EGAT, Thailand)	115	11.0	1	Single	ACSR	240	Bolikhamxai - [Thailand]	EDL	
11	Thakhek (S)	Nakhon Phanom (EGAT, Thailand)	115	14.7	2	Single	ACCC	325	Khammouan - [Thailand]	EDL	Conductor size was upgraded on 2016.
12	Pakbo (S)	Mukdahan 2 (EGAT,Thailand)	115	14.0	1	Single	ACSR	240	Khammouan - [Thailand]	EDL	
13	Bang Yo (S)	Sirindhorn (H) (EGAT, Thailand)	115	52.0	1	Single	ACSR	240	Champasak - [Thailand]	EDL	
14	Houayxai District	Chiengkhong (PEA, Thailand)	22	0.7	1	Single	ACSR	185	Bokeo	EDL	Import
15	Kenthao District	Thali (PEA, Thailand)	22	0.4	1	Single	ACSR	240	Xayabuly	EDL	Import
16	Pangthong (Sing District)	Mang District (China)	22	28.6	1	Single	ACSR	150	Luangnamtha	EDL	Import
17	Khoub	Ban Houak (PEA, Thailand)	22	1.5	1	Single	ACSR	150	Xayabuly	EDL	Import
18	Ngeun District	Houay kone (PEA, Thailand)	22	1.0	1	Single	ACSR	150	Xayabuly	EDL	Import
19	Chiang Hon	Ban Mai (PEA, Thailand)	22	1.3	1	Single	ACSR	150	Xayabuly	EDL	Import
20	Boten Dankham	Bohan (China)	22	3.4	1	Single	ACSR	90	Luangnamtha	EDL	Import
21	M. Mai	Dienbien (EVN, Vietnam)	35/22	25.0	1	Single	ACSR	150	Phongsaly	EDL	Import
22	Ngot Ou	Jang xeun District (China)	22	52.8	1	Single	ACSR	120	Phongsaly	EDL	Import
23	Boten	Danxai (PEA, Thailand)	22	81.9	1	Single	ACSR	150	Xayabuly	EDL	Import
24	Thon Pheng	Xieng Sen (PEA, Thailand)	22	3.0	1	Single	ACSR	185	Bokeo	EDL	Import
25	Long District	Xieng Kok (Myanmar)	22	1.5	1	Single	ACSR	150	Luangnamtha	EDL	Export
26	Dansvan	Laobao (EVN)	35/22	0.8	1	Single	ACSR	95	Savannakhet	EDL	Import
27	Dakchung	Vietnam	35/22	10.0	1	Single	ACSR	150	Sekong	EDL	Import
28	KaLum	Vietnam	35/22	8.0	1	Single	ACSR	150	Sekong	EDL	Import
29	Lali (Samouay Village)	Are Ngor (EVN, Vietnam)	35/22	2.0	1	Single	ACSR	150	Saravan	EDL	Import
30	Ban Hat	Chiang Teng (Stung Treng) (Cambodia)	22	26.0	1	Single	ACSR	150	Champasak	EDL	Export
31	Ban Hat	Khampongsalao (Cambodia)	22	11.0	1	Single	ACSR	240	Champasak	EDL	Export, 115kV design
32	Vangtut Coal Mining	Vietnam	35/22	50.0	1	Single	ACSR	150	Attapeu	EDL	Import

Appendix 4-4_Existing substation list

Existing Substations in Whole Country.

No.	Name Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	Remarks
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity (MVA)	(MVar)	(MVA)	Total (MVA)		
	Northern		**13**	**3**	**-**	**441.0**	**440.0**	**-**	**881.0**	**63.5**		**82.6**		
1	Luang Prabang 1	Luang Prabang	1			(2x12.5)			25		(2x3.6)+(2x5)	17.2	1996	
2	T-off Xieng Ngeun (SwS)	Luang Prabang	1										1996	
3	Xayabuly	Xayabuly	1			(1x20)+(1x16)			36		(2x3.6)	7.2	2001	
4	Na Mo 1	Oudomxai	1			(1x30)			30		(2x3.6)	7.2	2009	
5	Luangnamtha 1	Luangnamtha	1			(1x20)			20				2009	
6	Pakmong 1	Luang Prabang	1			(1x20)+(1x10)			30				2009	
7	Sensouk (Sien Souk)	Luang Prabang	1			(1x30)			30				2009	
8	Udomxai	Oudomxai	1			(1x20)			20	(1x3.5)			2009	
9	Na Mo 2	Oudomxai		1		30	(1x120)		150	(2x10)	(2x9)	18	2015	3 wire TR (22kV no load)
10	Viengkeo	Sayaboury	1			(1x20)			20				2015	
11	Luang Prabang 2	Luang Prabang		1		(1x30)	(1x200)		230	(2x10)			2015	
12	Bountai (SwS)	Phongsaly											2015	
13	Pakmong 2	Luang Prabang		1			(1x120)		120	(2x10)	(2x9)	18	2015	3 wire TR (22kV no load)
14	Pak Beng	Oudomxai	1			(1x30)			30		(1x2.5)+(2x1.25)	5	2016	Temporary substation
15	Paklay	Xayabuly	1			(1x30)			30		(2x2.5)+(1x5)	10	2017	
16	Meuang Nga	Oudomxai	1			(1x30)			30				2017	Temporary substation
17	Thafar (Nam Thoung)	Borkeo	1			(1x20)			20				2017	
18	Houayxay	Bokeo				(2x30)			60				2018	

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity (MVA)	(MVar)	(MVA)	Total (MVA)		
	Central 1		**24**	**3**	**-**	**939.5**	**800**	**-**	**1,739.5**	**69.0**		**129.7**		
1	Nam Ngum 1	Vientiane	1			(1x7.5)			7.5				1971	
2	Thalat	Vientiane	1			(1x30)			30		(4x2.5)	10	1972	
3	Phonsoung	Vientiane	1			(1x22)			22		(4x2.5)	10	1972	
4	Phontong	Vientiane Capital	1			(4x50)			200		(7x5)	35	1972	
5	Tha Ngon	Vientiane Capital	1			(1x30)			30				1996	
6	Thanaleng	Vientiane Capital	1			(3x30)			90		(8x2.5)	20	1996	
7	Ban Don	Vientiane	1			(1x16)			16				2003	
8	Non hai	Vientiane	1			(1x16)			16				2003	
9	Nam Mang 3	Vientiane	1			(1x5)			5				2005	
10	Khoksa ad	Vientiane Capital	1			(2x22)+(1x30)			74		(4x5)	20	2005	
11	Nam Leuk	Vientiane	1			(1x10)			10				2007	
12	T-off Tongkoun 1	xaysomboun	1										2007	
13	Vang Vieng	Vientiane	1			(1x16)+(1x16)			32				1994	
14	Phonsavan	Xieng Kuang	1			(30x1)+(1x16)			46				2003	
15	Xamneua	Houaphanh	1			(1x20)			20	(2x4.5)	(2x3.6)	7.2	2010	
16	Nam Lik 1/2	Vientiane	1			(1x16)			16				2010	
17	Hinheup	Vientiane		1		(1x20)	(1x200)		220	(2x10) + (2x10)			2011	
18	Naxaythong	Vientiane Capital		1		(2x30)	(2x200)		460	(1x10)	(8x2.5)	20	2012	
19	Donkoi	Vientiane Capital	1			(1x50)			50				2012	
20	Pakthang	Vientiane Capital	1			(1x30)			30				2012	
21	viengkeo (Nongviengkham)	Vientiane Capital	1			(1x30)			30				2012	
22	Nam Ngum 5	Xieng Kuang	1			(1x20)			20				2012	
23	T-off Na hor (SwS)	Xieng Kuang	1										2012	
24	Tongkoun 2	xaysomboun	1			(1x25)			25				2012	
25	Kasi	Vientiane	1			(1x30)			30		(2 x 2.5)	5	2014	
26	Nabong	Vientiane Capital	1			(1x30)			30				2016	
27	Thavieng	xaysomboun		1		(1x30)	(1x200)		230	(1x10)	(1x1)+(1x1.5)	2.5	2016	
28	SwS (SwS)	Houaphanh												

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity (MVA)	(MVar)	(MVA)	Total (MVA)		
	Central 2		**13**	**-**	**-**	**432.0**	**300.0**	**-**	**732.0**			**66.7**		
1	Pakbo	Savannaket	1			(2x20)			40		(2x3.6)	7.2	1996	
2	Kengkok	Savannaket	1			(2x10)			20				2004	
3	Pakxan	Bolikhamxai	1			(2x16)			32		(1x2.5)+(1x5)	7.5	2000	
4	Thakhek	Khammuane	1			(2x30)			60		(2x2.5)+(2x5)	15	2004	
5	Mahaxai	Khammuane	1			(2x20)			40		(1x2.5)+(1x5)	7.5	2009	
6	Nam Theun 2	Khammuane	1			(1x20)			20				2009	
7	Thasala	Bolikhamxai	1			(1x20)			20				2012	
8	Konsong	Bolikhamxai	1			(1x20)			20		(1x2.5)+(1x2.5)	5	2012	
9	Nongdeun	Savannaket	1			(1x50)			50		(2x5)	10	2012	
10	Thabok	Bolikhamxai	1			(1x20)	(1x100)		120				2015	
11	Luk 20 (pompik) (S)	Bolikhamxai	1			(1x30)	(1x200)		230		(1x2.5)	2.5	2015	
12	Muang Phin	Savannaket	1			(1x20)			20		(2x2.5)	5	2016	
13	Banmat (Seno)	Savannaket	1			(1x30)			30		(2x3.5)	7	2017	
14	Phone Ngam	Bolikhamxai				(1x30)			30					Temporary substation

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity (MVA)	(MVar)	(MVA)	Total (MVA)		
	Southern		**10**	**-**	**-**	**413.0**	**0.0**	**-**	**413.0**			**65.8**		
1	Bang yo	Champasak	1			(2x25)			50		(2x3.15)	6.3	1996	
2	Jiengxai	Champasak	1			(1x30)			30		(1x2.5)+(1x5)	7.5	2005	
3	Ban Na	Champasak	1			(2x30)			60		(2x3.5)	7	2005	
4	Ban Hat	Champasak	1			(2x20)			40		(2x5)	10	2005	
5	Saphaothong	Attapeu	1			(2x20)			40		(1x2.5)+(1x5)	7.5	2005	
6	Xeset 1	Saravane	1			(1x5)+(1x8)			13				2009	
7	Pak Xong	Champasak	1			(1x50)+(1x30)			80				2010	
8	Nongbong	Xekong	1			(1x30)			30		(2x2.5)	5	2012	
9	Nathone (Saravan)	Saravan	1			(2x20)			40		(2x2.5)+(2x5)	15	2012	
10	Taothan	Saravan	1			(1x30)			30		(1x2.5)+(1x5)	7.5	2016	
	Whole Country		**60**	**6**	**-**	**2225.5**	**1540.0**		**3765.5**			**344.8**		

Appendix 4-5_Under construction substation list

Under Construction Substations in Whole Country.

No.	Name Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	Remarks
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity	(MVar)	(MVA)	Total (MVA)		
	Northern		**0**	**0**	**0**	**260.0**	**400.0**	**-**	**660.0**					
	Xayabuly Extension	Xayabuly											2018	Bay extension
	Nohai Extension	Vientiane											2019	Bay extension
	Boun Neua	Phongsaly				(1x30)			30				2019	
	Tonfeung	Bokeo				(1x50)			50				2020	
	Pha Oudom	Oudomxai				(1x50)	(2x200)		450				2020	
	M. Kenthao	Xayabuly				(1x30)			30				2020	
	M. Khoua	Phongsaly				(2x50)			100				2020	

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity	(MVar)	(MVA)	Total (MVA)		
	Central 1		**0**	**0**	**0**	**400.0**	**1800**	**3000.0**	**5,200.0**	**9.6**		**55**		
	Nabong	Vientiane Capital					(2x100)		200				2018	Assumption COD
	Nam Ngun 1 Extension	Vientiane					(1x200)		200				2018	
	230kV Dongphosy	Vientiane Capital				(2x50)	(1x200)		300	(4x2.4)	(1x22)	22	2020	
	Na Hai	Vientiane Capital				(1x50)			50		(6x5)	30	2020	
	Naphia	Xieng Kuang				(1x50)	(1x200)	(1x750)	1000				2020	
	Pia Lat	Vientiane Capital				(1x50)	(1x200)	(1x750)	1000				2020	
	Xam Tai	Houaphanh				(1x50)	(2x200)		450				2020	
	Houa Muang	Houaphanh				(1x50)	(1x200)	(2x750)	1750				2020	
	Nong Het	Xieng Kuang				(1x50)	(1x200)		250				2025	
	M. Mok. Mai	Xieng Kuang											2021	Shall be deleted from list

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity	(MVar)	(MVA)	Total (MVA)		
	Central 2		0	0	0	0.0	0.0	-	0.0					

No.	Substation	Province	Substation type			Power Transformer Capacity (MVA)				Shunt Reactor	Power Capacitor Bank		COD	
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity	(MVar)	(MVA)	Total (MVA)		
	Southern		**0**	**0**	**0**	**50.0**	**800.0**	**-**	**850.0**					
	Ban Lak 25	Champasak				(1x50)	(2x200)		450				2019	
	Ban Hat Extension	Champasak					(2x200)		400				2019	
Whole Country			**-**	**-**	**-**	**710.0**	**3000.0**	**3000.0**	**6710.0**	**9.6**		**55.0**		

Appendix 11-1 Applicable Unit Price for Cost Estimation (Transmission Line)

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
1	500kV DC T/L, Plain area, 10km length					
A1	Plant and Equipment					
A1-1	Suspension tower	tower	19	73,100	1,388,900	
A1-2	Tension tower	tower	3	93,500	280,500	
A1-3	Suspension insulator set inc. fittings	set	114	890	101,460	
A1-4	Tension insulator set inc. fittings	set	36	1,071	38,556	
A1-5	Phase conductor "hawk" inc.	km	240	11,188	2,685,120	610 mm2
A1-6	OPGW inc. damper & accessories	km	10	5,600	56,000	
A1-7	Earthing system	tower	22	373	8,206	
A1-8	Spare parts & tools	L/S	1	227,931	227,931	
	Total A				4,786,673	
B1	Construction and Installation					
B1-1	Survey and sub soil test	km	10	2,795	27,950	
B1-2	Clearing ROW	km	10	2,450	24,500	
B1-3	Access road	L/S	1	17,000	17,000	
B1-4	Foundation concrete	cu.m	810	700	567,000	
B1-5	Tower erection	tower	22	10,713	235,686	
B1-6	Installation of insulator set and conductor	km	10	10,248	102,480	
B1-7	Installation of OPGW	km	10	1,200	12,000	
B1-8	Installation of earthing system	tower	22	177	3,894	
B1-9	Commissioning	L/S	1	1,000	1,000	
B1-10	Local transportation	L/S	1	165,911	165,911	
B1-11	Accessories for tower	L/S	1	6,000	6,000	
B1-12	Mobillization	L/S	1	3,500	3,500	
	Total B				1,166,921	
	GRAND TOTAL				5,953,594	
					0.595	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
2	500kV DC T/L, Mountain area, 10km length					
A2	Plant and Equipment					
A2-1	Suspension tower	tower	16	73,100	1,169,600	
A2-2	Tension tower	tower	6	93,500	561,000	
A2-3	Suspension insulator set inc. fittings	set	96	890	85,440	
A2-4	Tension insulator set inc. fittings	set	72	1,071	77,112	
A2-5	Phase conductor "hawk" inc.	km	240	11,188	2,685,120	610 mm2
A2-6	OPGW inc. damper & accessories	km	10	5,600	56,000	
A2-7	Earthing system	tower	22	373	8,206	
A2-8	Spare parts & tools	L/S	1	232,118	232,118	
	Total A				4,874,596	
B2	Construction and Installation					
B2-1	Survey and sub soil test	km	10	3,354	33,540	
B2-2	Clearing ROW	km	10	3,500	35,000	
B2-3	Access road	L/S	1	21,000	21,000	
B2-4	Foundation concrete	cu.m	960	700	672,000	
B2-5	Tower erection	tower	22	11,105	244,310	
B2-6	Installation of insulator set and conductor	km	10	10,248	102,480	
B2-7	Installation of OPGW	km	10	1,200	12,000	
B2-8	Installation of earthing system	tower	22	204	4,488	
B2-9	Commissioning	L/S	1	1,000	1,000	
B2-10	Local transportation	L/S	1	221,215	221,215	
B2-11	Accessories for tower	L/S	1	6,000	6,000	
B2-12	Mobillization	L/S	1	3,500	3,500	
	Total B				1,356,533	
	GRAND TOTAL				6,231,129	
					0.623	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
3	230kV DC T/L, Plain area, 10km length					
A3	Plant and Equipment					
A3-1	Suspension tower	tower	22	25,500	561,000	
A3-2	Tension tower	tower	3	42,500	127,500	
A3-3	Suspension insulator set inc. fittings	set	132	515	67,980	
A3-4	Tension insulator set inc. fittings	set	36	620	22,320	
A3-5	Phase conductor "hawk" inc.	km	120	10,888	1,306,560	610 mm2
A3-6	OPGW inc. damper & accessories	km	10	3,150	31,500	
A3-7	Earthing system	tower	25	287	7,175	
A3-8	Spare parts & tools	L/S	1	106,198	106,198	
	Total A				2,230,233	
B3	Construction and Installation					
B3-1	Survey and sub soil test	km	10	2,150	21,500	
B3-2	Clearing ROW	km	10	1,400	14,000	
B3-3	Access road	L/S	1	16,000	16,000	
B3-4	Foundation concrete	cu.m	450	700	315,000	
B3-5	Tower erection	tower	25	3,888	97,200	
B3-6	Installation of insulator set and conductor	km	10	7,883	78,830	
B3-7	Installation of OPGW	km	10	1,200	12,000	
B3-8	Installation of earthing system	tower	25	137	3,425	
B3-9	Commissioning	L/S	1	900	900	
B3-10	Local transportation	L/S	1	125,690	125,690	
B3-11	Accessories for tower	L/S	1	5,000	5,000	
B3-12	Mobillization	L/S	1	3,500	3,500	
	Total B				693,045	
	GRAND TOTAL				2,923,278	
					0.292	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
4	230kV DC T/L, Mountain area, 10km length					
A4	Plant and Equipment					
A4-1	Suspension tower	tower	19	25,500	484,500	
A4-2	Tension tower	tower	6	42,500	255,000	
A4-3	Suspension insulator set inc. fittings	set	114	515	58,710	
A4-4	Tension insulator set inc. fittings	set	72	620	44,640	
A4-5	Phase conductor "hawk" inc.	km	120	10,888	1,306,560	610 mm2
A4-6	OPGW inc. damper & accessories	km	10	3,150	31,500	
A4-7	Earthing system	tower	25	287	7,175	
A4-8	Spare parts & tools	L/S	1	109,400	109,400	
	Total A				2,297,485	
B4	Construction and Installation					
B4-1	Survey and sub soil test	km	10	2,580	25,800	
B4-2	Clearing ROW	km	10	1,250	12,500	
B4-3	Access road	L/S	1	20,000	20,000	
B4-4	Foundation concrete	cu.m	525	700	367,500	
B4-5	Tower erection	tower	25	4,176	104,400	
B4-6	Installation of insulator set and conductor	km	10	7,883	78,830	
B4-7	Installation of OPGW	km	10	1,200	12,000	
B4-8	Installation of earthing system	tower	25	157	3,925	
B4-9	Commissioning	L/S	1	900	900	
B4-10	Local transportation	L/S	1	167,587	167,587	
B4-11	Accessories for tower	L/S	1	5,000	5,000	
B4-12	Mobillization	L/S	1	3,500	3,500	
	Total B				801,942	
	GRAND TOTAL				3,099,427	
					0.310	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
5	115kV DC T/L, Plain area, 10km length					
A5	Plant and Equipment					
A5-1	Suspension tower	tower	26	8,500	221,000	
A5-2	Tension tower	tower	3	11,322	33,966	
A5-3	Suspension insulator set inc. fittings	set	156	199	31,044	
A5-4	Tension insulator set inc. fittings	set	36	239	8,604	
A5-5	Phase conductor "hawk" inc.	km	60	4,620	277,200	240 mm2
A5-6	OPGW inc. damper & accessories	km	10	2,800	28,000	
A5-7	Earthing system	tower	29	200	5,800	
A5-8	Spare parts & tools	L/S	1	30,277	30,277	
	Total A				635,891	
B5	Construction and Installation					
B5-1	Survey and sub soil test	km	10	1,500	15,000	
B5-2	Clearing ROW	km	10	875	8,750	
B5-3	Access road	L/S	1	15,000	15,000	
B5-4	Foundation concrete	cu.m	229	700	160,300	
B5-5	Tower erection	tower	29	1,134	32,886	
B5-6	Installation of insulator set and conductor	km	10	5,500	55,000	
B5-7	Installation of OPGW	km	10	800	8,000	
B5-8	Installation of earthing system	tower	29	95	2,755	
B5-9	Commissioning	L/S	1	800	800	
B5-10	Local transportation	L/S	1	72,000	72,000	
B5-11	Accessories for tower	L/S	1	4,000	4,000	
B5-12	Mobillization	L/S	1	3,500	3,500	
	Total B				377,991	
	GRAND TOTAL				1,013,882	
					0.101	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
6	115kV DC T/L, Mountain area, 10km length					
A6	Plant and Equipment					
A6-1	Suspension tower	tower	23	8,500	195,500	
A6-2	Tension tower	tower	6	11,322	67,932	
A6-3	Suspension insulator set inc. fittings	set	138	199	27,462	
A6-4	Tension insulator set inc. fittings	set	72	239	17,208	
A6-5	Phase conductor "hawk" inc.	km	60	4,620	277,200	240 mm2
A6-6	OPGW inc. damper & accessories	km	10	2,800	28,000	
A6-7	Earthing system	tower	29	200	5,800	
A6-8	Spare parts & tools	L/S	1	30,952	30,952	
	Total A				650,054	
B6	Construction and Installation					
B6-1	Survey and sub soil test	km	10	1,800	18,000	
B6-2	Clearing ROW	km	10	1,250	12,500	
B6-3	Access road	L/S	1	19,000	19,000	
B6-4	Foundation concrete	cu.m	270	700	189,000	
B6-5	Tower erection	tower	29	1,282	37,178	
B6-6	Installation of insulator set and conductor	km	10	5,500	55,000	
B6-7	Installation of OPGW	km	10	800	8,000	
B6-8	Installation of earthing system	tower	29	110	3,190	
B6-9	Commissioning	L/S	1	800	800	
B6-10	Local transportation	L/S	1	96,000	96,000	
B6-11	Accessories for tower	L/S	1	4,000	4,000	
B6-12	Mobillization	L/S	1	3,500	3,500	
	Total B				446,168	
	GRAND TOTAL				1,096,222	
					0.110	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
1	500kV SC T/L, Plain area, 10km length					
A1	Plant and Equipment					
A1-1	Suspension tower	tower	19	39,100	742,900	
A1-2	Tension tower	tower	3	51,000	153,000	
A1-3	Suspension insulator set inc. fittings	set	57	890	50,730	
A1-4	Tension insulator set inc. fittings	set	18	1,071	19,278	
A1-5	Phase conductor "hawk" inc.	km	120	11,188	1,342,560	610 mm2
A1-6	OPGW inc. damper & accessories	km	10	5,600	56,000	
A1-7	Earthing system	tower	22	317	6,974	
A1-8	Spare parts & tools	L/S	1	118,569	118,569	
	Total A				2,490,011	
B1	Construction and Installation					
B1-1	Survey and sub soil test	km	10	2,376	23,760	
B1-2	Clearing ROW	km	10	2,450	24,500	
B1-3	Access road	L/S	1	17,000	17,000	
B1-4	Foundation concrete	cu.m	560	700	392,000	
B1-5	Tower erection	tower	22	5,749	126,478	
B1-6	Installation of insulator set and conductor	km	10	7,173	71,730	
B1-7	Installation of OPGW	km	10	1,200	12,000	
B1-8	Installation of earthing system	tower	22	151	3,322	
B1-9	Commissioning	L/S	1	1,000	1,000	
B1-10	Local transportation	L/S	1	138,259	138,259	
B1-11	Accessories for tower	L/S	1	6,000	6,000	
B1-12	Mobillization	L/S	1	3,500	3,500	
	Total B				819,549	
	GRAND TOTAL				3,309,560	
					0.331	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
2	500kV SC T/L, Mountain area, 10km length					
A2	Plant and Equipment					
A2-1	Suspension tower	tower	16	39,100	625,600	
A2-2	Tension tower	tower	6	51,000	306,000	
A2-3	Suspension insulator set inc. fittings	set	48	890	42,720	
A2-4	Tension insulator set inc. fittings	set	36	1,071	38,556	
A2-5	Phase conductor "hawk" inc.	km	120	11,188	1,342,560	610 mm2
A2-6	OPGW inc. damper & accessories	km	10	5,600	56,000	
A2-7	Earthing system	tower	22	317	6,974	
A2-8	Spare parts & tools	L/S	1	120,917	120,917	
	Total A				2,539,327	
B2	Construction and Installation					
B2-1	Survey and sub soil test	km	10	2,851	28,510	
B2-2	Clearing ROW	km	10	3,500	35,000	
B2-3	Access road	L/S	1	21,000	21,000	
B2-4	Foundation concrete	cu.m	680	700	476,000	
B2-5	Tower erection	tower	22	5,978	131,516	
B2-6	Installation of insulator set and conductor	km	10	7,173	71,730	
B2-7	Installation of OPGW	km	10	1,200	12,000	
B2-8	Installation of earthing system	tower	22	173	3,806	
B2-9	Commissioning	L/S	1	1,000	1,000	
B2-10	Local transportation	L/S	1	184,346	184,346	
B2-11	Accessories for tower	L/S	1	6,000	6,000	
B2-12	Mobillization	L/S	1	3,500	3,500	
	Total B				974,408	
	GRAND TOTAL				3,513,735	
					0.351	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
3	230kV SC T/L, Plain area, 10km length					
A3	Plant and Equipment					
A3-1	Suspension tower	tower	22	17,000	374,000	
A3-2	Tension tower	tower	3	25,500	76,500	
A3-3	Suspension insulator set inc. fittings	set	66	515	33,990	
A3-4	Tension insulator set inc. fittings	set	18	620	11,160	
A3-5	Phase conductor "hawk" inc.	km	60	10,888	653,280	610 mm2
A3-6	OPGW inc. damper & accessories	km	10	3,150	31,500	
A3-7	Earthing system	tower	25	244	6,100	
A3-8	Spare parts & tools	L/S	1	59,324	59,324	
	Total A				1,245,854	
B3	Construction and Installation					
B3-1	Survey and sub soil test	km	10	1,827	18,270	
B3-2	Clearing ROW	km	10	1,400	14,000	
B3-3	Access road	L/S	1	16,000	16,000	
B3-4	Foundation concrete	cu.m	338	700	236,600	
B3-5	Tower erection	tower	25	2,544	63,600	
B3-6	Installation of insulator set and conductor	km	10	5,518	55,180	
B3-7	Installation of OPGW	km	10	1,200	12,000	
B3-8	Installation of earthing system	tower	25	116	2,900	
B3-9	Commissioning	L/S	1	900	900	
B3-10	Local transportation	L/S	1	104,742	104,742	
B3-11	Accessories for tower	L/S	1	5,000	5,000	
B3-12	Mobillization	L/S	1	3,500	3,500	
	Total B				532,692	
	GRAND TOTAL				1,778,546	
					0.178	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
4	230kV SC T/L, Mountain area, 10km length					
A4	Plant and Equipment					
A4-1	Suspension tower	tower	19	17,000	323,000	
A4-2	Tension tower	tower	6	25,500	153,000	
A4-3	Suspension insulator set inc. fittings	set	57	515	29,355	
A4-4	Tension insulator set inc. fittings	set	36	620	22,320	
A4-5	Phase conductor "hawk" inc.	km	60	10,888	653,280	610 mm2
A4-6	OPGW inc. damper & accessories	km	10	3,150	31,500	
A4-7	Earthing system	tower	25	244	6,100	
A4-8	Spare parts & tools	L/S	1	60,925	60,925	
	Total A				1,279,480	
B4	Construction and Installation					
B4-1	Survey and sub soil test	km	10	2,193	21,930	
B4-2	Clearing ROW	km	10	1,250	12,500	
B4-3	Access road	L/S	1	20,000	20,000	
B4-4	Foundation concrete	cu.m	401	700	280,700	
B4-5	Tower erection	tower	25	2,688	67,200	
B4-6	Installation of insulator set and conductor	km	10	5,518	55,180	
B4-7	Installation of OPGW	km	10	1,200	12,000	
B4-8	Installation of earthing system	tower	25	133	3,325	
B4-9	Commissioning	L/S	1	900	900	
B4-10	Local transportation	L/S	1	139,656	139,656	
B4-11	Accessories for tower	L/S	1	5,000	5,000	
B4-12	Mobillization	L/S	1	3,500	3,500	
	Total B				621,891	
	GRAND TOTAL				1,901,371	
					0.190	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
5	115kV SC T/L, Plain area, 10km length					
A5	Plant and Equipment					
A5-1	Suspension tower	tower	26	6,800	176,800	
A5-2	Tension tower	tower	3	6,800	20,400	
A5-3	Suspension insulator set inc. fittings	set	78	199	15,522	
A5-4	Tension insulator set inc. fittings	set	18	239	4,302	
A5-5	Phase conductor "hawk" inc.	km	30	4,620	138,600	240 mm2
A5-6	OPGW inc. damper & accessories	km	10	2,800	28,000	
A5-7	Earthing system	tower	29	170	4,930	
A5-8	Spare parts & tools	L/S	1	19,426	19,426	
	Total A				407,980	
B5	Construction and Installation					
B5-1	Survey and sub soil test	km	10	1,275	12,750	
B5-2	Clearing ROW	km	10	875	8,750	
B5-3	Access road	L/S	1	15,000	15,000	
B5-4	Foundation concrete	cu.m	146	700	102,200	
B5-5	Tower erection	tower	29	960	27,840	
B5-6	Installation of insulator set and conductor	km	10	3,850	38,500	
B5-7	Installation of OPGW	km	10	800	8,000	
B5-8	Installation of earthing system	tower	29	81	2,349	
B5-9	Commissioning	L/S	1	800	800	
B5-10	Local transportation	L/S	1	57,600	57,600	
B5-11	Accessories for tower	L/S	1	4,000	4,000	
B5-12	Mobillization	L/S	1	3,500	3,500	
	Total B				281,289	
	GRAND TOTAL				689,269	
					0.069	**mil. USD/km**

