CHAPTER 5 CONFIRMATION OF THE ROLE OF NAM NGUM 1 HYDROPOWER EXPANSION IN UPDATED POWER SUPPLY AND DEMAND

5.1 PRESENT CONDITION OF NN1 HYDROPOWER STATION

5.1.1 History of NN1 Hydropower Development

The Nam Ngum 1 (NN1) hydropower station was constructed having a capacity of 7 billion m^3, which is the largest reservoir size in Laos. The NN1 hydropower station started generating electricity with an initial 30 MW power capacity in 1971. The NN1 hydropower station has been expanded twice to produce 110 MW in 1978, and 150 MW in 1984 in order to meet the increasing power demand in the central area. The present installed capacity is 155 MW. The plant factor of the power station was at 66% in the beginning of its operation. Plant factor further was increased to 74% due to the increase of inflow to the reservoir from the Nam Son diversion which was constructed in 1995 and the Nam Leuk Hydropower Project that was developed in 2000. The increment of inflow to the NN1 reservoir by Nam Son diversion and Nam Leuk hydropower station are at 65 m^3/s and 15 m^3/s, respectively. The principal features of NN1 hydropower station are shown in Table 5.1.1.

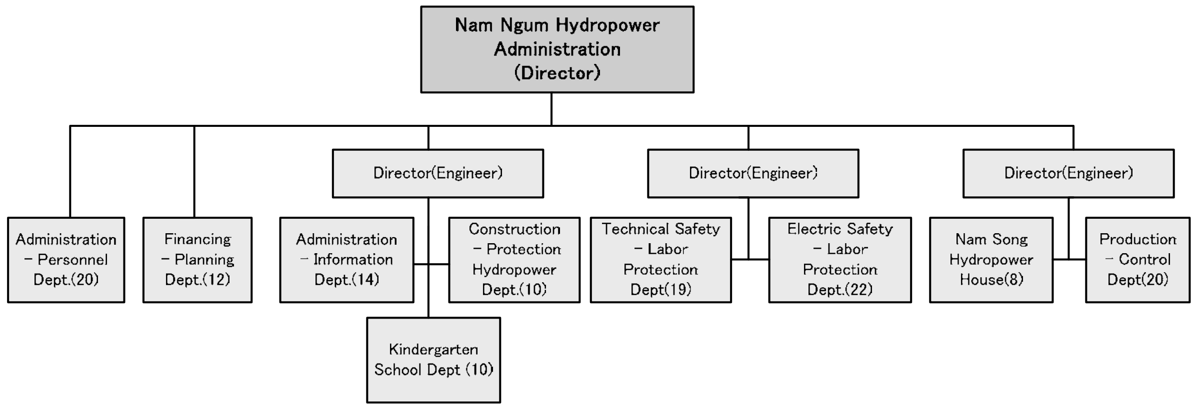
Table 5.1.1 Principal Features of the Nam Ngum River Basin and NN1 Hydropower Station

Feature	Data	Description
River Basin Area	8,460 km^2	Nam Ngum basin only
Annual Average Inflow	382 m^3/s	Including inflows from Nam Song diversion and Nam Leuk hydropower station (Average for 2001-2008)
Installed Capacity	155 MW	Unit 1, 2 : 17.5 MW x 2, Unit 3, 4, 5 : 40 MW x 3
Max. Plant Discharge	465.3 m^3/s	57m^3/s x 2, 117.1 m^3/s x 3
Reservoir Capacity	7.03 billion m^3	at W.L. 212.0 masl
Reservoir Area	370 km^2	at W.L. 212.0 masl
Dam Height	75 m	Concrete Gravity Type
Dam Length	468 m	-
Dam Volume	360,000 m^3	-

Prepared by the Study Team

5.1.2 Organization of NN1 Hydropower Station

Figure 5.1.1 shows the organizational chart of NN1 hydropower station. The administration system consists of nine departments under three directors. One of the nine departments is in charge of works related to NN1 hydropower station operation.



Source: NN1 power station

Figure 5.1.1 Organizational Chart of the NN1 Hydropower Station

5.1.3 Role of NN1 in Power Generation in the Central Area

The NN1 hydropower station is being operated to meet the power demand in the central area through the coordination with EDL-Gen power station for the operation of the Nam Leuk hydropower station and Nam Mang 3 hydropower station. In 2010, the IPP(d) hydropower project of Nam Lik 1/2 started its operation aiming to supply electricity to the central area. The principal feature of existing power stations for power supply for the central area other than NN1 hydropower station is shown in Table 5.1.2.

Table 5.1.2 Principal Features of Existing Hydropower Station Other Than NN1 in Central Area

Item/project		Nam Leuk	Nam Mang 3	Nam Lik 1/2
Purpoose		Domestic	Domestic	IPP (Domestic)
Status		Existing	Existing	Existing
Main Developer		EDL	EDL	China International Water & Electric Corp.
Planened Commencement of Power Generation		2000	2004	2010
Principal Feature				
Catchment area	(km^2)	274	65	1993
Storage at FSL	(MCM)	154	45	1095
Average annual inflow	(MCM)	438	-	2690
Type of dam		Rockfill	RCC	CFRD
Dam hieght	(m)	46.5	22	101.4
Design flood of spillway	(m^3/s)	2100	57	2080
Powerhouse		Above ground	Above ground	Above ground
Rated output	(MW)	60	40	100
Max. plant discharge	(m^3/s)	63	9.1	160.6
Average annual energy	(GWh)	230	134	395

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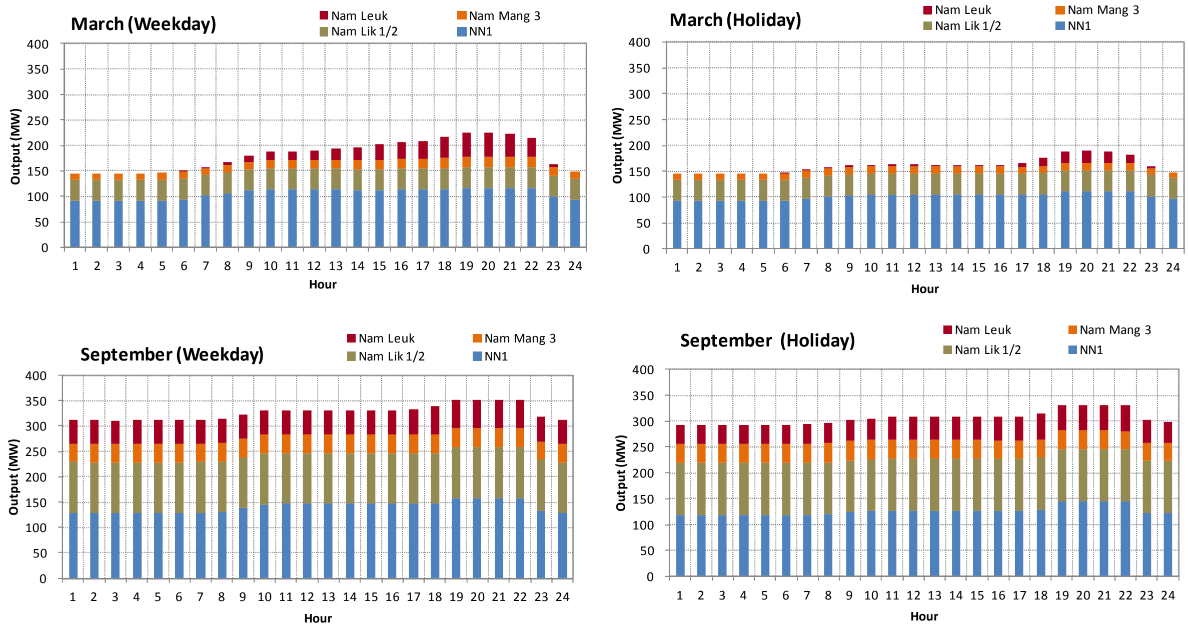
The average of hourly power output of the hydropower stations in March (dry season) and September (wet season) is shown in Figure 5.1.2.



Prepared by the Study Team

Figure 5.1.2 Power Generation Pattern of NN1 and Other Existing Hydropower Station

As shown in the figure, NN1 hydropower station operates for the base load power supply as well as peak load power supply during dry season. NN1 hydropower station still supplies the majority of electricity in the central area especially during dry season.

5.1.4 Development of Water Resource in the Upstream of NN1

The upstream of NN1 dam is intensively developed and is used mainly for hydropower project. The hydropower development in the Nam Ngum River basin is shown in Figure 5.1.3.

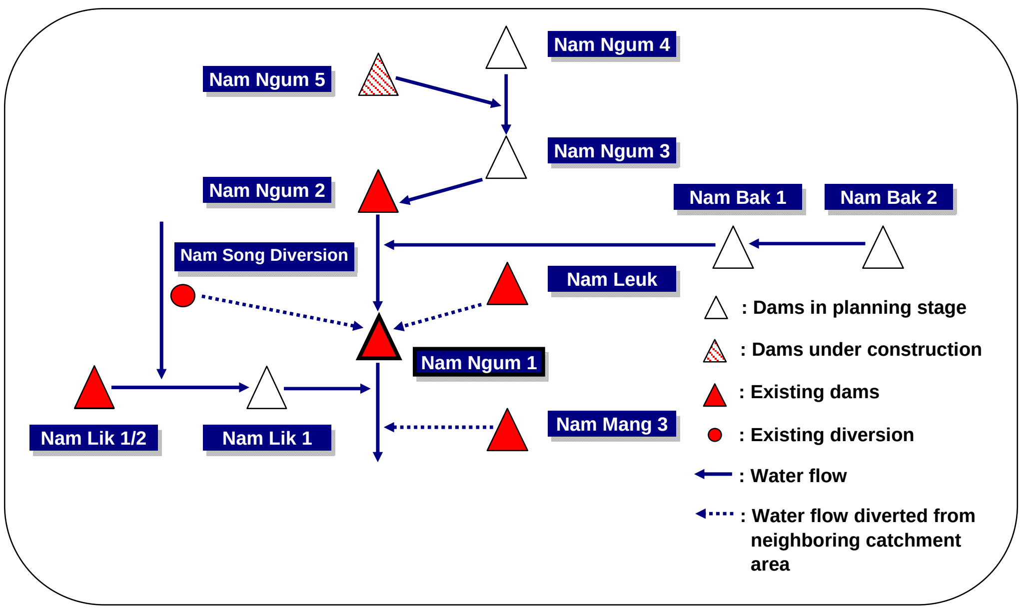


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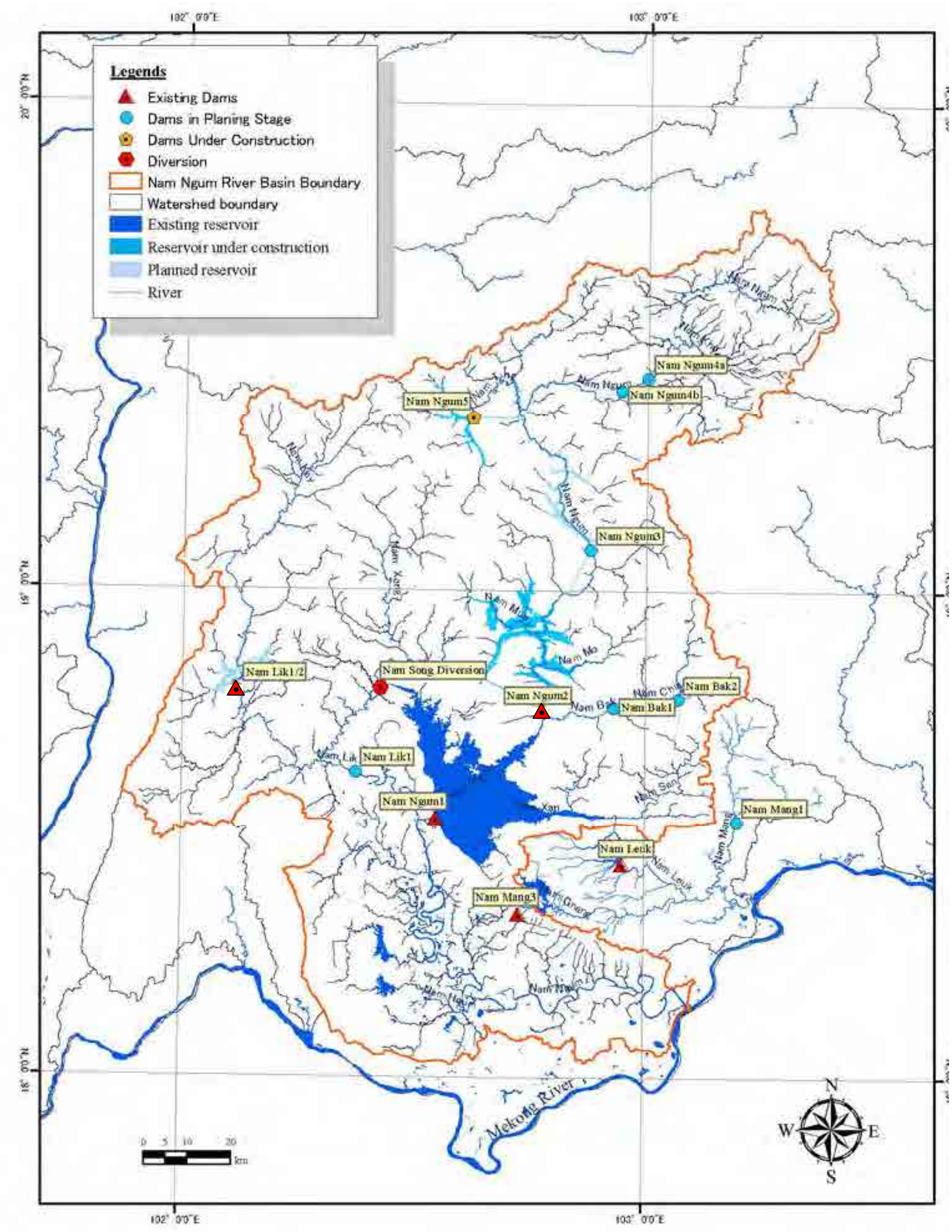
Figure 5.1.3 Hydropower Development in the Nam Ngum River Basin

The location map of the NNRB development is shown in Figure 2.2.5 and reiterated in below.



Source：Preparatory Survey on Nam Ngum 1 Hydropower Station Expansion

Location Map of Hydropower Stations in NNRB

In 2010, the Nam Ngum 2 (NN2) Hydropower declared its initial operation day (IOD) and started operation for hydropower generation. So far, NN2 has not declared a commercial operation day (COD), therefore, NN2 operation does not meet operation requirements stipulated in the PPA. It is expected that the operation of NN2 will be changed after the COD which is expected by the end of 2012 or January 2013. The actual operation of the NN2 in compliance with the PPA is still unknown during this study unless NN2 states COD. Therefore the impact of the NN2 operation to NN1 reservoir cannot be determined yet.

The principal feature of the planned/existing hydropower development in the upstream of NN1 is shown in Table 5.1.3.

Table 5.1.3 Principal Features of Planned Hydropower Station in Upstream of NN1

Items \ Project	Nam Ngum 2	Nam Ngum 3	Nam Ngum 4	Nam Ngum 5	Nam Bak 1	Nam Bak 2
Purpose	IPP (Export)	IPP (Export)	IPP (Export)	IPP (Domestic)	IPP (Export)	IPP (Domestic)
Status	Existing	PPA Signed	Pre-F/S	Under construction	Pre-F/S	Pre-F/S
Main Developer	Southeast Asia Energy Limited (Thailand)	GMS Power	Saigon Invest Group	NN5PC	Southeast Asia Energy Limited (Thailand)	Southeast Asia Energy Limited (Thailand)
Planned Commencement of Power Generation	December 2010	-	-	2012	-	2015
Principal Feature						
Catchment area (km_2)	5,640	3,888		483	597	320
Storage at FSL (MCM)	2,617	1,407		314	250	190
Average annual inflow (MCM)	6,270	3,090		719	750	400
Type of dam	CFRD	RCC		RCC	RCC	RCC
Dam Height (m)	181	220	125	99	83	85
Design flood of spillway (m^3/s)	10,855	7,900		3,231	1800	963
Powerhouse	Above ground	Underground		Semi-ground	Semi-ground	Semi-ground
Rated output (MW)	615	440	185	120	115	68
Average annual energy (GWh)	2,310	1,919	748	400	600	357

Prepared by the Study Team

5.1.5 Updating Hydrology

(1) Annual Precipitation

The annual rainfall observed in the NN 1 hydropower station is shown in Figure 5.1.4.

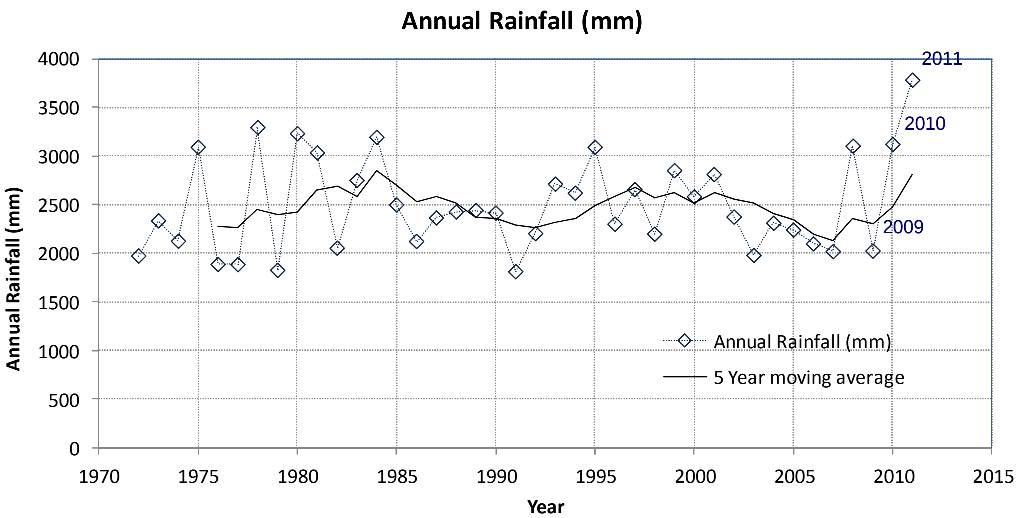


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Figure 5.1.4 Observed Annual Rainfall at NN1 Hydropower Station

It is noted that the annual rainfall observed in 2011 recorded the highest amount since NN1 commenced its operation in 1972. The annual rainfall in 2010 and 2011 were higher than the average of 2500 mm a year.

(2) Inflow Update

The inflow data is received from the NN1 power station. The inflow collected into the NN1 reservoir for the past five years is shown in Figure 5.1.5.

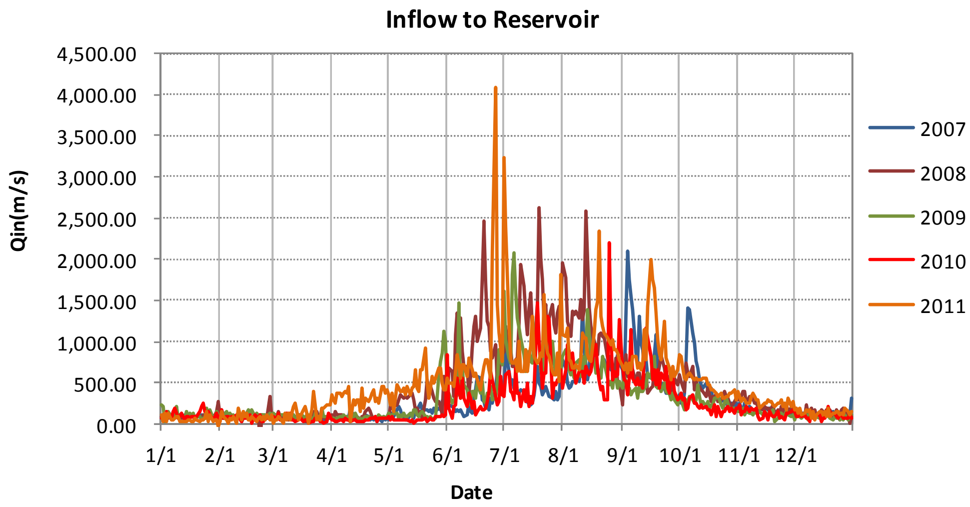

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Figure 5.1.5 Observed Inflow into NN1 Reservoir

The annual average of inflow to the NN1 reservoir is shown in Table 5.1.4.

Table 5.1.4 Annual Average of Inflow to NN1 Reservoir

Year	Average Inflow (m^3/s)
2007	288
2008	449
2009	309
2010	247
2011	476

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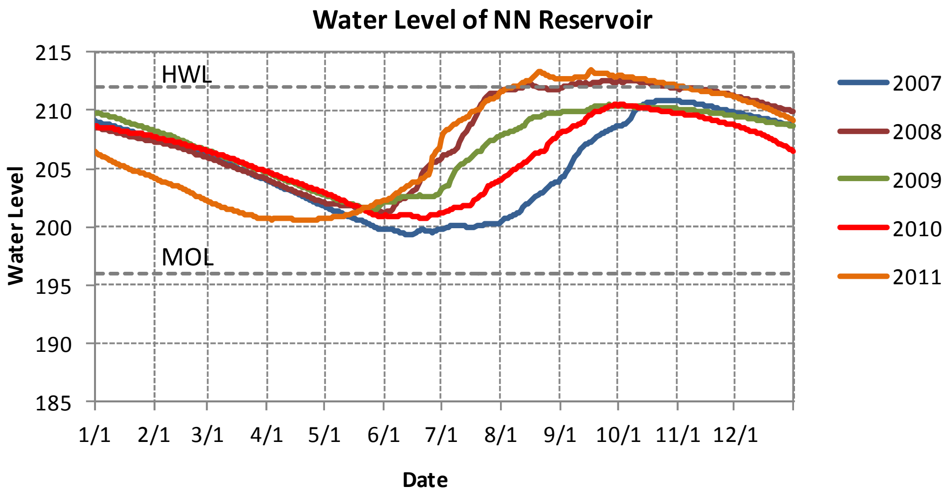
As shown in the table, the inflow into NN1 reservoir was the largest in 2011. It is noted that the inflow to the reservoir in 2010 was the smallest as compared to other years. In 2010, NN2 implemented the impounding of the reservoir. Water was not released from NN2 during the impounding. During that time, NN1 received water from the diversion from Nam Leuk, Nam Song diversion weir, and intermediate basins between NN1 dam and NN2 dam.

5.1.6 Reservoir Operation and Power Generation

(1) Reservoir Operation

The reservoir operation record of NN1 is shown in Figure 5.1.6.



Prepared by the Study Team

Figure 5.1.6 Reservoir Operation Record of NN1 Reservoir

It is noted that the water level in wet season in 2010 was relatively lower than those of the other years due to the impounding done at NN2 reservoir. In 2011, the starting water level is lower than other years since the water level could not be recovered during the year 2010 due to impounding of NN2. However, the water level was quickly recovered to HWL in 2011, due to the largest rainfall ever recorded that year.

(2) Power Generation

The power generation for the past five years are shown in the table below.

Table 5.1.5 Monthly and Annual Energy Production

(Unit; GWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007	72	71	83	80	73	58	76	63	58	63	80	72	852
2008	68	66	80	80	89	96	117	122	125	129	88	86	1,146
2009	84	82	83	76	71	78	109	121	105	93	58	57	1,017
2010	61	58	72	66	72	63	49	56	79	84	71	100	832
2011	85	73	72	68	68	68	116	128	125	128	112	110	1,154
Avergae	74	70	78	74	75	73	93	98	98	100	82	85	1,000

Prepared by the Study Team

As shown in the Table 5.1.5 above, the annual energy was largest in 2011 and the annual energy was smallest in 2010 due to the NN2 impounding.

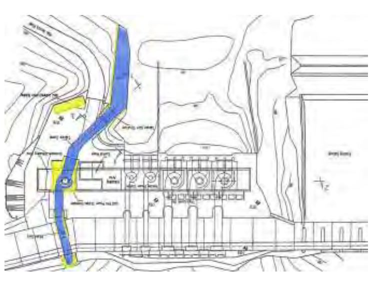
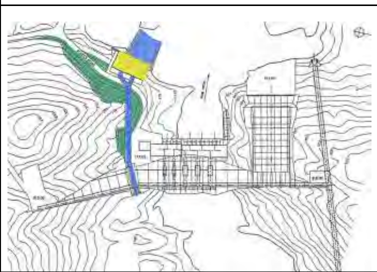
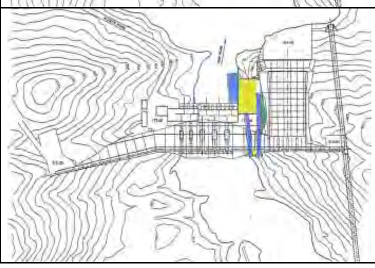
5.2 OUTLINE OF NN 1 HYDROPOWER STATION EXPANSION

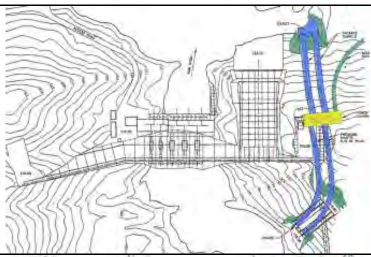
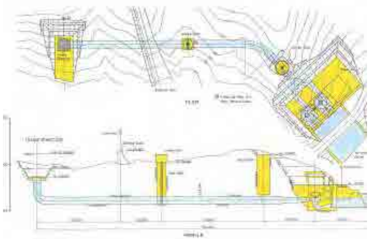
In this chapter, the contents of the preparatory survey on the Nam Ngum 1 hydropower station expansion in 2010 is briefly explained.

(1) Selection of Optimum Scale of Expansion

In the preparatory survey on NN1 expansion in 2010, the following eight alternative plans were considered.

Table 5.2.1 NN1 Expansion Plans Considered in the Preparatory Survey (2010)

Alternative	Layout	Design Outline	Nos. of Unit	Installed Capacity	Remarks
A1- A3		An additional unit block is arranged between the spillway and the existing powerhouse. A penstock is built in a horizontal hole excavated through the existing concrete dam and an intake entrance is fixed on the upstream face of the dam.	1	40 MW to 80 MW	Layout finally selected in the F/S（40 MW） A1:40 MW A2:60 MW A3:80 MW
A4		An additional unit block is arranged outside the southern end of the existing control building. Penstock and intake arrangement for the additional unit is similar to that in Alternatives A1-A2. Turbine water of the additional unit is discharged to the tail bay through a culvert or tunnel.	1	40 MW & 60 MW	One of the alternative layouts in the F/S
B1		A new powerhouse building is arranged on the left bank of the existing tail bay and set perpendicular to the existing powerhouse. Although the penstock and intake arrangement is similar to that in Alternative A4, the length of the penstock is longer than in Alternative A4.	2	80 MW	One of the alternative layouts in the F/S
B2		A new powerhouse building is arranged on the left bank downstream of the existing tail bay. Although the penstock and intake arrangement is similar to that in Alternative B1, the length of the penstock is longer.	2	80 MW	One of the alternative layouts in the F/S
C		A new powerhouse building to accommodate two additional units is arranged in the space between the spillway and tail bay. Two sets of intake tower and penstock are built, each similar to that in Alternative A1.	2	80 MW	One of the alternative layouts in the F/S

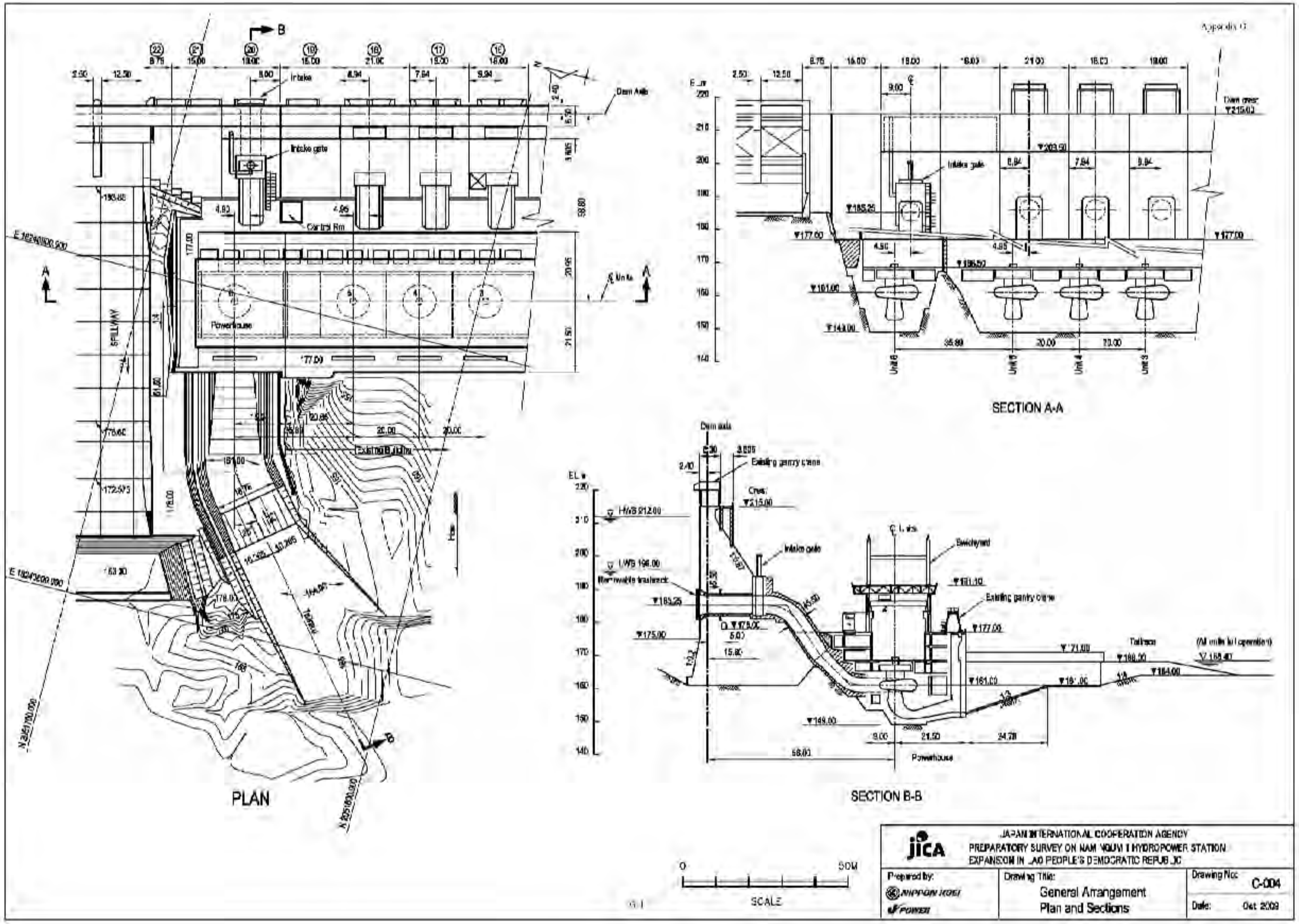
Alternative	Layout	Design Outline	Nos. of Unit	Installed Capacity	Remarks
D1		A new underground powerhouse is arranged in the right abutment hill. The originally constructed diversion tunnel is intended to be utilized as one of two headrace tunnels. New intake structures are independent from the existing dam	2 or 3	80 MW and 120 MW	One of the alternative layouts in the F/S
D2		A new surface type powerhouse is arranged on the right bank of the spillway plunge pool. Similar to D1, the diversion tunnel is intended to be utilized as one of two headrace tunnels. New intake structures are independent from the existing dam.	2 or 3	80 MW and 120 MW	One of the alternative layouts in the F/S
E		An independent intake tower is built in the reservoir upstream of the left bank dam. A headrace tunnel crossing the dam foundation is extended from the intake to a new powerhouse located downstream of the ridge similar to Alternative B2.	2 or 3	80 MW and 120 MW	New additional alternative

Source: Preparatory Survey on Nam Ngum 1 Hydropower Station Expansion (2010)

Among the eight alternative plans, four were selected, namely, A1-A2, A4, B2, and D2. This was done through the screening in regards to its geological characteristics, impact to existing dam and power plant, environment, and economical aspects.

Finally, the 40 MW expansion plan (A1) was selected as the most optimum expansion scale considering the economical and financial B/C ratios, stability analysis of load flow, environmental impacts, and construction method.

In the preparatory survey, basic design was conducted for the expansion plan. The plan and section of the 40 MW expansion plan is shown in Figure 5.2.1.



Source; Preparatory Survey of the Nam Ngum 1 Hydropower Station Expansion (2010)

Figure 5.2.1 Nam Ngum 1 Expansion Plan (Additional Unit No.6) in the Preparatory Survey in 2010

(2) Role of NN1 Expansion in Power Supply in the Central Area

The role of NN1 hydropower station expansion in power supply in the central area is;

1) To enable to meet the increasing power demand especially during night peak hours, the expansion of NN1 hydropower station enables to shift off peak energy during peak hours by utilizing the massive NN1 reservoir capacity.
2) To enable NN1 power plants with low cost maintenance as the operation hours per unit is decreased.
3) To enables EDL to export surplus power to EGAT during rainy season. The capacity of interconnection between the EGAT and EDL grid is planned to be reinforced from 100 MW to 600 MW in 2016.

(3) Reservoir Operation Plan

The expansion of NN1 hydropower station increases the flexibility of reservoir operation. The current annual energy production of NN1 is 1012 GWh and is expected to increase to 1071 GWh (59 GWh increase) after the NN2 completion. Also, the NN1 expansion will produce annual energy of 1127 GWh (56 GWh increase with NN2 case without expansion).

(4) Environmental and Social Considerations

Unlike the new hydropower scheme, the expansion of the existing NN1 hydropower station will have no significant environmental and social impact. This is because no additional reservoirs or transmission lines by the expansion.

The influence to the downstream environment due to the expansion would be the change in the water level fluctuation before and after expansion. The preliminary hearing survey for local inhabitants, and the hydraulic calculation was conducted in the preparatory survey. Results showed that the water level fluctuation was within the allowable level. The IEE was prepared and Environmental Compliance Certificate (ECC) was issued upon the completion and approval of IEE.

(5) Project Cost and Implementation Schedule

The project cost for the expansion was estimated to JPY 7006 million on the currency basis and price level as of August 2008. The construction period was estimated at 36 months (3 years), and commercial operation is expected in 2015.

(6) Economic and Financial Analysis

The economic analysis of expansion plan assumed the thermal power plant as an alternative power source. EIRR was calculated at 17.68% thus, it was economically feasible. However, the financial analysis resulted in that the FIRR of 2.75%. This is due to that the electricity tariff in Lao PDR was set to low level. Therefore, the survey concluded that expansion of NN1 is financially feasible only when the project was given a soft loan with low interest rate.

5.3 ROLE OF EXPANDED NN1 HYDROPOWER STATION IN UPDATED POWER SUPPLY AND DEMAND IN THE CENTRAL AREA

5.3.1 General

In this chapter, the expanded NN1 hydropower station operation is simulated using its updated inflow series up to 2011. The purpose of the simulation is to confirm the role of expanded NN1 station in the updated power supply and demand balance. The added inflow series are described in Section 5.1.4. The reservoir operation rule for the Study is the one applied in the Preparatory Survey in 2010. The power generation simulation was conducted using the inflow series from 1972 to 2011.

The construction of the NN1 expansion is considered to be completed in 2017. In 2017, the following supply and demand balance conditions are anticipated:

- The large scale IPP(d) hydropower will be developed in the northern area.
- Estimating power generation pattern in the northern area shows that the power generation will be 24-hour base load power supply. Thus, the power coming from the northern area forms as the base load supply in the central area.
- Importing power from the northern area will be reduced during peak hours due to consumption in the northern area. This will also be the case to the power coming from the southern area.

The expected power supply and demand balance in the central area after 2017 is shown in Figure 5.3.1.

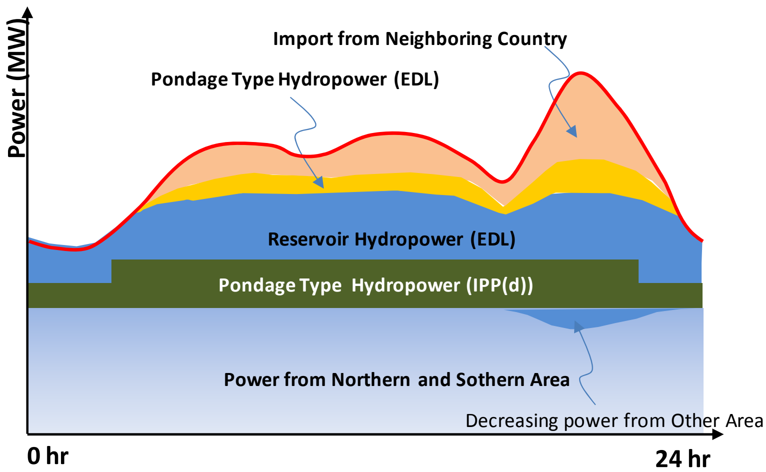


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Figure 5.3.1 Concept of Expected Power Supply and Demand Balance in the Central Area

The power generation simulation is carried out for the NN1 power station for the years 2017, 2020 and 2025. For the simulation of 2017, the operation rule for 2015 which was developed in the preparatory survey was tentatively used.

5.3.2 Power Generation Simulation

(1) Reservoir Operation

The power generation simulation was carried out using the inflow series from 1972 to 2011 for the case with a 40 MW expansion and without a 40 MW expansion. The simulated reservoir water level for with and without the 40 MW expansion for the year 2017, 2020, and 2025 is shown in Figure 5.3.2.

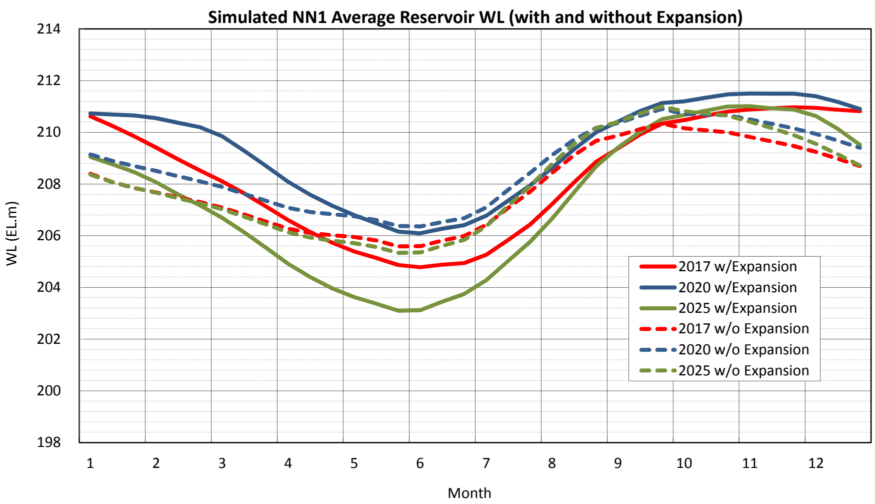

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Figure 5.3.2 Simulated Reservoir Water Level of NN1 with and without Expansion

The figure shows that the NN1 reservoir operation with 40 MW expansion case changes to lower the water level during the dry season so as to generate power in that season. By the end of the wet season, the water level is higher for the without expansion case to keep the water for the dry season.

The result of the water level was compared to the previous preparatory survey in 2010. The results of the Study on the reservoir water level of NN1 reservoir with expansion case and preparatory survey are shown in Figure 5.3.3.

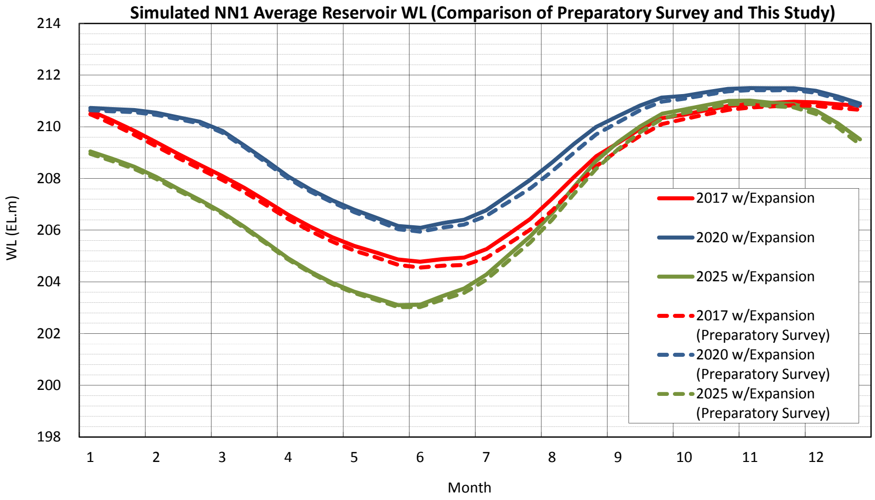

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Figure 5.3.3 Comparison of Reservoir Water Level between This Study and Previous Preparatory Survey

The water level in this Study was slightly higher than those in the preparatory survey. This was due to including the 2011 flood event.

(2) Hourly Power Output

The daily power output pattern on weekdays and holidays is shown in Figure 5.3.4.

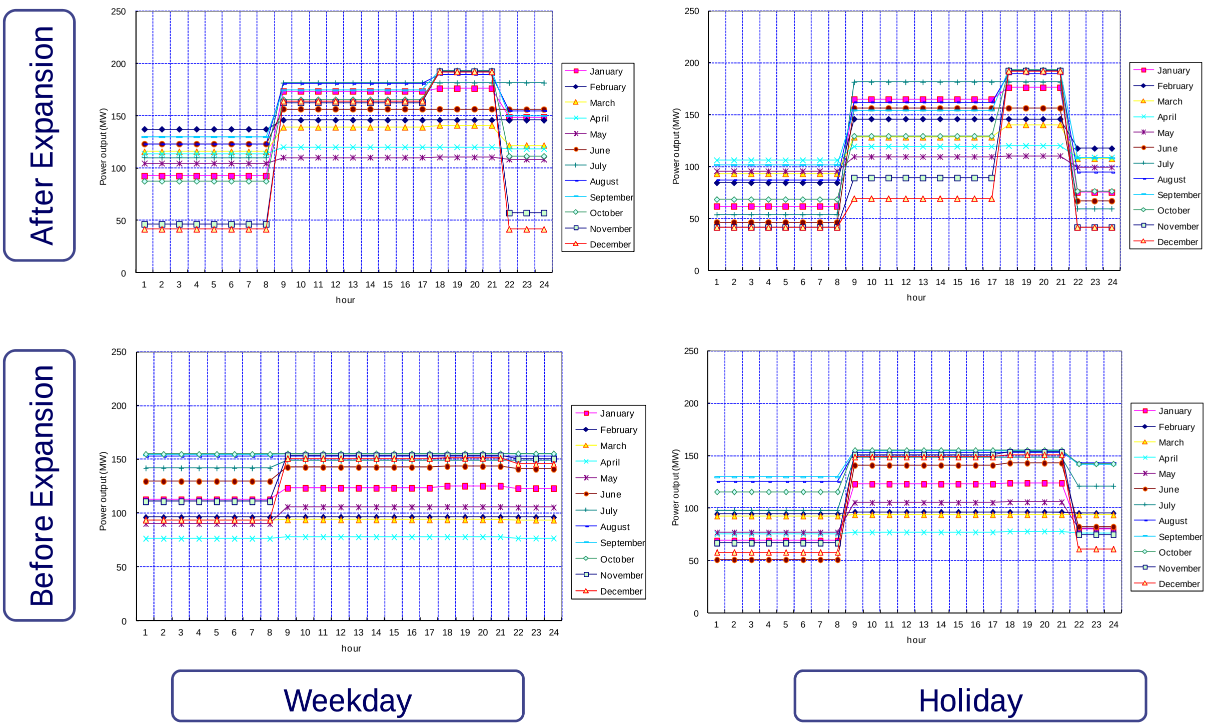

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Figure 5.3.4 Hourly Average Power Output of the NN1 Hydropower Station

As shown in the figure, the NN1 operation is change to peak power supply especially during dry season. The off-peak power output is decreased to 40 MW. The 40 MW generation is required by environmental aspect to release water equivalent to 40MW during the off-peak hours.

(3) Annual Energy

The power and energy output for with and without 40 MW expansion are shown in Table 5.3.1.

Table 5.3.1 Calculated Annual Energy and Dependable Power

Before Expansion with NN2

Year	Anual Energy (GWh)	Average Energy		Dependable Energy Weekday		Dependable Capacity (MW) (95%)							
		in Peak hours (GWh)	in Off-Peak hours (GWh)	Night Peak (GWh)	Daytime Peak (GWh)	Weekday				Holiday			
						18:00-22:00	9:00-18:00	22:00-0:00	0:00-9:00	18:00-22:00	9:00-18:00	22:00-0:00	0:00-9:00
2017	1,063	441	622	102	166	70	65	57	42	69	60	29	29
2020	1,066	450	616	115	200	79	78	60	38	79	72	31	31
2025	1,062	441	621	114	199	78	78	38	37	78	60	32	32
Average	1,064	444	620	110	188	76	74	51	39	75	64	31	31

After Expansion with NN2

Year	Anual Energy (GWh)	Average Energy		Dependable Energy Weekday		Dependable Capacity (MW) (95%)							
		in Peak hours (GWh)	in Off-Peak hours (GWh)	Night Peak (GWh)	Daytime Peak (GWh)	Weekday				Holiday			
						18:00-22:00	9:00-18:00	22:00-0:00	0:00-9:00	18:00-22:00	9:00-18:00	22:00-0:00	0:00-9:00
2017	1,125	540	585	163	254	111	99	37	37	111	38	36	36
2020	1,146	553	593	170	281	116	110	38	38	116	39	37	37
2025	1,119	536	583	151	238	103	93	37	36	103	37	31	31
Average	1,130	543	587	161	258	110	101	37	37	110	38	35	35

Note: "Dependable Capacity (MW) (95%) is the power output at 95% of power duration curve. This value is equivalent to the capacity that is available at 95% of chance in a year.
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As shown in the table, the annual energy without expansion is 1064 GWh and 1130 GWh with expansion. The difference in energy is 66 GWh. In the previous preparatory survey in 2010, the increment of energy due to NN1 expansion was estimated at 54 GWh. The increase in the energy was due to the inclusion of the 2011 hydrology. The increment in the annual energy was 5% in the previous preparatory survey and 6% in this study. The difference is only 1% of the total energy.

In summary, it can be said that the increment of energy due to expansion to 40 MW will increase the annual energy from 5% to 6% .

(4) Power Output in Updated Power Supply and Demand in the Central Area

The difference of the power supply and demand balance in the central area due to NN1 expansion is shown in Figure 5.3.5.

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Figure 5.3.5 Hourly Power Supply and Demand in Central Area in 2017

In the figure, the orange dotted line represents the power supply with 40 MW expansion of NN1 and the blue dotted line represents the power supply without 40 MW expansion. The figure shows the increment in power supply during dry season especially during peak hours.

The difference of power supply capacity between with and without NN1 expansion in the central area is shown in Table 5.3.2.

Table 5.3.2 Difference of Aggregate Power Output in Central Area between with and without Expansion of 40MW at NN1 Hydropower Station

Diffrence in power output for before and after expansion of 40MW												(Unit:MW)
	Month											
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
2.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
3.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
4.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
5.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
6.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
7.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
8.0	-20	41	22	37	14	-6	-32	-30	-24	-68	-65	-52
9.0	50	50	45	42	4	14	33	28	19	10	9	13
10.0	50	50	45	42	4	14	33	28	19	10	9	13
11.0	50	50	45	42	4	14	33	28	19	10	9	13
12.0	50	50	45	42	4	14	33	28	19	10	9	13
13.0	50	50	45	42	4	14	33	28	19	10	9	13
14.0	50	50	45	42	4	14	33	28	19	10	9	13
15.0	50	50	45	42	4	14	33	28	19	10	9	13
16.0	50	50	45	42	4	14	33	28	19	10	9	13
17.0	50	50	45	42	4	14	33	28	19	10	9	13
18.0	51	50	47	42	5	13	33	36	38	38	39	41
19.0	51	50	47	42	5	13	33	36	38	38	39	41
20.0	51	50	47	42	5	13	33	36	38	38	39	41
21.0	51	50	47	42	5	13	33	36	38	38	39	41
22.0	26	50	28	42	3	15	33	2	-5	-44	-93	-104
23.0	26	50	28	42	3	15	33	2	-5	-44	-93	-104
24.0	26	50	28	42	3	15	33	2	-5	-44	-93	-104

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A negative sign "-" in the table (marked in red) shows that the power supply with expansion case is decreased compared to the power supply without expansion case. A positive figure shows that the power supply with expansion case increased. The table also shows that the power supply during off peak hours from June to January is decreased. The power generation simulation shows off-peak power is shifted to peak hours and dry season generation. This may be one of the effects of the expansion, as the expansion of the existing power plant increases the flexibility of power generation operation. The role of NN1 in the power supply system of the central area will be changed more to peak power supply.

Due to this shift from off-peak energy to peak energy, the power shortfall during peak hours will be improved by 12% in 2017 if the NN1 hydropower station expansion is implemented.

(5) Reduction of Operation and Management (O&M) Cost for Existing Generation Units

As discussed in the preparatory survey in 2010, the expansion project will improve the operational efficiency of the whole power station. Thus, it was considered that the project will result to reduce the O&M cost of the existing generation units. Table 5.3.3 shows the average reduction in the operation time rate at 11% with expansion project case.

Table 5.3.3 Operation Time Rate Saving

Item	Without Expansion	With Expansion	Change in %
Operation Rate			
Year 2017	82%	70%	12%
Year 2020	80%	71%	10%
Year 2025	81%	70%	11%
			11%

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5.4 UPDATE OF ENVIRONMENTAL AND SOCIAL CONDITION OF NN1 HYDOROPOWER STATION EXPANSION

5.4.1 Validity on Issued Environmental Compliance Certificate

An Environmental Compliance Certificate (ECC) shall be obtained from the Ministry of Natural Resources and Environment (MoNRE) by the project developer before starting construction works.[1] In order to obtain the ECC, the project developer shall conduct an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA)[2] The result of the IEE/EIA will be submitted to the MoNRE as a report of IEE/EIA, including an Environmental Management and Monitoring Plan (EMMP) and a Social Management and Monitoring Plan (SMMP). The MoNRE reviews the result and issues of the certificate to the project developer. In the case of the NN1 Hydropower Station extension project, an IEE was required and the ECC was issued in April 2010 to the EDL (project developer).

The ECC is valid through the operation period of the project. The ECC, however, will automatically expire and cannot be used if the project does not start to operate within two years from the date of issuance.[3] It may be extended if the project developer makes a request to the MoNRE. In the case of NN1 extension project, the EDL had made a request to the MoNRE for the extension of the ECC in March 2012. The request was accepted and the ECC was extended on 9 July, 2012.

The ECC needs to be extended every two years until the commencement of the operation provided there is no change on the project's design and/or planning.

5.4.2 Updating Information on Natural and Social Environment

(1) Result from previous study

In the previous study, it was concluded that any significant negative impact on natural and social environment was expected on the extension of the NN1 hydropower station. It is because there is no

[1] Article 4 General Principles, Decree on Environmental Impact Assessment, No.112/PM, 2010
[2] A project developer must utilize the list of an investment project ("List of Projects Development shall be doing IEE and EIA" No.679/PMO-WREA, March 2010) for screening and determine to carry out either IEE or EIA.
[3] Article 18 Expiry date of the environmental compliance certificate, Decree on Environmental Impact Assessment, No.112/PM, 2010

need to construct additional reservoir or transmission line to the existing NN1 station. The only continuous impact that may have an affect on the natural and social environments is an increase in the daily water level fluctuation range at the downstream of NN1 resulting from change of operation pattern in the NN1 during dry season. Accordingly, villagers engaged in river related activities such as boat transportation, fishery, fish farming, and riverbank gardening, were considered as the would-be affected people. In addition, villagers who use river water for irrigation and water supply were also considered as would-be affected people. The impact was assessed taking into account the river related activities by the would-be affected people with hydrological analysis. Consequently, it was concluded that the impact in the water level fluctuation on those activities is to be within the acceptable level.[4]

(2) River related activities in the downstream of the Nam Ngum River

Based on the results of the previous study in 2009, information regarding natural and social environments within the project area was reconfirmed and updated through field observations and hearings with village heads. The target area was set as the same area from the previous study. The area covers up to 1 km from the Nam Ngum river edge along 50 km downstream of the Nam Ngum River from the Nam Ngum dam site. Within the area, there are three districts, namely Keo-Oudom, Viengkham, and Thoulakhom, comprising 24 villages. Ten out of the 24 villages were randomly selected for the hearing. Through the hearing, general information on the villages such as demography, ethnicity, and income were updated. In addition, information on river related activities such as riverbank gardening, fish farming and irrigation as well as water quality and water fluctuation were collected. The location of the surveyed villages is shown in Annex 1.1 and the questionnaire on the hearing is shown in Annex 1.2. A summary on the survey results of the 10 villages is shown in Annex 1.3. The following is a main result from the hearing:

- Village Profile

In all the surveyed villages, the predominant ethnic group was the Lao from the Thai family, which accounted for the main ethnicity in Lao PDR. The rate of the Lao ranged from 100% in six villages, namely: Thalat, Thaingnyoung, Keun-Kang, Hatxai, Nakhong and Cheng to 80% in Sengsavan Village. Village level survey found that all ethnic groups have a long association with the local area and the minority groups have been absorbed generally into the mainstream Lao-speaking society.

Rain-fed paddy rice cultivation was practiced during rainy season in all surveyed villages except in Thinkeo Village. The rice yield from rain-fed paddy field ranged from 4.5 ton/ha in Dongkouat Village as the highest to 2 ton/ha in Sengsavan Village as the lowest. Irrigated rice was produced during dry season in all the surveyed villages except in Thinkeo, Sengsavang and Keun-Kang. The yield of irrigated rice production ranged from 4 ton/ha in Dongkouat, Thinyoung and Cheng as the highest to 3 ton/ha in Thalat as the lowest. The village profile is summarized in Table 5.4.1.

[4] SD & XP Consultants Group and Nippon Koei. 2009. Executive Summary Initial Environmental and Social Examination (IESE) of Nam Ngum 1 (NN1) Hydropower Station. Report prepared for Electricite de Laos, Vientiane. SD & XP Consultants Group and Nippon Koei, August 2009

Table 5.4.1 Village Profile

	Entity	Population		Household	Ethnicity				Rice Yield (Ton/ha)	
		Total	Female		Lao	Hmong	Khamou	Other	Rain	Irrigation
1	**National**	6,256,197	3,133,059	1,027,468	N/A	N/A	N/A	N/A	3.71	4.73
2	**Vientiane Province**	475,140	233,055	86,730	61.10%	22.90%	16.00%	0.06%	4.05	4.5
3	**Keo-Oudom District**	18,988	9,401	3,912	97.85%	0.07%	2.08%	0	4.4	4.72
4	Sengsavang Village	1,403	726	313	80%	16%	4%	0	2	-
5	Thinkeo Village	1,168	568	218	99%	1%	0	0	-	-
6	Thalat Village	1,056	568	207	100%	0	0	0	3	3
7	**Viengkham District**	18,566	8794	3,780	98.52%	0.52%	0.93%	0	3.5	4
8	Muangkao Village	855	427	201	98%	1%	1%	0	3.5	3.5
9	Donkouat Village	892	447	185	90%	0	10%	0	4.5	4
10	Thingnyoung Village	1,501	732	310	100%	0	0	0	3.5	4
11	**Thoulakhom District**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Keun-Kang Village	1,999	979	368	100%	0	0	0	2.4	-
13	Hatxai Village	1,071	582	213	100%	0	0	0	3.5*	3.5*
14	Nakhong Village	842	426	166	100%	0	0	0	3.5	3.5
15	Cheng Village	1774	825	368	100%	0	0	0	3.5	4

* The Hatxai Village was a split up from Nakhong Village. The paddy field of villagers in Hatxai Village located in Nakhon Village has no irrigation.

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The average income ranged from USD 1400/capita/year in Keun-Kang Village as the highest to USD 700/capita/year in Cheng Village as the lowest. The average income in the villages of Hatxai, Nakhong, and Cheng was below the average income in Thoulakhom District where those villages belong. The main income came from the agricultural sector in 7 out of 10 surveyed villages. In the villages of Thinkeo and Thalat, the main income came from the trading sector. In Sengsavang Village, the main income came from the government services since most of the villagers work for EDL. The average income and income source in the surveyed villages are shown in Table 5.4.2.

Table 5.4.2 Average Income and Income Source

No.	Entity	Average Income (USD/capita/year)	Main Income					Remarks
			Agriculture	Fish Farming	Trading	Government Services	Others	
1	**National**	1,088	N/A	N/A	N/A	N/A	N/A	Statistical Yearbook 2010 Lao PDR
2	**Keo-Oudom District**	595	N/A	N/A	N/A	N/A	N/A	Information from 2009
3	Sengsavang Village	750	7.5%	2.5%	20%	70%	0	
4	Thinkeo Village	N/A	0.1%	0	95%	4.9%	0	
5	Thalat Village	N/A	20%	0	75%	5%	0	
6	**Viengkham District**	720	N/A	N/A	N/A	N/A	N/A	Social-Economic Development Plan for 2010-2011, Vientiane Province
7	Muangkao Village	850	100%	0	0	0	0	Average income was relatively high in this village, because most of the villagers are pensioner, who retired from government service sector
8	Donkouat Village	750	100%	0	0	0	0	
9	Thingnyoung Village	800	90%	0	10%	0	0	
10	**Thoulakhom District**	1,400	N/A	N/A	N/A	N/A	N/A	
11	Keun-Kang Village	1,400	70%	1%	19%	10%	0	
12	Hatxai Village	850	80%	0	0	3%	17%	
13	Nakhong Village	760	70%	0	20%	10%	0	
14	Cheng Village	700	90%	0.03%	3%	6.97%	0	

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-River Related Activities

The major activities related to the Nam Ngum River were irrigation, riverbank gardening, navigation (boat transportation), fishery, and fish farming. Irrigation was practiced in 7 out of 10 surveyed villages. The rate of dependency on irrigation during dry season was high at 81.1% in Donkouat Village and 63.9% in Cheng Village. Irrigation was not only used for rice production but also for vegetable gardening.

Riverbank gardening was not practiced in the villages of Sengsavang, Muaungkao, and Thingyoung because the riverbank in these villages was too steep and not suitable for planting. In the villages of Thinkeo, Thalat, Keun-Kang and Cheng, the income from riverbank garden contributed to a portion of the main income. In the villages of Donkouat, Hatxai and Nakhon, products from riverbank gardening were for domestic consumption only.

Two households in Keun-kang Village practiced navigation business as supplemental to their main income generated from agricultural sector.

Fishery was not so popular among surveyed villages except in Hatxai and Nakong where 79.8% and

48.2% respectively of the total households performed some fishing activities. However, it was mainly for domestic consumption and surplus went for sale occasionally.

Fish farming was practiced in Sengsavang and Keun-Kang. The income from fish farming business was quite high. Table 5.4.3 summarizes the river related activities in surveyed villages.