Item	Description	Unit	Qty	Unit Price (USD)	Total Price (USD)	Remarks
6	115kV SC T/L, Mountain area, 10km length					
A6	Plant and Equipment					
A6-1	Suspension tower	tower	23	6,800	156,400	
A6-2	Tension tower	tower	6	6,800	40,800	
A6-3	Suspension insulator set inc. fittings	set	69	199	13,731	
A6-4	Tension insulator set inc. fittings	set	36	239	8,604	
A6-5	Phase conductor "hawk" inc.	km	30	4,620	138,600	240 mm2
A6-6	OPGW inc. damper & accessories	km	10	2,800	28,000	
A6-7	Earthing system	tower	29	170	4,930	
A6-8	Spare parts & tools	L/S	1	19,552	19,552	
	Total A				410,617	
B6	Construction and Installation					
B6-1	Survey and sub soil test	km	10	1,530	15,300	
B6-2	Clearing ROW	km	10	1,250	12,500	
B6-3	Access road	L/S	1	19,000	19,000	
B6-4	Foundation concrete	cu.m	176	700	123,200	
B6-5	Tower erection	tower	29	960	27,840	
B6-6	Installation of insulator set and conductor	km	10	3,850	38,500	
B6-7	Installation of OPGW	km	10	800	8,000	
B6-8	Installation of earthing system	tower	29	93	2,697	
B6-9	Commissioning	L/S	1	800	800	
B6-10	Local transportation	L/S	1	76,800	76,800	
B6-11	Accessories for tower	L/S	1	4,000	4,000	
B6-12	Mobillization	L/S	1	3,500	3,500	
	Total B				332,137	
	GRAND TOTAL				742,754	
					0.074	**mil. USD/km**

Appendix 11-2_Applicable Unit Price for Cost Estimation (Substation)_rev1

Applicable Unit Price for Cost Estimate of Substation Project
New 1

Substation Type: New

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A-1	500 kV Transformer Bay	2	bay	6,917,335	13,834,670	Tr. Capacity/unit	500	MVA
A-2	500 kV Transmission Line Bay	2	bay	318,835	637,670			
A-3	500 kV 1+1/2 CB Configuration	2	bay	2,773,320	5,546,640			
B	230 kV Equipment (1+1/2 CB)							
B-1-1	230 kV Transformer Bay	2	bay	1,883,625	3,767,250	Tr. Capacity/unit	100	MVA
B-1-2	230 kV Transformer Bay excluding Transformer	2	bay	75,625	151,250			
B-2	230 kV Transmission Line Bay	2	bay	206,305	412,610			
B-3	230 kV 1+1/2 CB Configuration	3	bay	853,050	2,559,150			
C	115 kV Equipment (Main and Transfer)							
C-1-1	115 kV Transformer Bay	2	bay	1,566,325	3,132,650	Tr. Capacity/unit	50	MVA
C-1-2	115 kV Transformer Bay excluding Transformer	2	bay	153,825	307,650			
C-2	115 kV Transmission Line Bay	2	bay	248,325	496,650			
C-3	115 kV Bus Coupler Bay	1	bay	237,440	237,440			
D	22kV Equipment	4	bay	66,150	264,600			
E	Control and Protection	1	lot	1,046,850	1,046,850			
F	Micellaneous materials and equipment	1	lot	289,800	289,800			
G	Station service facilities	1	lot	301,000	301,000			
H	Communication equipment	1	lot	1,589,000	1,589,000			
I	Civil Works							
I-1	Civil Works for New Substation	1	lot	2,920,000	2,920,000			
I-2	Civil Works for Bay Extension	0	lot	0	0			
	Total				**37,494,880**	$74.99 per kVA		

Applicable Unit Price for Cost Estimate of Substation Project
New 2

Substation Type: New

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A-1	500 kV Transformer Bay	2	bay	10,307,335	20,614,670	Tr. Capacity/unit	750	MVA
A-2	500 kV Transmission Line Bay	4	bay	318,835	1,275,340			
A-3	500 kV 1+1/2 CB Configuration	3	bay	2,773,320	8,319,960			
B	230 kV Equipment (1+1/2 CB)							
B-1-1	230 kV Transformer Bay	2	bay	1,883,625	3,767,250	Tr. Capacity/unit	100	MVA
B-1-2	230 kV Transformer Bay excluding Transformer	2	bay	75,625	151,250			
B-2	230 kV Transmission Line Bay	4	bay	206,305	825,220			
B-3	230 kV 1+1/2 CB Configuration	4	bay	853,050	3,412,200			
C	115 kV Equipment (Main and Transfer)							
C-1-1	115 kV Transformer Bay	2	bay	1,566,325	3,132,650	Tr. Capacity/unit	50	MVA
C-1-2	115 kV Transformer Bay excluding Transformer	2	bay	153,825	307,650			
C-2	115 kV Transmission Line Bay	2	bay	248,325	496,650			
C-3	115 kV Bus Coupler Bay	1	bay	237,440	237,440			
D	22kV Equipment	4	bay	66,150	264,600			
E	Control and Protection	1	lot	1,298,850	1,298,850			
F	Micellaneous materials and equipment	1	lot	357,000	357,000			
G	Station service facilities	1	lot	301,000	301,000			
H	Communication equipment	1	lot	2,492,000	2,492,000			
I	Civil Works							
I-1	Civil Works for New Substation	1	lot	3,640,000	3,640,000			
I-2	Civil Works for Bay Extension	0	lot	0	0			
	Total				**50,893,730**	$67.86 per kVA		

Applicable Unit Price for Cost Estimate of Substation Project
New 3

Substation Type: New

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A−1	500 kV Transformer Bay	2	bay	10,307,335	20,614,670	Tr. Capacity/unit	750	MVA
A−2	500 kV Transmission Line Bay	4	bay	318,835	1,275,340			
A−3	500 kV 1+1/2 CB Configuration	3	bay	2,773,320	8,319,960			
B	230 kV Equipment (1+1/2 CB)							
B−1−1	230 kV Transformer Bay	0	bay	1,883,625	0	Tr. Capacity/unit	100	MVA
B−1−2	230 kV Transformer Bay excluding Transformer	2	bay	75,625	151,250			
B−2	230 kV Transmission Line Bay	4	bay	206,305	825,220			
B−3	230 kV 1+1/2 CB Configuration	3	bay	853,050	2,559,150			
C	115 kV Equipment (Main and Transfer)							
C−1−1	115 kV Transformer Bay	0	bay	1,566,325	0	Tr. Capacity/unit	50	MVA
C−1−2	115 kV Transformer Bay excluding Transformer	0	bay	153,825	0			
C−2	115 kV Transmission Line Bay	0	bay	248,325	0			
C−3	115 kV Bus Coupler Bay	FALSE	bay	237,440	0			
D	22kV Equipment	4	bay	66,150	264,600			
E	Control and Protection	1	lot	962,850	962,850			
F	Micellaneous materials and equipment	1	lot	214,200	214,200			
G	Station service facilities	1	lot	301,000	301,000			
H	Communication equipment	1	lot	2,040,000	2,040,000			
I	Civil Works							
I−1	Civil Works for New Substation	1	lot	2,440,000	2,440,000			
I−2	Civil Works for Bay Extension	0	lot	0	0			
	Total				**39,968,240**	$53.29 per kVA		

Applicable Unit Price for Cost Estimate of Substation Project
New 4

Substation Type: New

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A-1	500 kV Transformer Bay	0	bay	10,307,335	0	Tr. Capacity/unit	750	MVA
A-2	500 kV Transmission Line Bay	0	bay	318,835	0			
A-3	500 kV 1+1/2 CB Configuration	0	bay	2,773,320	0			
B	230 kV Equipment (1+1/2 CB)							
B-1-1	230 kV Transformer Bay	2	bay	1,883,625	3,767,250	Tr. Capacity/unit	100	MVA
B-1-2	230 kV Transformer Bay excluding Transformer	0	bay	75,625	0			
B-2	230 kV Transmission Line Bay	2	bay	206,305	412,610			
B-3	230 kV 1+1/2 CB Configuration	2	bay	853,050	1,706,100			
C	115 kV Equipment (Main and Transfer)							
C-1-1	115 kV Transformer Bay	2	bay	1,566,325	3,132,650	Tr. Capacity/unit	50	MVA
C-1-2	115 kV Transformer Bay excluding Transformer	2	bay	153,825	307,650			
C-2	115 kV Transmission Line Bay	2	bay	248,325	496,650			
C-3	115 kV Bus Coupler Bay	1	bay	237,440	237,440			
D	22kV Equipment	4	bay	66,150	264,600			
E	Control and Protection	1	lot	815,850	815,850			
F	Micellaneous materials and equipment	1	lot	189,000	189,000			
G	Station service facilities	1	lot	301,000	301,000			
H	Communication equipment	1	lot	1,137,000	1,137,000			
I	Civil Works							
I-1	Civil Works for New Substation	1	lot	1,840,000	1,840,000			
I-2	Civil Works for Bay Extension	0	lot	0	0			
Total					**14,607,800**	$19.48 per kVA		

Applicable Unit Price for Cost Estimation of Substation Project
Expansion 1

Substation Type: Expansion

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A-1	500 kV Transformer Bay	2	bay	10,307,335	20,614,670	Tr. Capacity/unit	750	MVA
A-2	500 kV Transmission Line Bay	2	bay	318,835	637,670			
A-3	500 kV 1+1/2 CB Configuration	2	bay	2,773,320	5,546,640			
B	230 kV Equipment (1+1/2 CB)							
B-1-1	230 kV Transformer Bay	0	bay	1,883,625	0	Tr. Capacity/unit	100	MVA
B-1-2	230 kV Transformer Bay excluding Transformer	2	bay	75,625	151,250			
B-2	230 kV Transmission Line Bay	2	bay	206,305	412,610			
B-3	230 kV 1+1/2 CB Configuration	2	bay	853,050	1,706,100			
C	115 kV Equipment (Main and Transfer)							
C-1-1	115 kV Transformer Bay	0	bay	1,566,325	0	Tr. Capacity/unit	50	MVA
C-1-2	115 kV Transformer Bay excluding Transformer	0	bay	153,825	0			
C-2	115 kV Transmission Line Bay	0	bay	248,325	0			
C-3	115 kV Bus Coupler Bay	0	bay	237,440	0			
D	22kV Equipment	0	bay	66,150	0			
E	Control and Protection	1	lot	359,100	359,100			
F	Micellaneous materials and equipment	1	lot	147,000	147,000			
G	Station service facilities	0	lot	0	0			
H	Communication equipment	0	lot	0	0			
I	Civil Works							
I-1	Civil Works for New Substation	0	lot	0	0			
I-2	Civil Works for Bay Extension	1	lot	1,440,000	1,440,000			
	Total				**31,015,040**	$41.35 per kVA		

Applicable Unit Price for Cost Estimation of Substation Project
Expansion 2

Substation Type: Expansion

	Item	Qty'	Unit	Unit Price (USD)	Total (USD)	Remarks		
A	500 kV Equipment (1+1/2 CB)							
A-1	500 kV Transformer Bay	0	bay	10,307,335	0	Tr. Capacity/unit	750	MVA
A-2	500 kV Transmission Line Bay	0	bay	318,835	0			
A-3	500 kV 1+1/2 CB Configuration	0	bay	2,773,320	0			
B	230 kV Equipment (1+1/2 CB)							
B-1-1	230 kV Transformer Bay	0	bay	1,883,625	0	Tr. Capacity/unit	100	MVA
B-1-2	230 kV Transformer Bay excluding Transformer	0	bay	75,625	0			
B-2	230 kV Transmission Line Bay	2	bay	206,305	412,610			
B-3	230 kV 1+1/2 CB Configuration	1	bay	853,050	853,050			
C	115 kV Equipment (Main and Transfer)							
C-1-1	115 kV Transformer Bay	0	bay	1,566,325	0	Tr. Capacity/unit	50	MVA
C-1-2	115 kV Transformer Bay excluding Transformer	0	bay	153,825	0			
C-2	115 kV Transmission Line Bay	0	bay	248,325	0			
C-3	115 kV Bus Coupler Bay	0	bay	237,440	0			
D	22kV Equipment	0	bay	66,150	0			
E	Control and Protection	1	lot	128,100	128,100			
F	Micellaneous materials and equipment	1	lot	46,200	46,200			
G	Station service facilities	0	lot	0	0			
H	Communication equipment	0	lot	0	0			
I	Civil Works							
I-1	Civil Works for New Substation	0	lot	0	0			
I-2	Civil Works for Bay Extension	1	lot	360,000	360,000			
	Total				**1,799,960**	$2.40 per kVA		