Table 5.4.3 River Related Activities

No.	Village	District	Households	Irrigation (HHs)	%	Riverbank Garden (HHs)	%	Navigation (HHs)	%	Fishery (HHs)	%	Fish Farming (HHs)	%
1	Sengsavang	Keo-Oudom	313	0	0	0	0.0	0	0	0	0.0	8	2.6
2	Thinkeo		218	0	0	1	0.5	0	0	6	2.8	0	0
3	Thalat		207	21	10.1	30	14.5	0	0	10	4.8	0	0
4	Muaungkao	Viengkham	201	N/A*	-	0	0.0	0	0	15	7.5	0	0
5	Donkouat		185	150	81.1	90	48.6	0	0	0	0.0	0	0
6	Thingyoung		310	114	36.8	0	0.0	0	0	10	3.2	0	0
7	Keun-Kang	Thoulakhom	368	0	0	35	9.5	2	0.5	15	4.1	2	0.5
8	Hatxai		213	N/A*	-	174	80.0	0	0	170	79.8	0	0
9	Nakhong		166	50	30.1	12	7.2	0	0	80	48.2	0	0
10	Cheng		368	235	63.9	200	85	0	0	5	1.4	1	0.3

*Number of household was not available. The village was split out from its adjacent villages where their own paddy fields remained. There was no irrigation in the split out village, however, irrigation did exist in the village where they owned their paddy fields and they used irrigation in dry season.

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-Riverbank Garden

Impact from water level fluctuation: In the previous study, it was concluded that the range of water level fluctuation would increase between 40 cm and 50 cm from present level during dry season after the extension of the NNI. At the hearing, it was confirmed that farmers have accustomed to plant their vegetables in secured areas at least 1 m from the edge of the lowest water level during dry season as a buffer zone. Table 5.4.4 shows the range of buffer zone in the surveyed villages. Depending on each village, the range of the buffer zone is between 1 m as the minimum in Hatxai Village to 5 m as the maximum in the villages of Keun-Kang and Nakhong. Accordingly, if the increase of the water level remains within the range of buffer zone, there will be no negative impact on the riverbank garden. For further study, the possible range of water level fluctuation in the target area resulting from the extension of the NNI needs to be re-calculated through hydrological analysis in considering the actual water flow from the newly constructed Nam Lik ½ Hydropower Plant.

Land ownership on river bank: Based on the Land Law,[5] submerged land, land at river source (catchment area), riverbanks, islands, newly-formed land, land formed when water recedes or land formed by change or diversion of waterways were categorized as water area land.[6] It used to be the

[5] Land Law, No.04/NA 21 October 2003
[6] Article 23 Water Area Land, Land Law, No.04/NA 21 October 2003

Ministry of Agriculture and Forestry (MoAF) as the responsible ministry for managing the area,[7] however, the task has been taken by the MoNRE since its establishment in 2011. The use of the water area land can be allocated to individuals or organizations for appropriate protection and use in case the village administration, where the water area land is located, make a request to the concerned authority (district or municipal administration). The request is then reviewed and approved by the said authority and the MoNRE.[8] As for the surveyed villages, it was found that both the defined status and area on river bank varied among villages due to lack of detailed legislation on this matter. The status of land ownership on river bank in surveyed villages is summarized in Table 5.4.4.

Table 5.4.4 Buffer Zone and Status of Land on Riverbank

No.	Village	Buffer Zone (m)	Status of the Land in Riverbank Area
1	Sengsavang	No Riverbank Garden	Permanent land use right certificate is not issued for the riverbank area
2	Thinkeo	N/A	Permanent land use right certificate is not issued for the riverbank area Villagers use riverbank area by custom
3	Thalat	2	Permanent land use right certificate is not issued for the riverbank area Villagers use riverbank area by custom
4	Muangkao	No Riverbank Garden	Permanent land use right certificate is not issued for the riverbank area
5	Donkouat	2	Permanent land use right certificate is not issued for the riverbank area Villagers use riverbank area by custom
6	Thingnyoung	No Riverbank Garden	Permanent land use right certificate is not issued for the riverbank area
7	Keun-Kang	5	The land, which is 15 meters from the lowest point of water level measured in April, is applicable for permanent land use right certificate
8	Hatxai	1	Permanent land use right certificate is not issued for the riverbank area Villagers use riverbank area by custom Tax is imposed on the profit from the riverbank garden by the District Land Authority
9	Nakhong	4-5	Permanent land use right certificate is not issued for the riverbank area from the highest point of the bank to the river. Permanent land use right certificate can be issued from the highest point of riverbank to inland area.
10	Cheng	2	Permanent land use right certificate can be issued for the land located 7 meters from the highest point of the riverbank to inland. However, if the riverbank area is not steep and it has been used by the family for generations, it used to be issued the permanent land use right certificate even for the land located 7 meters from the highest point of the river bank to the riverside. However, presently this is not practice due to the change in policy.

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- Vulnerability

It was found that various definitions exist for vulnerability among surveyed villages.[9] The number of poor households in all the surveyed villages was very small. Only five households in Dongkouat Village, three households in Thinnyoung Village, two in Keun-Kang Village, and 30 households in Hatxai Village were defined as poor households.

- Electrification rate

7 Article 24 Management of Water Area Land, Land Law, No.04/NA 21 October 2003
8 Article 26 Use of Water Area Land, Land Law, No.04/NA 21 October 2003
9 See Annex 1.3 A summary of 10 surveyed villages' results

All the surveyed villages already have electricity.

- Tourism island in Dongkouat

There are four islands within the boundary of Dongkouat Village in the Nam Ngum River. A big festival to celebrate New Year has taken place in one of the islands (GPS: N18 24’09 65’’ E102 32’ 30 24’’) for more than 15 years for three days during the new year holiday. The photo of this island is shown in Annex 1.1 titled, “the Location of the Surveyed Villages”. The size of the island reached about 1 ha as its maximum during the festival period because the water level of the river was at its lowest around that time. During the three-day festival, tourists visit this island for recreation such as relaxing near riverside and shopping at street shops that temporarily open only for the festival. Since the height of the island was 3 m at the highest and 70% to 80% of the island was submerged at the time of festival, any increase from the present water level would decrease the island area and might affect the festival. Detailed information needs to be collected at the time of the festival during the detailed design phase and mitigation measures shall be considered as appropriate.

(3) Water Fluctuation

After the completion of the previous study, two hydropower stations have been operating. The new plants are the Nam Lik ½ Hydropower Plant, which started operating in August 2010 and the Nan Ngum 2 Hydropower Plant that started operating in March 2011. With these newly operated hydropower plants taken into account, information on daily water fluctuations from previous study was updated. The results of maximum water level difference between 9:00 and 19:00 at Pakkhahanhoung Monitoring Station from January 2006 to December 2011 is shown in Table 5.4.5. and Figure 5.4.1. In order to compare the water fluctuations before construction of the Nam Lik ½ and the NN2, the mean results between January 2006 and July 2010 was calculated and described as the “average” in the table.

The biggest gap between the “before construction of two hydropower plants (average in the table)” and the “after construction of two hydropower plants (the result after August 2010 till December 2011 in the table) on the maximum water level difference in rainy season and in dry season were recorded at +0.88 m in August 2010 and -0.41 m in December 2010, respectively. Both results were within the range of past records. Thus, any significant change on maximum water level difference were found before and after construction of the two hydropower plants.

Table 5.4.5 Maximum Water Level Difference between 9:00 and 19:00 at Pakkhahanhoung Monitoring Station

Unit: m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	N/A	N/A	N/A	N/A	N/A	0.43	1.57	0.20	0.56	0.82	0.51	0.90
2007	N/A	N/A	N/A	N/A	N/A	0.91	0.71	0.85	0.94	1.44	N/A	N/A
2008	N/A	N/A	N/A	N/A	N/A	0.42	2.96	0.92	0.74	0.51	0.25	1.33
2009	0.34	0.52	0.02	0.02	0.60	0.91	0.57	0.74	0.90	0.60	0.52	0.79
2010	0.68	0.48	0.66	0.35	0.75	0.98	2.38	1.56	0.88	0.79	0.65	0.60
2011	0.39	0.85	0.26	0.20	0.68	1.60	0.94	0.86	0.66	0.60	0.42	0.63
Average	0.51	0.50	0.34	0.19	0.68	0.73	1.64	0.68	0.79	0.84	0.43	1.01

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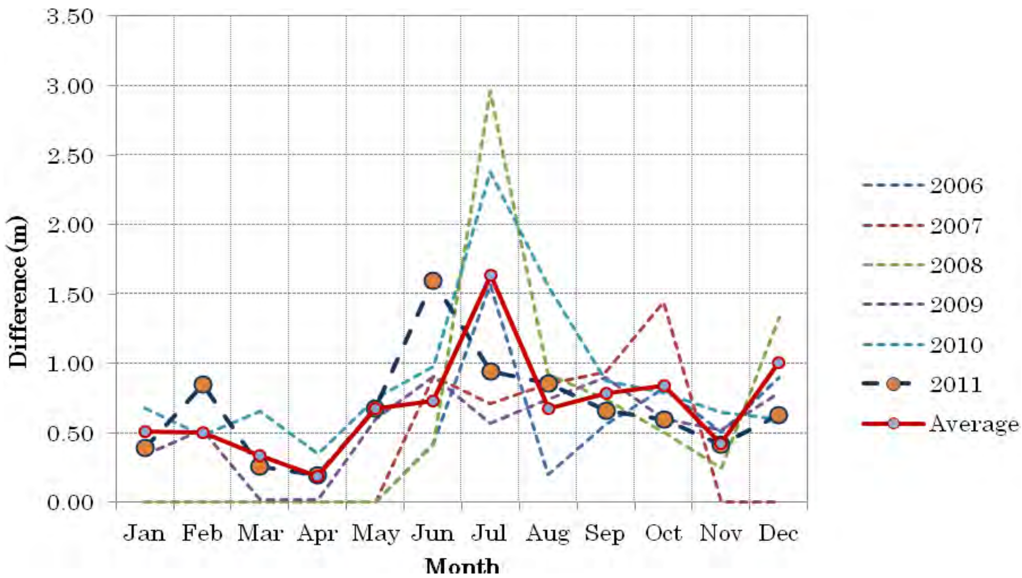

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Figure 5.4.1 Maximum Water Level Difference at Pakkanhoung Monitoring Station

(4) Water Quality

During May until August 2011, it was reported that massive fishes bred in fish farming cages of the Nan Ngum River died and eight fish farmers were affected by the incident. The photo of the affected fish farming cages are shown in Annex 1.1, “the Location of Surveyed Villages”. The area is near the Thalat Bridge located 4 km from the Nam Ngum Dam. After the investigation conducted by the Institute of Natural Resources and Environmental Research (INRER) together with the district and provincial officers, it was concluded that the water with low rate of dissolved oxygen (DO) released from the NN2 Hydropower Plant was the cause of the incident. The result of the water quality checking in 9 points between the Nam Ngum Dam and Tha Gon Bridge located about 60 km downstream from the Nam Ngum Dam in July 2010 is shown in Annex 1.4. At the water quality checking, extremely low rate of DO was confirmed from the river water taken around the Nam Ngum dam site up to the Thalat Bridge. Accordingly, the environmental committee[10] was organized by the

[10] Committee responsible for environmental and social issues under the jurisdiction of the Vientiane Province

Vientiane Province and 35 stakeholders including representatives from the Nam Lik ½ Hydropower Plant, the NN1 Hydropower Plant, the NN2 Hydropower Plant, the INRER, technical team from relevant sectors at the district and provincial levels were called to the committee. Matters agreed with the committee were as follows;[11] 1) appropriate financial support to be provided by the project developer (NN2 Hydropower Company) to affected fish farmers,[12] 2) the NN2 Hydropower Company will reconduct an EIA study including the downstream area of NN1 and re-obtain the ECC from the MoNRE,[13] 3) the INRER and the Nam Ngum River Basin Committee[14] in cooperation with the village district and provincial authorities will conduct long term water monitoring along the Nam Ngum River and the budget to be shared between the government and the project developers.[15]

The water quality monitoring including the rate of DO in the Nan Ngum River started at seven sites including the Nam Lik River before the confluence point to the Nam Ngum River, Thalat Bridge, and Ban Keun Kang on a monthly basis by the INRER since January 2012.[16] Nothing abnormal has been detected up to the present.[17]

(5) Further Study

The following tasks are recommended to carry out in a further study:

- The impact on the downstream of the Nan Ngum River resulting from the extension of the NN1 Hydropower Plant needs to be restudied with the result of hydrological calculation of daily water fluctuations after the commencement of operation of Nam Lik ½ and NN2, which both plants were not yet operating in the previous study;

- The results in the monitoring water quality after construction of Nam Lik ½ and NN2 needs to be collected in order to update the monitoring plan on the extension of the NN1 Hydropower Plant prepared in the previous study; and

- Information regarding present monitoring program on the management of the Nan Ngum River such as responsible agency for monitoring, monitoring items, and existing monitoring scheme needs to be collected in order to update the monitoring plan prepared in the previous study.

[11] Minutes of meeting on February 6, 2012 on fish die-off incident
[12] It was confirmed with the village head of the Sengsavang Village where the affected fish farmers reside that any financial support have yet to be provided to the affected fish farmers. (as of May 25, 2012)
[13] It was confirmed with the Department of Environmental and Social Impact Assessment, MoNRE that the EIA report has not been submitted to MoNRE (as of June 4, 2012)
[14] Committee responsible for the environmental and social issues within the Nan Ngum basin area
[15] It was confirmed at the INRER that the monitoring is not yet realized due to lack of budget. (as of 4 June, 2012)
[16] The water monitoring has started using the scheme not intended for the environmental committee but purposely for capacity building project supported by the Government of Finland.
[17] The information was confirmed with the INRER, however, detailed monitoring result was not provided because the data is under process for disclosure to outsiders. (as of June 4, 2012)

5.5 PROSPECTIVE POWER IMPORT/EXPORT WITH THAILAND AFTER NN 1 HYDROPOWER STATION EXPANSION

5.5.1 Methodology of Power Trade Simulation

For the estimation of prospective import and export energy in cases with and without expansion of NN1, the difference of load and generation output (with and without NN1 expansion) for the whole country were calculated at hourly intervals to estimate the imported and exported energy to Thailand. This simulation analysis was extended on weekdays and holidays of each month, because the unit price (THB/kWh) of import/export differ between peak and off-peak hours[18], and the daily load curve and generation pattern change in trend on weekdays or holidays.

The flow of this simulation is summarized in Figure 5.5.1 below.

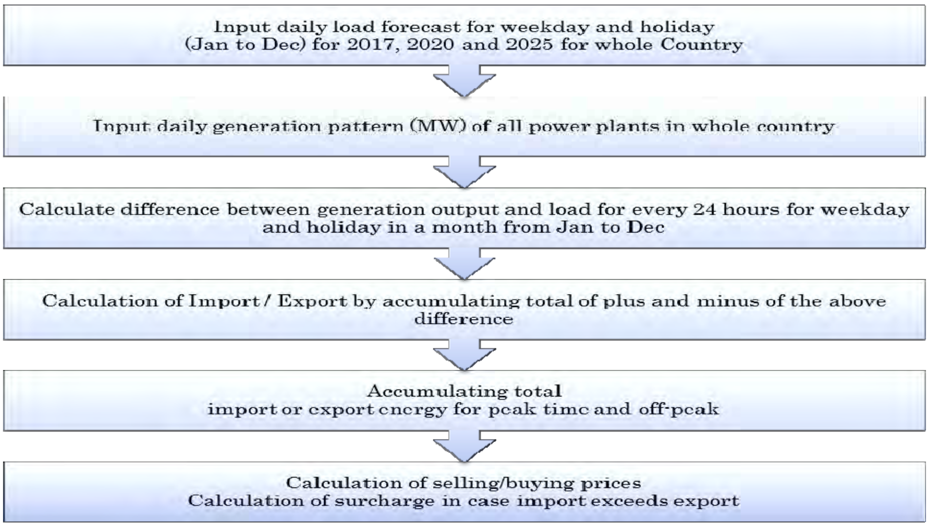

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Figure 5.5.1 Flow of Method for Simulation of Power Import or Export

Finally, the result of the import and export of energy in the above simulation were converted to the selling and buying prices of electricity to Thailand. In cases that the imported energy from Thailand exceeds the exported energy on the annual basis, EDL is required to additionally pay surcharge to EGAT. This surcharge is calculated, if required in the simulation.

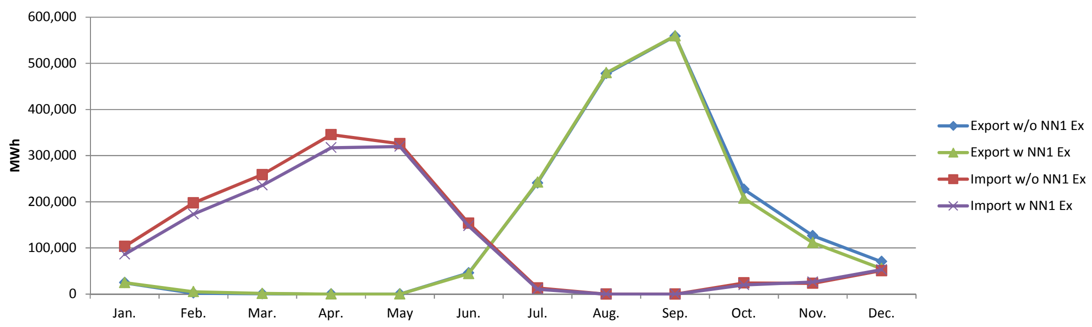
5.5.2 Estimation of Import and Export Energy

According to the above procedure, the Study Team computed the import and export energy based on an hourly demand-supply balance for the whole country for the years 2017, 2020, and 2025. The year of 2017 was expected as the COD of the expanded NN1 power station.

(1) Power Import and Export in 2017

Table 5.5.1 and Figure 5.5.2 show the result of simulation of power import and export in 2017.

18 Peak hour: 9:00AM to 10PM on weekdays, and
Off-peak hour: 10PM to 9AM on weekdays and all hours on holidays.



Prepared by Study Team

Figure 5.5.2 Comparison Import/Export With and Without NN1 Expansion (2017)

Table 5.5.1 Prospective Export/Import Energy in 2017

	w/o NN1 Expansion				(MWh)		40MW Expansion					(MWh)
	Export			Import			Export			Import		
	Off-peak	Peak	Total	Off-peak	Peak	Total	Off-peak	Peak	Total	Off-peak	Peak	Total
Jan.	24,565	0	24,565	45,293	57,886	103,179	24,580	0	24,580	42,514	43,460	85,974
Feb.	1,874	0	1,874	88,106	109,564	197,670	4,950	0	4,950	76,591	96,685	173,276
Mar.	443	0	443	114,656	144,203	258,858	1,242	0	1,242	105,076	130,544	235,620
Apr.	0	0	0	190,891	154,498	345,389	0	0	0	173,415	143,511	316,926
May	0	0	0	157,671	168,233	325,904	0	0	0	152,724	166,893	319,617
Jun.	45,515	0	45,515	48,954	104,576	153,530	44,277	0	44,277	46,957	100,709	147,667
Jul.	216,372	24,092	240,464	4,139	8,982	13,122	211,402	30,895	242,297	3,592	6,878	10,470
Aug.	362,030	115,388	477,417	0	0	0	354,871	124,472	479,343	0	0	0
Sep.	417,012	141,556	558,568	0	0	0	410,999	148,438	559,436	0	0	0
Oct.	204,199	22,624	226,823	5,189	18,843	24,032	182,548	24,624	207,172	4,263	15,509	19,771
Nov.	88,261	38,205	126,465	11,397	11,947	23,344	70,292	40,858	111,150	16,602	9,388	25,990
Dec.	62,733	7,353	70,085	28,425	22,415	50,839	45,843	9,279	55,122	34,317	18,422	52,739
Total	1,423,003	349,218	1,772,221	694,720	801,146	1,495,866	1,351,004	378,566	1,729,571	656,050	731,999	1,388,048

Prepared by Study Team

As indicated in Figure 5.5.2, in 2017, the power import and export are nearly balanced on an annual basis. During dry season, the import exceeded the export. On the contrary, during wet season the export exceeded the import. The power import will grow to its maximum in April and May, and the export will rise to its peak in August and September. These trends on seasonal variations in power import and export will not largely change regardless of with or without expansion of NN1 power station in 2017.

Table 5.5.2 Comparison of Power Import/Export With and Without NN1 Expansion in 2017

2017		Off-Peak	Peak	Total
w/o NN1 Ex	Export	1,423,003	349,218	1,772,221
	Import	694,720	801,146	1,495,866
	Balance	728,283	-451,929	276,354
w NN1 Ex	Export	1,351,004	378,566	1,729,571
	Import	656,050	731,999	1,388,048
	Balance	694,955	-353,433	341,522
Difference	Export	-71,999	29,348	-42,650
between	Import	-38,671	-69,148	-107,818
with and w/o	Balance	-33,328	98,496	65,168
Note: Balance : Export-Import				

Prepared by Study Team

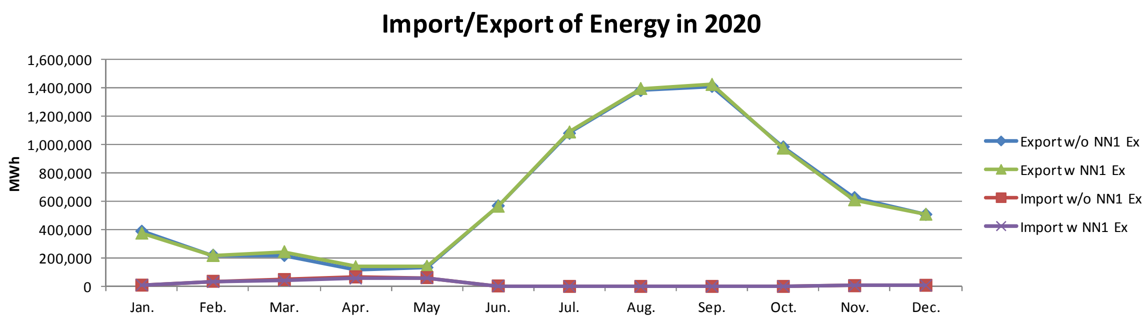
Table 5.5.2 shows the change of power import and export in comparison between with or without of

NN1 expansion. In case there is an expansion, the prospective power export will achieve 1,772.2 GWh in 2017, whereas the power import will be 1,495.9 GWh. When NN1 is expanded, the power export will come down to 1,729.6 GWh and power import will also go down to 1388 GWh in the same year. In this connection, the reduction of power import is larger than that of the power export by 65.2 GWh. This means that the export of energy in power trade will relatively grow by 65.2 GWh with the expansion of NN1.

In addition to the above comments, it is also remarked that with relation to generation pattern, after NN1 expansion, the power export tends to relatively decrease in power export by 72.0 GWh and decrease the import by 38.7 GWh during off-peak time, whereas it increases export by 29.3 GWh and decrease the import by 69.1 GWh during peak time.

(2) Power Import and Export in 2020

Table 5.5.3 and Figure 5.5.3 show the result of simulation of power import and export in 2020.



Prepared by Study Team

Figure 5.5.3 Comparison Import/Export With and Without NN1 Expansion (2020)

Table 5.5.3 Prospective Export / Import Energy in 2020

	w/o NN1 Expansion				(MWh)		**40MW Expansion**					(MWh)
		Export			Import			Export			Import	
	Off-peak	Peak	Total	Off-peak	Peak	Total	Off-peak	Peak	Total	Off-peak	Peak	Total
Jan.	216,184	172,807	388,991	9,409	0	9,409	197,465	177,932	375,397	9,912	0	9,912
Feb.	136,373	84,050	220,423	34,530	1,341	35,870	122,266	96,009	218,275	32,498	348	32,846
Mar.	142,806	75,109	217,915	46,670	1,495	48,165	156,232	88,253	244,485	39,214	400	39,614
Apr.	74,014	43,159	117,173	56,997	10,249	67,246	85,914	53,298	139,212	48,921	7,216	56,137
May	87,656	45,658	133,314	56,616	5,526	62,142	94,719	46,820	141,539	54,230	5,195	59,425
Jun.	368,967	199,289	568,255	3,151	0	3,151	361,979	203,577	565,556	3,015	0	3,015
Jul.	680,057	399,351	1,079,408	0	0	0	680,295	408,883	1,089,177	0	0	0
Aug.	900,022	481,403	1,381,425	0	0	0	904,201	491,271	1,395,472	0	0	0
Sep.	896,664	514,084	1,410,749	0	0	0	901,825	522,513	1,424,338	0	0	0
Oct.	616,144	367,683	983,827	0	0	0	601,390	373,777	975,167	0	0	0
Nov.	336,072	290,604	626,676	5,245	0	5,245	312,995	297,512	610,506	4,361	0	4,361
Dec.	285,625	222,054	507,679	7,729	0	7,729	275,985	232,842	508,826	6,544	0	6,544
Total	4,740,584	2,895,250	7,635,834	220,347	18,611	238,959	4,695,264	2,992,687	7,687,951	198,696	13,158	211,854

Prepared by Study Team

As indicated in Figure 5.5.3, if all power plant projects are completed as scheduled, power import will not be required. The power export will rapidly increase from June to December of 2020, finally achieving 7,688.9 GWh in total.

Table 5.5.4 Comparison of Power Import/Export With and Without NN1 Expansion in 2020

2020		Off-Peak	Peak	Total
w/o NN1 Ex	Export	4,740,584	2,895,250	7,635,834
	Import	220,347	18,611	238,959
	Balance	4,520,237	2,876,639	7,396,875
w NN1 Ex	Export	4,695,264	2,992,687	7,687,951
	Import	198,696	13,158	211,854
	Balance	4,496,568	2,979,529	7,476,097
Difference	Export	-45,320	97,437	52,117
between	Import	-21,651	-5,453	-27,104
w and w/o	Balance	-23,669	102,890	79,221
Note: Balance : Export-Import				

Prepared by Study Team

Table 5.5.4 shows the change of power import and export for cases with or without NN1 expansion. In case of no expansion of NN1, the prospective export will achieve 7635 GWh in 2020, whereas the import will be 239.0 GWh. If NN1 is expanded by 40 MW, the power export will grow to 7688 GWh and import will also grow to 211.9 GWh in the same year. The benefit of energy in power trade with Thailand will relatively be 79.2 GWh after the 40 MW expansion of the NN1 hydropower station.

In addition to the above comments on the annual gross import or export, it is remarked that in relation to the generation pattern after the NN1 expansion, the power trade tends to decrease in power export by 45.3 GWh and decrease the import by 21.7 GWh during off-peak time, whereas it increases export by 97.4 GWh and decrease the import by 5.4 GWh during peak time.

5.5.3 Prices for Power Import and Export

According to the tariff for power trade with Thailand, the electricity prices for power import and export were calculated under the conditions with and without NN1 expansion. Since the unit rate of EDL's buying unit price was higher than selling unit price (see Table 5.5.5), although the annual energy of export was a little higher than import in 2017, EDL is still required to pay THB 58.57 million to EGAT in 2017 as shown in Table 5.5.6 in case of no NN1 expansion. On the contrary, after expansion of NN1, EDL is not required to pay the electricity expense to EGAT. Meanwhile, EGAT has to pay the amount of THB 74.13 million to EDL.

Table 5.5.5 Unit Price for Export and Import with Thailand

Unit: Bath/kWh

Tariff	Export	Import
Peak	1.6	1.74
Off-Peak	1.2	1.34

Source: EDL

Table 5.5.6 Electricity Prices for Import and Export of Power to Thailand (2017)

Without NN1 Expansion (2017)

	Export			Import			Payment
	Off-peak	Peak	Total	Off-peak	Peak	Total	(*1000Baht)
Jan.	29,478	0	29,478	60,693	100,721	161,414	131,937
Feb.	2,248	0	2,248	118,062	190,641	308,703	306,454
Mar.	532	0	532	153,638	250,913	404,552	404,020
Apr.	0	0	0	255,794	268,827	524,621	524,621
May	0	0	0	211,279	292,725	504,004	504,004
Jun.	54,618	0	54,618	65,598	181,962	247,560	192,942
Jul.	259,646	38,548	298,194	5,547	15,629	21,176	-277,018
Aug.	434,436	184,620	619,056	0	0	0	-619,056
Sep.	500,414	226,490	726,905	0	0	0	-726,905
Oct.	245,039	36,198	281,237	6,953	32,786	39,739	-241,498
Nov.	105,913	61,128	167,040	15,272	20,787	36,059	-130,981
Dec.	75,279	11,764	87,043	38,089	39,001	77,090	-9,953
Total	**1,707,604**	**558,748**	**2,266,352**	**930,925**	**1,393,994**	**2,324,920**	**58,568**
							(Pay to EGAT by EDL)

With NN1 Expansion (2017)

	Export			Import			Payment
	Off-peak	Peak	Total	Off-peak	Peak	Total	(*1000Baht)
Jan.	29,496	0	29,496	56,968	75,621	132,589	103,092
Feb.	5,940	0	5,940	102,632	168,232	270,863	264,923
Mar.	1,491	0	1,491	140,801	227,146	367,948	366,457
Apr.	0	0	0	232,376	249,710	482,086	482,086
May	0	0	0	204,651	290,393	495,044	495,044
Jun.	53,132	0	53,132	62,923	175,234	238,157	185,025
Jul.	253,683	49,432	303,115	4,813	11,967	16,780	-286,335
Aug.	425,845	199,155	625,000	0	0	0	-625,000
Sep.	493,198	237,500	730,699	0	0	0	-730,699
Oct.	219,058	39,399	258,457	5,712	26,985	32,697	-225,760
Nov.	84,350	65,373	149,723	22,246	16,335	38,581	-111,142
Dec.	55,011	14,847	69,858	45,985	32,055	78,039	8,181
Total	**1,621,205**	**605,706**	**2,226,911**	**879,106**	**1,273,678**	**2,152,784**	**-74,127**
							(Pay to EDL by EGAT)

Note) Payment: positive amount means payment of EDL to EGAT, negative amount means payment of EGAT to EDL
Prepared by the Study Team

In simulation of power import and export for 2020, since the power export is growing and far exceeded the import, EDL is not required to pay any buying cost to EGAT. Whereas, EGAT pays electricity cost to EDL on actual consumption of EGAT. If EGAT purchases all surplus power from EDL, the price was estimated at THB 9.99 billion in case of no NN1 expansion, and THB 10.13 billion in case NN1 expansion is constructed, as shown in Table 5.5.7.

Table 5.5.7 Electricity Prices for Import and Export of Power to Thailand (2020)

Without NN1 Expansion (2020)

	Export			Import			Payment
	Off-peak	Peak	Total	Off-peak	Peak	Total	(*1000Baht)
Jan.	259,421	276,491	535,911	12,609	0	12,609	-523,303
Feb.	163,647	134,481	298,128	46,270	2,333	48,603	-249,525
Mar.	171,368	120,175	291,542	62,538	2,602	65,140	-226,402
Apr.	88,817	69,054	157,871	76,376	17,834	94,209	-63,661
May	105,188	73,053	178,240	75,865	9,615	85,481	-92,760
Jun.	442,760	318,862	761,622	4,222	0	4,222	-757,400
Jul.	816,068	638,961	1,455,029	0	0	0	-1,455,029
Aug.	1,080,027	770,244	1,850,271	0	0	0	-1,850,271
Sep.	1,075,997	822,535	1,898,532	0	0	0	-1,898,532
Oct.	739,373	588,292	1,327,665	0	0	0	-1,327,665
Nov.	403,286	464,966	868,252	7,029	0	7,029	-861,224
Dec.	342,750	355,287	698,037	10,357	0	10,357	-687,679
Total	**5,688,701**	**4,632,400**	**10,321,101**	**295,265**	**32,384**	**327,649**	**-9,993,452**
							(Pay to EDL by EGAT)

With NN1 Expansion (2020)

	Export			Import			Payment
	Off-peak	Peak	Total	Off-peak	Peak	Total	(*1000Baht)
Jan.	236,958	284,692	521,650	13,283	0	13,283	-508,367
Feb.	146,719	153,615	300,334	43,548	605	44,153	-256,181
Mar.	187,478	141,204	328,683	52,546	696	53,242	-275,440
Apr.	103,097	85,277	188,374	65,555	12,556	78,110	-110,264
May	113,663	74,912	188,575	72,668	9,039	81,707	-106,868
Jun.	434,374	325,723	760,097	4,041	0	4,041	-756,057
Jul.	816,354	654,212	1,470,566	0	0	0	-1,470,566
Aug.	1,085,041	786,034	1,871,075	0	0	0	-1,871,075
Sep.	1,082,189	836,021	1,918,211	0	0	0	-1,918,211
Oct.	721,668	598,043	1,319,711	0	0	0	-1,319,711
Nov.	375,594	476,019	851,612	5,844	0	5,844	-845,768
Dec.	331,182	372,547	703,728	8,769	0	8,769	-694,959
Total	**5,634,316**	**4,788,299**	**10,422,616**	**266,253**	**22,895**	**289,148**	**-10,133,468**
							(Pay to EDL by EGAT)

Note) Payment: positive means EDL payments to EGAT, negative means EGAT payments to EDL
Prepared by the Study Team

5.6 UPDATE ON THE ECONOMIC AND FINANCIAL ANALYSES OF NN1 HYDROPOWER STATION EXPANSION

5.6.1 Update of Project Cost Estimation

The present analysis has updated the project cost estimated by the previous preparatory survey through price adjustment in the consumer price index (CPI) to acquire the 2012 present price. Foreign currency portion was converted with the average CPI change of major advanced economies (G7) from 2008 through 2011 (3.88%) and local currency portion was converted with that of Lao PDR (11.42%).[19]

Other assumptions applied in the update are shown in the table below.

Table 5.6.1 Major Assumptions Used for Cost Estimates Update

Item	Value	Source
Exchange Rates	USD 1.00 = JPY 81.49 = LAK 7,890.3 = THB 32.04 LAK 1.00 = JPY 0.0103	JICA Information JICA Information Bank of Thailand (May 2012)
Price Escalation	Foreign Currency: 2.1% per annum Local Currency: 4.7% per annum	JICA Information World Economic Outlook, April 2012, IMF (average of five years from 2007 to 2011)
Physical Contingencies	Construction: 10% Consulting Services: 5%	2010 Preparatory Survey 2010 Preparatory Survey
ODA Loan Conditions	Interest rate: 0.70% per annum (consulting services: 0.01% per annum) Repayment period: 30 years (including 10 years grace period)	JICA Information JICA Information

Source: various sources

Results of the project cost update are presented in Table 5.6.2. The updated project cost was JPY 7,212 million in total. Compared to the estimates of the previous survey (JPY 7,006 million), the cost was increased by 2.9%.

[19] Inflation rates used in the conversion are based on World Economic Outlook (April 2012), International Monetary Fund.

Table 5.6.2 Updated Project Cost

(FC and Total: million Yen, LC: million Kip)

Description	2013			2014			2015			2016			2017			Total		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. Eligible Portion																		
I. Construction Cost																		
Civil Works	0	0	0	185	3,144	218	742	12,577	871	742	12,577	871	556	9,432	653	**2,225**	**37,730**	**2,614**
Hydro-mechanical Works	0	0	0	23	383	27	90	1,533	106	90	1,533	106	68	1,150	80	**271**	**4,600**	**319**
Electro-mechanical Works	0	0	0	138	2,348	163	554	9,390	651	554	9,390	651	415	7,043	488	**1,661**	**28,171**	**1,952**
Total Base Cost	0	0	0	346	5,875	407	1,386	23,500	1,628	1,386	23,500	1,628	1,039	17,625	1,221	**4,158**	**70,500**	**4,884**
Price Escalation	0	0	0	15	565	21	89	3,472	125	120	4,739	169	114	4,550	161	**338**	**13,326**	**475**
Physical Contingency (10%)	0	0	0	36	644	43	148	2,697	175	151	2,824	180	115	2,218	138	**450**	**8,383**	**536**
Total Construction Cost	**0**	**0**	**0**	**397**	**7,084**	**470**	**1,623**	**29,669**	**1,928**	**1,657**	**31,063**	**1,977**	**1,269**	**24,393**	**1,520**	**4,945**	**92,209**	**5,895**
II. Consulting Services																		
Base Cost	127	383	131	129	450	134	153	605	159	165	643	172	164	671	171	**739**	**2,752**	**767**
Price Escalation	3	18	3	5	43	6	10	89	11	14	130	16	18	173	20	**50**	**454**	**55**
Physical Contingency (5%)	6	20	7	7	25	7	8	35	9	9	39	9	9	42	10	**39**	**160**	**41**
Total Consulting Services	**136**	**421**	**141**	**141**	**518**	**147**	**171**	**729**	**179**	**188**	**812**	**197**	**191**	**886**	**200**	**828**	**3,366**	**863**
Total Eligible Portion	**136**	**421**	**141**	**539**	**7,602**	**617**	**1,794**	**30,398**	**2,107**	**1,845**	**31,875**	**2,173**	**1,460**	**25,279**	**1,720**	**5,774**	**95,575**	**6,758**
B. Non-Eligible Portion																		
Administration Cost	**0**	**731**	**8**	**0**	**3,185**	**33**	**0**	**10,860**	**112**	**0**	**11,200**	**115**	**0**	**8,865**	**91**	**0**	**34,841**	**359**
C. Interest During Construction	**1**	**0**	**1**	**4**	**0**	**4**	**17**	**0**	**17**	**31**	**0**	**31**	**42**	**0**	**42**	**95**	**0**	**95**
TOTAL	**137**	**1,151**	**149**	**543**	**10,788**	**654**	**1,811**	**41,257**	**2,236**	**1,876**	**43,075**	**2,320**	**1,502**	**34,144**	**1,854**	**5,869**	**130,416**	**7,212**

Prepared by the Study Team

5.6.2 Economic Analysis

The present section updates the economic analysis made in the previous preparatory survey. The cost-benefit analysis based on the economic values applied the discounted cash flow method. Indices used in the analysis are the economic internal rate of return (EIRR) and net present value (NPV).

(1) Assumptions

In reference to the previous survey, the following assumptions are adopted for the present analysis:

Table 5.6.3 Assumptions for Economic Analysis

Item	Value
Project Life	55 years in total (50 years of service life and 5 years of construction)
Opportunity Cost of Capital (Social Discount Rate)	10% was applied as the threshold of economic viability
Standard Conversion Factor	Standard conversion factor of 0.95 for local currency portion to acquire economic value
Price Escalation	Price escalation was not considered in the analysis; economic values were expressed in constant price.
Taxes	Taxes and duties such as VAT were considered as transfer items and excluded from the analysis.
Interest During Construction	Since the analysis aimed to calculate the project IRR of the total capital used, interest during construction was excluded from the calculation.

Prepared by the Study Team

(2) Economic Costs

The economic cost of the project was calculated based on the project cost estimate updated in the previous section. Annual O&M cost and reinvestment (replacement cost) were also estimated. Economic cost was calculated by excluding transfer items such as taxes and conversion of the local currency portion with the standard conversion factor presented above.

1) Construction Cost

The construction cost at economic price sorted by major items is shown in the table below. The economic cost of the project was estimated at USD 79.5 million in total.

Table 5.6.4 Construction Cost (Economic Price)

(USD 1,000)

Description	1st Year		2nd Year		3rd Year		4th Year		5th Year		Total		
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	Total
I. Construction Cost													
Civil Works	0	0	2,276	379	9,102	1,514	9,102	1,514	6,827	1,136	27,307	4,543	31,850
Hydro-mechanical Works	0	0	277	46	1,110	185	1,110	185	832	138	3,329	554	3,883
Electro-mechanical Works	0	0	1,699	283	6,796	1,131	6,796	1,131	5,097	848	20,389	3,392	23,780
Total Base Cost	0	0	4,252	707	17,008	2,829	17,008	2,829	12,756	2,122	51,024	8,488	59,513
Physical Contingency (10%)	0	0	425	71	1,701	283	1,701	283	1,276	212	5,102	849	5,951
Total Construction Cost	**0**	**0**	**4,677**	**778**	**18,709**	**3,112**	**18,709**	**3,112**	**14,032**	**2,334**	**56,127**	**9,337**	**65,464**
II. Consulting Services													
Base Cost	1,560	46	1,586	54	1,879	73	2,024	77	2,015	81	9,064	331	9,395
Physical Contingency (5%)	78	2	79	3	94	4	101	4	101	4	453	17	470
Total Consulting Services	**1,638**	**48**	**1,665**	**57**	**1,973**	**76**	**2,125**	**81**	**2,116**	**85**	**9,517**	**348**	**9,865**
III. Administration Cost													
Administration Cost	**0**	**88**	**0**	**384**	**0**	**1,308**	**0**	**1,348**	**0**	**1,067**	**0**	**4,195**	**4,195**
TOTAL (I to III)	**1,638**	**136**	**6,342**	**1,219**	**20,682**	**4,496**	**20,834**	**4,542**	**16,147**	**3,486**	**65,644**	**13,880**	**79,524**
TOTAL (FC + LC)	**1,774**		**7,561**		**25,179**		**25,376**		**19,634**		**79,524**		

Prepared by the Study Team

2) Operation and Maintenance Cost

The annual O&M cost of the constructed facilities were calculated at USD 345,000 per year based on the following conditions:

- Civil Works： 0.5% of initial investment cost of civil works, excluding temporary works

- Hydro-mechanical Works: i. 0.75% of initial investment cost of intake gate and hoist

  ii. 0.25% of initial investment cost of trash rack and stop log

- Electro-mechanical Works: 1% of initial investment of total electromechanical works

Table 5.6.5 Operation and Maintenance Cost (Economic Price)

(USD 1,000)

Item	Construction Cost (incl. Physical Contingency)	Factor	O&M Cost
Civil Works (excl. Tenporary Works)	14,075	0.50%	70
Hydro-mechanical Works			
Intake Gate and Hoist	1,903	0.75%	14
Trash Rack and Stop Log	609	0.25%	2
Electro-mechanical Works	25,916	1.00%	259
Total	---	---	345

Prepared by the Study Team

3) Reinvestment Cost (Replacement Cost of Equipment)

The reinvestment cost was estimated for the hydro-mechanical and electro-mechanical works in 30 years after commissioning. Residual value of the reinvestment was added in the cash flow projection on the last year.

- Hydro-mechanical Works: 5% of initial investment cost of intake gate and hoist

- Electro-mechanical Works : i. 70% of initial investment cost of turbine and generator

  ii. 100% of initial investment cost of other equipment

Table 5.6.6 Reinvestment Cost (Economic Price)

(USD 1,000)

Item	Construction Cost (incl. Physical Contingency)	Factor	Reinvestment Cost
Hydro-mechanical Works	1,903	5%	95
Electro-mechanical Works			
Turbine and Generator	20,724	70%	14,507
Others	5,192	100%	5,192
Total	---	---	19,794

Prepared by the Study Team

(3) Reduction of O&M Cost for Existing Generation Units

The expansion project will improve the operational efficiency of the whole power station. It was planned that the O&M cost of the existing generation units will be reduced as an effect of the project. As shown in the following table, in the with-project case, the operation time rate will be reduced by 12.4% on the average. This is equivalent to the reduction of O&M cost by USD 167,000 annually.

Table 5.6.7 Operation Time Rate and O&M Cost Saving (Economic Price)

Item	Unit	Without Project	With Project	Change %
Operation Rate (Unit No.1-No.5)				
Year 2018 -		80.5%	69.2%	14.1%
Year 2023 -		79.3%	71.2%	10.3%
Year 2028 -		79.7%	69.4%	13.0%
Average		-	-	**12.4%**
O&M Cost (Unit No.1-No.5)	USD 1,000	1,338	1,172	**167**

* O&M Cost of Unit No.1 - 5 = Unit No.6 O&M Cost / 40MW * 155 MW

Prepared by the Study Team

(4) EIRR Calculation: Effects to Electricity Trade Balance

The increase in energy supply and shift to peak energy were regarded as the primary benefits of the expansion project. According to the projection made in Section 5.5, EIRR was tentatively calculated based on the tariff revised in August 2011. Table 5.6.8 summarizes the EDL trade balance projection. Surcharge payments were not anticipated because import amount will not exceed the export in any case. The difference between with- and without-project cases was regarded as the annual benefit of the expansion project for each year. The annual benefit between years 2017, 2020, and 2021 onwards was regarded the same as in 2017 and 2020, respectively.

Table 5.6.8 EDL Trade Deficit (Surplus) Projection

Year		EDL Trade Deficit (Surplus) with EGAT		
		A. Without Project	B. With Project	C. Benefit (A-B)
2017	THB 1,000	58,568	(74,127)	132,695
	USD 1,000	*1,828*	*(2,314)*	*4,142*
2020	THB 1,000	(9,993,452)	(10,133,468)	140,016
	USD 1,000	*(311,905)*	*(316,276)*	*4,370*

Prepared by the Study Team

Table 5.6.9 presents the cash flow projection using the improvement of trade balance as an economic benefit.. EIRR was calculated at 4.04%, which was lower than the discount rate of 10%. NPV with 10% discount rate was USD -31.4 million. The low IRR in this analysis was primarily because of the low tariff level and small difference between peak and off-peak energy values. It will be questionable if the current cross-border trade tariff reflects the actual economic values of energy supply.

Table 5.6.9 Calculation of EIRR (Effect to Trade Balance)

(USD 1,000)

	Year	Cost						Net Benefit
		Construction and Reinvestment	Operation and Maintenance	Total	Effect on Power Trade	Unit No.1-5 OM Cost Saving	Total	
1	2013	1,774	0	1,774	0	0	0	-1,774
2	2014	7,561	0	7,561	0	0	0	-7,561
3	2015	25,179	0	25,179	0	0	0	-25,179
4	2016	25,376	0	25,376	0	0	0	-25,376
5	2017	19,634	0	19,634	0	0	0	-19,634
6	2018	0	345	345	4,142	167	4,308	3,963
7	2019	0	345	345	4,142	167	4,308	3,963
8	2020	0	345	345	4,370	167	4,537	4,191
9	2021	0	345	345	4,370	167	4,537	4,191
10	2022	0	345	345	4,370	167	4,537	4,191
11	2023	0	345	345	4,370	167	4,537	4,191
12	2024	0	345	345	4,370	167	4,537	4,191
13	2025	0	345	345	4,370	167	4,537	4,191
14	2026	0	345	345	4,370	167	4,537	4,191
15	2027	0	345	345	4,370	167	4,537	4,191
16	2028	0	345	345	4,370	167	4,537	4,191
17	2029	0	345	345	4,370	167	4,537	4,191
18	2030	0	345	345	4,370	167	4,537	4,191
19	2031	0	345	345	4,370	167	4,537	4,191
20	2032	0	345	345	4,370	167	4,537	4,191
21	2033	0	345	345	4,370	167	4,537	4,191
22	2034	0	345	345	4,370	167	4,537	4,191
23	2035	0	345	345	4,370	167	4,537	4,191
24	2036	0	345	345	4,370	167	4,537	4,191
25	2037	0	345	345	4,370	167	4,537	4,191
26	2038	0	345	345	4,370	167	4,537	4,191
27	2039	0	345	345	4,370	167	4,537	4,191
28	2040	0	345	345	4,370	167	4,537	4,191
29	2041	0	345	345	4,370	167	4,537	4,191
30	2042	0	345	345	4,370	167	4,537	4,191
31	2043	0	345	345	4,370	167	4,537	4,191
32	2044	0	345	345	4,370	167	4,537	4,191
33	2045	0	345	345	4,370	167	4,537	4,191
34	2046	0	345	345	4,370	167	4,537	4,191
35	2047	19,794	345	20,139	4,370	167	4,537	-15,603
36	2048	0	345	345	4,370	167	4,537	4,191
37	2049	0	345	345	4,370	167	4,537	4,191
38	2050	0	345	345	4,370	167	4,537	4,191
39	2051	0	345	345	4,370	167	4,537	4,191
40	2052	0	345	345	4,370	167	4,537	4,191
41	2053	0	345	345	4,370	167	4,537	4,191
42	2054	0	345	345	4,370	167	4,537	4,191
43	2055	0	345	345	4,370	167	4,537	4,191
44	2056	0	345	345	4,370	167	4,537	4,191
45	2057	0	345	345	4,370	167	4,537	4,191
46	2058	0	345	345	4,370	167	4,537	4,191
47	2059	0	345	345	4,370	167	4,537	4,191
48	2060	0	345	345	4,370	167	4,537	4,191
49	2061	0	345	345	4,370	167	4,537	4,191
50	2062	0	345	345	4,370	167	4,537	4,191
51	2063	0	345	345	4,370	167	4,537	4,191
52	2064	0	345	345	4,370	167	4,537	4,191
53	2065	0	345	345	4,370	167	4,537	4,191
54	2066	0	345	345	4,370	167	4,537	4,191
55	2067	-6,598	345	-6,253	4,370	167	4,537	10,789
Total		92,720	17,267	109,986	218,045	8,328	226,373	116,386
Discount Rate:		10.0%	PV (Cost):	59,097		PV (Benefit):	27,683	
							EIRR:	4.04%
							NPV:	-31,415
							B/C:	0.47

Prepared by the Study Team

(5) EIRR Calculation: Alternative Thermal Power

In this analysis, the economic benefit was measured by the capacity benefit (kW value) and the energy benefit (kWh value) increased by the expansion project through valuation of alternative thermal power. In reference with the previous preparatory survey, the data for a middle-speed diesel power plant were updated to estimate the economic value.[20]

1) Adjustment Factors

The adjustment factors for comparison of hydropower to diesel power were updated as shown in the table below.

Table 5.6.10 Adjustment Factors of Power Plant

Item	Hydropower		Diesel Power	
Transmission Loss	6.00%	A	6.00%	E
Overhaul and maintenance	0.00%	B	7.67%	F
Auxiliary Power Consumption	0.50%	C	4.00%	G
Forced outage	0.50%	D	2.19%	H
kW Adjustment Factor /1	-		1.142	I
kWh Adjustment Factor /2	-		1.036	J

Notes:

/1 I = ((1-A)*(1-B)*(1-C)*(1-D)) / ((1-E)*(1-F)*(1-G)*(1-H))

/2 J = ((1-A)*(1-C)) / ((1-E)*(1-G))

Prepared by the Study Team

2) kW Values

The kW value was calculated based on the construction cost of diesel power as shown in Table 5.6.11 below.

Table 5.6.11 Calculation of kW Value

Item		Unit	Middle Speed Diesel Power
A	Construction Cost per kW	USD/kW	960.0
C	Economic Life	Years	15
D	Discount Rate		10%
E	Capital Recovery Factor		0.1315
H	kW Adjustment Factor		1.142
I	kW Value (Power Value)	USD/kW/year	144.14

Notes: I = A * E * H

Prepared by the Study Team

3) kWh Value

The kWh value was calculated based on the fuel cost and variable O&M cost of diesel power as shown in Table 5.6.12.

[20] Data for the valuation of diesel power are updated based on the Feasibility Study on The Sihanoukville Diesel Power Development Project in the Kingdom of Cambodia (JETRO, 2005).

Table 5.6.12 Calculation of kWh Value

	Item	Unit	Middle Speed Diesel Power
A	Fuel Type		Heavy Fuel Oil
B	Fuel Price	USD/L	0.6376
C	Caloric Value	kcal/L	9,958
D	Thermal Efficiency		42.2%
E	Heat Rate	kcal/kWh	2,037.9
F	Fuel Amount	L/kWh	0.2047
G	Fuel Cost	USD/kWh	0.1305
H	Variable O&M Cost	USD/kWh	0.0125
I	kWh Value Adjustment Factor		1.036
J	kWh Value (Energy Value)	USD/kW	0.1482

Notes:

B: Fuel Price - Fuel Oil CIF average import price per litre: Lao State Fuel Company (2009 - May 2012)

J = (G + H) * I

Prepared by the Study Team

4) Calculation of Annual Benefit

The following table shows the calculation of economic benefit based on the updated kW and kWh values as well as the generated energy and dependable capacity of the project:

Table 5.6.13 Calculation of Economic Benefit

Item	Unit	Without Project	With Project	Net
Annual Energy				
Year 2017 -	GWh	1,062.85	1,125.35	62.51
Year 2020 -	GWh	1,066.19	1,145.84	79.66
Year 2025 -	GWh	1,062.19	1,119.34	57.15
Dependable Peak Capacity				
Year 2017 -	MW	70.1	111.4	41.32
Year 2020 -	MW	78.5	116.2	37.65
Year 2025 -	MW	78.1	103.1	24.96
Energy Benefit: kWh Value (USD 0.1482/kWh)				
Year 2017 -	USD 1,000	157,514	166,778	9,264
Year 2020 -	USD 1,000	158,010	169,815	11,805
Year 2025 -	USD 1,000	157,417	165,887	8,470
Capacity Benefit: kW Value (USD 144.14/kW)				
Year 2017 -	USD 1,000	10,105	16,060	5,955
Year 2020 -	USD 1,000	11,318	16,745	5,427
Year 2025 -	USD 1,000	11,264	14,862	3,598
Total Annual Benefit				
Year 2017 -	USD 1,000	167,619	182,838	15,219
Year 2020 -	USD 1,000	169,327	186,559	17,232
Year 2025 -	USD 1,000	168,681	180,749	12,068

Prepared by the Study Team

5) Calculation of EIRR

The cash flow projection based on the cost and benefit estimated above was developed as shown in Table 5.6.14 below. EIRR was calculated at 15.06% and NPV at USD 29.7 million with 10% discount rate. The project was considered economically viable.

Table 5.6.14 Calculation of EIRR (Alternative Thermal Power)

(USD 1,000)

	Year	Cost			Benefit				Net Benefit
		Construction and Reinvestment	Operation and Maintenance	**Total**	Capacity Benefit	Energy Benefit	Unit No.1-5 OM Cost Saving	**Total**	
1	2013	1,774	0	**1,774**	0	0	0	**0**	**-1,774**
2	2014	7,561	0	**7,561**	0	0	0	**0**	**-7,561**
3	2015	25,179	0	**25,179**	0	0	0	**0**	**-25,179**
4	2016	25,376	0	**25,376**	0	0	0	**0**	**-25,376**
5	2017	19,634	0	**19,634**	0	0	0	**0**	**-19,634**
6	2018	0	345	**345**	5,955	9,264	167	**15,386**	**15,040**
7	2019	0	345	**345**	5,955	9,264	167	**15,386**	**15,040**
8	2020	0	345	**345**	5,427	11,805	167	**17,399**	**17,053**
9	2021	0	345	**345**	5,427	11,805	167	**17,399**	**17,053**
10	2022	0	345	**345**	5,427	11,805	167	**17,399**	**17,053**
11	2023	0	345	**345**	5,427	11,805	167	**17,399**	**17,053**
12	2024	0	345	**345**	5,427	11,805	167	**17,399**	**17,053**
13	2025	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
14	2026	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
15	2027	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
16	2028	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
17	2029	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
18	2030	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
19	2031	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
20	2032	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
21	2033	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
22	2034	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
23	2035	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
24	2036	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
25	2037	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
26	2038	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
27	2039	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
28	2040	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
29	2041	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
30	2042	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
31	2043	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
32	2044	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
33	2045	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
34	2046	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
35	2047	19,794	345	**20,139**	3,598	8,470	167	**12,235**	**-7,905**
36	2048	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
37	2049	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
38	2050	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
39	2051	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
40	2052	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
41	2053	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
42	2054	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
43	2055	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
44	2056	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
45	2057	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
46	2058	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
47	2059	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
48	2060	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
49	2061	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
50	2062	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
51	2063	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
52	2064	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
53	2065	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
54	2066	0	345	**345**	3,598	8,470	167	**12,235**	**11,889**
55	2067	-6,598	345	**-6,253**	3,598	8,470	167	**12,235**	**18,487**
Total		92,720	17,267	**109,986**	193,770	441,761	8,328	**643,858**	**533,872**
Discount Rate:		10.0%	PV (Cost):	59,097			PV (Benefit):	88,762	
								EIRR:	**15.06%**
								NPV:	**29,665**
								B/C:	**1.50**

Prepared by the Study Team

6) Sensitivity Analysis

Sensitivity of the EIRR was analyzed in the following cases with the project cost increase and the fuel cost increase for the alternative thermal power. The table below present the respective cases and their results which show the economic viability in every case. The results indicate the high sensitivity to both project cost increase and fuel cost decrease.

Table 5.6.15 Sensitivity Analysis Results (EIRR)

	Project Cost Increase		
	-	10% Increase	20% Increase
Base Case	15.06%	13.74%	12.61%
Fuel Cost Decrease by 10%	14.18%	12.92%	12.08%
Fuel Cost Decrease by 20%	13.29%	12.08%	11.05%

Prepared by the Study Team

5.6.3 Financial Analysis

This section updates the financial analysis made in the previous preparatory survey. It evaluated the financial profitability from an executing agency's viewpoint through the calculation of the financial internal rate of return (FIRR).

(1) Construction Cost

The construction cost for the financial analysis was estimated at USD 80.2 million in total as shown in the table below.

Table 5.6.16 Construction Cost (Financial Price)

(USD 1,000)

Description	1st Year		2nd Year		3rd Year		4th Year		5th Year		Total		
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	Total
I. Construction Cost													
Civil Works	0	0	2,276	398	9,102	1,594	9,102	1,594	6,827	1,195	27,307	4,782	32,089
Hydro-mechanical Works	0	0	277	49	1,110	194	1,110	194	832	146	3,329	583	3,912
Electro-mechanical Works	0	0	1,699	298	6,796	1,190	6,796	1,190	5,097	893	20,389	3,570	23,959
Total Base Cost	0	0	4,252	745	17,008	2,978	17,008	2,978	12,756	2,234	51,024	8,935	59,959
Physical Contingency (10%)	0	0	425	74	1,701	298	1,701	298	1,276	223	5,102	894	5,996
Total Construction Cost	**0**	**0**	**4,677**	**819**	**18,709**	**3,276**	**18,709**	**3,276**	**14,032**	**2,457**	**56,127**	**9,829**	**65,955**
II. Consulting Services													
Base Cost	1,560	49	1,586	57	1,879	77	2,024	82	2,015	85	9,064	349	9,413
Physical Contingency (5%)	78	2	79	3	94	4	101	4	101	4	453	17	471
Total Construction Cost	**1,638**	**51**	**1,665**	**60**	**1,973**	**80**	**2,125**	**86**	**2,116**	**89**	**9,517**	**366**	**9,883**
III. Administration Cost													
Administration Cost	**0**	**93**	**0**	**404**	**0**	**1,376**	**0**	**1,419**	**0**	**1,124**	**0**	**4,416**	**4,416**
TOTAL (I to III)	**1,638**	**144**	**6,342**	**1,283**	**20,682**	**4,733**	**20,834**	**4,781**	**16,147**	**3,670**	**65,644**	**14,610**	**80,254**
TOTAL (FC + LC)	**1,781**		**7,625**		**25,415**		**25,615**		**19,817**		**80,254**		

Prepared by the Study Team

(2) Operation and Maintenance Cost

The table below shows the updated O&M cost of the project.