Cost Breakdown of Easc Substation Items

Item	Materials	Specifications	Unit	Qty'	Unit price USD	Installation cost USD	Transportation USD	Total price USD	Remarks
A	500 kV Equipment (1+1/2 CB)								
A-1	500 kV Transformer Bay								
A-1-01	500/230 kV Transformer	500/230kV, 50Hz, Outdoor, Single-phase, oil-immersed, on-load tap changer	MVA	1	12,000	960	600	13,560	per 1 MVA
A-1-02	Disconnector with earthing switch	500kV, AIS, 2500A, 50A, 40kA (1sec)	set	1	70,000	5,600	3,500	79,100	
A-1-03	Surge arrester	420kV, 50 Hz, Nominal discharge current:20kA	pcs	3	10,000	800	500	33,900	
A-1-04	Post Insulator	500kV	pcs	3	4,500	360	225	15,255	
Subtotal for Item A-1 excluding transformer								137,335	
A-2	500 kV Transmission Line Bay								
A-2-01	Disconnector with earthing switch	500kV, AIS, 2500A, 50A, 40kA (1sec)	set	1	70,000	5,600	3,500	79,100	
A-2-02	CVT with connection facilities for PLC equipment	500kV, 50Hz, 500kV/√3:110V/√3:110V/√3, class0.5	pcs	3	25,000	2,000	1,250	84,750	
A-2-03	Current transformer	500kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	3	25,000	2,000	1,250	84,750	
A-2-04	Surge arrester	420kV, 50 Hz, Nominal discharge current:20kA	pcs	3	10,000	800	500	33,900	
A-2-05	Post Insulator	500kV	pcs	3	4,500	360	225	15,255	
Subtotal for Item A-2								318,835	
A-3	500 kV 1+1/2 CB Configuration								
A-3-01	500 kV Gas circuit breaker	500kV, AIS, SF6, 2500A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	3	500,000	40,000	25,000	1,695,000	
A-3-02	Disconnector with earthing switch	500kV, AIS, 2500A, 50A, 40kA (1sec)	set	6	70,000	5,600	3,500	474,600	
A-3-03	Current transformer	500kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	12	25,000	2,000	1,250	339,000	
A-3-04	Post Insulator	500kV	pcs	6	4,500	360	225	30,510	
A-3-05	Bus Bar		lot	1	45,000	3,600	2,250	50,850	
Subtotal for Item A-3								2,773,320	
B	230 kV Equipment (1+1/2 CB)								
B-1	230 kV Transformer Bay								
B-1-01	230/115 kV Transformer	230/115kV, 50Hz, Outdoor, Three-phase, oil-immersed, on-load tap changer	MVA	1	16,000	1,280	800	18,080	per 1 MVA
B-1-02	Disconnector with earthing switch	245kV, AIS, 2500A, 50A, 40kA (1sec)	set	1	25,000	2,000	1,250	28,250	
B-1-03	Surge arrester	198kV, 50 Hz, Nominal discharge current:20kA	pcs	3	8,500	680	425	28,815	
B-1-04	Post Insulator	230kV	pcs	3	4,000	320	200	13,560	
Subtotal for Item B-1 excluding transformer								75,625	
B-2	230 kV Transmission Line Bay								
B-2-01	Disconnector with earthing switch	230kV, AIS, 2500A, 50A, 40kA (1sec)	set	1	25,000	2,000	1,250	28,250	
B-2-02	CVT with connection facilities for PLC equipment	230kV, 50Hz, 230kV/√3:110V/√3:110V/√3, class0.5	pcs	3	18,000	1,440	900	61,020	
B-2-03	Current transformer	230kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	3	18,000	1,440	900	61,020	
B-2-04	Surge arrester	198kV, 50 Hz, Nominal discharge current: 20kA	pcs	3	8,500	680	425	28,815	
B-2-05	Post Insulator	230kV	pcs	3	4,000	320	200	13,560	
Subtotal for Item B-2								206,305	
B-3	230 kV 1+1/2 CB Configuration								
B-3-01	230 kV Gas circuit breaker	254kV, AIS, SF6, 2500A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	3	90,000	7,200	4,500	305,100	
B-3-02	Disconnector with earthing switch	254kV, AIS, 2500A, 50A, 40kA (1sec)	set	6	25,000	2,000	1,250	169,500	
B-3-03	Current transformer	230kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	12	18,000	1,440	900	244,080	
B-3-04	Post Insulator	230kV	pcs	6	4,000	320	200	27,120	
B-3-05	Bus Bar		lot	1	45,000	3,600	2,250	50,850	
Subtotal for Item B-3								853,050	
C	115 kV Equipment (Main and Transfer)								
C-1	115 kV Transformer Bay								
C-1-01	115/22 kV Transformer	115/22kV, 50Hz, Outdoor, Three-phase, oil-immersed, on-load tap changer	MVA	1	25,000	2,000	1,250	28,250	per 1 MVA
C-1-02	115 kV Gas circuit breaker	126kV, AIS, SF6, 2500A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	1	70,000	5,600	3,500	73,500	
C-1-03	Disconnector with earthing switch	126kV, AIS, 2500A, 50A, 40kA (1sec)	set	2	18,000	1,440	900	37,800	
C-1-04	Disconnector without earthing switch	126kV, AIS, 1250A, 50A, 40kA (1sec)	set	1	18,000	1,440	900	18,900	
C-1-07	Surge arrester	103kV, 50 Hz, Nominal discharge current: 10kA	pcs	3	7,500	600	375	23,625	
Subtotal for Item C-1 excluding transformer								153,825	
C-2	115 kV Transmission Line Bay								
C-2-01	115 kV Gas circuit breaker	126kV, AIS, SF6, 2500A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	1	70,000	5,600	3,500	73,500	
C-2-02	Disconnector with earthing switch	126kV, AIS, 2500A, 50A, 40kA (1sec)	set	2	18,000	1,440	900	37,800	
C-2-03	Disconnector without earthing switch	126kV, AIS, 1250A, 50A, 40kA (1sec)	set	1	18,000	1,440	900	18,900	
C-2-04	CVT with connection facilities for PLC equipment	126kV, 50Hz, 115kV/√3:110V/√3:110V/3, class 0.5	set	3	15,000	1,200	750	47,250	
C-2-05	Current transformer	126kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	3	15,000	1,200	750	47,250	
C-2-06	Surge arrester	103kV, 50 Hz, Nominal discharge current: 10kA	pcs	3	7,500	600	375	23,625	
Subtotal for Item C-2								248,325	
C-3	115 kV Bus Coupler Bay								
C-3-01	115 kV Gas circuit breaker	126kV, AIS, SF6, 2500A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	1	70,000	5,600	3,500	73,500	
C-3-02	Disconnector with earthing switch	126kV, AIS, 2500A, 50A, 40kA (1sec)	set	2	18,000	1,440	900	37,800	
C-3-03	Disconnector without earthing switch	126kV, AIS, 1250A, 50A, 40kA (1sec)	set		18,000	1,440	900	0	
C-3-05	Current transformer	126kV, 50Hz, 2500-1250A:1A, class 5P20 for protection, class 0.5 for metering	pcs	6	15,000	1,200	750	94,500	
C-3-06	Bus Bar		lot	1	28,000	2,240	1,400	31,640	
Subtotal for Item C-3								237,440	
D	22kV Equipment								
D-01	22kV gas circuit breaker	24kV, AIS, SF6, 2000A, 50Hz, 40kA (1sec), O-0.3sec-CO-3min-CO	set	1	20,000	1,600	1,000	21,000	
D-02	Line disconnector with earth switch	24kV, AIS, 1600A, 50A, 40kA (1sec)	set	2	7,000	560	350	14,700	
D-03	Busbar disconnector	24kV, AIS, 1600A, 50A, 40kA (1sec)	set	1	7,000	560	350	7,350	
D-04	Voltage transformer	24kV, 50Hz, 22kV/√3:110V/√3, class0.5	pcs	1	4,000	320	200	4,200	
D-05	Cuurent transformer	22kV, 50Hz, 400-200A:1A, class 5P20 for protection, class 0.5 for metering	pcs	3	4,000	320	200	12,600	
D-06	Surge arrester	10kA	pcs	3	2,000	160	100	6,300	
Subtotal for Item D								66,150	

Cost Breakdown of Easc Substation Items

Item	Materials	Specifications	Unit	Qty'	Unit price USD	Installation cost USD	Transportation USD	Total price USD	Remarks
E	**Control and Protection**								
E-01	Line protection system		set	4	50,000	4,000	2,500	210,000	
E-02	Transformer protection system		set	4	50,000	4,000	2,500	210,000	
E-03	Protection and communication interface		set	1	20,000	1,600	1,000	21,000	
E-04	Bus protection relays		set	1	85,000	6,800	4,250	89,250	
E-05	Bus couple protection relays		set	1	30,000	2,400	1,500	31,500	
E-06	Metering set		set	4	10,000	800	500	42,000	
E-07	Control cables		m	1,000	2	0	0	2,100	
E-08	Reactor relays		set		30,000	2,400	1,500	0	
E-09	Gas temperature alarm equipment		set		50,000	4,000	2,500	0	
E-10	SCADA system		lot	1	200,000	16,000	10,000	210,000	
	Subtotal for Item E							**815,850**	
F	**Micellaneous materials and equipment**								
F-01	Bus support station post insulators		pcs	32	2,000	160	100	67,200	
F-02	Conductors, insulator strings, clamps & hardware		bay	13	5,000	400	250	68,250	
F-03	Terminal box		pcs	39	1,000	80	50	40,950	
F-04	Grounding grid conductor		m	2,000	6	0	0	12,600	
	Subtotal for Item F							**189,000**	
G	**Station service facilities**								
G-01	Station service transformer	Outdoor, 11/0.4kV, 500kVA, 50Hz, ONAN, oil-immersed	set	1	50,000	4,000	2,500	52,500	
G-02	Station batteries	Lead-acid, valve-regulated, 300AH	lot	1	100,000	8,000	5,000	105,000	
G-03	MVAC panel	Indoor, 400V, MCCB, 50Hz	panel	1	20,000	1,600	1,000	21,000	
G-04	110V DC panels	Indoor, MCB, 50Hz,	panel	1	20,000	1,600	1,000	21,000	
G-05	48V DC panels	Indoor, MCB, 50Hz,	panel	1	20,000	1,600	1,000	21,000	
G-06	DC battery charger	Indoor, rectifier, AC220V/DC110V, 50Hz	panel	1	20,000	1,600	1,000	21,000	
G-07	DC/DC converter	Indoor, 110/48V, 50Hz, 1kW	panel	1	20,000	1,600	1,000	21,000	
G-08	Emergency diesel engine set	300kW, 400V, 50Hz	lot	1	30,000	2,400	1,500	31,500	
G-09	400V power cables		m	500	13	1	1	6,825	
	Subtotal for Item G					**0**		**300,825**	
H	**Communication equipment**								
H-01	High frequency switchpower supply		lot	1	20,000	1,600	1,000	21,000	
H-02	Dispatching exchange switchboard		pcs	1	20,000	1,600	1,000	21,000	
H-03	Synthesize thread disposal system		lot	1	50,000	4,000	2,500	52,500	
H-04	Synthesize data network		lot	1	100,000	8,000	5,000	105,000	
H-05	Line traps		pcs	12	5,000	400	250	63,000	
H-06	Power line carrier equipment		set	4	200,000	16,000	10,000	840,000	
H-07	UHF/VHF equipment plus radio mast		set		30,000	2,400	1,500	0	
H-08	Combined filter		pcs		10,000	800	500	0	
H-09	Communication cabinet		panel	1	10,000	800	500	10,500	
H-10	High frequency, power and communication cable		m	500	30	2	2	15,750	
H-11	Telephone		pcs	4	2,000	160	100	8,400	
H-12									
	Subtotal for Item H							**1,137,150**	

Appendix 11-3_Construction Cost of Transmission Line

North

From	To	Status	Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor	Size [sqmm]	Estimated Cost (mil.USD)
Hongsa Lignite (T) IPP.E	Mae Moh (Thailand)	Existing	500	265	2	Quad	ACSR	630	164.30
Luangprabang 2 (S)	Hinheup (S)	Existing	230	164.8	2	Twin	ACSR	630	51.09
Pakmong 2 (S)	Luangprabang 2 (S)	Existing	230	91.75	2	Twin	ACSR	630	28.44
Nam Ou 2 (H) IPP.D	Pakmong 2 (S)	Existing	230	22.91	1	Single	ACSR	630	4.35
Namo 2 (S)	Pakmong 2 (S)	Existing	230	86.88	2	Twin	ACSR	630	26.93
Bountai (S)	Namo 2 (S)	Existing	230	68.48	2	Twin	ACSR	400	21.23
Nam Ou 5 (H) IPP.D	Bountai (S)	Existing	230	63.4	2	Single	ACSR	410	19.65
Nam Ou 6 (H) IPP.D	Bountai (S)	Existing	230	55.4	2	Single	ACSR	410	17.17
Luangprabang 1 (S)	Luangprabang 2 (Xieng Ngeun) (S)	Existing	115	16.5	1	Single	ACSR	240	1.16
Luangprabang 2 (Xieng Ngeun) (S)	Xieng Ngeun T-off (S)	Existing	115	0.8	1	Single	ACSR	117	0.06
Xieng Ngeun T-off (S)	Kasi (S)	Existing	115	81.2	1	Single	ACSR	117	5.68
Xayabuly (S)	Xieng Ngeun T-off (S)	Existing	115	76	1	Single	ACSR	240	5.32
Na Mo 1 (S)	M. La (Chica)	Existing	115	93	1	Single	ACSR	185	6.51
Na Mo 1 (S)	Luangnamtha 1 (S)	Existing	115	42.7	1	Single	ACSR	240	2.99
Na Mo 1 (S)	Luangnamtha 1 (S)	Existing	115	43	1	Single	ACSR	240	3.01
Na Mo 1 (S)	Na Mo 2 (S)	Existing	115	5.59	2	Single	ACSR	240	0.61
Na Mo 2 (S)	Oudomxai (S)	Existing	115	35.32	2	Single	ACSR	240	3.89
Mekong Xayabuly (H) IPP.E	Xayabuly (S)	Existing	115	15.5	1	Single	ACSR	240	1.09
Oudomxai (S)	Pakmong 2 (S)	Existing	115	51.74	1	Single	ACSR	240	3.62
Oudomxai (S)	Seinsouk (S)	Existing	115	124.53	1	Single	ACSR	240	8.72
Pakmong 2 (S)	Luangprabang 1 (S)	Existing	115	86.9	1	Single	ACSR	240	6.08
Seinsouk (S)	Luangprabang 1 (S)	Existing	115	17.5	1	Single	ACSR	240	1.23
Hongsa Lignite (T) IPP.E / Viengkeo (S)	Luangprabang 2 (S)	Existing	115	101.77	2	Single	ACSR	400	11.19
Nam Khan 2 (H) EDL	Luangprabang 2 (S)	Existing	115	23.79	2	Single	ACSR	400	2.62
Nam Khan 3 (H) EDL	Luangprabang 2 (S)	Existing	115	6.9	1	Single	ACSR	400	0.48
Pakmong 2 (S)	Pakmong 1 (S)	Existing	115	0.366	2	Single	ACSR	240	0.04
Nam Beng (H) IPP.D	Nam Beng (S)	Existing	115	0.2	1	Single	ACSR	185	0.01
Paklay (S)	Non Hai (S)	Existing	115	89.3	1	Single	ACSR	240	6.25
Paklay (S)	Non Hai (S)	Existing	115	104	1	Single	ACSR	240	7.28
Pakmong 2 - Luangprabang 1 (T/L)	Gold Mining	Existing	115	8.16	1	Single	ACSR	240	
Nam Nga 2 (H) IPP.D	Meuang Nga (S)	Existing	115	0.55	1	Single	ACSR	70	0.04
Nam Thoung (Thafar) (S)	Luangnamta 1 (S)	Existing	115	85	2	Single	ACSR	240	9.35
Pha Oudom (S)	500 kV M. Houn (S)	Existing	230	86.4	2	Twin	ACSR	410	26.78
Nam Beng (H) IPP.D	T-off Hongsa - Luangprabang 2 (T/L)	UC	115	40	1	Single	ACSR	240	2.80
Xayabuly (S)	Paklay (S)	UC	115	123	2	Single	ACSR	240	13.53
Paklay (S)	Kenthao (S)	UC	115	67	2	Single	ACSR	240	7.37
Nam Tha 1 (H) IPP.D	230 kV Pha Oudom (S)	UC	115	4	3	Single	ACSR	300	0.72
Houayxay (S)	Nam Thoung (Thafar) (S)	UC	115	57	2	Single	ACSR	300	6.27
Nam Ou 3 (H) IPP.D	Pakmong 2 (S)	UC	230	35	2	Single	ACSR	410	10.85
Nam Ou 4 (H) IPP.D	M. Khoua (S)	UC	115	7	2	Single	ACSR	410	0.77
M. Khoua (S)	Oudomxai (S)	UC	115	100	2	Single	ACSR	410	11.00
Nam Ou 7 (H) IPP.D	Nam Ou 6 - Bountai (T/L)	UC	230	40	2	Single	ACSR	410	12.40
Nam Tha 2 (B. Hat Mouak) (H) IPP.D	Pha Oudom (S)	UC	115	18	1	Single	ACSR	240	1.26
Nam Ou 1 (H)	Pakmong 2 - Luang Prabang 2 (T/L)	UC	230	1	2	Single	ACSR	410	0.31
Pha Oudom (S)	Nam Thoung (Thafar) - Houayxay (T/L)	UC	115	14	2	Single	ACSR	300	1.54
Houayxay (S)	Ton Pheung (S)	UC	115	51	2	Single	ACSR	240	5.61
Nam Ngao (H) IPP.D	Houayxay (S)	UC	115	21	1	Single	ACSR	240	1.47
Bountai (S)	Boun Neua (S)	UC	115	26	1	Single	ACSR	240	1.82
Kenthao (S)	Tha Li (Thailand) up to border	UC	115	6	2	Single	ACSR	240	0.66
Boun Neua (S)	Gnot Ou	UC	115	80	1	Single	ACSR	240	5.60
Nam Pha	Munsing	Plan	115	100	2	Single	ACSR	240	11.00
Munsing	Luangnamta 1 (S)	Plan	115	65	2	Single	ACSR	240	7.15
Pha Oudom	Houayxay	Plan	115	58	2	Single	ACSR	240	6.38
Houayxay	Ton Pheng	Plan	115	51	2	Single	ACSR	240	5.61
T-off Hongsa - Luangprabang 2 (T/L)	Chomphet (S)	Plan	115	75.6	1	Single	ACSR	240	5.29
Pakmong 2 (S)	Vieng Kham	Plan	115	84	2	Single	ACSR	240	9.24
Meuang Nga (S)	Oudomxai (S)	Plan	115	55	1	Single	ACSR	240	3.85
Luangprabang 2 (S)	Data Center	Plan	230	1.5	1	Twin	ACSR	400	0.29
500 kV M. Houn (S)	500 kV M. Nan (S)	Plan	500	110	2	4	ACSR	630	68.20
500 kV M. Nan (S)	500 kV Napia (S)	Plan	500	130	2	4	ACSR	630	80.60
M.Houn	Tha Wang Pha (Border)	Plan	500	95	2	4	ACSR	630	58.90
M.Houn	MK. Pakbeng	Plan	500	10	2	4	ACSR	630	6.20
Pha Oudom (S)	Nam Pha	Plan	230	90	2	Twin	ACSR	630	27.90
Pha Oudom (S)	Ton Pheung (S)	Plan	115	109	2	Single	ACSR	240	11.99