Table 5.6.17 Operation and Maintenance Cost (Financial Price)

(USD 1,000)

Item	Construction Cost (incl. Physical Contingency)	Factor	O&M Cost
Civil Works (excl. Tenporary Works)	14,181	0.50%	71
Hydro-mechanical Works			
Intake Gate and Hoist	1,917	0.75%	14
Trash Rack and Stop Log	613	0.25%	2
Electro-mechanical Works	26,111	1.00%	261
Total	---	---	348

Prepared by the Study Team

(3) Reinvestment (Replacement Cost)

The table below shows the updated reinvestment cost (replacement cost) of the project which will be incurred at the 30th year of operation.

Table 5.6.18 Reinvestment Cost (Financial Price)

(USD 1,000)

Item	Construction Cost (incl. Physical Contingency)	Factor	Reinvestment Cost
Hydro-mechanical Works	1,917	5%	96
Electro-mechanical Works			
Turbine and Generator	20,880	70%	14,616
Others	5,231	100%	5,231
Total	---	---	19,943

Prepared by the Study Team

(4) Reduction of O&M Cost for Existing Generation Units

As explained in the economic analysis, the expansion project will improve the operational efficiency of the whole power station. In the same manner as presented in the economic analysis, for the with-project case, the operation time rate will be reduced by 12.4% on average. This is equivalent to the reduction of O&M cost by USD 168 thousand annually.

(5) Financial Benefit: EDL Electricity Tariff Revenue

According to the EDL officials, it was confirmed that EDL would be responsible for the construction of NN1 expansion and the debt service of the ODA loan. Operation of the power station will be undertaken by EDL-Gen under the ownership of EDL, who will be also responsible for the transmission and distribution of the energy generated. Thus the FIRR in the present analysis was calculated in the viewpoint of EDL and its increased electricity tariff revenue was recognized as the financial benefit of the project. Taking into account the tariff increase recently approved by the government (20% in 2012 and annual 2% from 2013 to 2017), it applies that the average domestic tariff as of 2017 (LAK 741/kWh or USD 9.39 cents) increased from the current level (LAK 559/kWh). The financial benefits were estimated as shown in Table 5.6.19 below.

Table 5.6.19 Financial Benefit (Tariff Revenue)

Item	Unit	Without Project	With Project	Net
Annual Energy				
Year 2017 -	GWh	1,062.85	1,125.35	62.51
Year 2020 -	GWh	1,066.19	1,145.84	79.66
Year 2025 -	GWh	1,062.19	1,119.34	57.15
Loss Rates				
Auxiliary Consumption	%	0.5%	0.5%	
Forced Outage	%	0.5%	0.5%	
Transmission Loss	%	6.0%	6.0%	
Electricity Sold				
Year 2017 -	GWh	989.11	1,047.28	58.17
Year 2020 -	GWh	992.22	1,066.35	74.13
Year 2025 -	GWh	988.50	1,041.68	53.19
Electricity Revenue				
Year 2017 -	USD 1,000	92,842	98,302	5,460
Year 2020 -	USD 1,000	93,134	100,092	6,958
Year 2025 -	USD 1,000	92,785	97,777	4,992

Prepared by the Study Team

(6) Weighted Average Cost of Capital

In reference to the previous preparatory survey, the FIRR will be compared with the capital cost expressed as Weighed Average Cost of Capital (WACC) to evaluate the financial feasibility of the project. WACC is also used as the discount rate for calculation of Net Present Value (NPV). It was assumed that ODA Loan of 0.70% per annum would be applied for 85% of the total project cost and the rest would be funded by EDL's own fund whose cost is nominal 10% per annum. To acquire real cost of capital, a minimum rate test of 4%[21] was applied to the ODA loan portion as the generally accepted practice among multilateral development banks. The nominal domestic cost (EDL own fund) was adjusted for price escalation (inflation rate) whereas the foreign loan (ODA loan) was not adjusted in order to offset the exchange risk premium. As shown in the table below, WACC was calculated at 4.20% per annum.

[21] Minimum rate test is applied to have a WACC reasonably high to ensure sufficiently conservative financial analysis. In MRT, the real cost of capital for each component should be at least 4 percent. If not, the value is replaced with 4 percent. (Source: "Guidelines for Financial Management and Financial Analysis of Projects " African Development Bank, 2006)

Table 5.6.20 Weighted Average Cost of Capital

Item	ODA Loan	EDL	Total
Weight	0.85	0.15	1.00
Nominal Cost	0.70%	10.0%	-
Price Escalation (Inflation)	-	4.70%	-
Real Cost	0.70%	5.30%	-
Minimum Rate Test *	4.00%	5.30%	
Weighted Component of WACC	3.40%	0.80%	**4.20%**

* Minimum rate test adjusts low foreign interest rate to 4%.

Prepared by the Study Team

(7) Calculation of FIRR

Table 5.6.21 shows the financial cash flow projection. The FIRR was calculated at 5.50% and NPV with 4.20% discount rate was USD 15.6 million. Compared to the previous JICA survey results in 2010 (2.75%), the FIRR was improved mainly because of the increased tariff. The FIRR slightly higher than the WACC of 4.20% indicates its marginal profitability and necessity of a concessional ODA loan to implement the project. A low tariff level compared to a large investment cost was considered a major factor for low FIRR. Since EDL has flat-rate tariff system and does not apply TOD rates, the results cannot reflect the increase in peak capacity enabled by the project.

Table 5.6.21 Calculation of FIRR

(USD 1,000)

	Year	Cost			Benefit			Net Benefit
		Construction and Reinvestment	Operation and Maintenance	Total	Incremental Revenue	Unit No.1-5 OM Cost Saving	Total	
1	2013	1,781	0	**1,781**	0	0	**0**	**-1,781**
2	2014	7,625	0	**7,625**	0	0	**0**	**-7,625**
3	2015	25,415	0	**25,415**	0	0	**0**	**-25,415**
4	2016	25,615	0	**25,615**	0	0	**0**	**-25,615**
5	2017	19,817	0	**19,817**	0	0	**0**	**-19,817**
6	2018	0	348	**348**	5,460	168	**5,628**	**5,280**
7	2019	0	348	**348**	5,460	168	**5,628**	**5,280**
8	2020	0	348	**348**	6,958	168	**7,126**	**6,778**
9	2021	0	348	**348**	6,958	168	**7,126**	**6,778**
10	2022	0	348	**348**	6,958	168	**7,126**	**6,778**
11	2023	0	348	**348**	6,958	168	**7,126**	**6,778**
12	2024	0	348	**348**	6,958	168	**7,126**	**6,778**
13	2025	0	348	**348**	4,992	168	**5,160**	**4,812**
14	2026	0	348	**348**	4,992	168	**5,160**	**4,812**
15	2027	0	348	**348**	4,992	168	**5,160**	**4,812**
16	2028	0	348	**348**	4,992	168	**5,160**	**4,812**
17	2029	0	348	**348**	4,992	168	**5,160**	**4,812**
18	2030	0	348	**348**	4,992	168	**5,160**	**4,812**
19	2031	0	348	**348**	4,992	168	**5,160**	**4,812**
20	2032	0	348	**348**	4,992	168	**5,160**	**4,812**
21	2033	0	348	**348**	4,992	168	**5,160**	**4,812**
22	2034	0	348	**348**	4,992	168	**5,160**	**4,812**
23	2035	0	348	**348**	4,992	168	**5,160**	**4,812**
24	2036	0	348	**348**	4,992	168	**5,160**	**4,812**
25	2037	0	348	**348**	4,992	168	**5,160**	**4,812**
26	2038	0	348	**348**	4,992	168	**5,160**	**4,812**
27	2039	0	348	**348**	4,992	168	**5,160**	**4,812**
28	2040	0	348	**348**	4,992	168	**5,160**	**4,812**
29	2041	0	348	**348**	4,992	168	**5,160**	**4,812**
30	2042	0	348	**348**	4,992	168	**5,160**	**4,812**
31	2043	0	348	**348**	4,992	168	**5,160**	**4,812**
32	2044	0	348	**348**	4,992	168	**5,160**	**4,812**
33	2045	0	348	**348**	4,992	168	**5,160**	**4,812**
34	2046	0	348	**348**	4,992	168	**5,160**	**4,812**
35	2047	19,943	348	**20,291**	4,992	168	**5,160**	**-15,130**
36	2048	0	348	**348**	4,992	168	**5,160**	**4,812**
37	2049	0	348	**348**	4,992	168	**5,160**	**4,812**
38	2050	0	348	**348**	4,992	168	**5,160**	**4,812**
39	2051	0	348	**348**	4,992	168	**5,160**	**4,812**
40	2052	0	348	**348**	4,992	168	**5,160**	**4,812**
41	2053	0	348	**348**	4,992	168	**5,160**	**4,812**
42	2054	0	348	**348**	4,992	168	**5,160**	**4,812**
43	2055	0	348	**348**	4,992	168	**5,160**	**4,812**
44	2056	0	348	**348**	4,992	168	**5,160**	**4,812**
45	2057	0	348	**348**	4,992	168	**5,160**	**4,812**
46	2058	0	348	**348**	4,992	168	**5,160**	**4,812**
47	2059	0	348	**348**	4,992	168	**5,160**	**4,812**
48	2060	0	348	**348**	4,992	168	**5,160**	**4,812**
49	2061	0	348	**348**	4,992	168	**5,160**	**4,812**
50	2062	0	348	**348**	4,992	168	**5,160**	**4,812**
51	2063	0	348	**348**	4,992	168	**5,160**	**4,812**
52	2064	0	348	**348**	4,992	168	**5,160**	**4,812**
53	2065	0	348	**348**	4,992	168	**5,160**	**4,812**
54	2066	0	348	**348**	4,992	168	**5,160**	**4,812**
55	2067	-6,648	348	**-6,300**	4,992	168	**5,160**	**11,460**
Total		93,549	17,396	**110,946**	260,382	8,390	**268,773**	**157,827**

FIRR: 5.50%

Prepared by the Study Team

(8) Sensitivity Analysis

Sensitivity of the FIRR was analyzed in the following cases with different conditions. The table below shows the respective cases and their results. The FIRRs in the different cases ranged from 2.31% to 10.30%, which exceeded the current interest rate of JICA ODA Loan for Lao PDR (0.70% p.a.). However, compared to WACC of 4.20%, low financial viability was observed in the cases applying the current tariff level. With the current tariff level, the case with the project cost increased by 10% can exceed the 4.20% WACC.

Table 5.6.22 Sensitivity Analysis Results (FIRR)

EDL Average Tariff		Project Cost Increase		
		-	10% Increase	20% Increase
Present Tariff	USD 6.59 cents/kWh	3.45%	2.84%	2.31%
2017 Tariff Level (Base)	USD 9.93 cents/kWh	**5.50%**	**4.79%**	4.18%
"Tariff Update Study" Recommentionation	USD 16.15 cents/kWh	**10.30%**	**9.31%**	8.47%

Note: "Tariff Update Study" recommendation is the tariff level (LAK 1,274/kWh on average) recommended in the World Bank study "Tariff Study Update" for EDL to acquire cost-recovery level by 2016
Prepared by the Study Team

(9) FIRR with EDL-Gen Off-take Tariff Revenue as Financial Benefit

Presently EDL-Gen has the off-take agreement with EDL for the operation of NN1 with the flat-rate off-take tariff. The present analysis calculated the project FIRR in the viewpoint of EDL-Gen, taking the off-take tariff revenue as the financial revenue. Table 5.6.23 show the financial benefit projection based on the off-take tariff revenue scheduled in 2018 (LAK 439 or USD 5.57 cents).

Table 5.6.23 Financial Benefit (Domestic Tariff)

Item	Unit	Without Project	With Project	Net
Annual Energy				
Year 2017 -	GWh	1,062.85	1,125.35	62.51
Year 2020 -	GWh	1,066.19	1,145.84	79.66
Year 2025 -	GWh	1,062.19	1,119.34	57.15
Loss Rates				
Auxiliary Consumption	%	0.5%	0.5%	
Forced Outage	%	0.5%	0.5%	
Transmission Loss	%	6.0%	6.0%	
Electricity Sold				
Year 2017 -	GWh	989.11	1,047.28	58.17
Year 2020 -	GWh	992.22	1,066.35	74.13
Year 2025 -	GWh	988.50	1,041.68	53.19
Electricity Revenue				
Year 2017 -	US$1,000	88,723	93,941	5,218
Year 2020 -	US$1,000	89,002	95,651	6,649
Year 2025 -	US$1,000	88,668	93,439	4,771

Prepared by the Study Team

The FIRR was calculated at 2.15% showing low profitability of the project to EDL-Gen. Similar to the EDL tariff for customers, the off-take agreement between EDL and EDL-Gen does not apply TOD rates. Thus, the increase in peak capacity cannot be reflected in the financial benefit calculation.

CHAPTER 6 REVIEW OF TRANSMISSION LINE NETWORK IN THE CENTRAL AREA

6.1 TRANSMISSION LINE NETWORK IN LAO PDR

6.1.1 Current Transmission Line Network in Lao PDR

Figure 6.1.1 and Figure 6.1.2 show the current power network system of Lao PDR enclosed in the PDP 2010-2020 (Revision-1).

The north and central systems are currently connected by 115 kV single circuit transmission line from Luangprabang 1 to Vang Vieng with a conductor (1 x 117 mm^2), at an estimated capacity limited to 30 to 40 MW.

The construction of 115 kV double circuit transmission line (conductor size: 1 x 240 mm^2) from Takhek to Pakbo was completed in the beginning of 2011 while Pakxan to Thakhek in June 2011, so as to connect the power system from central to southern area.

Under such circumstance, the power system of Lao PDR is still separated into two parts, namely: i. north and central system up to Pakbo and Kengkok in the south, and ii. Xeset system in the southern area.

In the current power system, there is only one 230 kV double circuit transmission line, which is Hinheup to Naxathong (conductor size: 1 x 630 mm^2), for domestic supply purpose. Meanwhile, the other transmission lines are intended for 115 kV (or 33 kV).

6.1.2 Future Integration of Transmission System in Lao PDR

North and central system does not connect to Xeset system in the south yet. It is planned that the 115 kV transmission line between Pakbo and Saravan will be constructed and commence operation in 2016 under the finance of JICA. Thus, the power systems in Lao PDR will be integrated into one network.

Furthermore, the 230 kV transmission system will also be extended from Hinheup to Luangprabang 2 in future as well as connected to China via Oudomxai, with conductor consisting of 2 x 630 mm^2 (730 MW in capacity for one circuit), as shown in the single line diagram for 2014 (see Figure 6.1.2). These 230 kV transmission lines will be used for feeding power generated by various hydropower plants to be developed in the northern to central area.

Consequently, the transmission line systems for the north, central, and south will be integrated into one system in 2016.

The single line diagram of the power system for 2014, 2017, and 2020 are illustrated in Figures 6.1.2, 6.1.3, and 6.1.4, respectively. The locations of various transmission and substation projects introduced in PDP are shown in Figure 6.1.5.

6.2 TRANSMISSION LINES IN THE CENTRAL AREA

6.2.1 Current Transmission Lines in the Central Area

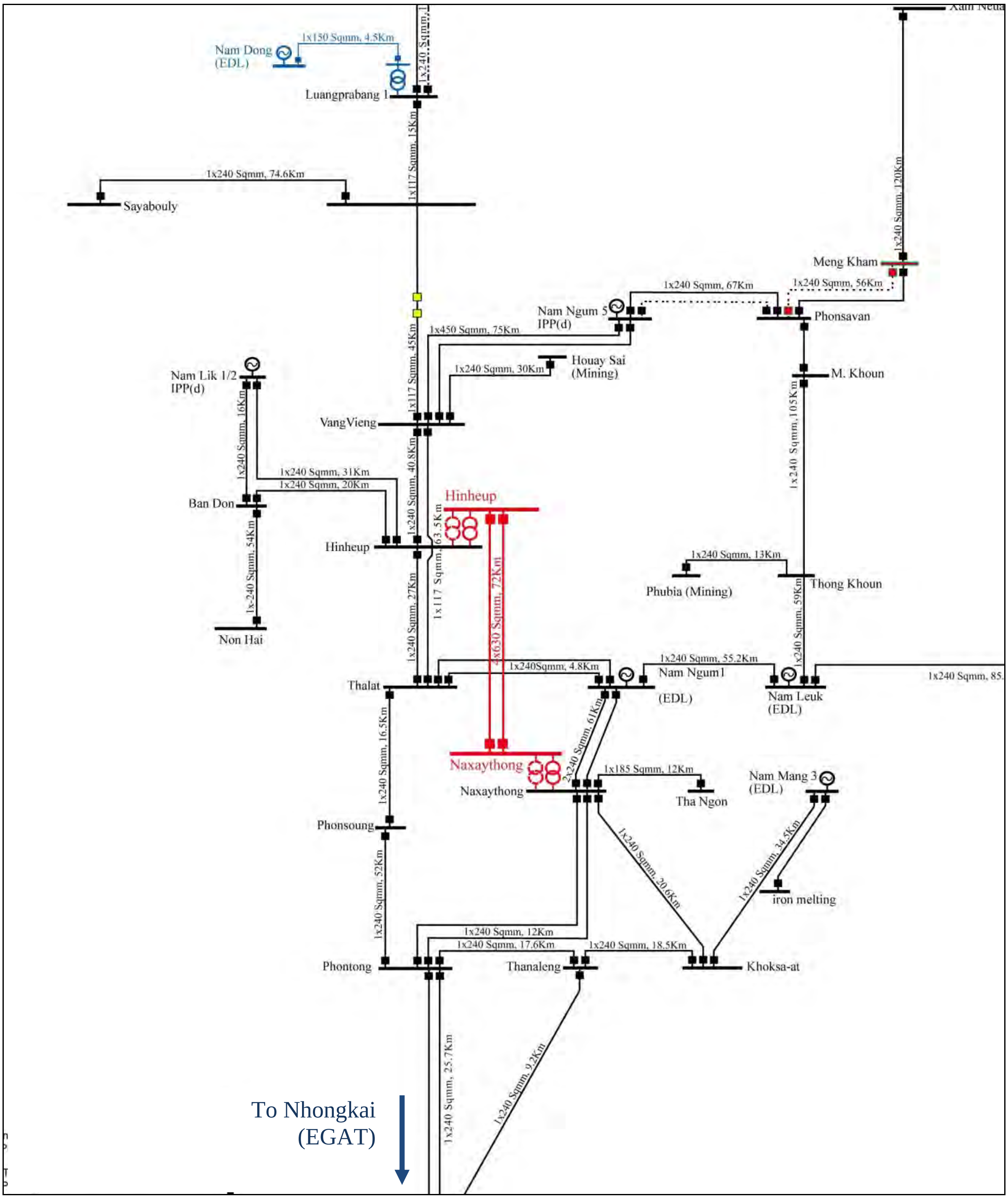
The existing transmission lines in the central area (PDP 2010-2020 Revision 1) are listed in Table 6.2.1, and the single line diagram is illustrated in Figure 6.2.1.

Table 6.2.1 Existing Transmission Lines in the Central Area

No	Project		Length		No. of CCT	Voltage	ACSR Conductor Size	Comm. Year
	From	To	(Km)	(cctŒkm)		(kV)	(Sq.mm)	
1	Nam Ngum 1	Thalat	4.8	9.6	2	115	240	1971
2	Thalat	Phon soung	16.5	16.5	1	115	240	1972
3	Phonsoung	Phontong	52	52	1	115	240	1972
4	Phontong	Nongkhai (Thailand)	25.7	51.4	2	115	240	1972
5	Phontong	Thanaleng	17.6	17.6	1	115	97	1996
6	Thanaleng	Nongkhai (Thailand)	9.2	9.2	1	115	240	1996
7	Naxaithong	Tha Ngon	12	12	1	115	185	1996
8	Thalat	Vangvieng	63.5	63.5	1	115	117	1996
9	Num Ngum 1	Naxaithong	61	122	2	115	240	2000
10	Nam Leuk	Paksan	85.2	85.2	1	115	240	2000
11	Nam Ngum 1	Nam leuk	55.2	55.2	1	115	240	2000
12	Paksan	BoungKhan	11	11	1	115	240	2000
13	Ban Don	Non Hai	54	54	1	115	240	2003
14	Naxaithong	Khoksa ad	20.6	20.6	1	115	240	2005
15	Nam Mang 3	Khoksa ad	34.5	34.5	1	115	240	2005
16	khoksa ad	Thanaleng	18.5	18.5	1	115	240	2005
17	Naxaithong	Phontong	12	24	2	115	240	2006
18	Nam Leuk	Thongkhoun	59	59	1	115	240	2007
19	Thongkhoun	Phubia mining	13	13	1	115	240	2007
20	Vangvien	Hin Heup	40.8	40.8	1	115	240	2009
21	Hin Heup	Thalat	27	27	1	115	240	2009
22	Hin Heup	Ban Don	20	20	1	115	240	2009
23	Nam Leuk 1/2	Hin Heup	31	31	1	115	240	2010
24	Nam Leuk 1/2	Ban Don	15	15	1	115	240	2010
25	Hin Heup	Naxaithong	71.5	143	2	230	630	2011
Total Central Region			877.6	1052.6	31			

Source: PDP 2010-2020 Revision 1

A 230 kV double circuit transmission line from Hinheup to Naxaythong was installed in 2011 with a single conductor of 630 mm^2 per phase at 365 MW capacity for each circuit.



Note: Because this single line diagram is excerpted from the PDP 2010-2020 (Revision 1) without any change, Nam Ngum 5 hydropower station (NN5) is already indicated as originally scheduled although it is still under construction . NN5 is expected to start operation in 2012.

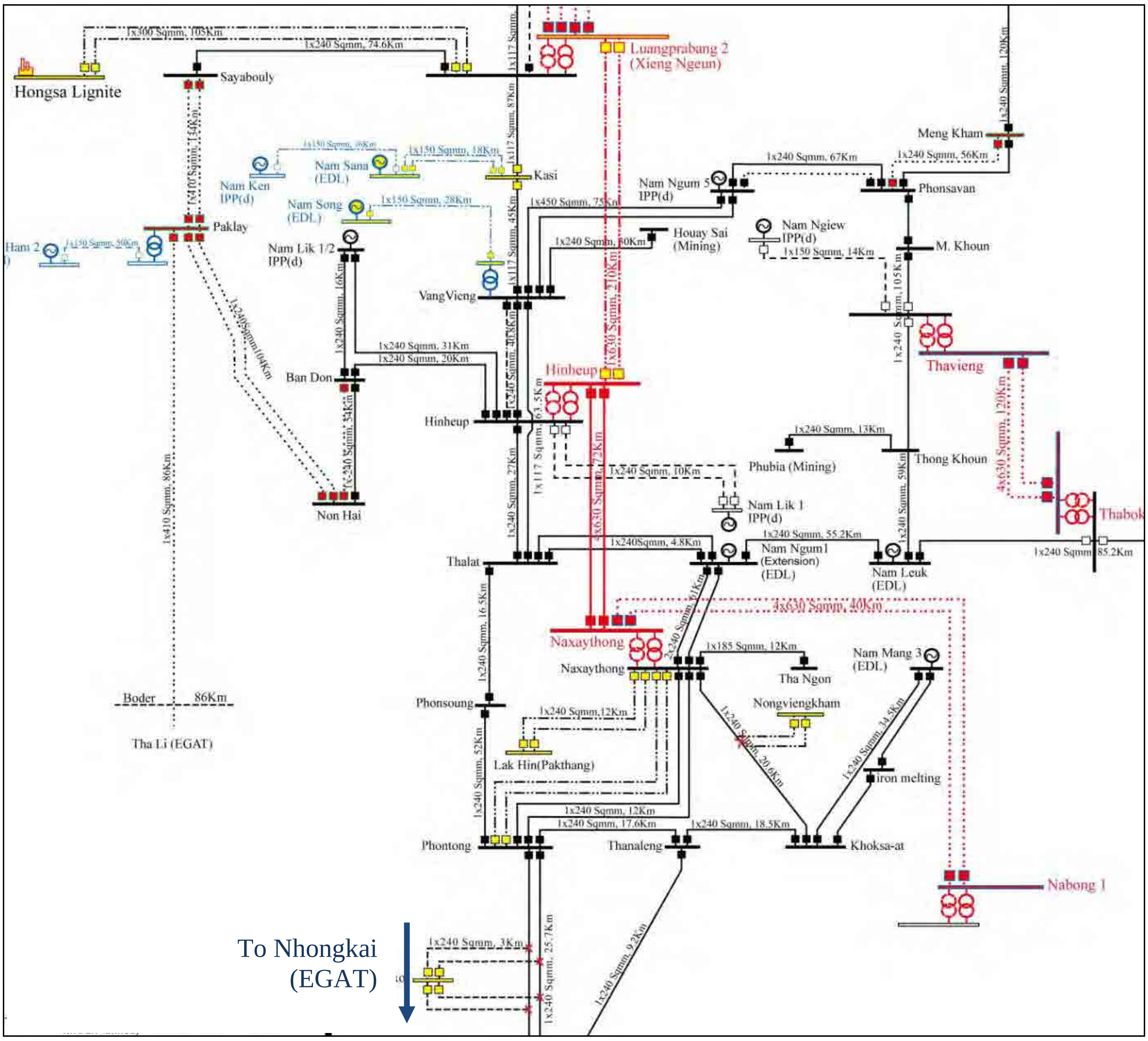
Source : PDP 2010-2020 Revision 1

Figure 6.2.1 Current Transmission Line Network in the Central Area

6.2.2 Transmission Line Development Scenario in the Central Area

(1) Future Transmission Line Network in the Central Area (2014)

The transmission system in the central area in 2014 is pictured in Figure 6.2.2. The 230 kV double circuit transmission line is extended to Luangprabang 2 in the northern area, and also extended to Nabong 1 in the southern area. Nabong 1 Substation is expected to connect to the EGAT system in Thailand through 230 kV double circuit interconnection transmission line.



Prepared by the Study Team

Figure 6.2.2 Transmission Line Network in the Central Area in 2014

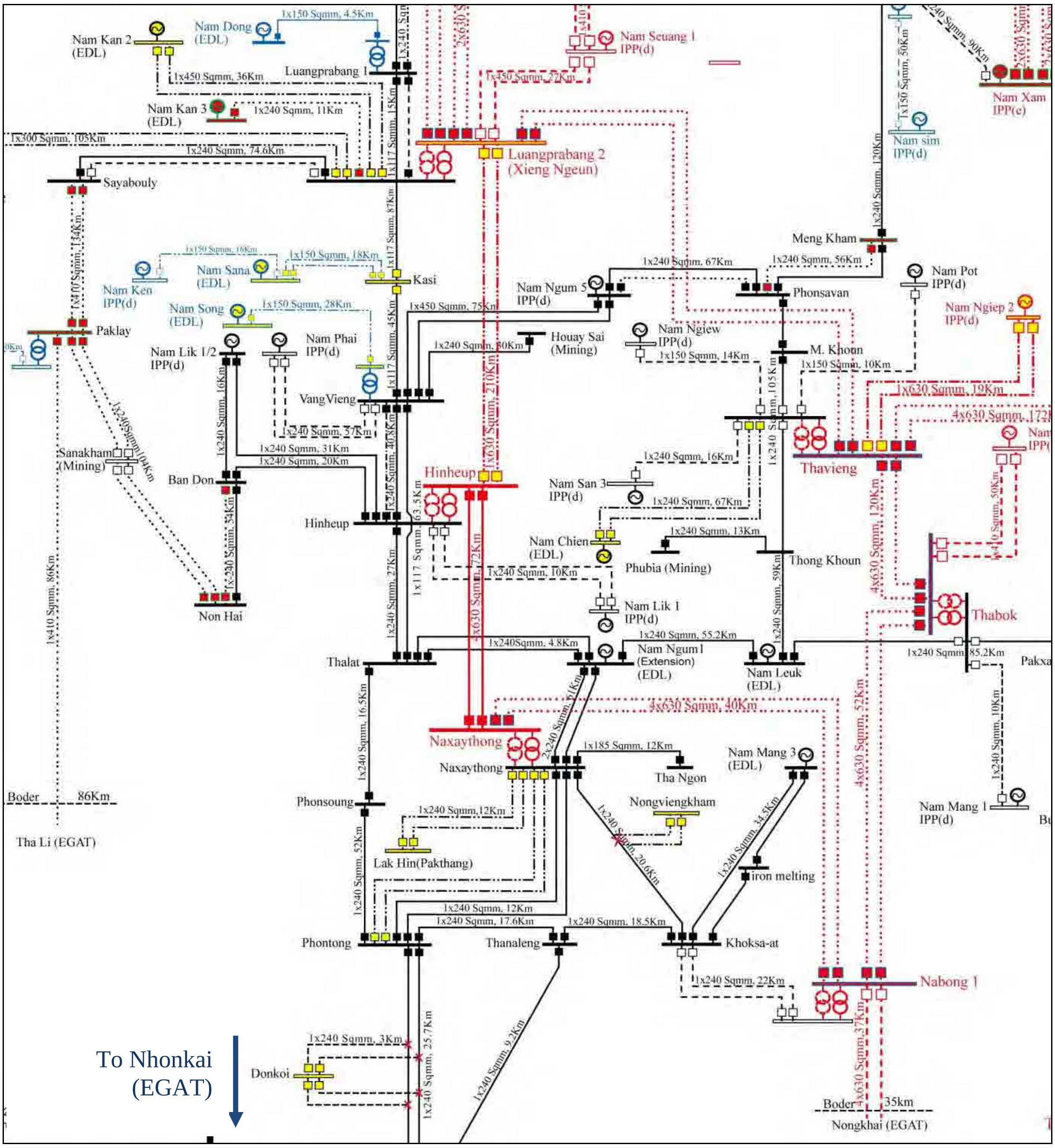
At an intermediate point on existing 115 kV transmission line from M. Khoun to Thong Khoun, 230 kV Thavieng Substation will be established. The 230 kV double circuit transmission line will be extended from Thavieng to Thabok, which will be newly constructed between Nam Leuk and Pakxan.

The 115 kV double circuit transmission line connecting Naxaythong and Phontong will be reinforced to become four circuits, with additional two circuits.

Some 115/22 kV substations such as Donkai, Nongviengkham, and Lak Hin are newly established as shown in Figure 6.2.2, to increase the transformer capacities for distribution of electricity to end consumers in the capital zone.

(2) Future Transmission Line Network in the Central Area (2017)

The transmission system in the central area in 2017 is pictured in Figure 6.2.3.



Prepared by the Study Team

Figure 6.2.3 Transmission Line Network in the Central Area in 2017

In this stage, the 230 kV double circuit transmission lines will consist of a ring-line with grid substations, including Luangprabang 2–Hinheup–Naxaythong–Nabong 1–Thabok–Thavieng.

The Nabong 1 Substation is expected to connect the 230 kV international interconnection transmission line for power trade with EGAT, as shown in PDP 2010-2020 (Revision 1). The transmission line is designed as a double circuit with four conductors of ACSR 630 mm^2 per phase.

In connection to the power trade via Nabong 1 Substation, EDL currently studies alternative design for modification of Nabong 1 Substation so as to connect its 230 kV bus-bars to those in IPP's Nabong Substation. This plan will make it possible to utilize the existing 500 kV transmission line owned by an IPP company, so that additional construction of transmission lines will not be required.

6.3 REVIEW OF LOAD FLOW ANALYSIS

6.3.1 General

In the previous JICA's Preparatory Survey on Expansion of Nam Ngum 1 Hydropower Station, some recommendations on reinforcement of bus conductors in substations were pointed out for the 40MW expansion case although the transmission lines had no overload. Consequently, Study Team checked first whether or not any actions for upgrading bus conductors in substation were taken by EDL

Then, the Study Team reviewed the load flow analysis which EDL has recently carried out in regard to their planned transmission line network in PDP, in order to check the transmission line capacity considering 40 MW expansion of NN1 Power Station.

6.3.2 EDL's Action for Bus Conductors in Substations

In the previous JICA's Preparatory Survey, it was reported that no overload was found on the transmission lines around NN1 P/S after 40MW NN1 expansion in the year of 2016. Contrarily, some issues of overload of bus conductors in Thalat S/S and NN1 Switchyard were pointed out. The Study Team checked whether such recommended actions for upgrading bus conductors were taken by EDL.

(1) Bus conductors in Thalat Substation

It was pointed out that 115kV bus conductors in Thalat substation did not have enough capacity for calculated load. It was however confirmed that the replacement of said bus conductors has been completed to upgrade to an adequate size.

(2) Bus conductors in Nam Ngum 1 Power Substation

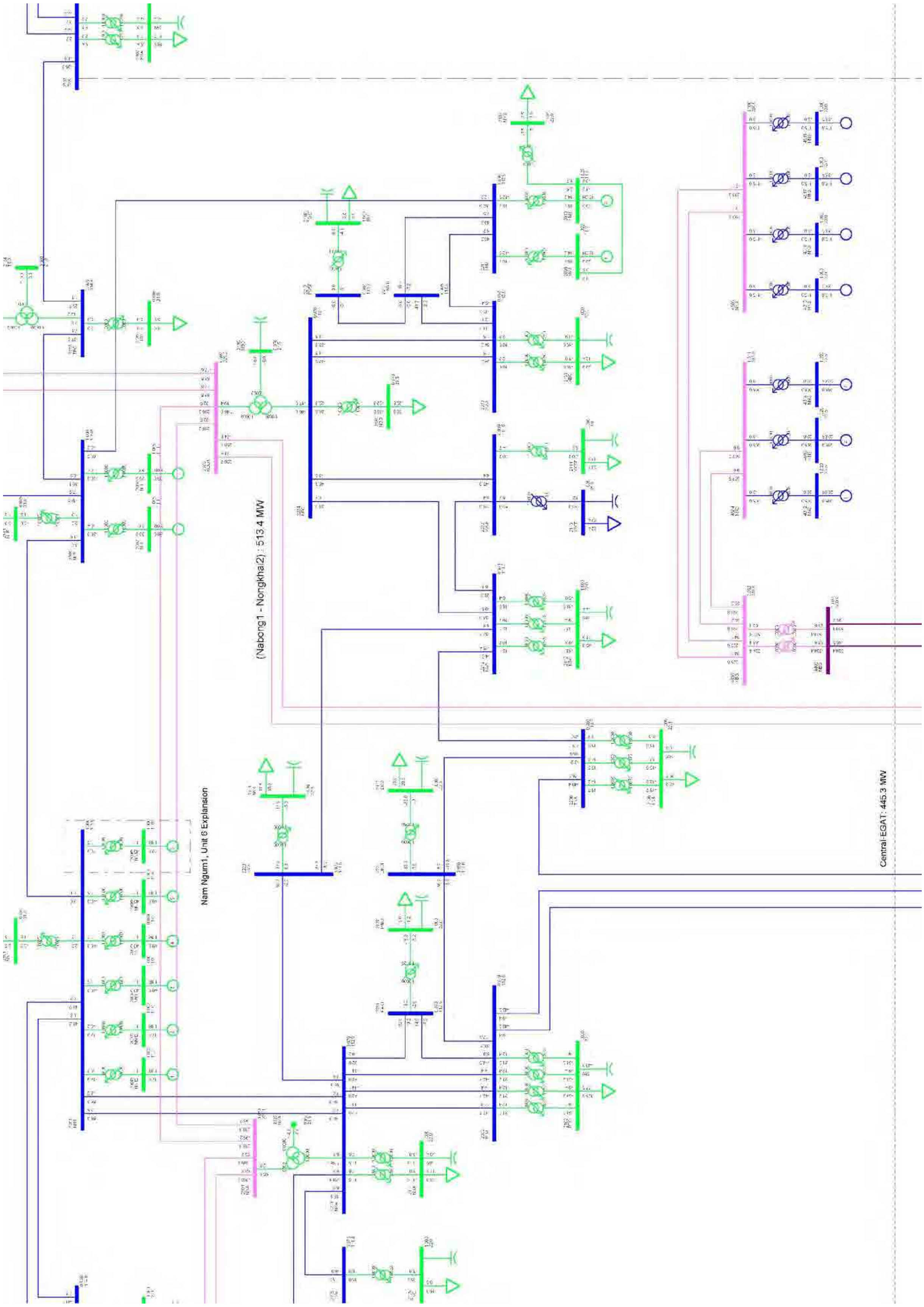
It was also pointed out that 115kV bus conductors in switchyard did not have enough capacity in case of NN1 expanded. The replacement of bus conductors has not yet been completed.

6.3.3 EDL's Load Flow Analysis

The result of EDL's load flow analysis on the power system in PDP 2010-2020 Revision 1 with consideration of 40MW expansion of NN1 Power Station in 2017 and 2020 was focused on 115 kV transmission network around NN1 in Figures 6.3.1 and 6.3.2.

According to result of this analysis, there was neither overload nor abnormal voltage on the transmission lines in the Nam Ngum system under normal conditions with 40 MW expansion. There seems to be no needs for installation of a new transmission line or upgrading the existing transmission line in case 40MW expansion. However, as reported in the previous JICA Study, it is still recommended that the size of bus conductors in NN1 switchyard should be upgraded.

Since some modifications on the power system were made after issue of PDP 2010-2020 Revision 1, EDL's load flow analysis may accordingly need to be updated. It is recommended that further detailed study on overload of transmission lines and bus conductors in consideration of N-1 conditions be carried out in the continued Preparatory Study on Expansion of NN1 Hydropower Station (Phase-2).



Prepared by the Study Team

Figure 6.3.1 EDL's Load Flow Analysis (2017)

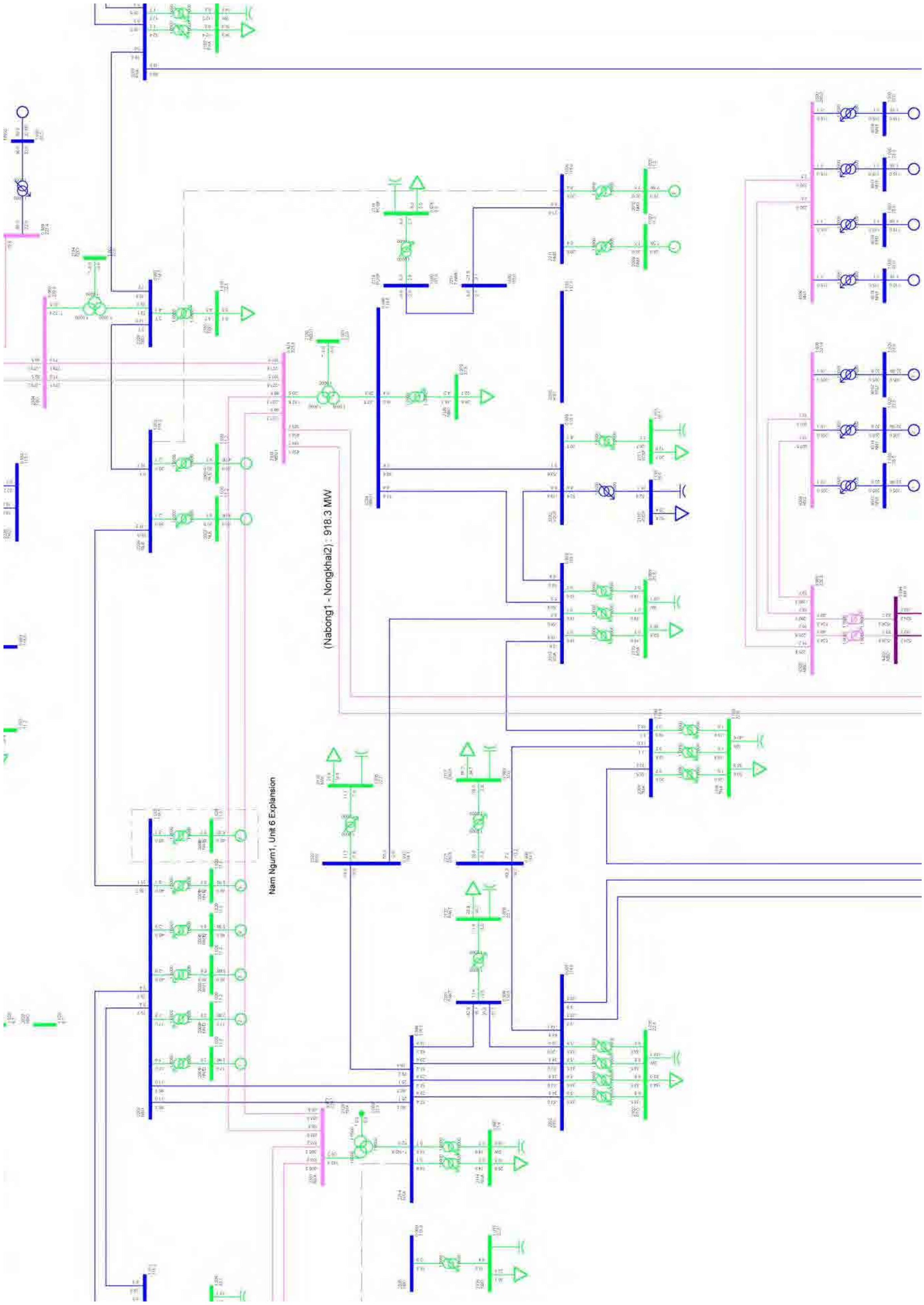


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Figure 6.3.2 EDL's Load Flow Analysis (2020)

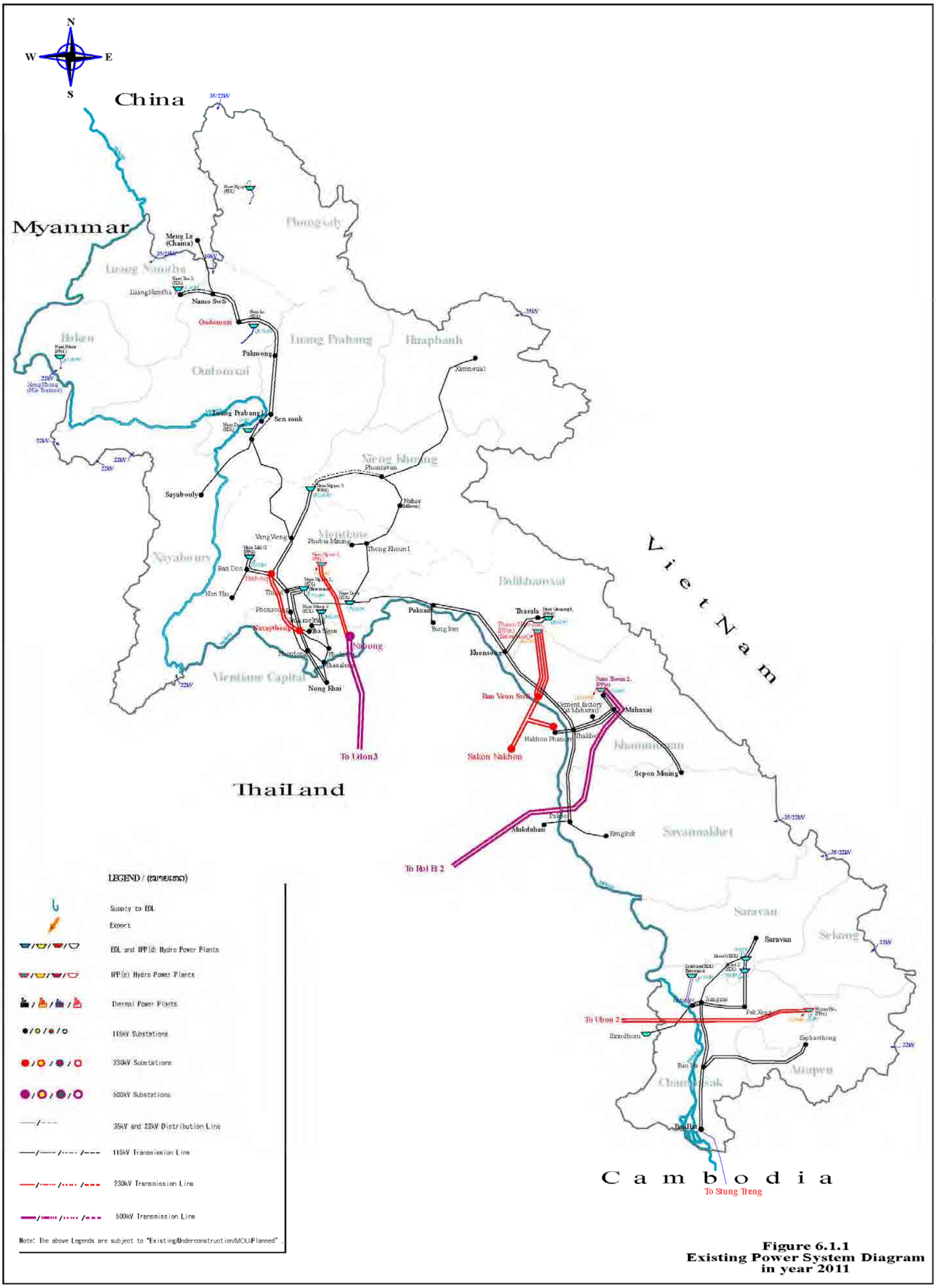


Figure 6.1.1
Existing Power System Diagram in year 2011

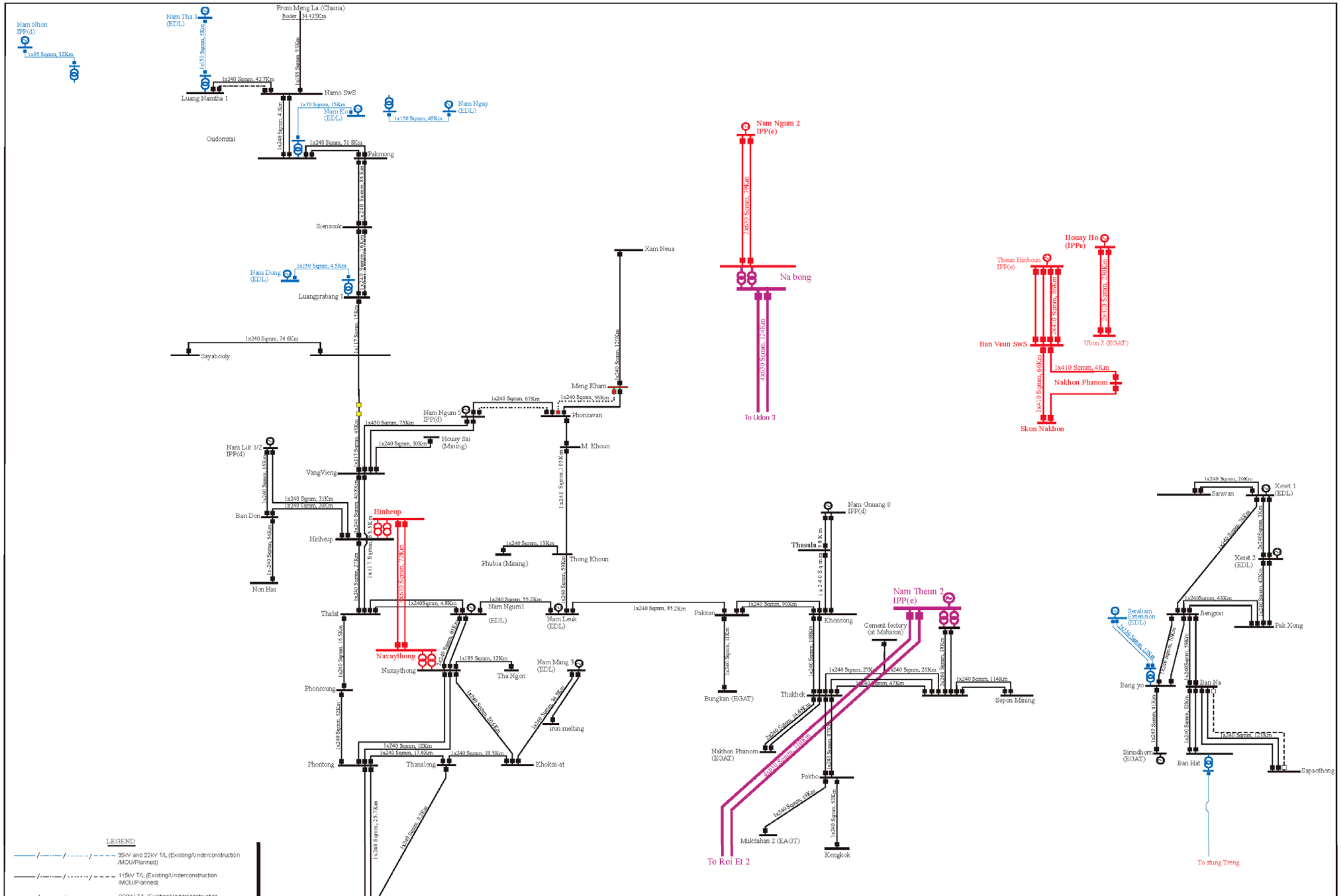
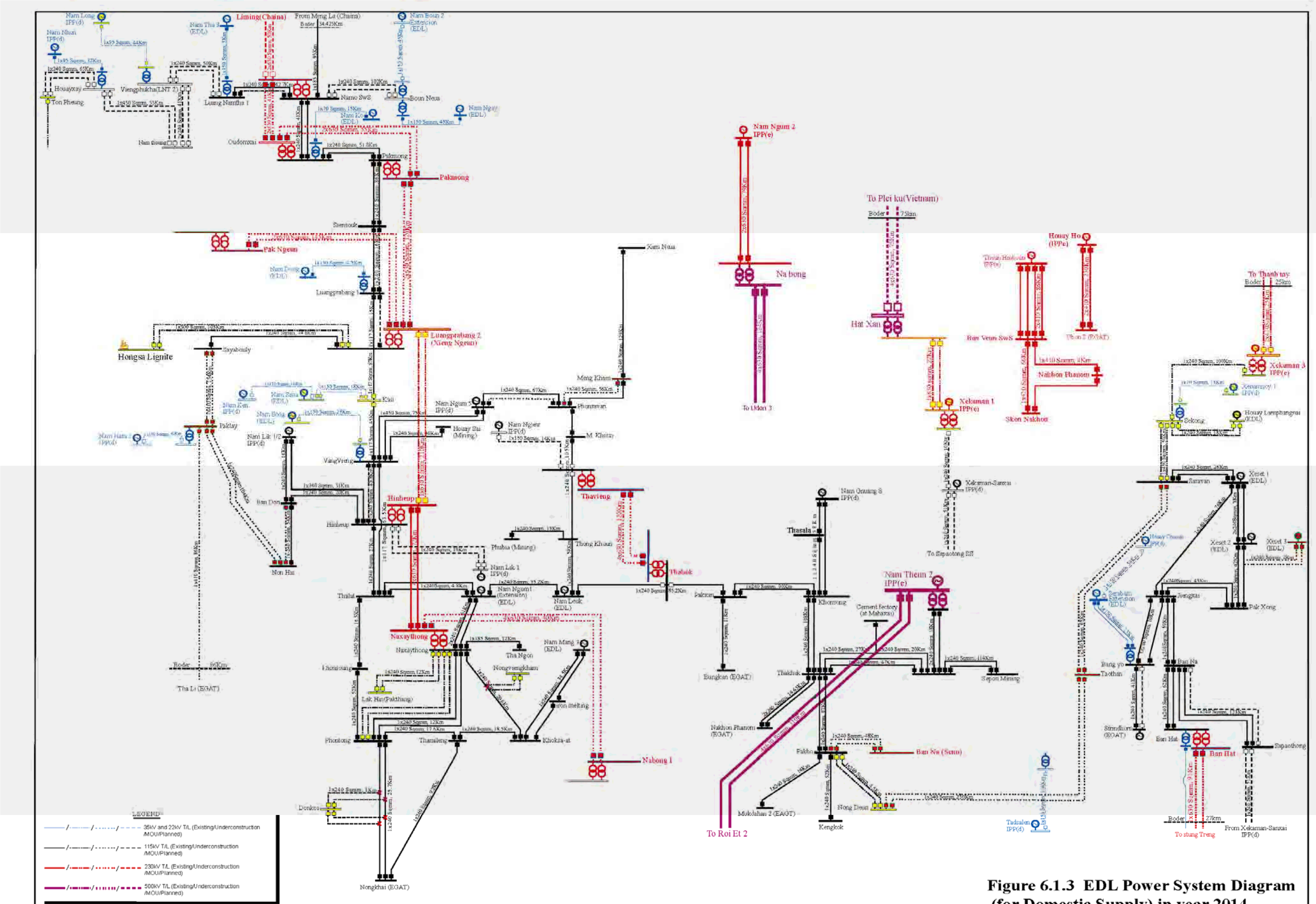


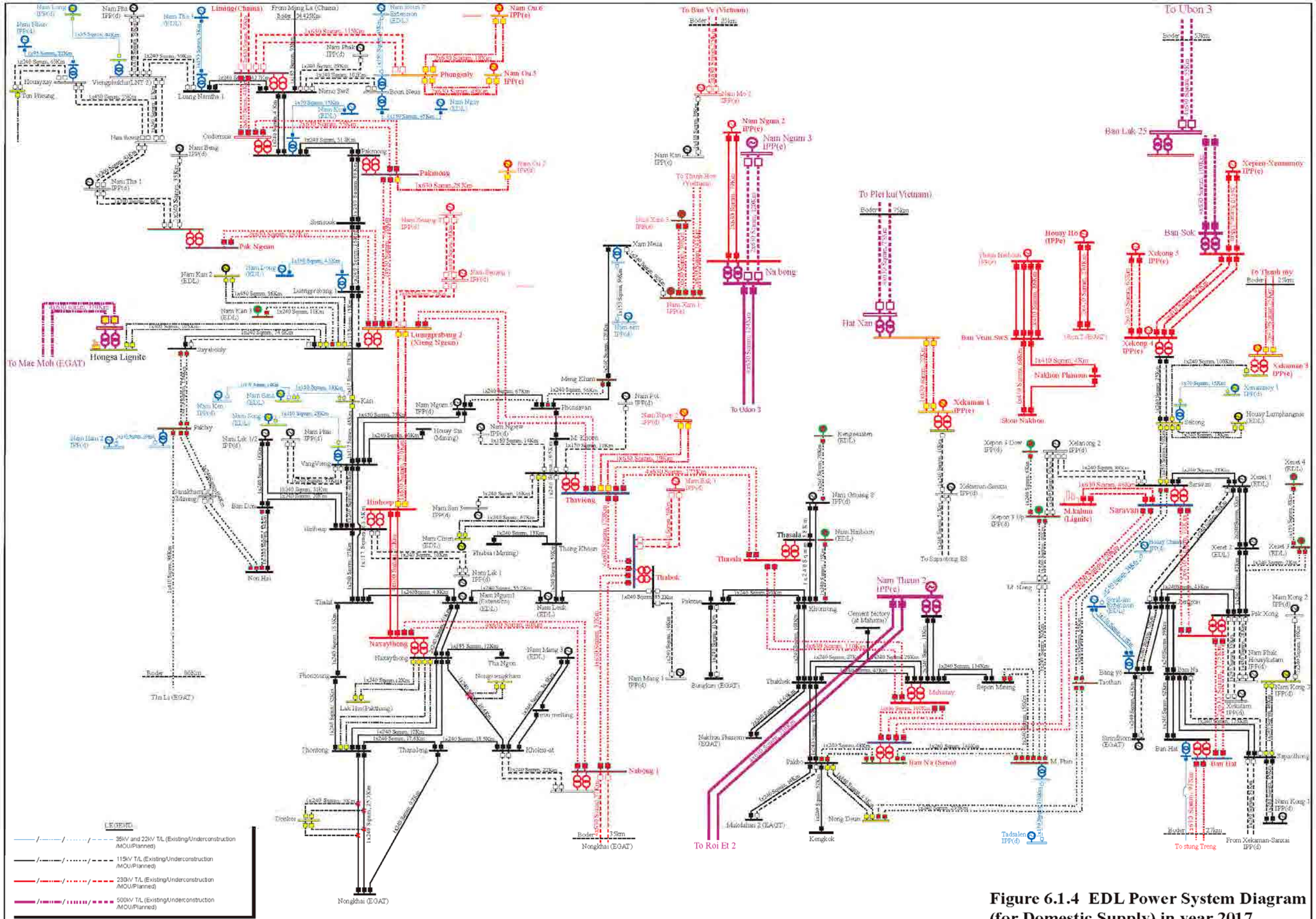
Figure 6.1.2 EDL Power System Diagram (for Domestic Supply) in year 2011

Source : PDP 2010-2020 R-1



Source : PDP 2010-2020 R-1

Figure 6.1.3 EDL Power System Diagram (for Domestic Supply) in year 2014



Source : PDP 2010-2020 R-1

Figure 6.1.4 EDL Power System Diagram (for Domestic Supply) in year 2017

(Case 1)