Central 1

From	To	Status	Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor	Size [sqmm]	Estimated Cost (mil.USD)
Hinheup (S)	Naxaythong (S)	Existing	230	72	2	Single	ACSR	630	20.88
Nam Ngiep 2 (H) IPP.D	Thavieng (S)	Existing	230	12.5	2	Single	ACSR	630	3.63
Thavieng (S)	Thabok (S)	Existing	230	154.8	2	Twin	ACSR	410	44.89
Thabok (S)	Nabong (S)	Existing	230	54	2	Single	CSRBitte	630	15.66
Nam Ngum 1 (H) EDL	Thalat (S)	Existing	115	5.1	1	Single	ACSR	240	0.36
Nam Ngum 1 (H) EDL	Thalat (S)	Existing	115	4.8	1	Single	ACSR	240	0.34
Phontong (S)	Nong Khai (EGAT, Thailand)	Existing	115	25.7	2	Single	ACSR	240	2.57
Thalat (S)	Phonsoung (S)	Existing	115	26	1	Single	ACSR	240	1.82
Thanaleng (S)	Nong Khai (EGAT, Thailand)	Existing	115	9.2	1	Single	ACSR	240	0.64
Naxaythong (S)	Thangon (S)	Existing	115	12	1	Single	ACSR	240	0.84
Thalat (S)	Vang Vieng (S)	Existing	115	63	1	Single	ACSR	117	4.41
Nam Ngum 1 (H) EDL	Naxaythong (S)	Existing	115	61	2	Single	ACSR	240	6.10
Nam Ngum 1 (H) EDL	Nam Leuk (H) EDL	Existing	115	55	1	Single	ACSR	240	3.85
Ban Don (S)	Non Hai (S)	Existing	115	54	1	Single	ACSR	240	3.78
Nam Mang 3 (H) EDL	Nabong (S)	Existing	115	29	2	Single	ACSR	240	2.90
Nabong (S)	Khoksaad (S)	Existing	115	34.5	2	Single	ACSR	240	3.45
Khoksaad (S)	Thanaleng (S)	Existing	115	16	1	Single	ACSR	240	1.12
Phonsoung (S)	Naxaythong (S)	Existing	115	30	1	Single	ACSR	240	2.10
Naxaythong (S)	Phontong (S)	Existing	115	13	3	Single	ACSR	240	2.73
Phonsavan (S)	Na Hor (M. Koun) T-off (S)	Existing	115	34	1	Single	ACSR	240	2.38
Thongkhoun 2 (S)	Nam Leuk (H) EDL	Existing	115	66	1	Single	ACSR	240	4.62
Thongkhoun 2 (S)	Thavieng (S)	Existing	115	51	1	Single	ACSR	240	3.57
Na Hor (M. Koun) T-off (S)	Thavieng (S)	Existing	115	29	1	Single	ACSR	240	2.03
Hinheup (S)	Thalat (S)	Existing	115	29.2	1	Single	ACSR	240	2.04
Hinheup (S)	Ban Don (S)	Existing	115	20	1	Single	ACSR	240	1.40
Vang Vieng (S)	Nam Ngum 5 (H) IPP.D	Existing	115	55.7	2	Single	ACSR	240	5.57
Nam Ngum 5 (H) IPP.D	Phonsavan (S)	Existing	115	68.8	1	Single	ACSR	240	4.82
Nam Lik 1/2 (H) IPP.D	Hinheup (S)	Existing	115	32.6	1	Single	ACSR	240	2.28
Nam Lik 1/2 (H) IPP.D	Ban Don (S)	Existing	115	13.6	1	Single	ACSR	240	0.95
Phonsavan (S)	Xamneua (S)	Existing	115	169.63	1	Single	ACSR	240	11.87
Vang Vieng (S)	Hinheup (S)	Existing	115	40.6	2	Single	ACSR	240	4.06
Naxaythong (S)	Pakthang (S)	Existing	115	11	1	Single	ACSR	240	0.77
Pakthang (S)	Phontong (S)	Existing	115	6	1	Single	ACSR	240	0.42
Phontong (S)	Donkoi (S)	Existing	115	14	1	Single	ACSR	95	0.98
Donkoi (S)	Thanaleng (S)	Existing	115	13	1	Single	ACSR	95	0.91
Naxaythong (S)	Viengkeo (S)	Existing	115	10	1	Single	ACSR	240	0.70
Viengkeo (S)	Khoksaad (S)	Existing	115	11	1	Single	ACSR	240	0.77
Nam Mang 3 - Nabong (T/L)	Iron melting (Tha Ngon) (S)	Existing	115	15	1	Single	ACSR	240	1.05
Nam Ngiep 3A (H) IPP.D	Na Hor (M. Koun) T-off (S)	Existing	115	3	1	Single	ACSR	240	0.21
Kasi (S)	Vang Vieng (S)	Existing	115	48	1	Single	ACSR	117	3.36
Nam San 3B (H) IPP.D	Thavieng (S)	Existing	115	25	1	Single	ACSR	410	1.75
Nam San 3A (H) IPP.D	Nam San 3B (H) IPP.D	Existing	115	10	1	Single	ACSR	150	0.70
Nam Phai (H) IPP.D	Thongkhoun 2 (S)	Existing	115	40.43	1	Single	ACSR	410	2.83
Nam Phai (H) IPP.D	Nam Pha Gnai (S) IPP.D	Existing	115	16.23	1	Single	ACSR	240	1.14
Nam Pha Gnai (S) IPP.D	Thongkhoun 2 (S)	Existing	115	25.8	1	Single	ACSR	240	1.81
Nam Peun 2 (H) IPP.D	Phonsavan - Xam Neua (T/L)	Existing	115	7.5	1	Single	ACSR	240	0.53
Nam Ngiep 2C (H) IPP.D	Thavieng - Na Hor T-off (T/L)	Existing	115	0.2	1	Single	ACSR	240	0.01
Thavieng - Thabok (T/L)	Pakxan - Khonsong (T/L)	Existing	115	47	2				4.70
Nam Chiene 1 (H) EDL	Thavieng (S)	UC	115	35	2	Single	ACSR	240	3.50
Hinheup (S)	Thalat 2 (S)	UC	230	58	2	Single	ACSR	410	16.82
Thalat 2 (S)	Nabong (S)	UC	230	32	2	Single	ACSR	410	9.28
Nam Peun 1 (H) IPP.D	Kor Hing (S)	UC	115	22	1	Single	ACSR	240	1.54
Nam Lik 1 (H) IPP.D	Hinheup (S)	UC	115	10	2	Single	ACSR	240	1.00
Nam Hao (H) IPP.D	Sopbao (S)	UC	115	8	2	Single	ACSR	240	0.80
Xamtai (S)	Houa Muang (S)	UC	230	88	2	Single	ACSR	410	25.52
Nam Ngum 3 (H) EDL	Nabong (S)	UC	230	100	2	Twin	ACSR	630	29.00
Nam Xam 3 (H) IPP.D	Xamtai (S)	UC	230	18	2	Single	ACSR	410	5.22
Naphia (S)	Pia Lat (S)	UC	500	210	2	Four	ACSR	630	126.00
Nam Mo 2 (H) IPP.D	M. Mok Mai (S)	UC	230	8	2	Twin	ACSR	410	2.32
M. Mok Mai (S)	Naphia (S)	UC	230	120	2	Twin	ACSR	410	34.80
Houa Muang (S)	Kor Hing (S)	UC	230	60	2	Twin	ACSR	410	17.40
Kor Hing (S)	Nonghet (S)	UC	230	100	2	Twin	ACSR	410	29.00
Nonghet (S)	M. Mok Mai (S)	UC	230	70	2	Twin	ACSR	410	20.30
Non Hai (S)	Ban Don (S)	Plan	115	54	1	Single	ACSR	240	3.78
Xamneua (S)	Xieng Khor	Plan	115	94	1	Single	ACSR	240	6.58
T-off Xamneua - Xieng Khor (T/L)	Nam Hao	Plan	115	0.5	2	Single	ACSR	240	0.05
500 kV Houaphan	500 kV Napia (S)	Plan	500	170	2	4	ACSR	630	102.00
Naxaythong (S)	500 kV Pialat (S)	Plan	230	48	2	4	ACSR	630	13.92
Naxaythong (S)	Dongphosy (S)	Plan	230	35	2	2	ACSR	630	10.15
Nam Xam1 (H)	Xam Tai (S)	Plan	115	90	2	1	ACSR	240	9.00
Nam Dick 1 (H)	Nam Xam 1(H)	Plan	115	18	1	1	ACSR	185	1.26

Central 2

From	To	Status	Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor	Size [sqmm]	Estimated Cost (mil.USD)
Lak 20 (Pompik) (S)	Thavieng (S)	Existing	230	220	2	Twin	ACSR	410	63.80
Pakbo (S)	Nongdeun (S)	Existing	115	3.82	2	Single	ACSR	240	0.38
Nongdeun (S)	Kengkok (S)	Existing	115	47	1	Single	ACSR	240	3.29
Pakxan (S)	Bungkan (EGAT, Thailand)	Existing	115	11	1	Single	ACSR	240	0.77
Nam Leuk (H) EDL	Thabok (S)	Existing	115	38.98	1	Single	ACSR	240	2.73
Pakxan (S)	Thabok (S)	Existing	115	47.03	1	Single	ACSR	240	3.29
Thakhek (S)	Mahaxai (S)	Existing	115	47	2	Single	ACSR	240	4.70
Thakhek (S)	Nakhon Phanom (EGAT, Thailand)	Existing	115	14.65	2	Single	ACCC	325	1.47
Pakbo (S)	Mukdahan 2 (EGAT,Thailand)	Existing	115	14	1	Single	ACSR	240	0.98
Nam Theun 2 (H) IPP.E	Mahaxai (S)	Existing	115	29.2	2	Single	ACSR	240	2.92
Mahaxai (S)	Sepon Mining (S)	Existing	115	117.11	1	Single	ACSR	240	8.20
Mahaxai (S)	Sepon Mining (S)	Existing	115	123	1	Single	ACSR	240	8.61
Nam Gnuang 8 (H) EDL	Konsong (S)	Existing	115	52	1	Single	ACSR	240	3.64
Pakxan (S)	Konsong (S)	Existing	115	90	2	Single	TACSR	240	9.00
Thasala (S)	Lak 20 (Pompik) (S)	Existing	115	47.8	1	Single	ACSR	240	3.35
Konsong (S)	Thakhek (S)	Existing	115	105	2	Single	ACSR	240	10.50
Thakhek (S)	Pakbo (S)	Existing	115	87	2	Single	TACSR	240	8.70
Nam Mang 1 (H) IPP.D	Thabok (S)	Existing	115	6.3	1	Single	ACSR	240	0.44
Nam Gnuang 8 (H) EDL	Thasala (S)	Existing	115	2	1	Single	ACSR	240	0.14
Taothan (S)	Nongdeun (S)	Existing	115	154.3	2	Single	ACSR	240	15.43
Maeungphin (S)	Nathon (Saravan) (S)	Existing	115	116.97	2	Single	ACSR	240	11.70
Nongdeun (S)	Banmat (Seno) (S)	Existing	115	42.8	2	Single	ACSR	400	4.28
Banmat (Seno) (S)	Maeungphin (S)	Existing	115	108.17	2	Single	ACSR	240	10.82
Nam Hinboun (H) EDL	Khonsong (S)	UC	115	15	1	Single	ACSR	240	1.05
Nam Ngiep 1 (H) IPP.E	Pakxan (S)	UC	115	35	1	Single	ACSR	240	2.45
Nam Theun 1 (H) IPP.E	Phone Ngam (S)	UC	115	9	2	Single	ACSR	240	0.90
Nam Hinboun (Down) (H) IPP.D	Song Hong	UC	115	1.7	1	Single	TACSR	240	0.12
Pakbo (S)	Mukudahan (Thailand)	Plan	115	14	1	Single	ACSR	240	0.98
Nam Theun 1 (H) IPP.E	Lak 20 (Pompik) (S)	Plan	115	115	2	Single	ACSR	240	11.50
Thabok (S)	Bungkan (EGAT, Thailand)	Plan	230	58.03	2	Twin	ACSR	410	16.83
Lak 20 (Pompik) (S)	Mahaxai (S)	Plan	230	100	2	Twin	ACSR	410	29.00
Thakhek (S)	Mahaxai (S)	Plan	115	47	2	Single	ACSR	240	4.70
Sepon Mining (S)	M. Phin (S)	Plan	115	46	2	1	ACSR	240	4.60
M. Phin (S)	M. Nong (S)	Plan	115	50	2	1	ACSR	240	5.00
T-off M. Phin (S) - Nathon (Saravan) (S) (T	Xelanong 1 (H)	Plan	115	35		2	ACSR	241	3.50
Nam Bak 2 (H)	Thabok (S)	Plan	115	55	2	1	ACSR	240	5.50

South

From	To	Status	Voltage [kV]	Length [km]	No. of Circuits	No. of Bundles	Conductor	Size [sqmm]	Estimated Cost (mil.USD)
Houay Ho (H) IPP.E	Pakxong (S)	Existing	230	72	2	Single	ACSR	410	20.88
Bang Yo (S)	Sirindhorn (H) (EGAT, Thailand)	Existing	115	52	1	Single	ACSR	240	3.64
Jiengxai (S)	Bang Yo (S)	Existing	115	8.16	1	Single	ACSR	240	0.57
Jiengxai (S)	Bang Yo (S)	Existing	115	9.23	1	Single	ACSR	240	0.65
Jiengxai (S)	Xeset 1 (H) EDL	Existing	115	63.2	1	Single	ACSR	240	4.42
Jiengxai (S)	Ban Na (S)	Existing	115	59.62	2	Single	ACSR	240	5.96
Ban Na (S)	Ban Hat (S)	Existing	115	62.23	2	Single	ACSR	240	6.22
Ban Na (S)	Saphaothong (S)	Existing	115	112.5	2	Single	ACSR	240	12.38
Xeset 1 (H) EDL	Xeset 2 (H) EDL	Existing	115	3.1	2	Single	ACSR	240	0.34
Xeset 2 (H) EDL	Pakxong (S)	Existing	115	42.9	1	Single	ACSR	240	3.00
Pakxong (S)	Xeset 3 (H) EDL	Existing	115	21	1	Single	ACSR	240	1.47
Xeset 2 (H) EDL	Xeset 3 (H) EDL	Existing	115	20.8	1	Single	ACSR	240	1.46
Pakxong (S)	Jiengxai (S)	Existing	115	43.24	2	Single	ACSR	240	4.76
Xeset 1 (H) EDL	Nathon (Saravan) (S)	Existing	115	24.27	2	Single	ACSR	240	2.43
Nathon (Saravan) (S)	Nongbong (S)	Existing	115	50	2	Single	ACSR	240	5.00
Nongbong (S)	Xekaman 3 (H) IPP.E	Existing	115	100	1	Single	ACSR	240	7.00
Saphaothong (S)	Sugar Factory (T) IPP.D	Existing	115	23	1	Single	ACSR	240	1.61
Houylamphanyai (H) EDL	Nongbong (S)	Existing	115	11	2	Single	ACSR	240	1.21
Xenamnoi 1 (H) IPP.D	Nongbong (S)	Existing	115	33	1	Single	ACSR	185	2.31
Nathon (Saravan) (S)	Taothan (S)	Existing	115	68.67	2	Single	ACSR	240	7.55
Xenamnoy 2 - Xekatam 1 (H) IPP.D	Xenamnoi 1 (H) IPP.D	Existing	115	10	1	Single	ACSR	240	0.70
Houay por (H) EDL	Xeset 1 (H)	Existing	115	11	1	Single	ACSR	240	0.77
Bang Yo (S)	Sirindhorn (H)	Plan	115	42	2	Twin	ACSR	410	4.62
MK. Donsahong (H) IPP.D	Ban Hat (S)	Plan	115	30	1	Single	ACSR	240	2.10
Pak Xong (S)	Nathon (Saravan) (S)	Plan	230	70	2	1	ACSR	410	21.70
Nongbong (S)	Dak Choung	Plan	115	100	1	Single	ACSR	240	7.00
Bang Yo (S)	Jiengxai (S)	Plan	115	10	2	Twin	ACSR	410	1.00
Jieng Xai (S)	New3	Plan	115	9	2	1	ACSR	240	0.90
Bang Yo (S)	Vang Tao	Plan	115	40	2	1	ACSR	240	4.40
Ban Na	Don Talad	Plan	115	21	2	1	ACSR	240	2.31
Saphaothong (S)	Hat Xan	Plan	115	60	2	1	ACSR	240	6.60
Hat Xan	Vang Tad Gold	Plan	115	50	2	1	ACSR	240	5.50

Appendix 11-4_Construction Cost of Substation

Sustation Name	Area	Existing									
		500/230 kV Tr.		230/115 kV Tr.		115/22 kV Tr.		Transmission Line Bay			Cost
		Capacity	Qty'	Capacity	Qty'	Capacity	Qty'	500 kV	230 kV	115 kV	mil. USD
500 kV M. Houn (S)	North										
500 kV M. Nan (S)	North										
Chomphet (S)	North										
Houayxay (S)	North										
Luangnamtha 1 (S)	North					20	1			4	5.42
Luangprabang 1 (S)	North					12.5	2			3	5.23
Luangprabang 2 (S)	North			200	1	30	1		4	7	16.85
Meuang Nga (S)	North					30	1			1	4.35
Munsing	North										
Na Mo 1 (S)	North					30	1			5	6.37
Nam Pha (S)	North										
Oudomxai (S)	North					30	1			4	5.70
Pakmong 2 (S)	North			120	1				5	4	13.31
Pha Oudom (S)	North										
T-off Hongsa-Luangprabang 2 (SwS)	North									2	3.16
Ton Pheung (S)	North										
Viengkeo (Hongsa Lignite) (S)	North					20	1			2	4.07
Vieng Kham	North										
Subtotal (N)	North										115.31
500 kV Houaphan	Central 1										
500 kV Napia (S)	Central 1										
500 kV Pialat (S)	Central 1										
Ban Don (S)	Central 1					16	1			3	4.63
Dongphosy (S)	Central 1										
Naxaythong (S)	Central 1			200	2	30	2		2	9	21.81
New 1 (S)	Central 1										
Non Hai (S)	Central 1					16	1			3	4.63
Pakthang (S)	Central 1					30	1			2	4.35
Phontong (S)	Central 1					50	4			7	13.55
Thangon (S)	Central 1					30	1			1	3.68
Vang Vieng (S)	Central 1					16	2			7	8.12
Viengkeo (Nonviengkham) (S)	Central 1					30	1			2	4.35
Xam Tai (S)	Central 1										
Xamneua (S)	Central 1					20	1			1	3.94
Xieng Khor	Central 1										
Subtotal (C1)	Central 1										177.14
Nongdeun (S)	Central 2					50	1			7	8.28
Song Hong	Central 2										
Thakhek (S)	Central 2					30	2			9	10.26
Subtotal (C2)	Central 2										99.19
Ban Hat (S)	South					20	2			2	4.98
Ban Na (S)	South					30	2			6	8.24
Bang Yo (S)	South					25	2			3	5.99
Dak Choung	South										
Don Talad	South										
Hat Xan	South										
Jiengxai (S)	South					30	1			7	7.72
Nathon (Saravan) (S)	South					20	2			8	9.02
New3	South										
Nongbong (S)	South					30	1			6	7.05
Pakxong (S)	South					50+30	1+1			4	7.45
Saphaothong (S)	South					20	2			3	5.65
Vang Tao	South										
Subtotal (S)	South										61.80

Sustation Name	Area	Underconstruction									
		500/230 kV Tr.		230/115 kV Tr.		115/22 kV Tr.		Transmission Line Bay			Cost
		Capacity	Qty'	Capacity	Qty'	Capacity	Qty'	500 kV	230 kV	115 kV	mil. USD
500 kV M. Houn (S)	North										
500 kV M. Nan (S)	North										
Chomphet (S)	North										
Houayxay (S)	North					30	2			4	6.89
Luangnamtha 1 (S)	North										
Luangprabang 1 (S)	North										
Luangprabang 2 (S)	North										
Meuang Nga (S)	North										
Munsing	North										
Na Mo 1 (S)	North										
Nam Pha (S)	North										
Oudomxai (S)	North									2	0.91
Pakmong 2 (S)	North								2		1.80
Pha Oudom (S)	North			200	2	50	1		2	6	19.16
T-off Hongsa-Luangprabang 2 (SwS)	North									1	0.46
Ton Pheung (S)	North					50	1			2	4.92
Viengkeo (Hongsa Lignite) (S)	North										
Vieng Kham	North										
Subtotal (N)	North										62.20
500 kV Houaphan	Central 1										
500 kV Napia (S)	Central 1	750	1	200	1	50	1	2	2		26.42
500 kV Pialat (S)	Central 1	750	1	200	1	50	1	2			24.19
Ban Don (S)	Central 1										
Dongphosy (S)	Central 1										
Naxaythong (S)	Central 1										
New 1 (S)	Central 1										
Non Hai (S)	Central 1										
Pakthang (S)	Central 1										
Phontong (S)	Central 1										
Thangon (S)	Central 1										
Vang Vieng (S)	Central 1										
Viengkeo (Nonviengkham) (S)	Central 1										
Xam Tai (S)	Central 1			200	2	50	1		4		16.99
Xamneua (S)	Central 1										
Xieng Khor	Central 1										
Subtotal (C1)	Central 1										132.74
Nongdeun (S)	Central 2										
Song Hong	Central 2					30	1			5	6.37
Thakhek (S)	Central 2									1	0.46
Subtotal (C2)	Central 2										34.14
Ban Hat (S)	South			200	2				2		11.11
Ban Na (S)	South										
Bang Yo (S)	South										
Dak Choung	South										
Don Talad	South										
Hat Xan	South										
Jiengxai (S)	South										
Nathon (Saravan) (S)	South										
New3	South										
Nongbong (S)	South										
Pakxong (S)	South										
Saphaothong (S)	South										
Vang Tao	South										
Subtotal (S)	South										26.50

Sustation Name	Area	Plan										
		500/230 kV Tr.		230/115 kV Tr.		115/22 kV Tr.		Transmission Line Bay			B2B	Cost
		Capacity	Qty'	Capacity	Qty'	Capacity	Qty'	500 kV	230 kV	115 kV	MW	mil. USD
500 kV M. Houn (S)	North	500	2					6	2		1,000	305.33
500 kV M. Nan (S)	North	300	2					4	4			27.76
Chomphet (S)	North					20	1			1		3.39
Houayxay (S)	North									4		1.81
Luangnamtha 1 (S)	North									4		1.81
Luangprabang 1 (S)	North									2		0.91
Luangprabang 2 (S)	North								1			0.91
Meuang Nga (S)	North									2		0.91
Munsing	North					20	1			4		5.42
Na Mo 1 (S)	North									1		0.46
Nam Pha (S)	North			100	2				2	2		11.10
Oudomxai (S)	North									3		1.36
Pakmong 2 (S)	North									2		0.91
Pha Oudom (S)	North								2	4		3.59
T-off Hongsa-Luangprabang 2 (SwS)	North									1		0.46
Ton Pheung (S)	North									4		1.81
Viengkeo (Hongsa Lignite) (S)	North					20	1					0.92
Vieng Kham	North					20	1			2		4.07
Subtotal (N)	North											372.93
500 kV Houaphan	Central 1	750	2	~~200~~	~~1~~	~~50~~	~~1~~	2				31.11
500 kV Napia (S)	Central 1							2				3.95
500 kV Pialat (S)	Central 1								2			1.80
Ban Don (S)	Central 1									1		0.46
Dongphosy (S)	Central 1			200	1	50	2		2			11.85
Naxaythong (S)	Central 1								4			3.59
New 1 (S)	Central 1					50	2			2		6.67
Non Hai (S)	Central 1									1		0.46
Pakthang (S)	Central 1					50	2					3.53
Phontong (S)	Central 1									2		0.91
Thangon (S)	Central 1					30	1					1.21
Vang Vieng (S)	Central 1									1		0.46
Viengkeo (Nonviengkham) (S)	Central 1					50	2					3.53
Xam Tai (S)	Central 1									2		0.91
Xamneua (S)	Central 1									1		0.46
Xieng Khor	Central 1									1		0.46
Subtotal (C1)	Central 1											71.36
Nongdeun (S)	Central 2					50	1					1.77
Song Hong	Central 2					30	1					1.21
Thakhek (S)	Central 2					30	1					1.21
Subtotal (C2)	Central 2											4.19
Ban Hat (S)	South					20	1			1		1.37
Ban Na (S)	South									2		0.91
Bang Yo (S)	South									6		2.70
Dak Choung	South					20	1			1		3.39
Don Talad	South					20	1			2		4.07
Hat Xan	South									4		4.51
Jiengxai (S)	South									4		1.81
Nathon (Saravan) (S)	South			100	1				2			4.65
New3	South					30	1			2		4.35
Nongbong (S)	South									1		0.46
Pakxong (S)	South			120	1				4			6.80
Saphaothong (S)	South									2		0.91
Vang Tao	South					30	1			2		4.35
Subtotal (S)	South											40.28

Appendix 11-5_Construction Cost of Facility to Large Industry

Area	District	LI Name	Substation	Voltage	cct	Length	Cost (mil.USD) excl. TR		
						(km)	Existing	U/C	Plan
North	Phongsaly	Copper Mining 2 at Yot Ou District	Boun Neua	115	1	10			3.18
North	Bokeo	Dokngiewkham	Ton Pheung	115	1	10			3.18
North	Luangnamtha	Economic Spicial Zone (Boten)	Na Mo 1	115	1	75			8.41
North	Luangnamtha	Railway Station	Luangnamtha	115	2	30			5.26
North	Oudomxai	Railway Station	Oudomxai	115	2	2			3.30
North	Oudomxai	Botel Railway Station	Boten SEZ	115	2	2			3.30
North	Oudomxai	M.Nga Railway Station	M. Nga	115	2	5			3.51
North	Luangprabang	Railway Station	Luangprabang 1	115	2	11			3.93
North	Luangprabang	Gold Mining at Phapon Village, Pak Ou District	Luangprabang 2	115	1	8.16	3.05		
North	Luangprabang	Total Load during Construction of Hydro Power Plants	Seinsouk	115	1	18		3.74	
North	Luangprabang	Data Center	Luangprabang 2	230	1	1.5		2.83	
North	Xayabuly	Copper Mining at Pang Kham Village, Paklay District	Paklay	115	1	10			3.18
North	Xayabuly	Total Load during Construction of Hydro Power Plants	Xayabuly	115	1	10	3.18		
Central 1	Houaphan	Gold Mining at Phiangum District	Xing Khor	115	1	10			3.18
Central 1	XiengKhuang	Silicon factory. At Xai village. Pukuad District (Max Green lao company)	Phonsavan	115	1	10	3.18		
Central 1	XiengKhuang	Silicon factory. At Nahor village. Khouan District (Phongsapthavy company)	Na Hor	115	1	10		3.18	
Central 1	Xaysomboun	Phubia Gold/copper Mining, PouKham Village, AnouVong District, Sayxomboun Provice, (Existing 115KV at Thongkhuan Substation)	Thongkhoun 1	115	1	13	3.39		
Central 1	Vientiane	Houaysai Gold/copper Mining, Na Mon Village, Vangvieng District (Existing, 115KV at Vangvieng Substation)	Vang Vieng	115	1	38	5.14		
Central 1	Vientiane	Cement Factory No.3 at PhonSu Village, Vangvieng Dist (Existing, 115 KV at Vangvieng Substation)	Vang Vieng	115	1	10	3.18		
Central 1	Vientiane	Cement Factory at Hinheup Village	Hinheup	115	1	10		3.18	
Central 1	Vientiane	NongKhon Specific Economic Zone (Industries Zone) at Phonehong District, (Plan, 115KV at F1, 49 Substation)	Talat	115	1	10			3.18
Central 1	Vientiane	Gold/Copper Mining at Maipakphoun Village, Sanakham District, (F2 Nonhai Substation)	Non Hai	115	1	10			3.18
Central 1	Vientiane	Railway station	Vang Vieng	115	1	2.5			2.66
Central 1	Vientiane Capital	Kea Potash Factory at Thongmang Village, Saythany District, (Existing 115KV, NamMang 3-Khoksaat Substation)	Nam Mang 3 - Khoksaad	115	1	3	2.69		
Central 1	Vientiane Capital	Vientian Industrial and Trad Area (VITA PARK), NolThong village , Xaythany District, (22KV, KhokSaat Substation)	Khoksaad	115	1	4.32	2.78		
Central 1	Vientiane Capital	EZC Vientiane Nelamit at DongPhoXee Village, Hatxaifong District	Thanaleng	115	1	10		3.18	
Central 1	Vientiane Capital	Thatluang Lake Natural and Cultural Tourism Specific Economic Zone at ThatLuang Village, Sayshettha District, (Plan)	Donkoi	115	1	10		3.18	
Central 1	Vientiane Capital	Saysettha Development Zone at Nano village, Saythany District	Khoksaad	115	1	10		3.18	
Central 1	Vientiane Capital	Nongchan World Trad Center at Ban Fai, Chanthabuly District	Phontong	115	1	10		3.18	
Central 1	Vientiane Capital	Long- Thanh Vientiane EZC at Dongphosy, Hatxaifont District, (Existing 22KV, MSS 6.2 at Thanaleng Substation)	Thanaleng	115	1	10		3.18	
Central 1	Vientiane Capital	DoneChan development Zone at , Chanthabuly District	Donkoi	115	1	10		3.18	
Central 1	Vientiane Capital	Railway station	Khoksaad	115	1	10			3.18
Central 2	Bolikhamxai	Nagadok gold mining, at Lak 20	Lak 20	115	1	5	2.83		
Central 2	Bolikhamxai	Cement Factory, Lanchang Conpany at KhounNguen Village, Khounkham district	Konsong and Thasala	115	1+1	26.04+27.12	6.88		
Central 2	Bolikhamxai	No.1 Iron melting factory, at Phonsi Village PakXan District (sinhouang) will construct 115KV, TR (63MVAx3+40MVAX1)	Pakxan	115	1	10			3.18
Central 2	Khammouane	Lao Kai Yuan Potassium at Nam Ma LatVillage, Thakhek District, (Exisiting, 22KV at FD 9&FD 10 Thakek Substation)	Thakhek	115	1	10			3.18
Central 2	Khammouane	Cement Factory at Nakham Village, Mahaxay District, (Existing 115KV, at Mahaxay-Thakek Line)	Mahaxai and Thakhek	115	1	20	3.88		
Central 2	Khammouane	Phonesack Cement Company Limited (PSCC) at Ban Tham Village in Gnommalath district	Thakhek	115	1	27	4.37		
Central 2	Khammouane	Cement Factory, Lao Pattana Xangkham Conpany at PhonKham-Namdik Village, Hinboun district	Thakhek	115	1	10		3.18	
Central 2	Khammouane	MCS Mining industry lao co.ltd, at Ban phine, Thakhek District		115	1	0.5	2.52		
Central 2	Khammouane	Khammuan Cement Lao (KCL) at Ban Phova, Mahaxai distict	T-off Thakhek - Mahaxai	115	1	11	3.25		
Central 2	Khammouane	Economic Spacial Zone Phoukyo	Thakhek	115	1	10			3.18
Central 2	Khammouane	Thakhek Specific Economic Zone	Thakhek	115	1	10			3.18
Central 2	Savanakhet	Savan-Seno Economic Spacial Zone (Zone A)	Nongdeum + Pakbo	115	1	10			3.18
Central 2	Savanakhet	Savan-Seno Economic Spacial Zone (Zone B)	Nongdeum + Pakbo	115	1	10		3.18	
Central 2	Savanakhet	Savan-Seno Economic Spacial Zone (Zone C)	Nongdeum + Pakbo	115	1	10		3.18	
Central 2	Savanakhet	Savan-Seno Economic Spacial Zone (Zone D)	Nongdeum + Pakbo	115	1	10		3.18	
Central 2	Savanakhet	Savan-Seno Economic Spacial Zone (Zone E)	Nongdeum + Pakbo	115	1	10		3.18	
South	Champasak	Specific Economic Zone Vang Tao, Ban Vang Tao, PholThong Dist	Bang Yo	115	1	10		3.18	
South	Champasak	Mahanaty Siphandon Special Economic Zone	Bang Yo	115	1	10			3.18
South	Saravan	Phonesack Ligmite at Tongxa village Ta-oi District	Nathon (Saravan)	115	1	10			3.18
South	Xekong	No Name	Dak Choung	115	1	10			3.18
South	Attapeu	Industries Zone at Km18	Dak Choung	115	1	10			3.18
South	Attapeu	Hong Ang Ya lai Sugar factory at Palai village, PhouVong District, (Existng 115KV, at SaphaoThong Substation)	Sapaothong	115	1	10	3.18		
	Total						53.50	51.09	81.25

Appendix 12-2_12-4_Status of environmental and Social Considerations for Power Generation Development etc,

A12-2. Status of Environmental and Social Considerations for Power Network System Development

Status of Environmental and Social Considerations for Power Network System Development in EDL

No.	Name of Project	ECC (Environmental Compliance Certificate)		Date of Approval
		Approved	Not yet	
A1	115kV Transmission Line Hongsa – Xienghone Project	x		14/09/2016
A2	115kV Transmission Line Ban Done- NonHay Project	x		03/10/2016
A3	115kV Transmission Line Loungpabang1-Loungpabang2 Project	x		12/02/2017
A4	115kV Transmission Line Korring-Naphiew Project	x		24/07/2017
A5	115kV Transmission Line Nahay-Dongphosy Project	x		26/02/2015
A6	115kV Transmission Line Houaysay-Tonpheung Project	x		30/06/2016
A7	115kV Transmission Line Xekaman sanxay Hydropower project - 500/230/115/22kV substation Hatsan (Lak 37) Project	x		27/02/2018
A8	115kV Transmission Line Tonpheung-Ban TanOr Project	-		
A9	230 kV Transmission Line Houameung-Xamtay Project	x		19/09/2016
A10	230 kV Transmission Line Xekaman-Xekong 2 (Ban Vangsang) Project	x		18/08/2016
A11	230 kV Transmission Line Phaoudom-ThaPha Project	x		04/09/2017
A12	230 kV Transmission Line Thavieng-Naphiew Project	x		08/11/2018
A13	500 kV Transmission Line Mahaxay-Viengthong Project	x		14/06/2018
A14	500 kV Transmission Line Naphiew-Viegthong	x		20/07/2018
A15	500 kV Transmission Line Vangxang-Hatxan-Lao – Vietnam Border Project	x		23/01/2019
A16	230 kV Transmission Line Xamneua –Houameung Project		x	
A17	230 kV Transmission Line Nathone-Paksong Project		x	

No.	Name of Project	ECC (Environmental Compliance Certificate)		Date of Approval
		Approved	Not yet	
A18	230 kV Transmission Line Nathone-Vangxang (Xekong2) Project		**x**	
A19	230 kV Transmission Line Nam Ou Phase II Project		**x**	
A20	230 kV Transmission Line Meunglong-Tonpheung Project		**x**	
A21	500 kV Transmission Line Xeno-Salavan (ECC extension) Project	-		
A22	500/300 kV Transmission Line Meunghoun-Meung Nan-Xiengkhoung Project		**x**	

Source: Environment Office, Department of Transmission & Substation Development, EDL

A12-3 SEA Study of Power Network System Development- 1

(1) Preliminary Environmental Scoping

Preliminary Environmental Scoping of Power Network System Development

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
(1) Social Environment						
1) Land acquisition and resettlement (Involuntary resettlement)	A/B	A/B	B	B	B	(T) To secure the lands/spaces for power network system (transmission/distribution line, substation and related facilities), there is a possibility of involuntary resettlement including land acquisition and resettlement as well as wayleaves acquisition, generation of Project Affected Persons (PAPs), although it depends on the details of the plan (site location/route, scale, components etc.).
2) Local economy such as employment and livelihood etc.	C	C	C	C	C	(T) Beneficial impacts are expected on local economy; (i) creation of employment opportunity for civil work during construction and decommissioning stage, (ii) new power generation may improve living condition. However, extent of impact is unknown at present.
3) Energy use	C	C	D	D	D	(T) Basically, the power network system is itself matter of no relation to energy use.
4) Water use	B	C	B	C	B	(II, IV) Surface water and/or groundwater use for construction and decommissioning work is expected.
5) Land use and utilization of local resources	B	B	B	C	C	(T) Some alteration of existing land use and utilization of local resources is expected. However, extent of impact depends on the plan of power plants and related facilities.
6) Social institutions such as social infrastructure and local decision-making institutions, a split of communities	C	C	C	C	C	(T) There is a possibility of missing acceptance by the communities and causing split of community, if the plan is not properly informed to relevant stakeholders including community-based organizations for participation.

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
7) Existing social infrastructures and services	C	C	C	C	C	(T) Electricity supply by power network system will contribute surely to improvement condition of basic infrastructure and at the same time to upgrading social services. However, extent of impact is unknown at present.
8) The poor, indigenous of ethnic people	C	C	C	C	C	(T) Power network system is expected to contribute to creation of employment opportunity for construction and decommissioning work and improvement living condition by supply of electricity. However, it is unknown whether the poor and vulnerable are able to enjoy the benefit equally or not at present.
9) Misdistribution of benefit and damage (Equality of benefits and losses and equality involved in development process)	C	C	C	C	C	(T) Beneficial impacts such as contribute to creation of employment opportunity for construction and decommissioning work and improvement living condition by supply of electricity through power plants and related facilities. However, there is a possibility of misdistribution of benefit and damage, if the plan is not appropriately accepted to relevant stakeholders including communities through proper information disclosure and public participation.
10) Local conflict of interests	C	C	C	C	C	(T) Beneficial impacts such as contribute to creation of employment opportunity for construction and decommissioning work and improvement living condition by supply of electricity through power plants and related facilities. However, there is a possibility of generation of local conflict, if the plan is not appropriately accepted to relevant stakeholders including communities through proper information disclosure and public participation.
11) Cultural property and heritage	B	D	B	B	B	(II, III, IV) In Laos sites of cultural properties and heritages are distributed in the whole country. Thus, adverse impact on them is expected, if the site of power network system is located within or close to the site.

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
12) Fishing Rights, Water Rights and Rights of Common	C	C	C	C	C	(T) There is a possibility of disturbing fishing rights, water rights and rights of common depending on the project plan. However, extent of impact is unknown at present.
13) Public health and Sanitation	B/C	D	B	C	B	(II, IV) There is a possibility of deterioration respiratory functions due to inhalation of air pollutants such as NOx and PM10, if control of pollutants emission in construction and decommissioning work is not conducted appropriately. However, at present extent of impact is unknown.
14) Infectious diseases such as HIV/AIDS	C	D	C	C	C	(II, IV) In many developing countries spreading of infectious diseases such as HIV/AIDS were often reported due to contact of workers with affected peoples at their camp in construction work. Thus, it is expected somewhat spreading of infectious diseases during construction and decommissioning stage. However, extent of impact is unknown at present.
15) Working condition including occupational safety	C	D	C	C	C	(II, III, IV) Adverse impacts on working condition including occupational safety are expected somewhat due to insufficient management of workers at construction and decommissioning work, and at operation of power plants and related facilities. However, extent of impact is unknown at present.
16) Hazard/risk (disaster, security)	B	B	B	B	B	(T) No additional risk of disaster and public security are expected due to installation of power network system.
17) Accidents	B	D	B	B	B	(II, III, IV) 1) Occurrence of accidents is expected somewhat, if inappropriate handling and management of construction and decommissioning work, and insufficient operation of installed power plants and related facilities are carried out. 2) UXOs (Un-exploded Ordnances) is below ground for about 25% of villages of Laos and some 8.7 million ha. Thus, accidental contact with UXOs may cause loss or damage of life.
(2) Natural Environment						

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
18) Topography and Geology	C	D	C	C	C	(II, IV) There is a possibility of causing adverse impact, if that a large-scale alteration of topographic and geologic features are included in construction plan of power plants and related facilities. However, extent of impact is unknown at present.
19) Soil erosion/sand movement	C	D	C	C	C	(II, IV) There is a possibility of occurrence of soil erosion, if that a large-scale alteration of topographic and geologic features as well as cutting and filling of surface soil are included in construction plan of power plants and related facilities. However, extent of impact is unknown at present.
20) Movement of water/Hydrological situation	C	D	C	C	C	(II, III, IV) There is a possibility that hydrological conditions such as water flow and water level are adversely affected due to landing work of fuels and other materials at port and/or water storage by pumping up at hydropower plant. However, extent of impact is unknown at present.
21) Riverbank and/or lakeside zone	C	D	C	D	C	(II, IV) In case of power network system is located in riverbank or lakeside area, some impact on coastal conditions is expected due to construction and decommissioning work. However, extent of impact is unknown at present.
22) Environmentally sensitive areas (Protected Areas, IBAs etc.)	B	D	B	B	C	(II, III, IV) 1) In Laos designated National Biodiversity Conservation Area (NBCA) and Protected Forests as well as Important Bird and Biodiversity Conservation Areas (IBAs) are distributed in the whole country. Thus, adverse impact on them is expected, if the site of power network system is located within or close to the area.
23) Flora, Fauna, Ecosystem and Biodiversity	B	D	B	B	C	(II, III, IV) 1) In Laos there are found many precious plant and animal species as well as important areas of valuable ecosystem and biodiversity. Thus, adverse impact on them is expected, if the site of power plants and related facilities is located within or close to the area. 2) In addition, there is a possibility of migratory

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
						birds striking to towers and cables of power network system.
24) Landscape	B	D	B	B	C	(III) In Laos cultural and heritage sites are distributed in the whole country and they consist of attractive landscape. Thus, there is a possibility of deterioration aesthetic value of landscape by spatial occupancy of power network system such as towers.
25) Micro-climate	C	D	C	C	C	(II, III, IV) In general, Laos has variety of topographical features, i. e., mountain, hills to flat areas and water bodies such as Mekong River However, it is unknown whether even a small change of topographical features such as appearance of new structures and facilities may cause influence to microclimate condition or not.
26) Global Warming	B	D	B	C	B	(II, IV) Generation of greenhouse gases (GHG) such as CO_2 and CH_4 is not expected from operation of power network system. However, generation of GHG is expected from construction vehicles and machines during construction and decommissioning stage. However, extent of emission is not known at present
(3) Environmental Pollution						
27) Air pollution	B	D	B	D	B	(II, IV) Generation of air pollutants such as dust and NOx are expected due to earth moving and engineering works during construction and decommissioning stage.
28) Water pollution	B	D	B	D	B	(II, IV) Generation of water pollutants such as SS and BOD is expected due to earth moving and engineering works during construction and decommissioning stage.
29) Soil contamination	B	D	B	B	C	(II, IV) There is a possibility of soil contamination due to leakage of toxic or hazardous materials from construction and decommissioning work. However, features of the contamination is unknown at present.
30) Bottom sediment	C	C	C	C	C	(II, IV) If power network system is installed near riverbank and/or lakeside, bottom sediment pollution is expected depending on the scale and extent of generating

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
						water pollutants and solid wastes during construction and decommissioning stage.
31) Solid waste	B	D	B	C	B	(II, IV) Generation of solid wastes is expected from are expected due to earth moving and engineering works during construction and decommissioning stage.
32) Noise and Vibration	B	D	B	B	C	(II, IV) Generation of noise and vibration are expected from are expected due to earth moving and engineering works during construction and decommissioning stage.
33) Ground Subsidence	C	D	C	C	C	(II, IV) There is a possibility of ground subsidence if extraction of a large-scale extraction of groundwater is included in the project plan. However, at present it is unknown.
34) Offensive odor	C	D	C	C	C	(II, IV) There is a possibility of offensive odor due to mal-functioned vehicles and construction machines during construction and decommissioning stage. However, at present it is unknown.
35) Sunshine inhibition/Reflection of sunlight	C	D	C	C	C	(III) 1) If power network system is installed in densely populated area and surrounded by tall buildings, sunshine inhibition is somewhat expected. However, at present it is unknown.
36) Electromagnetic interference	C	D	C	C	C	(III) If the power network system is installed in densely populated area and surrounded by tall buildings, electromagnetic interference is somewhat expected. However, at present it is unknown.
37) Safety from Electromagnetic Field	C	D	C	C	C	(III) If the power network system facilities are installed keeping with sufficient distance and height from houses and other structures, it is expected that strength of the electromagnetic field in ground level and upper floor level will be below the public electromagnetic exposure limit of the ICNIRP (International Commission for Non-Ionizing Radiation Protection). However, at present it is unknown.

Environmental item *, **	Rating ***, ****					Reasons
	T	I	II	III	IV	
38) UXO (Unexploded Ordnance)	B	B	B	B	B	(I, II, III, IV) In Laos about one fourth of villages left some 80 million pieces of unexploded ordnance (UXO) were left in village areas.
39) Interconnection of power network system	C	C	C	C	C	(I, II, III, IV) No negative impact is anticipated due to the interconnection, because it is just connection of electric power, and neither goods nor people. Thus, transboundary problems, which may be generated as a result of international flow of pollutants, goods or people is not expected.

Note 1: * Environmental items are selected based on the JICA Guidelines for Environmental and Social Considerations (2010.4) with referring to legislation and environmental conditions of Laos.

Note 2: ** Regarding the impacts on "Gender" and "Children's Right" might be related to all criterion (items) of Social Environment.

Note 4: **** (i) Rating (Extent of impacts); In general, both beneficial impact (+) and adverse impact (-) are expected due to the project activities. However, in this IEE "adverse impact" is taking into considerations for evaluation. {A} - Significant impact is expected, {B} - Not significant but some impact is expected, {C} - Extent of impact is unknown or not clear (Further examination is needed. It should be taken into consideration that impacts may become clear as study progresses.), {D} - Negligible or No impact is expected. (ii) Total rating; the worst value of rating among four stages.

Source: JICA Study Team

(2) Further Necessary Information/Data and Possible Mitigation Measures (TOR)

Table A13-4 Further Necessary Information/Data and Possible Mitigation Measures

Environmental item *, **	Rating ***, ****	Further Necessary Information/Data	Possible Mitigation Measures
	T		
(1) Social Environment			
1) Land acquisition and resettlement (Involuntary resettlement)	A/B	(T) 1) Laws and regulations for involuntary resettlement (land acquisition and resettlement) and easement/wayleaves. 2) Land use regulation and existing land use in Jordan and planned area. 3) Cases and	(T) 1) Consider alternative plans to avoid and/or minimize the occurrence of involuntary resettlement. 2) Detailed inventory survey on plots, facilities, structures and peoples living along the planned railway routes. 3) Survey on encroachment on ROW

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
		causes of involuntary resettlement in Jordan and planned area. 4) Anticipated land area and location for the site to be secured by the plan.	(Right of Way) of the planned site/alignment. 4) Examine procedure and condition of involuntary resettlement and compensation to PAPs taking relevant laws in Jordan and the JICA Guidelines into considerations. 5) From early stage of the project, pay attention to information disclosure and consultation with stakeholders including PAPs for thorough understanding of the issues or to make agreement as much as possible. 6) Elaborate Resettlement Action Plan (RAP), if involuntary resettlement is unavoidable.
2) Local economy such as employment and livelihood etc.	C	(T) 1) Development PPPs of Jordan and other sectors (tourism, industry, mining, regional development etc.) 2) Labor force and employment and working needs in planned area.	(T) 1) Promote consistency and synergy with other development plans (PPPs) by whole country and other sectors.
3) Energy use	C	(T) 1) Existing land use and land use regulation. 2) Topographic and geological data in the country.	Not required.
4) Water use	B	(T) 1) Laws and regulations for water use and water extraction form water resources. 2) Water demand and supply in Jordan and planned area. 3) Anticipated water use in construction and decommissioning work and in operation of power plants and related facilities.	(T) 1) Consider minimize water use in construction and decommissioning work and in operation of power plants and related facilities in the plan. 2) Monitor water consumption in the plan.
5) Land use and utilization of local resources	B	(T) 1) Laws and regulation for use of land and resources. 2) Existing and	(T) Consider appropriate and effective utilization of land and resources in the plan.