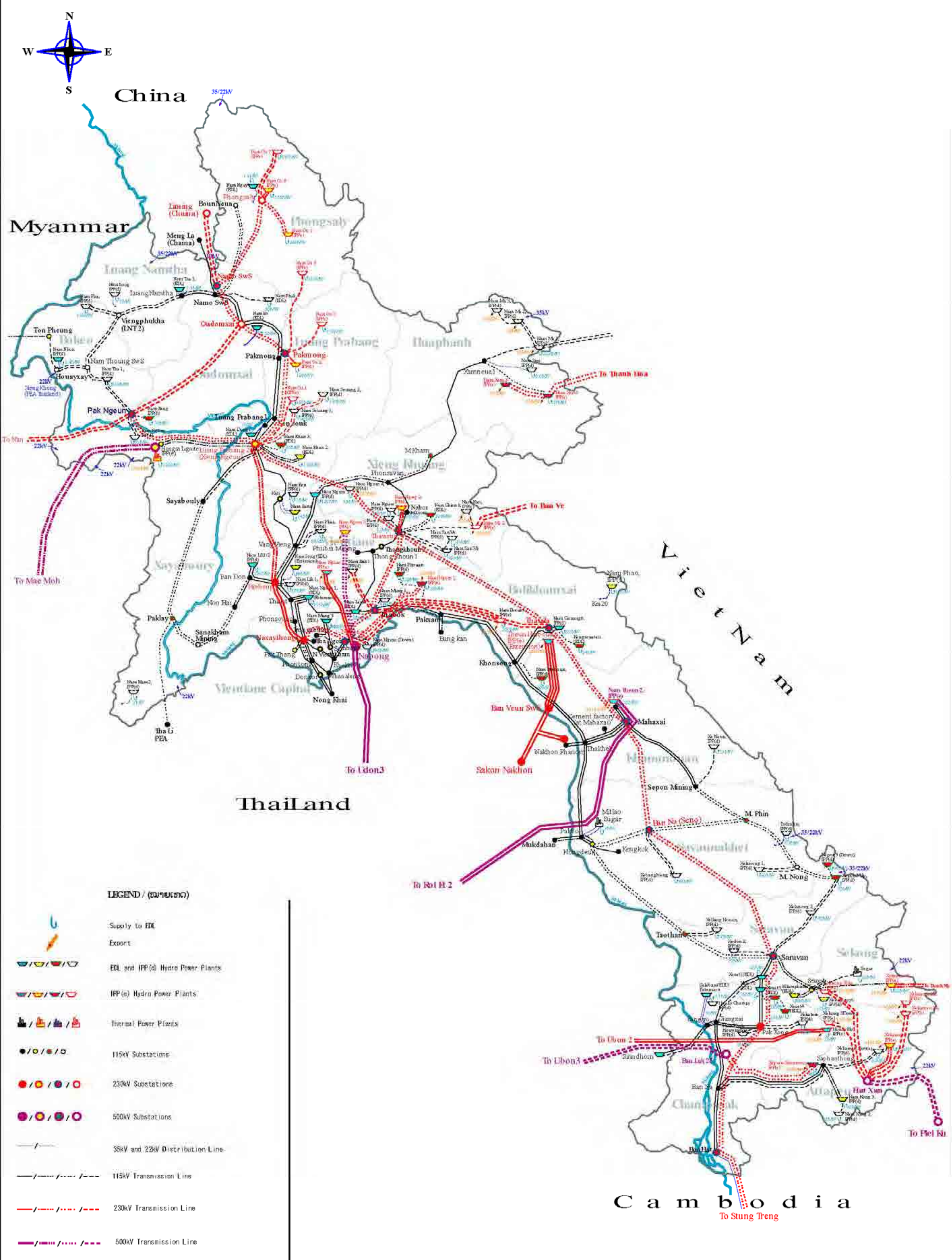


Figure 6.1.5
Planned Power System Diagram
in year 2020

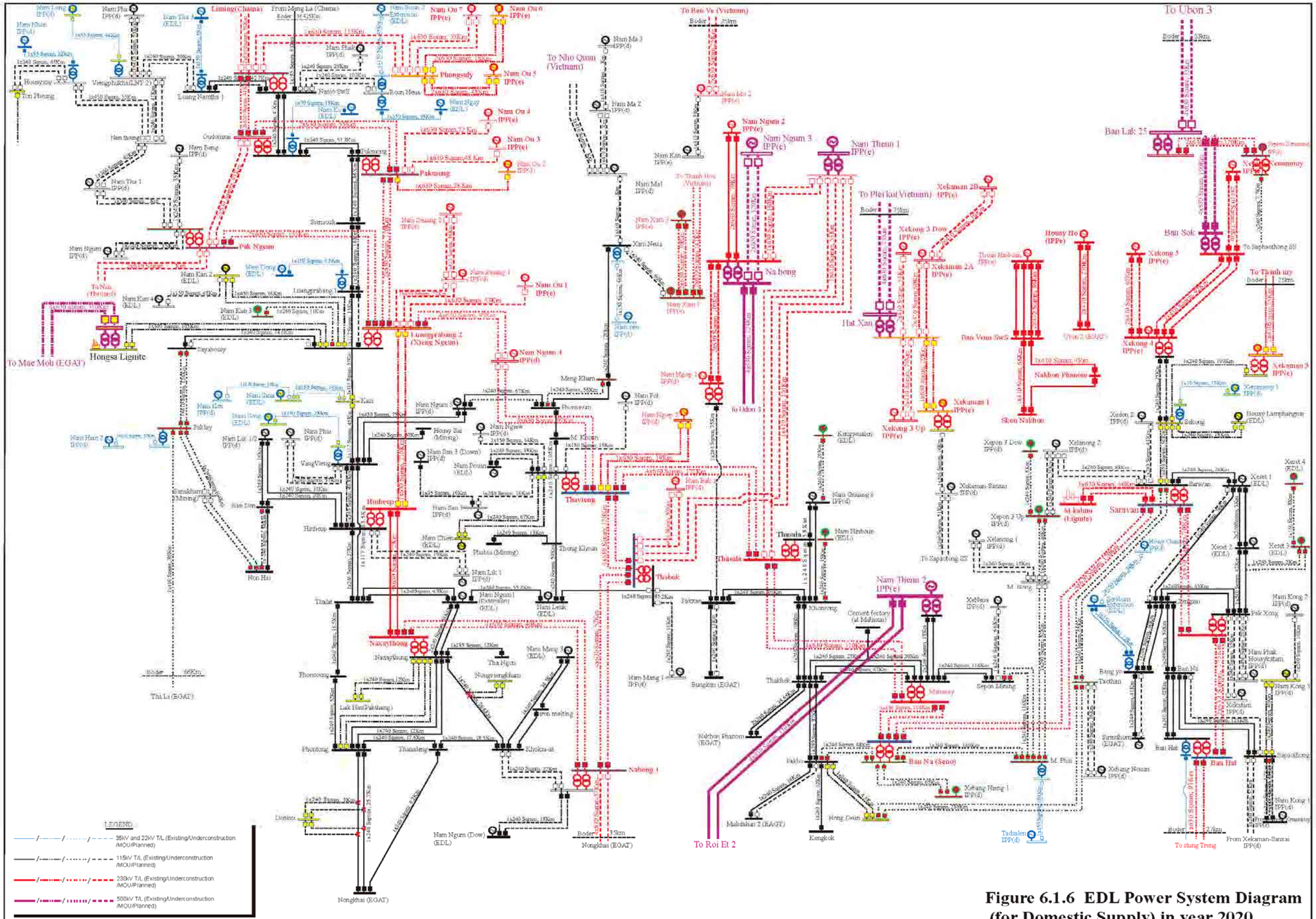


Figure 6.1.6 EDL Power System Diagram (for Domestic Supply) in year 2020

(Case 1)

Source : PDP 2010-2020 R-1

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 Issue on Power Supply in the Central Area

(1) Summary on Power Supply and Demand Analysis

In Chapter 3, the Study Team examined PDP 2010-2020 (Revision-1) and updated the power supply and demand projection. The power supply plan was updated considering the current development status and possible future development of the power plants. The power demand was also reviewed considering the loads of the large industries such as railway construction. The power supply and demand balance was compared in daily basis for the year 2017, 2020, and 2025. As a result, the Study Team found that the peak power supply in the central area of Laos PDR will be insufficient to meet the power demand especially during peak hours at night. The deficit of power supply in the central area was estimated to be over 700 MW at peak time, which should be covered by importing from neighboring country such as Thailand.

(2) Issue of Power Supply in the Central Area

Issue of power supply for peak power generation in the central area is discussed in Chapter 3 and summarized below.

- Reduction of Actual Power Generation during Dry Season

As majority of power source for domestic power supply in Lao PDR is hydropower, the energy and power output of those hydropower plants are affected by the hydrologic seasonal fluctuation. In the dry season, especially from March to May, the power output of hydropower plants is significantly lower than that in wet season.

- Power Shortage for Peak Time Demand

In the study of demand and supply balance for the year 2017, it is observed that power shortage will be more severe during night peak hours from 19:00 to 20:00 in April. EDL is required to secure a reliable power supply for peak load in the dry season at a maximum of additional 709 MW.

- Low Proportion of Controllable Power Capacity to the Total Power Supply

The installed capacity of EDL-owned power stations will reduce its proportion to the total capacity from 68% in 2010 to 17% in 2020. While, as many IPP domestic power generation projects will be completed in 2018, although EDL-owned generation capacity also increases to 885 MW, the proportion will decrease to 25% out of 3,425 MW capacity for the whole country. In 2020, this proportion will further decrease to 17%. This low rate of proportion of controllable capacity in EDL power system impedes the mobility and flexibility of power generation to follow the daily load fluctuation.

In addition to the above issues, as bulk power should be imported from EGAT for peak hours in 2017, the following concerns are anticipated:

- Interconnection Capacity

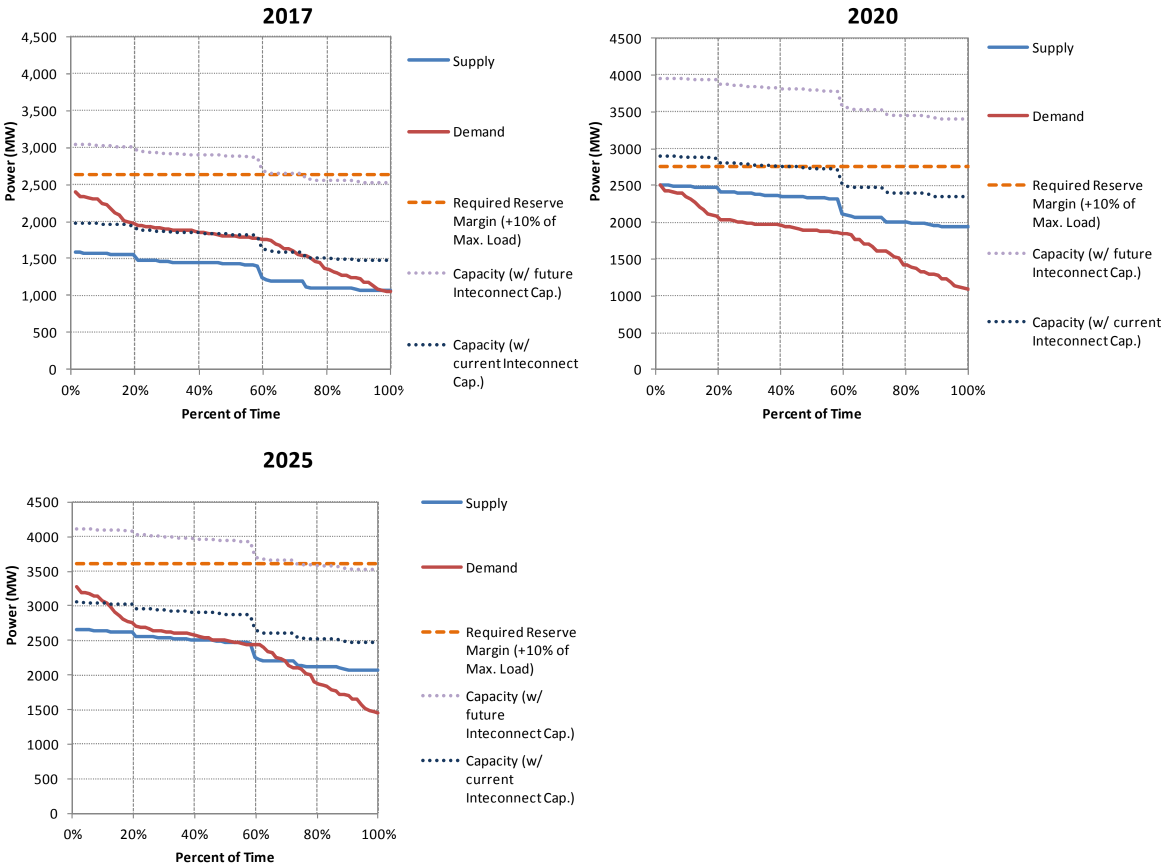
The current present interconnection capacity with Thailand is approximately 800 MW including all existing interconnection transmission lines without N-1 criteria. Thus, importing 709 MW is close to the physical capacity of interconnection, and the marginal capacity of the interconnection is quite limited considering the instantaneous load fluctuation. At present EDL plans to construct the additional interconnection lines between Nabong 1 to Nongkhai 2 for 1460 MW capacity with N-1 criteria. This additional interconnection line may resolve the limitation of capacity; however, any delay of this additional interconnection will worsen the power supply reliability.

- EGAT Capability for Power Export

According to Chapter 5, the reserve capacity of EGAT to the maximum power demand is estimated to be approximately 7000 MW. If this reserve capacity of 7000 MW is presumed in 2017, exporting additional 700 MW to EDL will reduce the 10% reserve margin of EGAT power supply, which is deemed to be generated by combined cycle gas turbine with rather expensive imported natural gas. Thus, this increment of power export of EGAT is not negligible with respect to the cost and power capacity. Although power exchange tariff between EGAT and EDL is set to be lower than the electricity tariff in Thailand, it is necessary for EDL to reduce the power import from EGAT, so as not to deteriorate the power supply reliability of EGAT.

(3) Necessary Reserve Margin of Power Supply

In general, the power supply reliability is visually understood from the comparison of duration curve of power generation and hourly loads. The load duration curve of the whole country combined, and the power generation duration curve for the whole country during the most severe dry months from March to May, are estimated and presented in Figure 7.1.



Prepared by the Study Team

Figure 7.1.1 Duration Curve of Load and Power Generation with Power Supply Capacity and Required Reserve Margin

As shown in the figure, power demand exceeds power supply capacity during most of the time in 2017. The power supply capability, which includes the interconnection capacity, is less than the power demand with the current interconnection capacity in 2017. If the interconnection capacity is strengthened to 1460 MW as planned, power supply capacity will exceed the estimated power demand. The required reserve margin is assumed to be 10% of the maximum load as presented in the figure. It shows that the power supply capability for domestic use cannot be achieved to meet the capacity with reserve margin in 2017 and 2025, if the strengthening the interconnection capacity is not implemented.

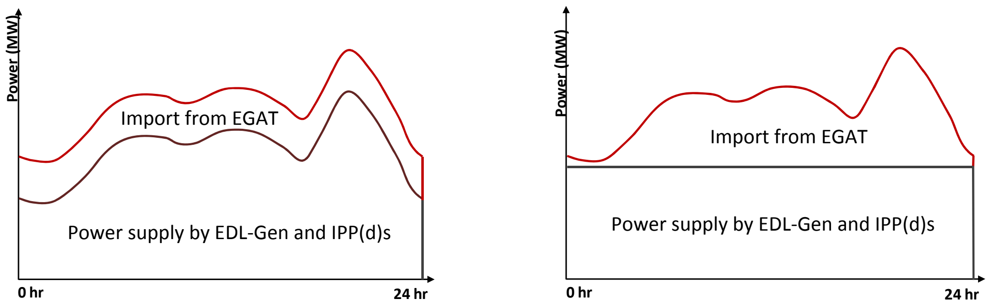
The interconnection capacity can be assumed as the reserve capacity for EDL power system; therefore, power import takes an important role for power supply in Lao PDR for power supply reliability. In summary, power import is indispensable for reliable power supply in Lao PDR. The strengthening the interconnection capacity should surely be implemented.

(4) Efficient Power Generation between EDL-EGAT System

If the power system of EDL and EGAT is considered as a whole, the system is considered as the mix of power sources of hydropower and thermal power plants. Such hydro-thermal system is generally optimum in operation for generation cost aspects when the thermal power plants generate power at constant output, and fluctuation of the daily load shape is covered by the hydropower generation.

Ideally, if the power plants in Laos generates the power plants to follow the daily load shape, the power import from EGAT becomes constant. This situation will be preferable for EGAT to avoid generates increment power with expensive imported natural gas. If the power plants in Laos generates at constant output, EGAT must generate power by combined cycle with imported natural gas to follow the load shape of Laos. Such mode of power generation is shown in Figure 7.1.2.

In this context, it would be preferable that the power plants in Laos should generates the power to follow the daily load shape to minimize the cost of power generation of EGAT for power exporting, thus the peak power supply capacity should be improved in Laos.



(Constant Power Import) Thermal Generation Cost of EGAT for Exporting to EDL Grid	<	(Variable Power Import) Thermal Generation Cost of EGAT for Exporting to EDL Grid

Total importing energy is assumed to the same for both cases.

Prepared by the Study Team

Figure 7.1.2 Concept of Load Shape Following and Constant Power Output

7.1.2 Reinforcement of the Peak Power Supply in the Central Area

(1) Comparative Study for Options for Strengthening Peak Power Supply

In Chapter 5, the options for strengthening the peak power supply were studied among all possible peak power sources available in Laos, which includes renewable energy such as biomass. After the screening of potential and availability of peak power source, the following options were selected:

a. Large scale hydropower development;

b. Small scale hydropower development;

c. Diesel power plant; and

d. Power import.

Among those selected for peak power source, the options were assessed based on four criteria, which consist of 1)Technical assessment, 2) Energy securities, 3) Cost, and 4) Environment. As a result of the comparison of options based on these criteria, large scale hydropower development was selected as the first option for strengthening the peak power supply.

Table below shows the result of comparison extracted from Table 4.4.8 in Chapter 4.

Comparison Result of Alternative Options

Options	Technical Assessment	Energy Securities	Cost	Environment	General Rating by Score
Large Scale Hydropower (NN1 Expansion)	A	A	B	A	11
Small Scale Hydropower	B	B	C	C	6
Diesel Power Plant	B	C	C	C	5
Power Import	A	B	A	B	10

Note) General rating by score is aggregates of points by assuming A = 3 pts, B = 2 pts, and C = 1 pt.
Prepared by the Study Team

It is noted that large scale hydropower development assumed implementation of the existing NN1 hydropower station expansion, as this option was the most exploitable power peak power source available for EDL. Although the power import is ranked in second, power import from EGAT is still important for power supply reliability of EDL as described in Chapter 7.1.1.

(2) NN1 Expansion as Urgent Peak Power Development and Renewal of Existing Dam

As NN1 expansion was selected as the first option for strengthening the peak power supply, the power development through the expansion of existing power plants has been implemented also in Japan. Since this type of expansion has minimal impact to the environment, it has been implemented as an urgent power development to meet the increasing peak power demand in Japan.

Further, it also noted that renewal of existing dams by piercing dam body is generally accepted to improve release capability in Japan. Examples of power plants expansion utilizing existing dams and renewal of existing dams in Japan are shown in Table 7.1.1.

Table 7.1.1 Example of Dam Renewal and Power Plant Expansion Projects Utilizing Existing Dams in Japan

Name of Dams	Akiba Dam	Okutadami Dam	Nanairo Dam	Kuki Dam	Katsukomi Dam
Height of dam	89.0m	157m	61m	28m	34m
Height of dam at piercing point	32.5m	61m	18.4m	26m	18m
Depth of water at piercing point	28m	56m	14.4m	23.5m	16.5m
Piercing diameter	D=6.5m	D=6.2m	D≒2.6m	D≒1.3m	D≒2.4m
Piercing length	L=21m	L=32m	L≒6m	D≒3m	D≒4.5m
Method of piercing	Slot Drilling	Slot Drilling	Diamond Wire Sawing	Diamond Wire Sawing	Abrasive Waterjet
Purpose of the piercing	Hydropower plant expansion	Hydropower plant expansion	Dam renewal	Dam renewal	Dam renewal
Increment Power/Energy	46.9MW/ 96GWh/year	200MW/ - GWh			

Source: J-Power, Preparatory Survey on NN1 Expansion (2010)

It is noted that the Okutadami dam power plants expansion does not expect energy increase by the expansion. As it is generally accepted that expansion of existing hydropower plants usually does not increase the annual energy[1], the Okutadami dam hydropower plant expansion is an example to valuate

1 U.S. Army Corps of Engineers: Engineering and Design Hydropower. EM1110-2-1701, 1985, USA

the expansion with respects to the capacity benefit.

NN1 expansion is similar to Okutadami case as it will be developed as an urgent peak power development to cover the bulk power supply shortage anticipated in the near future. It is inevitable that the increment of energy is limited; however this situation is exemplified by Okutadami dam hydropower plants expansion.

7.1.3 Role of Expanded NN1 in Updated Power Supply and Demand

(1) Increment of Energy

In this study, the inflow time series data is updated and prepared until 2011. Then, the power generation simulation was conducted for NN1 hydropower station with an expansion of 40 MW. The result of the power generation simulation showed that the annual energy will increase to 66 GWh if NN1 is expanded. In the previous study, the increment energy was calculated to be 56 GWh. The increase in incremental energy was due to the 2011 hydrology. However, the difference was less than 1% of the annual energy of NN1 hydropower plant. It can be said that NN1 expansion will increase the annual energy from 5% to 6%.

(2) Contribution to Peak Power Supply

The expansion scale of 40 MW is just 4% of the total installed capacity in the central area in 2017, which is 940 MW. However, by utilizing the massive reservoir storage capacity, expansion of NN1 will improve the flexibility of operation. Thus the off-peak energy is shifted to peak energy.

The power from the northern area to central area is expected to stabilize base power. Therefore, NN1 is allowed to concentrate on peak power operation while keeping a minimum power output to meet the environmental requirement during off-peak hours. This shifting of energy from off-peak to peak hours caused the peak energy deficit in 2017 to decrease to 12% in the central area. Therefore, NN1 expansion is an effective method to decrease power import from EGAT.

(3) Reduction of O&M Cost for Existing Generation Units

As discussed in the preparatory survey in 2010, the expansion project will improve the operational efficiency of the whole power station. Thus, it is envisaged that the project will result to the reduction of the O&M cost of the existing generation units. This study estimated that the saving of operation time was updated to 11% from 12.4% in the previous preparatory survey in 2010.

7.1.4 Environmental Study for Nam Ngum 1 Hydropower Station Expansion

In the case of Extension of NN1 hydropower station Project, an initial environmental examination (IEE) was required to conduct for obtaining an environmental compliance certificate (ECC). The result of the IEE was submitted to the Water Resources and Environment Administration (now Ministry of Natural Resources and Environment or MoNRE), and the ECC was issued in April 2010 to EDL. In March 2012, EDL issued a request to MoNRE for the extension of the ECC because its validity is limited only for two years. The request was accepted and the ECC was extended on 9 July, 2012.

The ECC needs to be extended every two years until the commencement of the operation, unless there is no change in the project design and/or planning.

Based on the result of the previous study in 2010, information regarding natural and social environments within the project area was reconfirmed and updated, taking into account any possible affects from newly operated two hydropower plants, namely, Nam Lik Hydropower Plant and Nam Ngum 2 Hydropower Plant. Consequently, any significant effects were found on water fluctuation. As for water quality, the low rate of dissolved oxygen water was observed in the downstream of the Nam Ngum Hydropower Plant after the commencement of the Nam Ngum 2 Hydropower Plant; however, the water quality has returned to normal at present.

7.1.5 Economic and Financial Analyses for Nam Ngum1 Hydropower Expansion

The project cost estimated in the previous preparatory survey was adjusted to the present price with recent inflation rates. The project cost was updated to JPY 7,212 million (increased by 2.9% from the preparatory survey estimates).

In the economic analysis, EIRR estimated with effects on international electricity trade balance was as low as 4.04%, which was lower than the discount rate of 10%. The low IRR was primarily because of the low tariff level and small difference between peak and off-peak energy values. It is questionable if the current cross-border trade tariff level reflects the actual economic values of energy supply. Surcharge payment, imposed in case EDL has excess import from EGAT, is not anticipated in both with- and without-project cases in 2017 and 2020. Taking the alternative thermal power as economic benefit, EIRR was calculated as 15.06%, and NPV was USD 29.7 million with 10% discount rate. Thus the project is economically viable.

In the financial analysis, the increased tariff revenue of EDL was considered as the project’s financial benefit. FIRR was calculated as 5.50%, showing marginal profitability of the project. Low tariff level compared to the large investment cost was considered as a major factor of the low FIRR. The tariff system of EDL does not apply TOD rates; thus, the increase in peak capacity cannot be reflected in the financial benefit calculation. Because of the very marginal financial viability of the project, a concessional ODA loan is considered necessary for implementation.

7.1.6 Review of Transmission Line Network in the Central Area

<u>Present Transmission Line in Lao PDR</u>

Presently, the power system of Lao PDR is still separated into two parts, namely, (i) north and central system up to Pakbo and Kengkok in the south, and (ii) Xeset system in the southern area. It is planned that the 115 kV transmission line between Pakbo and Saravan will be constructed and commence operation in 2016 under finance of JICA.

Nabong 1 Substation is expected to connect to EGAT system in Thailand through a new 230 kV transmission line for power trade, which was designed as a double circuit with four conductors of

ACSR 630 mm^2 per phase.

EDL's Action for Bus Conductors in Substations

In the previous JICA's Preparatory Survey, it was reported that no overload was found on the transmission lines around NN1 P/S after 40MW NN1 expansion in the year of 2016. Contrarily, some issues of overload of bus conductors in Thalat S/S and NN1 Switchyard were pointed out. The Study Team checked whether such recommended actions for upgrading bus conductors were taken by EDL.

(1) Bus conductors in Thalat Substation

It was pointed out in previous study that 115kV bus conductors in Thalat substation did not have enough capacity for calculated load. It was however confirmed that the replacement of said bus conductors has been completed to upgrade to an adequate size.

(2) Bus conductors in Nam Ngum 1 Power Substation

It was also pointed out in previous study that 115kV bus conductors in switchyard did not have enough capacity in case of NN1 expanded. The replacement of bus conductors has not yet been completed as of August 2012.

EDL's Load Flow Analysis

According to result of this analysis, there was neither overload nor abnormal voltage on the transmission lines in the Nam Ngum system under normal conditions with 40 MW expansion. There seems to be no needs for installation of a new transmission line or upgrading the existing transmission line in case 40MW expansion.

Since some modifications on the power system were made after issue of PDP 2010-2020 Revision 1, EDL's load flow analysis may accordingly need to be updated. It is recommended that further detailed study on overload of transmission lines and bus conductors in consideration of N-1 conditions be carried out in the continued Preparatory Study on Expansion of NN1 Hydropower Station (Phase-2).

7.2 RECOMMENDATIONS

7.2.1 Recommendations on Future Power Supply in the Central Area

The domestic power supply of Lao PDR is composed of power generation by domestic power sources and power import from EGAT. Power import takes significant role on reliable power supply for Lao PDR. However, considering the power demand and balance in EGAT, anticipated power import for over 700 MW from EGAT will consume 10% of their reserve margin, if the current reserve margin of EGAT is kept. Thus it is deemed that such situation is not preferable for EGAT power supply system. EDL is required to develop their own power source in Lao PDR, and schedule their power generation to secure the power capacity especially during dry season. Power development in own resources for domestic power supply is the first priority in the power supply sector of Lao PDR. In this context, NN1 expansion is selected as the first option for peak power capacity development as a result of the comparative study.

However, as reliable power supply is endorsed by the power import from EGAT, and power import is indispensable for power supply of EDL, it is recommended that the planned reinforcement of interconnection line should be implemented.

In addition, it is preferable to change some of IPP(d)s power generation operation from base power operation to peak power operation. Many of Power Purchase Agreement (PPA) signed between EDL and IPP(d) does not specify the operation hours or operation period per day. On the contrary, PPA between EGAT and IPP(e) hydropower specify the generation hours to meet the peak hours in load curve in Thailand. It is recommended to change the form of PPA, to focus on peak power supply by splitting current flat tariff to time of use (TOU) tariff, which consists of peak and off-peak tariff or simply specifying the operation period to meet peak hours. As it is anticipated that controllable power capacity for EDL will be very limited to the total capacity in the near future, the increment of peak power supply by IPP(d)s will help the peak power operation of EDL power generation scheduling.

7.2.2 Recommendations on Environmental Issue

The following tasks are recommended to be carried out in further study:

- Assess impact on the downstream of the Nan Ngum River resulting from the Extension of the Nan Ngum Hydropower Plant, taking the data of daily water fluctuation after the commencement of operation of Nam Lik 1/2 and Nam Ngum 2 into account;

- Collect monitoring result on water quality after construction of Nam Lik 1/2 and Nam Ngum 2 in order to review and update as appropriate the monitoring plan on the extension of the Nam Ngum Hydropower Plant prepared in the previous study; and

- Collect information regarding on-going monitoring program on management of the Nam Ngum River basin such as responsible agency for monitoring, monitoring items, and existing monitoring scheme, in order to review and update as appropriate the monitoring plan on the extension of the Nam Ngum Hydropower Plant prepared in the previous study.

Annexure;

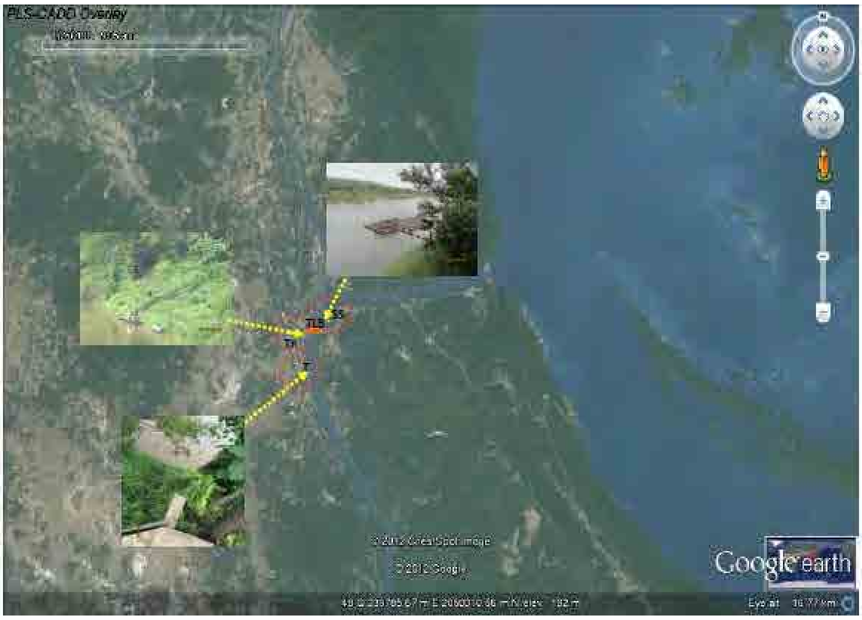
Annex 1.1: Location of Surveyed Village

Annex 1.2: Questionnaire of Hearing

Annex 1.3: Summary of 10 Surveyed Village Result

Annex 1.4: Monitoring Result in July 2011

Annex 1.1: The Location of the Surveyed Villages



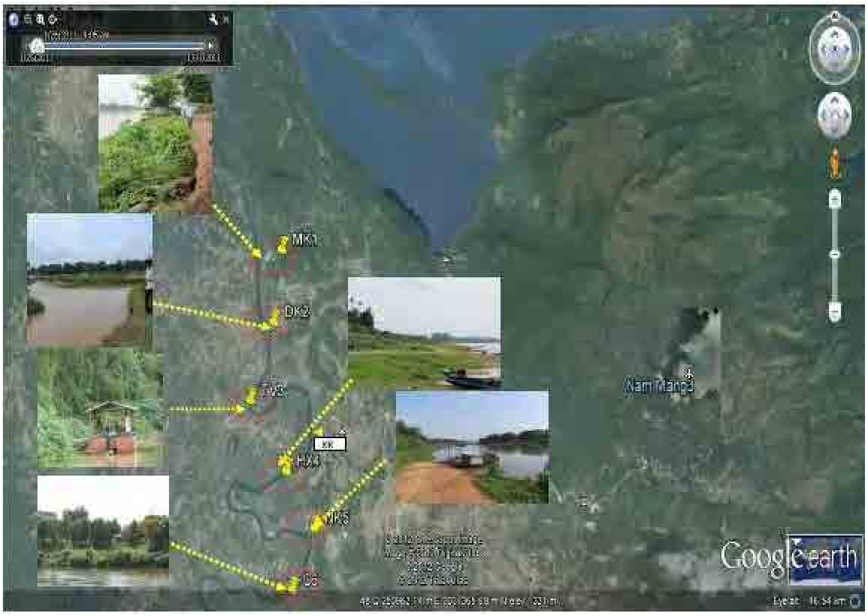
SS: Sengsavang Village, Keoudom District
Affected Fish Firm Cage

T: Thalat Village, Keoudom District
Riverbank Garden

TK: Thinkeo Village, Keoudom Distinct
Eroded River Edge

THB: Thalat Bridge

Prepared by the Study Team



MK1: Meuang Kao Village, Viengkham District
Eroded River Edge

DK2: DongKouat Village, Viengkham District
Island for New Year's Festival

TV3: Thin-Nyoung Village, Viengkham District
Irrigation Pump

KK: Keun-Kang Village, Thoulakhom District

HT4: Hatxai Village, Thoulakhom District
Riverbank Garden

NK5: Nakhong Village, Thoulakhom District
Navigation

C6: Cheng Village, Thoulakhom District
Riverbank Garden

Prepared by the Study Team

Annex 1.2: Questionnaire of the Hearing

BASELINE DATA

Village Identification

District:
Village:
Location GPS Lat (WGS84)
Location GPS Long (WGS84)
Mark Location on Map
Date of Data Collection:

List the names and positions of persons collecting data
Name:
Position:
Name:
Position:
Name:
Position:

Village Representation
No. Position First Name Surname Phone number
1.
2.
3.
4.
5.
6.
7.
8.