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
		future land and resources use in Jordan and planned area.	
6) Social institutions such as social infrastructure and local decision-making institutions, a split of communities	C	(T) Information of administrative and social structures and decision-making process and institutions in Jordan and planned area.	(T) Information disclosure and public participation should be fully considered for stakeholders including decision-makers of the communities from early stage of planning for obtaining thorough understanding and consensus of the people and communities by promoting that the plan may contribute to improvement of local economy and upgrading living conditions.
7) Existing social infrastructures and services	C	(T) 1) Laws and regulations for social infrastructures and services. 2) Existing situation of social infrastructures and services in Jordan and planned area.	(T) 1) Avoid or minimize disturbance existing social infrastructures and services in the plan. 2) Promote synergy with plans for other social infrastructure and services.
8) The poor, indigenous of ethnic people	C	(T) 1) Data of vulnerable groups such as the poor, female, children, elders, disabled, refugees and indigenous ethnic people in Jordan and planned area. 2) Supporting activities to living and livelihood condition by Jordan Government and donors.	(T) 1) Give higher priority to the vulnerable groups in the planned area with having a chance to get jobs and training to get working skills in the plan. 2) The vulnerable people should be taken fully considerations to compensate properly or support to restore the present living condition in case of involuntary resettlement, even if they are illegal occupants.
9) Misdistribution of benefit and damage (Equality of benefits and losses and equality involved	C	(T) Cases and causes of misdistribution of benefit and damage by the development plans of electric sector and others in Jordan and planned area.	(T) Information disclosure and public participation should be fully considered from early stage to obtain thorough understanding the plan and consensus among the communities and PAPs in order to share with benefit and damage equally.

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
in development process)			
10) Local conflict of interests	C	(T) Cases and causes of local conflict of interests by the development plans of electric sector and others in Jordan and planned area.	(T) Information disclosure and public participation should be fully considered from early stage to obtain thorough understanding the plan and consensus among the communities and PAPs in order to avoid or minimize local conflict of interests.
11) Cultural property and heritage	B	(II, III) 1) Laws and regulations of cultural property and heritage site. 2) Distribution of cultural property and heritage site in Jordan and the planned area.	(T) 1) Avoid the site and route penetrating or close to the sites of cultural properties, heritages and archaeological importance in the plan. 2) If any buried cultural properties are found at construction work, report and consult with concerned organizations such as Ministry of Tourism and Antiquities without delay.
12) Fishing Rights, Water Rights and Rights of Common	C	(T) Situation of Fishing Rights, Water Rights and Rights of Common in Jordan and planned area.	(T) Promote participation of those who have the rights in order to get their opinion and ensuring understanding and making consent in the course of the stakeholder meeting from the planning stage
13) Public health and Sanitation	B/C	(II, III, IV) 1) Laws and regulations of public health and sanitation. 2) Public health condition including respiratory disease and distribution of medical facilities in Jordan and planned area.	(T) 1) Preventive measures to control air pollutants emission in construction and decommissioning work and in operation of power plants and related facilities。2) Monitor public health condition by medical examination.
14) Infectious diseases such as HIV/AIDS	C	(II、IV) 1) Regulations for infectious diseases. 2) Cases and causes of infectious diseases such as HIV/AIDS in Jordan and planned area.	(II, IV) 1) Enlightenment and education of infectious diseases to people and workers. 2) Monitoring prevalence and safety shoes and

Environmental item *, **	Rating ***, ****	Further Necessary Information/Data	Possible Mitigation Measures
	T		
			hats. (3) Regular check of occupational safety and health condition.
15) Working condition including occupational safety	C	(II, III, IV) 1) Regulation for labor and occupational health and safety. 2) Cases and causes of working condition issues including occupational health and safety in Jordan and planned area. 3) Management plan for working condition in construction and decommissioning work, and in operation of power network system.	(II, III, IV) 1) Prepare tangible safety considerations in place for individuals involved in the plan, such as the installation of safety equipment which prevents accidents, and management of hazardous materials. 2) Plan and implement intangible measures for individuals involved in the plan, such as the establishment of a safety and health program, and safety training for workers etc. 3) Monitoring occupational health and safety condition.
16) Hazard/risk (disaster, security)	B	(T) 1) Cases and causes of hazard risks due to disaster in Laos and the planned area. 2) Existing condition of public security due to uncertain political situation and conflict of neighboring countries.	(T) 1) Monitor uncertain condition of neighboring countries. 2) Prepare emergency action plan for hazard and public security risks.
17) Accidents	B	(II, III, IV) 1) Cases and causes of accidents in Laos and planned area in construction and decommissioning work and in operation of power network system. 2) Cases and causes of accidental contact with UXOs in Laos.	(II, III, IV) 1) Preventive measures including emergency action plan to accidents in construction and decommissioning work and in operation of power network system.2) Prior to route selection of power network system, to consult with UXO-NRA, who is responsible national organization to manage UXO issues for surveying existence of UXOs in planned area, and ask to removal of UXOs and get evidence of clearance by the Authority, if necessary.
(2) Natural Environment			

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
18) Topography and Geology	C	(II, IV) 1) Topographical and geological data in Jordan and planned area. 2) Anticipated amount of construction materials for procurement and removal of soil and stones for land clearance of power plants and related facilities.	(II, IV) 1) To avoid site and route with unstable and easy to collapse condition. 2) To avoid land with topographical or geological importance.
19) Soil erosion/sand movement	C	(II, IV) 1) Regulation for soil erosion and land slide. 2) Cases and causes of soil erosion and land slide in Jordan and planned area.	(II, IV) To avoid site and route with unstable soil condition in the area likely to occurrence of soil erosion and land slide.
20) Movement of water/Hydrological situation	C	(II, III, IV) 1) Hydrological condition data in Jordan and planned area. 2) Distribution of surface water bodies (rivers, Wadis, etc.)and groundwater basin in planned area.	(II, III, IV) Monitoring hydrological condition of rivers, Wadis and groundwater
21) Coastal zone	C	(II, IV) 1) Regulation of development and environmental conservation in coastal area. 2) Existing environmental condition of coastal area.	(II,, IV) 1) Appropriate preventive measures against coastal erosion, and sedimentation of sand and soil in the plan. 2) Monitor oceanographic conditions, and coastal erosion and sedimentation of sand by physical observation and utilizing satellite image map.
22) Environmentally sensitive areas (Protected Areas, IBAs etc.)	B	(II, III, IV) 1) Distribution of Environmentally Sensitive Areas and protected Areas such as NBCA, Protected Forests and IBAs in the planned area. 2) Regulations for conservation of natural environment.	(II, III, IV) To avoid site location within or close to the designated Protected Areas and parks.
23) Flora, Fauna, Ecosystem and Biodiversity	B	(II, III, IV) 1) Distribution of site with valuable plant and animal species, ecosystem and biodiversity in Jordan and the planned area. 2) Regulations for	(II, III, IV) To avoid site location within or close to distribution areas of valuable plant and animal species, and environmentally sensitive areas.

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
		conservation of plant, animal species and biodiversity.	
24) Landscape	B	(III) 1) Distribution of site with valuable landscape in Jordan and the planned area. 2) Regulation for preserving valuable landscape.	(III) 1) To avoid site location close to existing important landscape. 2) Measures to harmonize power plants and related facilities with surrounding landscape by design and tree planting in the plan.
25) Micro-climate	C	(II, III, IV) Meteorological data in Jordan and planned area including cases and causes of change in micro-climate in Laos and planned area.	(II, III, IV) Monitor micro-climate by meteorological data and physical observation.
26) Global Warming	B	(II, IV) 1) Existing data of greenhouse gases emission in Jordan and planned area. 2) Anticipated greenhouse gases emission from construction and decommissioning work.	(II, IV) Preventive measures to reduce greenhouse gases emission in construction and decommissioning work.
(3) Environmental Pollution			
27) Air pollution	B	(II, IV) 1) Regulation of air pollution including air quality and emission standards. 2) Existing air quality in Jordan and planned area. 3) Anticipated emission of air pollutants from construction and decommissioning work	(II, IV) 1) Preventive measures to control air pollutants emission in construction and decommissioning work. 2) Monitor air pollutants emission and ambient air quality.
28) Water pollution	B	(II, IV) 1) Regulation of water pollution including water quality and effluent standards. 2) existing water quality in Jordan and planned area. 3) Anticipated discharge of water pollutants from construction and decommissioning work	(II, IV) 1) Preventive measures to control water pollutants discharge in construction and decommissioning work. 2) Monitor water pollutants discharge and environmental water quality.

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
29) Soil contamination	B	(II, IV) 1) Regulation of soil contamination. 2) Cases and causes of soil contamination in Jordan and planned area.	(II, IV) 1) Preventive measures to avoid leakage toxic/hazardous materials in construction and decommissioning work. 2) Monitor soil contamination.
30) Bottom sediment	C	(II, IV) 1) Regulation of bottom sediment contamination. 2) Cases and causes of bottom sediment contamination.	(II, IV) Monitoring bottom sediment contamination.
31) Solid waste	B	(II, IV) 1) Regulation for solid waste management. 2) Existing situation of solid waste management in Jordan and planned area. 3) Anticipated generation of sold waste from construction and decommissioning work.	(II, IV) 1) Preventive measures for reduction, proper treatment and disposal of solid waste during construction/decommissioning stage in the plan. 2) Reflect concept of 3R (Reduce, reuse and recycle) to the plan. 3) Enlighten awareness of waste management to workers and employees.
32) Noise and Vibration	B	(II, IV) 1) Regulation of noise and vibration. 2) Generation and ambient level of noise and vibration in Jordan and planned area. 3) Anticipated generation of noise and vibration from construction and decommissioning work.	(II, IV) Preventive measures against generation of noise and vibration during operation of power plants and related facilities as well as during construction and decommissioning work.
33) Ground Subsidence	C	(II, III) 1) Regulation of ground subsidence. 2) Cases and causes ground subsidence in Jordan and planned area.	(II, III) Monitor occurrence of ground subsidence by physical observation.
34) Offensive odor	C	(II, IV) 1) Regulation of offensive odor. 2) Cases and causes of offensive odor issues in Jordan and planned area.	(II, IV) Preventive measures for generation of offensive odor from construction and decommissioning work.
35) Sunshine inhibition/Reflection of sunlight	C	(III) 1) Regulation of sunshine inhibition. 2) Cases and causes of	(III) 1) To avoid site location close to densely populated area and tall buildings.

Environmental item *, **	Rating ***, **** T	Further Necessary Information/Data	Possible Mitigation Measures
		sunshine inhibition in Jordan and planned area.	
36) Electromagnetic interference	C	(III) 1) Regulation of electromagnetic interference. 2) Cases and causes of electromagnetic interference issues in Jordan and planned area.	(III) 2) To avoid site location close to densely populated area and tall buildings.
37) Safety from Electromagnetic Field	C	(III) 1) Regulation of safety from electromagnetic field. 2) Cases and causes of safety issues from electromagnetic filed in Jordan and planned area.	(III) 3) To keep location of power plants and related facilities with sufficient distance and height from houses and other structures.
38) UXO (Unexploded Ordnance)	B	(I, II, III, IV) 1) Distribution data and regulation of UXO. 2) Cases and causes of damages and safety issues from UXO.	(I, II, III, IV) Prior to route selection of power network system, consult with UXO-NRA, who is responsible national organization to manage UXO issues, for surveying existence of UXO in planned area to find safe route. If UXO are found, ask to removal of UXOs and get evidence of clearance by the UXO-NRA.
39) Interconnection of power network system	C	(I, II, III, IV) 1) Environmental regulation related to the interconnection, 2) Cases and causes of troubles	(I, II, III, IV) 1) Reexamine the regulations, if necessary, 2) To take measures to avoid or minimize troubles.

Note 1 to 4: Same legends Table A13-3.

Source: JICA Study Team

A12-4 SEA Study of Power Network System Development- 2 Priority Comparison among Candidate Routes

(1) Outline of Candidate Routes for Power Network System (Tentative)

As a part of SEA study, priority comparison among candidate routes in terms of environmental and social considerations. However, alignment of the routes is assuming basically straight forward line between substations

Candidate Routes for Power Network System (Tentative)

Candidate Route		Covering Area
C1	Lak 20 - Mahaxai	Khammouane Province
C2	Phialat – Naxaythong - Dongphosy	Vientiane Capital
C3	Dongphosy – Nong Khai	Vientiane Capital - Thailand
C4	Thabok – Pakxan – Bung Kan	Borikhamxai Province - Thailand

Note: 230 kV transmission line

Based on Google Map data and available secondary data, items to be necessary environmental and social considerations were examined for selection of suitable route and/or alignment of power network system development in target area.

1) Domestic Supply C1： Lak 20 – Mahaxai (230 kV)*

-Located in Khammouan Province

-The route connecting substations of Lak 20 and Mahaxai with about 80 km in direct distance.

-In target area topography is mostly mountain area and important areas for conservation of natural environment spread over as follows:

(i) two National Biodiversity Conservation Area (NBCA), i.e., Phounhinpin NBCA (western part), and Nakay-Namtheum NBCA (eastern part),

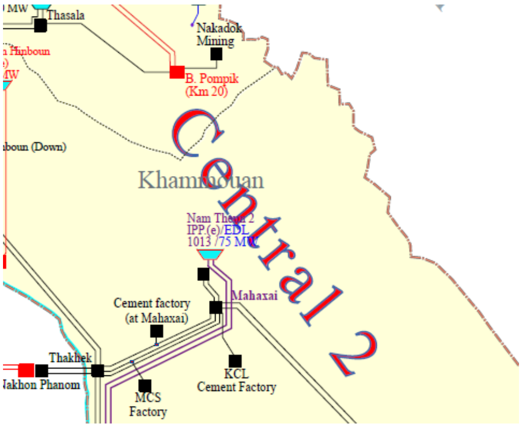
(ii) two Natural Protection Forests,

(iii) Water Resources Conservation Forest,

(iv) and Production Forests.

-National roads (No.1E and No.12) traversed low land area between two NBCAs.

* According to hearing from EDL (Environment Office) on June 12th 2019, as for 230 kV transmission line connecting Pompik substation and Mahaxai substation, MOU between EDL and Environmental Consultants was already done on March 13rd 2019 and Feasibility Study on transmission line development by ESIA is on-going.

	
Map of Transmission Line related to C1	Google Map of C1 related area

Candidate Route（C1）

Source: UNOSAT Laos Base Map

Map of Khammoune Province

2) Domestic Supply C2： Phialat – Naxaythong – Dongphosy (230kV)*

-Located in Vientiane Province and Viantiane Capital

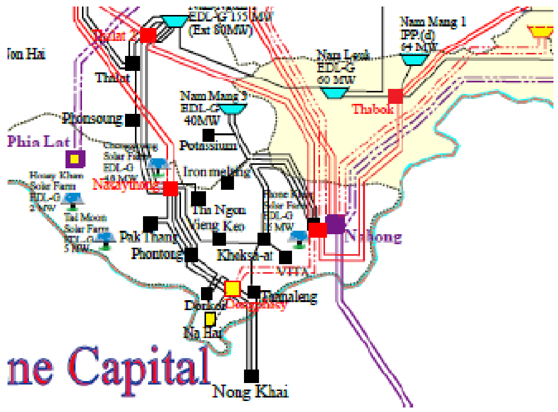
-About 65 km in direct distance

-Phouphanang NBCA, where very important for conservation of natural environment spread over between Phialat (Viantiane Province)- Naxaythong (Viantiane Capital). Thus, suitable alignment should be by taking a detour northwardly or southwardly in order to avoid passing through NBCA.

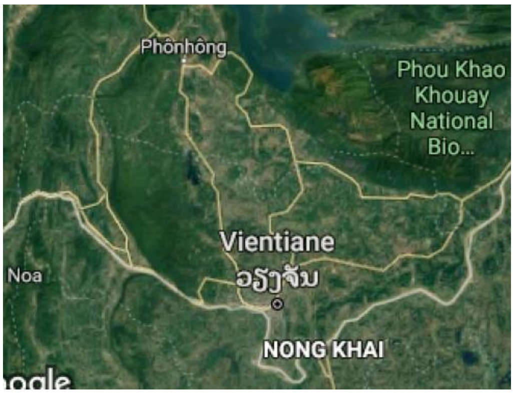
-Area between Naxaythong substation and Dongphosy substation the route traverses densely populated urban area of Vientiane Capital, where buildings, roads, bridges and temples are distributed.

-Thus, compensation of land and assets by land and wayleaves acquisition is somewhat expected.

* According to hearing from EDL (Environment Office) on June 12th 2019, as for 230 kV transmission line connecting Phialat substation and Naxaythong substation, ESIA and ESMMP study were already conducted and southwardly route are recommended. In addition, ESIA study for 500 kV transmission line is on-going, although technical feasibility study is not yet conducted.



Map of Transmission Line related to C2



Google Map of C2 related area

Candidate Route（C2）

Source: EDL (2018) ESIA of Phiaat -Naxaythong 230 kV Transmission Line

Alternative Routes between Phialat – Naxaythong Subsattion

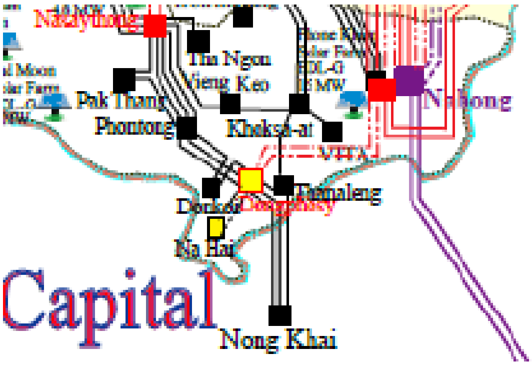
3) Interconnectiion 1：Dongphosy - Nong Khali (Thailand) (230kV)

-Located in Dongphosy of Vientiane Capital and in Nong Khali of Thailand.

-Interconnecting Dongphosy substation in Vientiane Capital and Nong Khali substation (Thailand) about 5 km in direct distance.

-Interconnection will be done using overhead cables crossing over Mekong River

-Dongphosy is located in urban area in Vientian City.



Map of Transmission Line related to C3

Google Map of C3 related area

Candidate Route（C3）

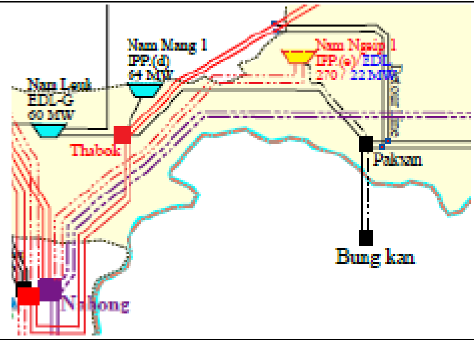
4) Interconnection 2：Thabok- Pakxan - Bung Kan (Thailand) (230kV)

-Located in Thabok and Pakxan in Bolikhamxai Province and Bung Kan of Thailand.

-Interconnecting with Bung Kan substation (Thailand) crossing over Mekong River

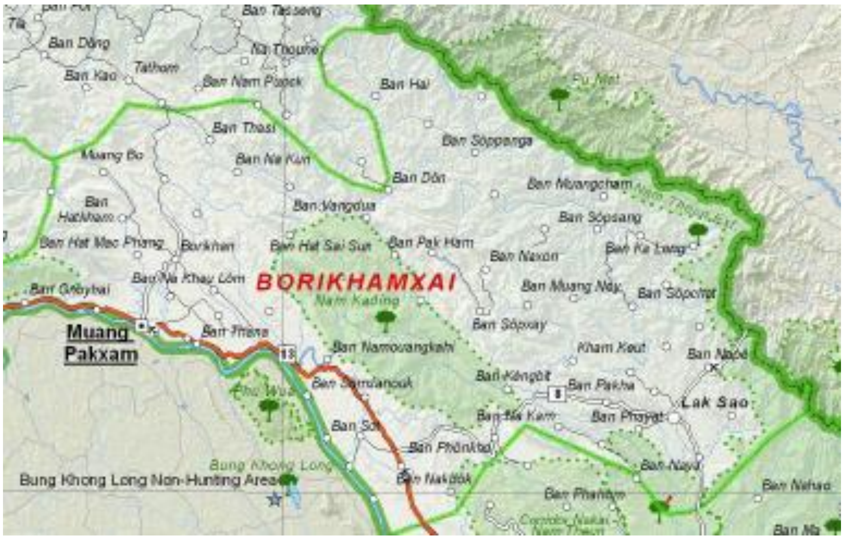
-Route is planned in parallel to existing 115 kV transmission line. Thus, land acquisition and wayleaves acquisition are expected little

-River bank area of Thabok to Pakxan prone to flooding in rainy season, although after construction of hydropower dam reservoirs such as Nam Ngum 2 river flow was considerably reduced.



Map of Transmission Line related to C4	Google Map of C4 related area

Candidate Route（C4）

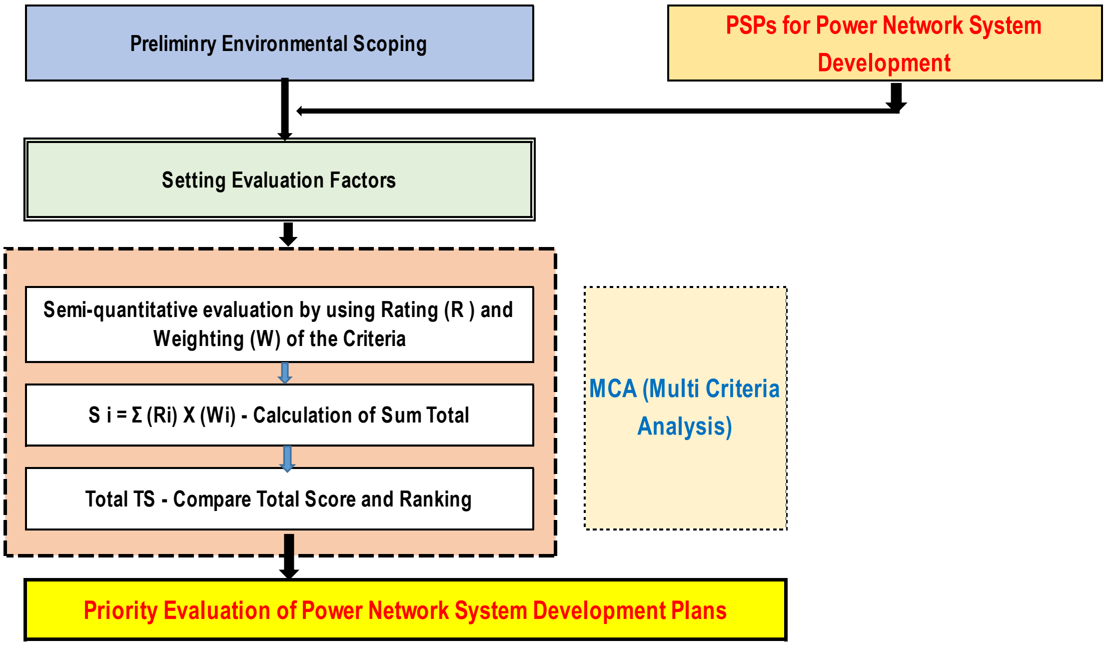


Source: UNOSAT Laos Base Map

Map of Borikhamxai Province

(2) Alternative comparison of Candidate Routes

Alternative comparison is conducted among four candidate routes in terms of environmental and social considerations by applying method of Multi-Criteria Analysis (MCA). Results are as follows:



Procedure for Priority Comparison of Power Network System Development Plan in terms of Environmental and Social Considerations

1) Rating by Impact Matrix

Results of Rating by Impact Matrix

Evaluation Indicator	Candidate Route			
	C1	**C2**	**C3**	**C4**
(I) Social Environment				
1) Occurrence of Land Acquisition/Resettlement/Wayleaves Acquisition	B	B	C	D
2) Restriction of land use	B	B	D	D
3) Disturbance of existing traffic conditions (roads/waterways)	C	C	C	C
4) Cultural heritage and properties	C	B	B	D
5) Existence of Ethnic minority groups	C	C	E	E
6) Natural Hazard Risk by land slide, flooding, earthquake, etc.	B	B	C	D
7) Accidental contact with UXO	B	B	D	D
(II) Natural Environment				

8) Protected Areas (NBCA, National Parks, National Protected Forest, IBD, etc.)	A	A	E	D
9) Provincial Protected Forest	A	A	D	E
10) Global warming/climate change	D	D	D	D
(III) Pollution				
11) Air pollution	C	C	D	D
12) Water pollution	C	C	D	E
13) Noise and vibration	C	C	D	D
14) Solid waste problem	D	C	D	D
15) Construction work of river crossing	D	D	C	C
16) Construction work of underground cable	E	C	C	E
17) Power Interconnection with neighboring country	E	E	C	C

Note1: Evaluation Indicators are set considering (i) environmental items in Table A13-3 and 13-4, (ii) power network system plan, and (iii) existing baseline conditions of target area.

2) Setting rating and Weighting of Evaluation Indicators

Considering extent of anticipated negative impacts during Planning, Construction, Operation and Decommissioning Stage, rating and weighting of Evaluation Indicators are set as shown in Table A13-7 and A13-8, respectively.

Rating of Anticipated Negative Impact

Rating	Extent of Negative Impacts	Point (P)
A	Significant	10
B	Not so significant but some	7
C	Medium impact	4
D	Little or at present unknown	2
E	No or negligible	1

Weighting of Evaluation Factors

Evaluation Factor	Weight
Resettlement, NBCA, Protected Forests, Ethnic minorities, UXO, etc.	0.6
Air Pollution, Water pollution, etc.	0.3
Noise and Vibration, etc.	0.1

3) Alternative Comparison Candidate 4 Power Network System Plan

Based on Table A13-6 to A13.8, results of priority comparison is shown in Table A13-9.

Results of Priority Comparison among Candidate Routes

Evaluation Factor	Candidate Route											
	C1			C2			C3			C4		
	Ri	Wi	Si	Ri	Wi	Si	Ri	Wi	Si	Ri	Wi	Si
(I) Social Environment												
1) Occurrence of Land Acquisition/Resettlement/Wayleaves Acquisition	7	0.6	4.2	7	0.6	4.2	4	0.6	2.4	1	0.6	0.6
2) Restriction of land use	7	0.6	4.2	7	0.6	4.2	2	0.6	1.2	1	0.6	0.6
3) Disturbance of existing traffic conditions (roads/waterways)	4	0.1	0.4	4	0.1	0.4	4	0.1	0.4	4	0.1	0.4
4) Cultural heritage and properties	4	0.6	2.4	7	0.6	4.2	7	0.6	4.2	2	0.6	1.2
5) Existence of Ethnic minority groups	4	0.6	2.4	4	0.6	2.4	1	0.6	0.6	1	0.6	0.6
6) Natural Hazard Risk by land slide, flooding, earthquake, etc.	7	0.6	4.2	7	0.6	4.2	4	0.6	2.4	2	0.6	1.2
7) Accidental contact with UXO	7	0.6	4.2	7	0.6	4.2	2	0.6	1.2	2	0.6	1.2
(II) Natural Environment												
8) Protected Areas (NBCA, National Parks, National Protected Forest, IBD, etc.)	10	0.6	6	10	0.6	6	1	0.6	0.6	2	0.6	1.2
9) Provincial Protected Forest	10	0.6	6	10	0.6	6	2	0.6	1.2	1	0.6	0.6
10) Global warming/climate change	7	0.3	2.1	2	0.3	0.6	2	0.3	0.6	2	0.3	0.6
(III) Pollution												
11) Air pollution	4	0.3	1.2	4	0.3	1.2	2	0.3	0.6	2	0.3	0.6
12) Water pollution	4	0.3	1.2	4	0.3	1.2	2	0.3	0.6	1	0.3	0.3
13) Noise and vibration	4	0.1	0.4	4	0.1	0.4	2	0.1	0.2	2	0.1	0.2
14) Solid waste problem	2	0.1	0.2	4	0.1	0.4	2	0.1	0.2	2	0.1	0.2
15) Construction work of river crossing	2	0.3	0.6	2	0.3	0.6	4	0.3	1.2	4	0.3	1.2
16) Construction work of underground cable	1	0.3	0.3	4	0.3	1.2	4	0.3	1.2	1	0.3	0.3
17) Power Interconnection with neighboring country	1	0.3	0.3	1	0.3	0.3	4	0.3	1.2	4	0.3	1.2
Total Score TS = {Σ (Ri x Wi)}	40.3			41.7			20			12.2		

Ranking in terms of Anticipated Negative Impacts	No. 2	No. 1	No. 3	No. 4

Note1: Evaluation Indicators are set considering (i) environmental items in Table A13-3 and 13-4, (ii) power network system plan, and (iii) existing baseline conditions of target area.

Note2: Si = Ri x Wi, Total score (TS) = { Σ(Ri X Wi) }

In terms of environmental and social considerations as shown in Table a13-9, C3 and C4 are prioritized. In addition, at the project level examination, alternative comparison will be required for at lese three (3) alternatives based on amended Decree on Environmental Impact Assessment (2019)..

(3) Conclusion

It is no wander to be not enough by examination through Google map and secondary data only. It is necessary to confirm through environmental and social field investigation on target area.

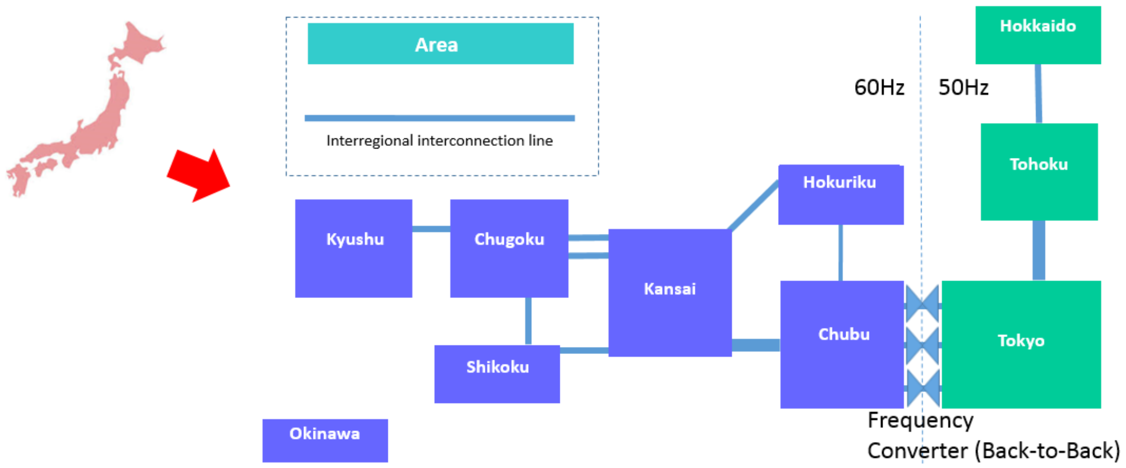
- C1 : In mountain area transmission line traverses route surrounded by NBCA areas. Suitable route is considered to traverse along low land area between two NBCAs.
- C2 : Suitable alignment should be by taking a detour northwardly or southwardly from Phialat substation in order to avoid passing through Phouphanang NBCA. In addition, route include urban area in Vientiane Capital. Thus, various restriction in view of environmental and social aspects.
- C3 : Candidate route is interconnecting between Dongphosy substation and Nong Khai substation (Thailand) and about 5 km in direct distanc. Interconnection is crossing over Mekong River is through overhead cable. Thus, any environmental and social impact is not expected.
- C4 : Candidate route is planned paralleling existing 115 kV transmission line . Thus, it is expected less restriction to land and assets by land and wayleaves acquisition.

Appendix 12-5_Transmission Business in Japan

Transmission Business in Japan

Overview of Transmission Business in Japan

Japan has no interconnection with other countries because of its background of being an island country. Instead, there are 10 power utilities operating with interconnections with one another. Furthermore, Japan has two types of frequency, 50Hz and 60Hz, since the 10 power utilities introduced generators imported from different countries which used either 50Hz or 60Hz. Currently, both 50Hz and 60Hz areas are connected via frequency converters to form a Back-to-Back system. Accordingly, the entire network can be operated as one power network as per the below.



Source: The JICA Team

Figure 7.2-6 Network Connections in Japan

Some power utilities have to coordinate as stakeholders in order to plan, construct and operate the interconnections. This situation would be similar to Laos's current one, where it faces the challenge of developing interconnections with other countries.

Hence, this section focuses on the history of procedures to gain agreement to develop interconnections with relevant utilities in Japan and the mechanisms for cost recovery.

Development of wheeling system in Japan

Japanese electric business areas are divided into 10 regions and the utilities in each region basically take charge of balancing demand and supply in their service area. The costs necessary to develop the network are recovered via a grid tariff through wheeling charges, taking into account a certain amount of revenue for utilities to secure a stable supply of electricity to aid the country's economic growth. The following is a description of the background to the development of the wheeling system.

Electric power reforms

Japan has implemented 5 electric power reforms since 1951, with the aim of lowering grid tariffs by introducing competition. Through these reforms, many entities other than conventional utilities have appeared, with the wheeling charge system thus being developed.

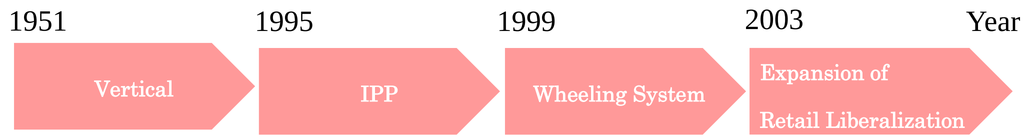


Figure 7.2-7 Electric power reforms

Vertical integration

For more than 40 years after 1951, Japan's electric power business was vertically integrated and conventional utilities took charge of all parts of the business, including generation, transmission, distribution and retailing. There were wholesale electric utilities in addition to conventional utilities acting as generation entities, attempting to develop energy resources efficiently when faced with electricity shortages after World War II. J-Power and The Japan Atomic Power Company were the only wholesale electric utilities; J-Power mainly developed hydro power and The Japan Atomic Power Company mainly developed nuclear power. Wholesale electric utilities could only sell electricity to conventional utilities, not to customers directly, so the power wheeling system had not appeared at this stage.

The grid tariff was regulated and calculated through the fully distributed cost (FDC) method, including an amount of business rewards permitted by METI.

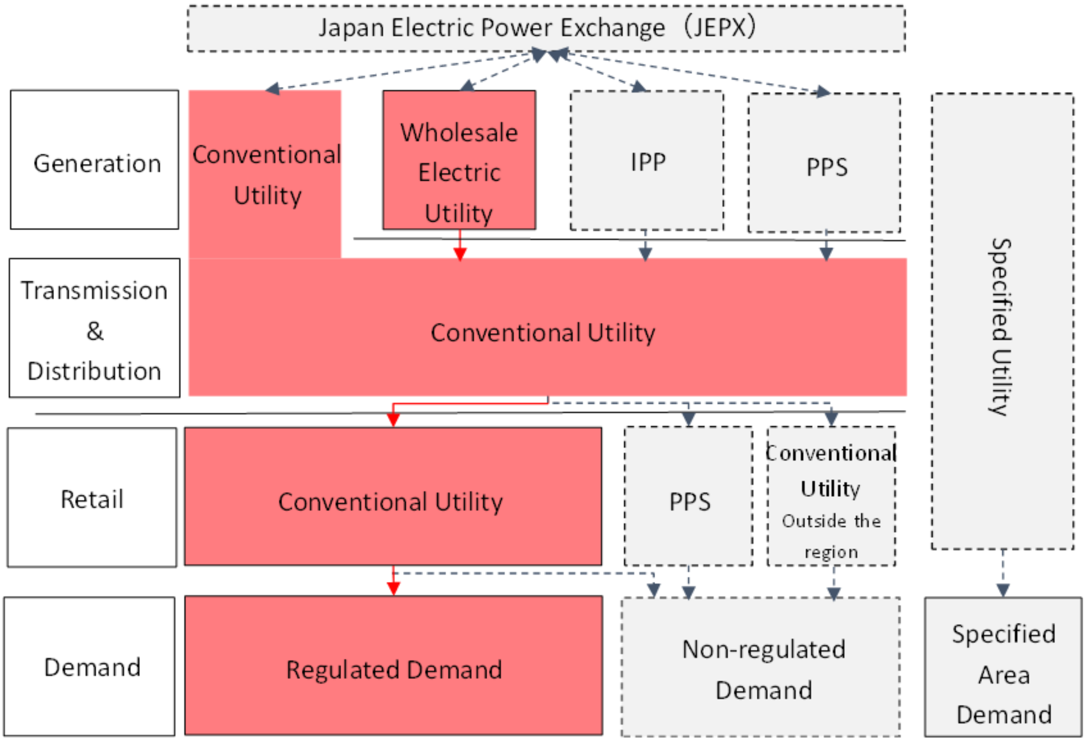
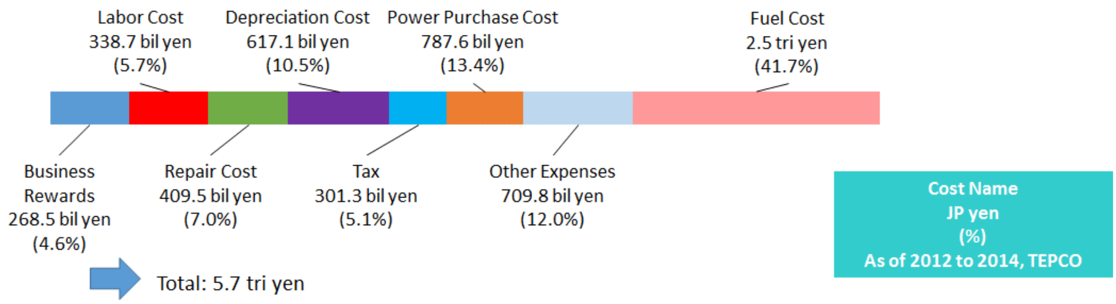


Figure 7.2-8 Transmission scheme (I)



Source: METI, Agency for Natural Resources and Energy

Figure 7.2-9 FDC

Appearance of IPP

Independent Power Producers (IPP) appeared with the liberalization of entry regulations to lower grid tariffs and improve national benefits through competition. At the same time, the specified utility system appeared, permitting entities to implement all business, through generation to retail, only in specific areas, such as industrial parks and military bases (Electric reform phase 1).

IPPs were also only permitted to sell electricity to conventional utilities, so the power wheeling system had not yet appeared at this stage either.

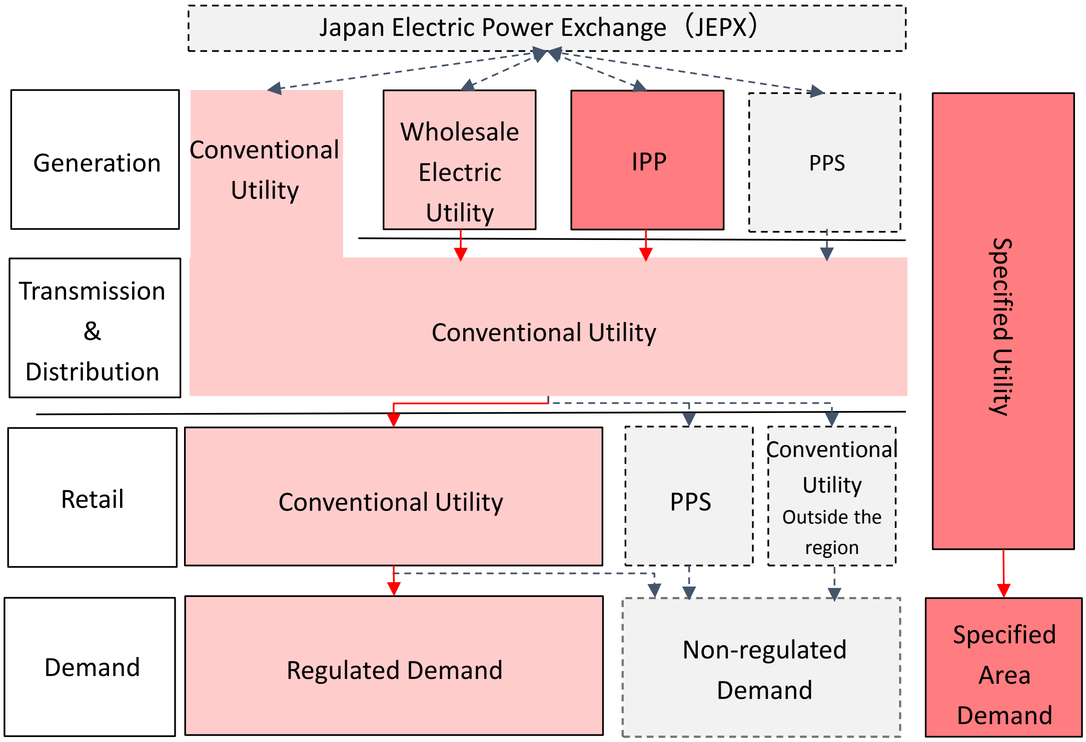


Figure 7.2-10 Transmission scheme (II)

Power supply line construction costs

When a conventional utility constructs a power supply line which the IPP uses to supply electricity to the conventional utility, the construction costs are basically borne by the IPP and the line is owned and operated by the conventional utility. If multiple IPPs jointly apply to use the power supply line, each IPP bears costs proportional to the capacity of the power plant which the IPP wants to connect to the utility's network. When an exclusive use power supply line first becomes a common use power line within 3 years after construction, the construction costs will be calculated again according to each power plant's capacity (METI Ordinance on power supply lines).

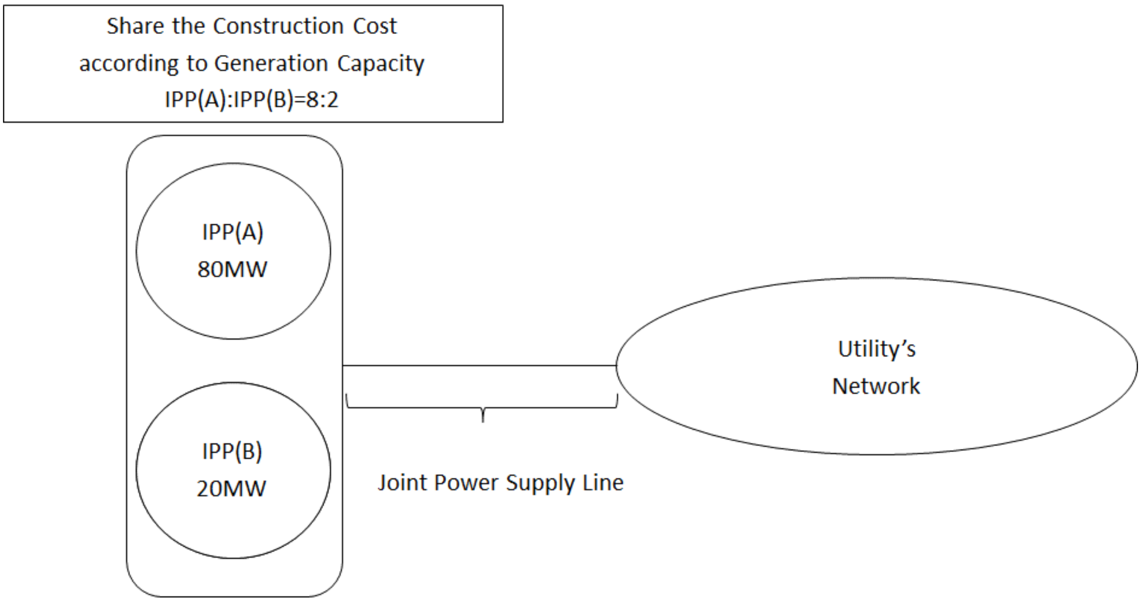


Figure 7.2-11 Power supply line costs

Appearance of power wheeling system

Power Producers and Suppliers (PPS) appeared with the partial liberalization of retail in 2000. Customers who receive electricity of 2,000kW or more, and 20kV or more, became able to select their power supplier freely due to this liberalization. PPSs did not have their own networks, so conventional utilities opened their networks and collected power transportation charges. With this, the wheeling system finally appeared.

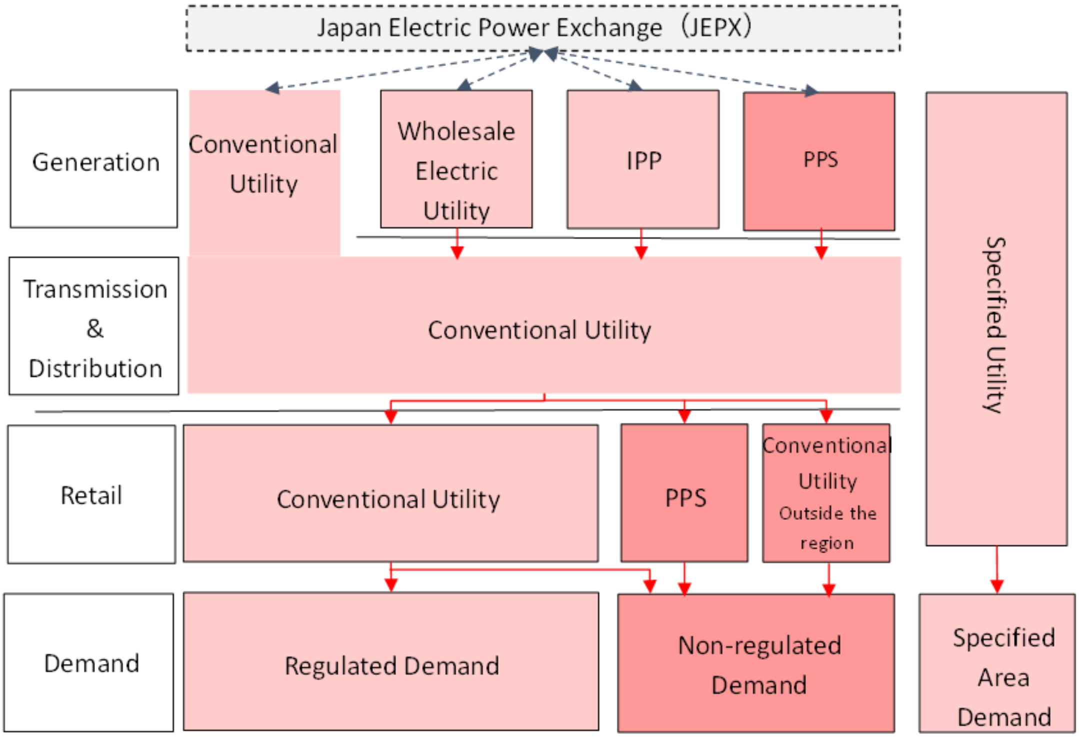


Figure 7.2-12 Transmission scheme (III)

Wheeling charges

Power transportation charges are regulated using the FDC method and calculated by dividing generation, transmission, distribution and retailing costs into each voltage level.

The grid tariff sets the capacity base and metered base according to the voltage class. The classes are: special high voltage (over 7,000V), high voltage (over 6,000V and under 7,000V) and low voltage (under 6,000V). Incidentally, all costs for power supply lines are collected at the time of construction so do not include the grid tariff. The method of calculation is stipulated in detail by ministerial ordinance.

As for transmission losses, the cost of losses is not included in the grid tariff, so a retail business entity has to secure preliminary supply capacity taking losses into consideration.

Collection method for wheeling charges

Japan adopts the postage stamp system, which charges a fixed wheeling charge according to the contracted capacity and consumption, regardless of the transmission distance, to collect the grid tariff, and each of the 10 conventional utilities has different prices.

Retail business entities collect wheeling charges from consumers as part of the grid tariff and then refund the transmission utility.

Deficiencies in power wheeling system

Customers buying electricity from outside the region had to pay two different types of cost, a transportation charge and a connection charge. This was called the pancake problem because charges accumulate like a pancake. Therefore, such a customer had to bear higher grid tariffs compared to one who buys electricity from inside the region. This disturbed the practice of wide-scale electricity transactions. In order to resolve the problem, utilize energy resources efficiently and promote wide-scale electricity transactions, the two types of charge were abolished and integrated into one charge, called the wheeling charge, in 2005 (Electric reform phase 3).

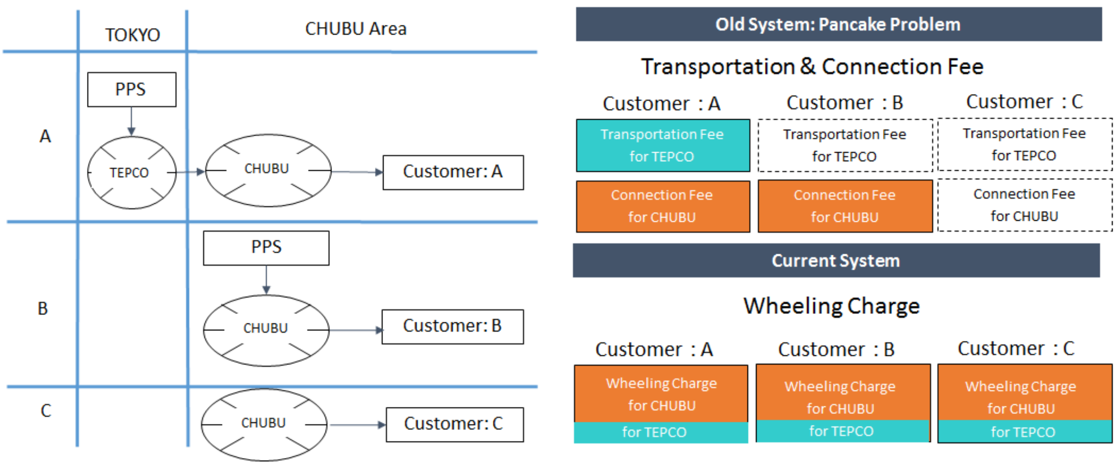


Figure 7.2-13 Pancake problem

Expansion of retail liberalization

For retail market liberalization, a decision was made to gradually expand the non-regulated range under the revision of electric business laws in 2003. In the revision, information blocking, prohibition of discriminatory treatment and accounting separation for conventional utilities were introduced.

・From April 2004: More than 500 kW demand

・From April 2005: More than 50 kW demand

・From April 2007: Commencement of study on full liberalization

(Full liberalization had been postponed at that time)

At the same time, the Japan Electric Power Exchange (JEPX) was created as a nationwide electricity market. Rules on how to use the power grid were also stipulated. In addition, the Electric Power System Council of Japan (ESCJ) was established as a neutral institution to conduct dispute resolution and so on (Electric reform phase 3).

A cabinet decision on the reform policy for the electric power system was taken in 2013. Full liberalization of retail, legal unbundling of transmission and distribution and establishment of the Organization of Cross regional Coordination of Transmission Operators (OCCTO) were incorporated in the decision. The work was split into the following 3 steps (Electric reform phase 5).

・From April 2015: Establishment of OCCTO

・From April 2016: Full liberalization of retail

・From April 2020: Legal unbundling of transmission and distribution

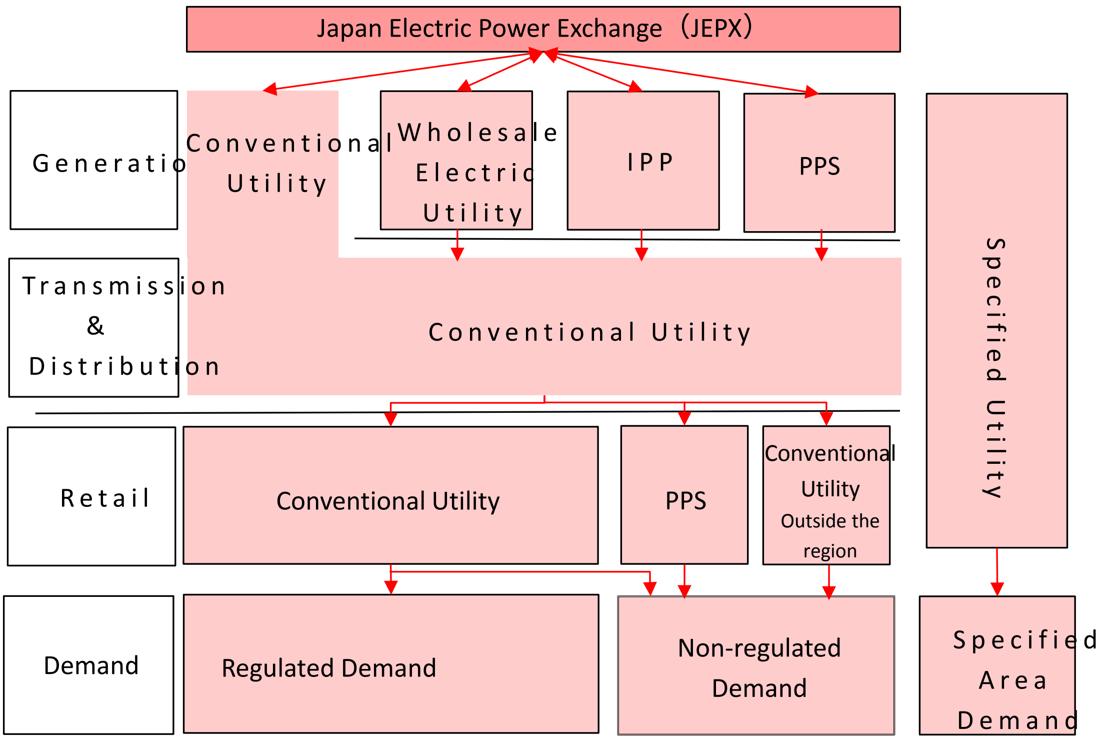
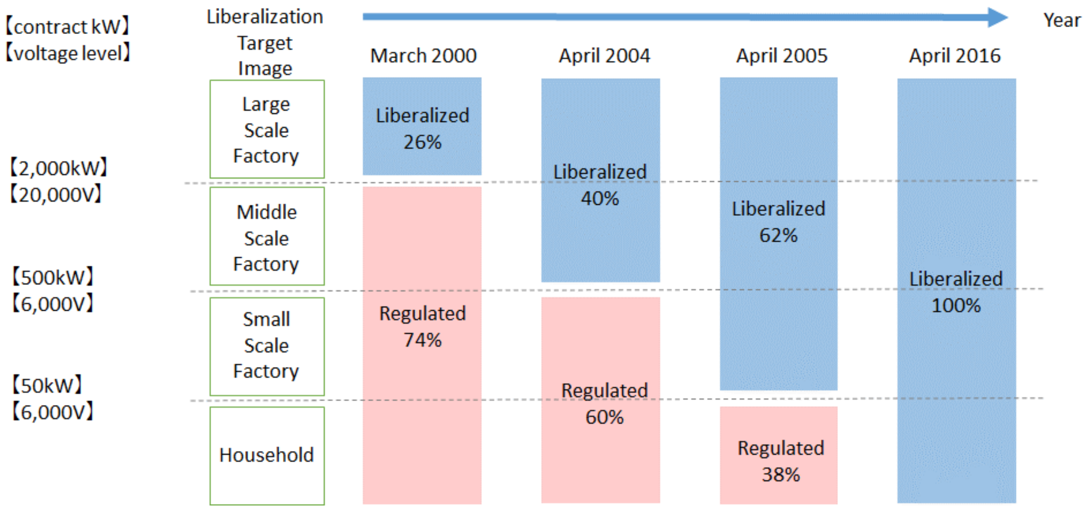


Figure 7.2-14 Transmission Scheme (IV)



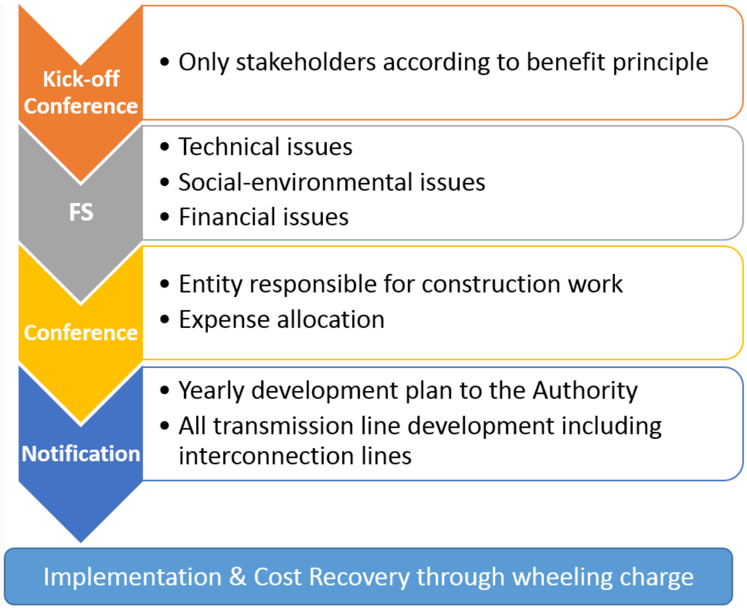
Source: METI, Agency for Natural Resources and Energy

Figure 7.2-15 Expansion of retail liberalization

Procedure to Develop Interconnections in Japan

The Electric Law in Japan recommended the reinforcement of more interconnection lines under vertically integrated utilities. It was simply a recommendation to develop them, not a legal instruction.

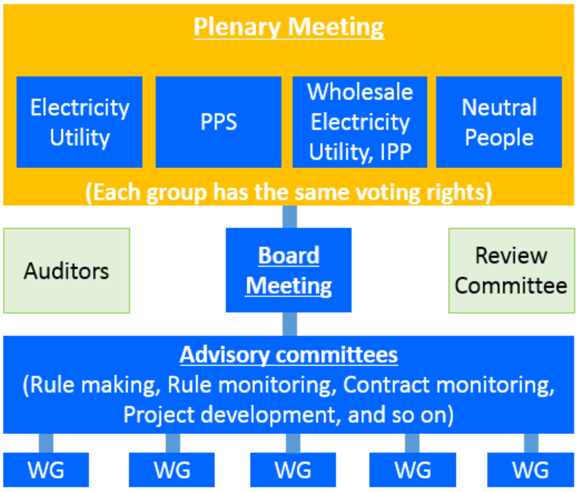
Each power utility compared the preferable development of either generation or interconnection to meet the increasing power demand in each service area, and mainly selected new generation development since they can operate generation plants without other stakeholders' involvement. This led to the fewest interconnections. In addition, triggers to start development of interconnection projects depended on each utility's decision. The crucial defect in this scheme was that there was no external organization to evaluate the utilities' development plans. The following shows the development procedure for interconnections as per the initial scheme.



Source: JICA Study Team

Figure 7.2-16 Development Procedure for Interconnections by Power Utilities (until 2004)

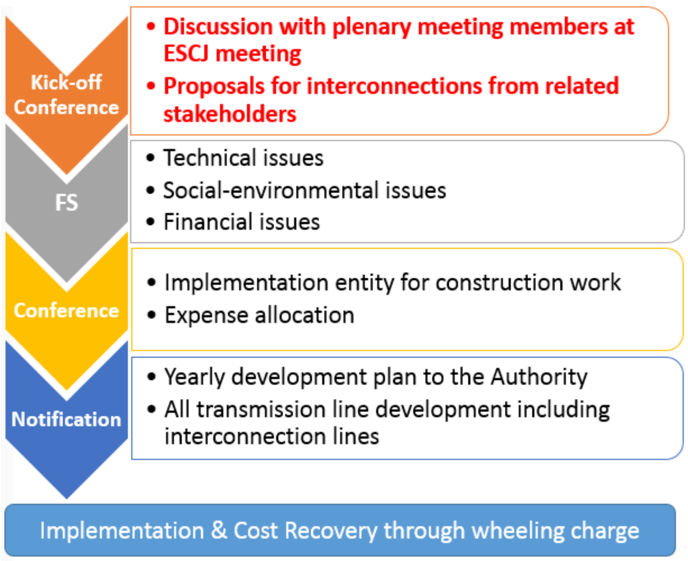
With the progress of the aforementioned power reform plan, the public and new stakeholders focused on the issue that only conventional utilities could evaluate the necessity of new interconnections, with no external monitoring. Hence, the Electric Law in Japan was amended, and the Electric Power System Council of Japan (hereinafter "ESCJ") was established in 2004. The main purpose of establishing the ESCJ was to develop fair and transparent rules for all stakeholders as a neutral organization. The following provides an overview of the ESCJ organization.



Source: JICA Study Team

Figure 7.2-17 ESCJ Organization

All participants as ESCJ members, which were selected through applications from conventional utilities, PPSs, IPPs and academic experts in neutral positions, have the same voting power for every decision. This means the ESCJ became a fairer organization for solving the aforementioned defects (decisions via closed discussions involving only conventional utilities). The ESCJ was in charge of all issues related to transmission business, such as the development of rules for transmission business, and the monitoring of rule compliance. Furthermore, the range of entities able to propose new interconnection developments could be expanded to ESCJ members, including PPSs and IPPs, not only conventional utilities. The following shows the development procedure for interconnections through the ESCJ.



Source: JICA Study Team

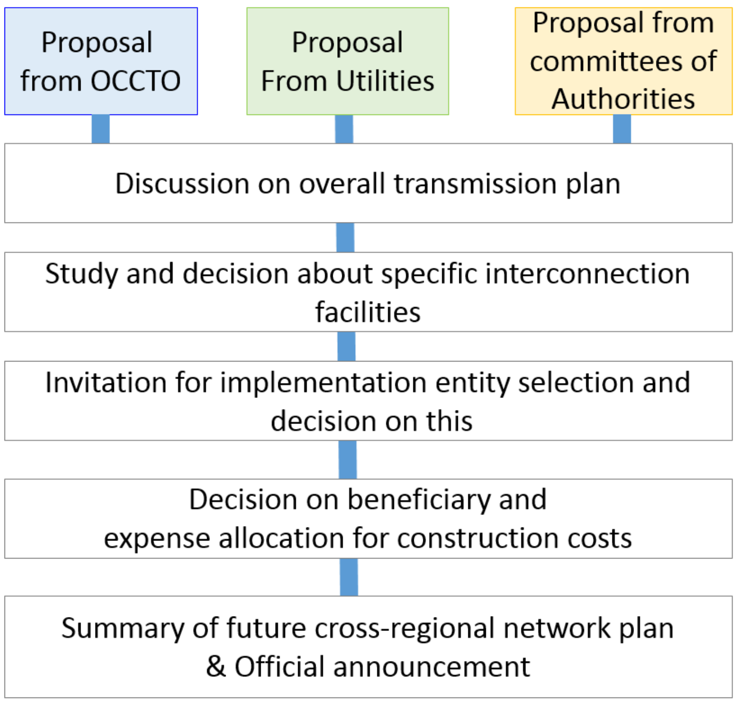
Figure 7.2-18 Development Procedure for Interconnections by ESCJ (from 2004 to 2015)

The red text in the above figure shows the improvements from the previous system. Each conventional power utility had to follow the ESCJ's decisions under this development scheme. Accordingly, the utilities had to undertake planning, design and procurement work, and were able to recover expenses through the wheeling charges.

As mentioned, the development procedure for interconnections under the ESCJ was clearer and more transparent. However, there remained the problem that the ESCJ could not evaluate the plans, construction methods and expense calculations developed by the conventional utilities.

With the progress in the power reform plans, including full liberalization of the retail market and unbundling, neutral organizations with stronger powers were proposed in order to maintain a reliable network after unbundling. Hence, the Organization of Cross-regional Coordination of Transmission Operators, Japan (hereinafter "OCCTO") was established as a successor to the ESCJ in 2015.

There are two main improvements with OCCTO compared to the ESCJ: i) all stakeholders must join OCCTO, and ii) OCCTO can designate specific methods to all members for transmission-related business, including for interconnection development. The following shows the development procedure for interconnections through OCCTO.



Source: JICA Study Team

Figure 7.2-19 Development Procedure for Interconnections at OCCTO (from 2015 to the present)

After OCCTO's establishment, all stakeholders, as OCCTO members, and the authority's committee became able to propose interconnection developments through OCCTO. Some problems with the ESCJ were also solved, with procedures becoming clearer. As an example, the organization in charge of feasibility studies and construction work for interconnection development is specified through applications by OCCTO members, not conventional power utilities. OCCTO then makes all final decisions.

The following shows the changes in procedure for interconnection development in Japan.

Table 7.2-1 Summary of Procedures for Interconnection Development in Japan

	Phase I: Utilities	Phase II: ESCJ	Phase III: OCCTO
Compatibility with Long term planning for whole of Japan	N/A	N/A	✓
Proposer for interconnection line	Utilities	Utilities ESCJ	Utilities OCCTO National policies
Implementation entity for construction work	Related utilities as beneficiary	Related utilities as beneficiary (No ESCJ involvement)	Selection through application from all OCCTO members
Expense allocation for construction work	Related utilities as beneficiary	Related utilities as beneficiary (No ESCJ involvement)	OCCTO's decision based on benefit principle
Cost recovery	Wheeling charge	Wheeling charge	Wheeling charge

Simply speaking, the procedures for decision making have been shifted from "closed discussion with selected members" to "open format with all stakeholders." Since an interconnection is a common facility for relevant stakeholders, the development procedure has been modified considering the increased number of stakeholders appearing due to the progress of power system reforms, such as PPS and IPP. Hence, the current procedure might be modified to create a more suitable scheme in future if there is further progress, or changes surrounding the power system network.

The number of interconnection projects in Japan is fewer than in Europe and Asia. Additionally, OCCTO does not specify criteria for evaluating each project from social, environmental, technical and financial points of view. OCCTO evaluates the expected benefits by comparing some cases with and without each project.

Interconnection development in Laos would be mainly a country-to-country project. Hence, methods that differ from the Japanese case, and that are more suited to the Laos case, might be required. However, the policy in Japan, namely that OCCTO is still attempting to develop a more transparent method as decision maker for the process, should be followed. Accordingly, a suitable organization for the Asian grid should be responsible for decisions and the development of interconnections, and it should maintain a proactive attitude in order to identify more suitable and transparent methods