1.1 Village Land
1.1-1 What is Village total land area?

…………………………….ha

1.1-2. What is the allocated land area in Village?

Allocated Land Area	1=Yes 0=No	Approximate Area in Hectares (ha)	Marked/Drawn/ Indicated on Map ☑
Residential Land in Village			☐
Land with public building (e.g. temple, school, market etc.) in Village			☐
Permanent Agriculture in Village			☐
Protected Forest in Village			☐
Conservation Forest in Village			☐
Tree Plantation in Village			☐
Community Land in Village			☐
Other (specify)			☐
Other (specify)			☐

1.2 Population, Demography and Settlement
What is the total population and women population in the Village?

………………………………….

	in Village?
How many households reside	HHs
How many households own agricultural land	HHs
How many households own forest land	HHs
How many ethnic groups and ethnic households living List all ethnic groups with number of households	- HHs - HHs - HHs - HHs

2.1 Economic Status of Village
2.1-1 How much total Village income per year

…………………………………Kip

2.1-2 How much an average income per capita per year?

…………………………………Kip

2.1-4 How much an average per capita income of poorest people/year?

…………………………………Kip

2.1-5 How much an average per capita income of wealthiest people/year?

…………………………………Kip

2.1.6 How many households with regular income?

…………………………………Households

2.1-7 How many households with seasonal income?

…………………………………Households

2.1-8 Is there a definition of vulnerable households by Village? (Yes=1, No=0)

…………………………………

2.1-9 What is the definition? (eg. Income less than LAK/person/month, Income less than LAK/person/day, Not having enough food, Lives in temporary house/hut, Landless, Lack of adequate clothing and/or not capable of meeting educational expenses, Not capable of meeting the expense for health care etc,)

…………………………………………………………………….

……………………………………………………………………..

……………………………………………………………………..

……………………………………………………………………..

……………………………………………………………………..

……………………………………………………………………

……………………………………………………………………...

2.1-10 How many households that are designated as poor (vulnerable)?

…………………………………Households

2.1-11 How many number of women headed households?

…………………………………Households

2.1-12 How many number of disabled or elderly (>70 yrs) headed households?

…………………………………Households

2.1.13 Is there a definition of economically better off, medium, sufficient and poor by Village? ((Yes=1, No=0)

2.1.14 List the definition

…………………………………………………………………………..

……………………………………………………………………………

……………………………………………………………………………

…………………………………………………………………………….

2.1-15 How many number of ethnic households with economically better off?

…………………………………Households

2.1-16 How many number of ethnic households with economically medium?

…………………………………Households

2.1-17 How many number of ethnic households with economically sufficient?

…………………………………Households

2.1-18 How many number of ethnic households with economically poor?

…………………………………Households

2.1-19 What is the main income source (%)?

Agriculture

………………………………….%

Agriculture (Lowland rice cultivation)

…………………………………..%

Agriculture (NTFP)
…………………………………..%

Agriculture (Upland rice cultivation)

…………………………………...%

Agriculture (Lowland vegetable cultivation)

……………………………………%

Agriculture (Upland vegetable cultivation)

…………………………………...%

Agriculture (Riverbank garden)

……………………………….....%

Agricultural trading

…………………………………%

Plantation work

…………………………………%

Small-scale trading (shops, stalls)

…………………………………%

Transportation (except boat)

…………………………………%

Transportation (boat)

……………………………….....%

Government service

…………………………………%

Factory work

…………………………………%

Fishing

………………………………….%

Fishing Culture

……………………………….....%

Laboring

…………………………………%

Collection of NTFPs

…………………………………%

Industry (e.g. mining)

…………………………………..%

Handicraft

…………………………………..%

2.2 Agriculture Production of Village

2.2-1 What is the rice production area in the total agricultural land of the Village?

……………………ha

2.2-1 What is the season rice field in ha?

…………………….ha

2.2-3 What is the season rice yield in tons?

…………………….tons

2.2-3 What is the season rice yield (ton/ha/year)?

………………….

2.2-4 What is the irrigated rice field in ha?

……………………ha

2.2-5 What is the irrigated rice yield in tons?

…………………….tons

2.2-6 What is the irrigated rice yield (ton/ha/year)?

…………………..

2.2-7 What is the upland rice field in ha?

……………………ha

2.2-8 What is the upland rice yield in tons?

…………………….tons

2.2-9 What is the upland rice yield (ton/ha/year)?

……………………….

2.2-10 What is the % or number of households with following level of rice supply?

Households with rice all year ……………………%

Households with rice for 9-12 months ……………..%

Households with rice for 6-9 months……………….%

Households with rice for 3-6 months ………………%

2.3 Community Assistance
2.7-1 Are there any projects concerning on the community development by a Domestic and/or International Organization in the Village?

Name of the Project…………………………………………………………

Name of the Organization………………………………………………..

Type of the Project…………………………………………………………..

3.1 Activities related to the nam ngum river
3.1-1 Categories of river water usage
Use for general purpose ………………….HHs

Use for drinking ………………….HHs

Use for commercial fishing ………………….HHs

Use for fish culture ………………….HHs

Use for transportation route ………………….HHs

Use for irrigation ………………….HHs

Use for riverbank garden ………………….HHs

3.1-2 Water Level
[water pump]
How many households use water pump? ………………….HHs

Do they use the water pump yearly or seasonally? Yearly Seasonally

Is there any change of water quality and/or level after the construction of Nam Ngum 2 HPS and Nam Lik 1/2 HPS?
No

Yes (degraded water quality, water level increase, experience of insufficiency of water etc) ……………………………………………………………………………….
……………………………………………………………………………….

[irrigation] location E: N:
Is there any change of water quality and/or level after the construction of Nam Ngum 2 HPS and Nam Lik 1/2 HPS?
No

Yes (degraded water quality, water level increase, experience of insufficiency of water etc) ……………………………………………………………………………….

…………………………………………………………………………………..

[fish culture] location E: N:
Is there any change of water quality and/or level after the construction of Nam Ngum 2 HPS and Nam Lik 1/2 HPS?
No

Yes (degraded water quality, water level increase, experience of insufficiency of water etc) …………………………………………………………………………………..
…………………………………………………………………………………..

[fishing] location E: N:
Is there any change of water quality and/or level after the construction of Nam Ngum 2 HPS and Nam Lik 1/2 HPS?
No

Yes (degraded water quality, water level increase, experience of insufficiency of water etc) …………………………………………………………………………………..
…………………………………………………………………………………..

[boat transportation] location E: N:
Is there any change of water quality and/or level after the construction of Nam Ngum 2 HPS and Nam Lik 1/2 HPS?
No

Yes (degraded water quality, water level increase, experience of insufficiency of water etc) …………………………………………………………………………………..
…………………………………………………………………………………..

3.1-3If the water level increased 50cm from the present water level, how many households will be affected?

………………………HHs

3.1-4 If the water lever increased 50cm from the present water level, how many % of the area will be affected in the total riverbank garden?

……………………….%

3.1-5 How many % of income from the affected area will be in total income?

……………………………….%

Annex 1.3: Summary of 10 Surveyed Villages' Results

1. Sengsavang Village, Keoudom District

Interviewed Date: 25/05/2012
Village Head: Mr. Khammany, head of village
Mr. Viengkham, deputy head of village

Village Area: N/A

- Construction Land N/A
- Rice field 1 ha
- Garden land 32.85 ha
- Community Land 30 ha

Total Population: 1,403 persons, Female: 726 persons
No. of Households: 313 HHs
No. of HHs own Agriculture Land: N/A
Ethnicity: 80% Lao Loum
16% Hmong
4% Khamou

Average Income: 750 USD/person/year
Average Income of Wealthiest: N/A
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition: N/A
No. of Poor HHs: 0 HH
No. of Women Headed HHs: N/A
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 7.5%
Fish Farming: 2.5% (8 families doing fish farming business)
Trading and Business: 20%
Government Services: 70 %

- The village area also covers the Nam Ngum reservoir area, however, the information did not include the households residing around the reservoir area
- Only 2-4 ha rice field in the village, which is produced for domestic consumption

Main Crop: Vegetables

Efficiency of Rain Rice: 2 ton/ha
Efficiency of Irrigation Rice: None
Upland Rice Field: None

Community Assistance

- KOICA- doing activities in primary and secondary school
- Room to Read- set up library and provide library materials
- Nam Saatt Project: provide clean water to school

Activities Related to the Nam Ngum River

- Fish farming 8 households
- 80 % of total households connected to tapped water

Water Level

- The water level has increased, the river island (called Viengkham island) used to come up during dry season, currently disappeared

Riverbank Ownership

- No riverbank garden activities in riverbank area
- No household owned riverbank area

Impact from NN2 and Nam Lik 1-2

- The quality of water has changed (e.g. color and odor), the natural and fish in fish farming cage had died a lot last year (2011)

Predicted Impacts from NN1 Expansion Project

- No impact predicted

Remarks

- During April to May 2011, the natural fish started dying
- Fish in fish farming cage started dying on July
- The impact was reported to relevant district and provincial authorities but until now the affected households have not yet compensated
- Very much interest in water quality

2. Thinkeo Village, Keoudom District

Interviewed Date: 25/05/2012
Village Head: Mr. Bouathong, head of village,
Mr. Khamphong, deputy head

Village Area: N/A
- Construction Land N/A
- Garden land N/A
- Community Land N/A

Total Population: 1,168 persons, Female: 568 persons
No. of Households: 218 HHs
No. of HHs own Agriculture Land: N/A
Ethnicity: 99% Lao Loum,
1% Yao

Average Income: N/A
Average Income of Wealthiest: N/A
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: 0 HH
Definition:
- Big business such as hotel and shops are classify as wealthy households
- Small to Medium trading are classified as medium households
- None of Poor household in this village

No. of Poor HHs: 0 hh
No. of Women Headed HHs: N/A
No. of Disabled/Elderly Headed HHs: N/A

<u>Main Income</u>
Agriculture: 0.1 %
Fish Farming: 0%
Trading and Business: 95%
Government Services: 4 %

- Only one family practices the riverbank garden faming in this village and the area of planting is around 0.18 ha
- There are 5-6 households doing fishing activities in the Nam Ngum river for domestic consumption

Main Crop: Vegetables

Efficiency of Rain Rice: N/A (No rice field)
Efficiency of Irrigation Rice: N/A
Upland Rice Field: None

<u>Community Assistance</u>
- GiZ (Germany) – providing clean water for school
- Room to Read – school maintenance

<u>Activities Related to the Nam Ngum River</u>

- All households in the village connected to the tapped water, however recently 21 households has been concerning for stop using the tapped water due to the increased price of water
- Occasionally, some households pump water from the river to use when they organize a ceremony for their family

Riverbank Ownership

- Villagers use riverbank area by custom

Impact from NN2 and Nam Lik 1-2

- The quality of water become poorer than before due to the mining activities and the NN2 project
- Due to the poor water quality in the river, fish died last year (2011)

Predicted Impacts from NN1 Expansion Project

No impact predicted

Remarks

- The head of the village could not provide details of their overall information on village, especially the area of the village as it was recently re-organized its administration area
- Although the village located close to the Nam Ngum River, main income of people is from trading and hotel services and only one family practices riverbank garden
- Because price of tapped water is very high, many households wait for the answer from Water Supply company to reconsider the pricing, otherwise they will cut off the connection.
- Water tariff
    - 1-5 m^3 = 800 kip/m^3
    - 6-10 m^3 = 3,000 kip/m^3
    - 11-25 m^3 = 3,400 kip/m^3
    - >26 m^3 = 3,800 kip/m^3

3. Thalat Village, Keoudom District

Interviewed Date: 25/05/2012
Village Head: Mr. Somphone, head of village

Village Area: N/A

- Construction Land: 5.88 ha
- Rice field: 14.35 ha (includes irrigation rice field 12 ha)
- Garden land: 5.05 ha
- Community Land: 35.44 ha

Total Population: 1,056 persons, Female: 568 persons
No. of Households: 207 HHs
No. of HHs own Agriculture Land: 21 HHs
Ethnicity: 100% Lao Loum

Average Income: N/A
Average Income of Wealthiest: N/A
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition: N/A
No. of Poor HHs: 0 HH
No. of Women Headed HHs: 30 HHs (not classified as a poor family)
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 20 %
Fish Farming: 0%
Trading and Business: 75%
Government Services: 5 %

- Around 10 hhs practice fishing in Nam Ngum River for domestic consumption
- 20-30 hhs have riverbank garden, which is main source of income in dry season

Main Crop: Vegetables

Efficiency of Rain Rice: 3 ton/ha
Efficiency of Irrigation Rice: 3 ton/ha (did not plant this year as the water pump has damaged)
Upland Rice Field: None

Community Assistance

- KOICA- doing activities with primary student
- Room to Read- set up library and provide library materials

Activities Related to the Nam Ngum River

- 21 hhs connected to irrigation system
- 20-30 hhs have riverbank garden, which none of them have water pump for their garden

Water Level

- 2 meters of river garden buffer zone (from the lowest point of river water to the garden)

Riverbank Ownership

- No Permanent Land Use Certificate for any riverbank gardens
- Villagers use riverbank area by custom

Impact from NN2 and Nam Lik 1-2

- Within past two years erosion has been proceeded in large scale along with the riverd edge of the Nan Ngum river, especially the area closed to the Thalat Bridge
- During wet season, the Nan Ngum 1 Hydropower Plant sometimes open its spin way and then the water from the Nam Ngum river flows into the small stream and causes flooding in rice field

Predicted Impacts from NN1 Expansion Project

- Increasing of water lever fluctuation in Nam Ngum due to the NN1 Expansion Project may cause riverbank erosion

Remarks

- Main concerns is erosion, because 9 meters from the riverbank to the inland area was eroded last year (2011)

4. **Meuang Kao Village, Viengkham District**

Interviewed Date: 26/05/2012
Village Head: Mr. Savang, head of village
Ms. Vieng, Women Union
Mr. Khamphon Chanthalangsy, deputy head
Mr. Khoun Sadakhom, deputy head
Mr. Oukham
Mr. Phouvieng Vilayhong, Youth Union
Mr. Kongdeunnoy Thepumnouay, elderly
Mr. BounYot, Village Consultant
Mr. Xien Keomanykone, Village Front

Village Area: N/A

- Construction Land 16.15 ha
- Commercial and factory 0.86 ha
- Community Land 10.6 ha

All household in this village have rice field but the rice field they owned belong to other village. Total area of the rice field belongs to other village is 93ha.

Total Population: 855 persons, Female: 427 persons
No. of Households: 201 HHs
No. of HHs own Agriculture Land: N/A
Ethnicity: 98% Lao Loum
1% Khamou
1% Hmong

Average Income: 850 USD/person/year
Average Income of Wealthiest: N/A
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition:
N/A
No. of Poor HHs: 0 HH
No. of Women Headed HHs: N/A
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 100 %
Fish Farming: 0 %
Trading and Business: 0 %
Government Services: 0 %

- The ferry using for crossing the Nan Ngum River does not belong to the village but it belongs to the district authority
- No riverbank garden in this village as the area is quite steep
- Fishing activities for domestic consumption

Main Crop: Rice

Efficiency of Rain Rice: 3.5 ton/ha
Efficiency of Irrigation Rice: 3.5 ton/ha
Upland Rice Field: None

Community Assistance

- JICA- clean water

Activities Related to the Nam Ngum River

- No activities related to the Nam Ngum River
- People use well water for domestic consumption

Riverbank Ownership

- N/A

Impact from NN2 and Nam Lik 1-2

- Within last two years, the fluctuation of water in Nam Ngum River was increased very much, the speed of the fluctuation was very rapid which could be caused erosion at riverbank area

Predicted Impacts from NN1 Expansion Project

- Normally during wet season, around 0.5 ha of the rice field would be flooded due to the over flown water from the Nan Ngum River. It is concerned that the Expansion of the Nan Ngum Hydropower Plant Project increases the flooding.

Remarks

- People have been moved their house far from riverbank side due to the erosion with great scale in last two years
- All household in this village have rice field but the rice field they owned belong to other village.

5. Donkouat Village, Viengkham District

Interviewed Date: 26/05/2012
Village Head: Mr. Yai, Village Secretarial
Mr. Tiengkham, Deputy head of Village
Mr. Khammoun, Village land Authority

Village Area: 427.36 ha

- Construction Land 18.3 ha
- Land with Public Building 3.43 ha
- Rice field 186.12 ha
- Garden land 137.9 ha
- Community Land 74.61 ha

Community land includes grazing land, pond, agricultural land and cemetery.

Total Population: 892 persons, Female: 447 persons
No. of Households: 185 HHs
No. of HHs own Agriculture Land: N/A
Ethnicity: 90 % Lao Loum
10 % Khamou

Average Income: 750 USD/person/year
Average Income of Wealthiest: N/A
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition:
N/A
No. of Poor HHs: 5 HHs
(No agriculture land, main income from daily worker)
No. of Women Headed HHs: 7 HHs
No. of Disabled/Elderly Headed HHs: 0 HHs

<u>Main Income</u>
Agriculture: 100 %

- Other source of income is a supplementary e.g. labor, fishing small trading etc,
- 80% of households doing riverbank garden activities

Main Crop: Vegetables (corn, chilly, nut and etc,.)

Efficiency of Rain Rice: 4.5 ton/ha
Efficiency of Irrigation Rice: 4 ton/ha (did not cultivated last year due to damage of water pump)
Upland Rice Field: None

<u>Community Assistance</u>

- KOICA- improve road condition, provide clean water,+ tap water, construct health Care Center
- Oxfam- support organic farm (e.g. provide training, village bank for doing organic farm etc,
- JICA- provide machine for separating rice seeds

Activities Related to the Nam Ngum River

- Around 50 % hhs connected to tapped water, the rest use well and underground water for domestic consumption
- 80 % of hhs have riverbank garden

Water Level

- 2 meters buffer zone for river garden

Riverbank Ownership

- Permanent land use right certificate is not issued for the riverbank
- Villagers use riverbank garden by custom

Impact from NN2 and Nam Lik 1-2

- Increasing of fluctuation range, the water level during a day is increased
- During wet season, water pumped could not used as the water level is too high and the plastic pipe to the river from the water pump is too short

Predicted Impacts from NN1 Expansion Project

- There are 4 islands in this village of which 3 islands were used for agriculture purposes during dry season. The rest island has been used for a big festival of cerebrating a New Year for more than 15 years during 3 days of New Year's holiday. The size of the island reaches about 1ha as its maximum during the festival period because the water level of the river is to be the lowest around this time. During three days of the Festival, tourist visit this island for recreation such as relaxing near riverside and shopping at street venders who open temporally shops only for this festival. Since the height of the island is 3m at the highest and 70% to 80% of the island submerged only at the time of festival, any increase from the present water level would be decrease the island area and it might affect the Festival.
- During the festival, around 50 to 100 shops are open for selling food to tourists and it is estimated that average profit in a shop is more than 3 million kips (about 300USD).

6. Thin -Nyoung Village, Viengkham District

Interviewed Date: 26/05/2012
Village Head: Mr. Bounhome, head of village
Mr. Khamvanh

Village Area: 922 ha

- Construction Land 24 ha
- Rice field 512 ha
- Garden land 124 ha
- Community Land 234.388 ha

Total Population: 1,501 persons, Female: 732 persons
No. of Households: 310 HHs
No. of HHs own Agriculture Land: N/A
Ethnicity: 100% Lao Loum

Average Income: 800 USD/person/year
Average Income of Wealthiest: 10,000 USD/person/year (27 hhs)
No. of Regular Income: 220 HHs
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition:
Classify by income at household level

- the households earn more than 5,000 USD/year – Wealthy HHs
- the household earn > 800 USD<5,000 USD/ year- Medium HHs
- the household earn<800 USD/year – poor HHs

No. of Poor HHs: 3 HHs
No. of Women Headed HHs: 6 HHs
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 90 %
Fish Farming: 0 %
Trading and Business: 10 %
Government Services: 0 %

- 3 households in this village are engaging in agricultural activities at commercial level throughout a year
- No household in this village practices riverbank garden due to the riverbank in this area is very steep
- Around 10 households practice fishing in the river but only for domestic consumption
- It used to have fish farming in this village but the business had stopped for few years due to on-going gravel mining activities in the Nan Ngum River

Efficiency of Rain Rice: 3.5 ton/ha
Efficiency of Irrigation Rice: 4 ton/ha
Upland Rice Field: None

Community Assistance

- KOICA- improve road condition, water supply and irrigation systems

Activities Related to the Nam Ngum River

- Most of the household in this village connected to tapped water, around 1/3 could not connect to the systems due to the distance of their location
- 114 households use irrigation systems for their dry season cultivation including rice and vegetables

Water Level

- Water level has been increased and it contribute to water availability for irrigation systems

Riverbank Ownership

- No riverbank activity in this village

Impact from NN2 and Nam Lik 1-2

- So far no impact, only the water fluctuation is highly recognized, the level of water in the river is very low during the day and very high during the night.
- Last year there was a flood in the village but it may not because of the dam, it may because of Typhoon

Predicted Impacts from NN1 Expansion Project

- No impacted is predicted

Remarks

- Concerned on the increase of water level when there is high rainfall

7. Keun-Kang Village, Thoulakhom District

Interviewed Date: 24/05/2012
Village Head: Mr. Khamphan Vongxai

Village Area: N/A

- Construction Land 32.75 ha
- Community land 2.97 ha
- Factory/commercial Land 1.7 ha
- Permanent Agriculture Land 65.72 ha (including riverbank garden)
- Rice field 29.27 ha (irrigation = 10.35 ha)

Total Population: 1,999 persons, Female: 979 persons
No. of Households: 368 HHs
No. of HHs own Agriculture Land: approximately 2/3 of total households in the village
Ethnicity: 100% Lao Loum

Average Income: 1,400 USD/person/year
Average Income of Wealthiest: 14,000 USD/HH/year (doing fish farming)
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: 2 HHs
Definition:

-Land ownership + Agriculture product
-Type of House – permanent, semi-permanent or temporary
-If the household has average income more than 260,000 kips/months that means they are over the poverty line (this guideline is provide by district office)

No. of Women Headed HHs: 10 HHs (these households were not identified as poor)
No. of Disabled/Elderly Headed HHs: 0

Main Income:

Agriculture: 70 % (including rice and riverbank garden)
Fish Farming: 1 % (2 HHs)
Trading: 19 %
Government Services: 10 %

- Other income sources were identified as the supplementary e.g. road transportation(15 hhs), boat transportation (2 hhs), fishing (15 hhs)
- 35 households were reported as having and doing riverbank garden activities along the Nam Ngum River
- Apart from rice, the crops that are likely to grow in the village are; vegetables (corns, sugar cane) and these crops are grown in both riverbank and inland

The Rice crops efficiency: 2.4 ton/ha

Community Assistance

- Room to Read Program: construction of kindergarten school in 2008
- JICA project: construction of Ban Keun primary school
- KOICA: maintenance the secondary school

Activities Related to the Nam Ngum River

- Tapped water (Nam Papa): The water was pumped from the Nam Ngum River to produce Nam Papa. 97% of households are connected to the tapped water, only 3% of the households have used well water. (these 3% of the households are located far from the central of village where the tapped water could not distributed to)
- No household in the village uses the Nam Ngum River water or tapped water for drinking purpose but buy bottled drinking water

Water level

- All 35 households who practice riverbank garden have their own water pump for pumping water for their garden. Of which, 10 are electricity pumps and 25 are petrol pumps. However those pumps are used during their crop season only, the crop season normally start from November to May (dry season)
- Buffer Zone: 5 meters

Riverbank Ownership

- *The ownership of the land around the riverbank area:* Permanent land use certificate can be issued for private sector from the immediate highest point of the bank to the inland section. These certificates were issued before the laws/regulations of riverbank land ownership were enforced
- 15 meters from the lowest point of water level in April can be applicable for Permanent land use right certificate

Predicted Impacts from NN1 Expansion Project

- No impact is predicted

Remarks

- Water level was not as low as previous year
- There was high turbidity in the water compare to previous year even in the dry season (normally there is high turbidity in rainy season but not in the dry season)
- The flooding period took longer time than previous years
  For example, during year 2003 to 2004 the village was flooded, but it took only short period (2-3 days) to be receded. On the contrary, there was a flood in the village last year (2011), but it took almost one month for the water to recede

8. Hatxai Village, Thoulakhom District

Interviewed Date: 24/05/2012
Village Head: Mr. Laythong Xaisana
Ms. Khanti deputy head

Village Area: 365.10 ha

- Construction Land 22.40 ha
- Community land 69.10 ha (Some area was cleared for gardening activities, but the land still belong to the village)
- Factory/commercial Land 7.69 ha
- Garden 182.20 ha (including riverbank garden)
- Rice field 19.41 ha (irrigation = 10.35 ha)

Total Population: 1,071 persons, Female: 582 persons
No. of Households: 213 HHs
No. of HHs own Agriculture Land: 130 HHs
Ethnicity: 100% Lao Loum

Average Income: 850 USD/person/year
Average Income of Wealthiest: N/A USD/HH/year
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: 30 HHs
Definition:

- The households that do not have productive agricultural land and their main income depend on daily labor work and have no permanent house (e.g. the houshold work for brick factory and live in the factory was defined as a poor household)

No. of Women Headed HHs: N/A
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 80 % (in this 15 hhs have gain high income from garden, rice producing in this village is only for domestic consumption)
Fish Farming: 0 %
Trading: N/A
Government Services: 3 %
Labor: 17%

- Almost all households in the village during fishing in the Nan Ngum River (80%), but only for domestic consumption
- In case they could collect large amount of fish, they would sale or make the fish source (Pa Daek)

Main Crop: Vegetables (corns, water melon, chilly etc,.)

The Rice crops efficiency: N/A

Community Assistance

- KOICA: construction School and upgrade village road.

- KOICA: setting up the village fund for community to borrow low interest loan (1.05%) for doing agriculture activities

Activities Related to the Nam Ngum River

- 80% of HHs in the village is engaging in riverbank garden farming and fishing

Water level

- There are 50 water pumps in the river for watering riverbank garden only in dry season
- 1 meter buffer zone in between lowest water level and riverbank planting area

Riverbank Ownership

- The owner of main land adjacent to the riverbank area have a right to use riverbank area
- Riverbank area can be used by the villagers but could not own (no land use certificate issued), the use of this land is recognized by District Land Authority (for tax payment)

Impact from NN2 and Nam Lik 1-2

- After the projects start operating it causes flooding and the turbidity in the water is higher than before
- Due to the increase of water, number of fish caught was increased last year (positive impact)

Predicted Impacts from NN1 Expansion Project

- No impact is predicted

Remarks

- The HHs in this village is highly depends on the garden activities. Villagers practice gardening activities in the main land for whole year

9. Nakhong Village, Thoulakhom District

Interviewed Date: 24/05/2012
Village Head: Mr. Khammou, head of village
Mr. Khankham, deputy head

Village Area: 549 ha

- Construction Land 114 ha
- Permanent Agriculture land 435 ha
- Community Land 8 ha

Total Population: 842 persons, Female: 426 persons
No. of Households: 166 HHs
No. of HHs own Agriculture Land: 50 HHs
Ethnicity: 100% Loum

Average Income: 760 USD/person/year
Average Income of Wealthiest: N/A USD/HH/year
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition:

1. If the household have agricultural land, permanent house with facilities e.g. TV, motorbike, video etc would be classified as wealthy household (50 hhs)
2. If the household do not have agriculture land, do small trading/ labor, newly migrant to the village would be classify as economically medium(40 hhs)
3. The family who has no land, have many children, earning from selling labor only would be classify as sufficient family (26 households in this village)

There is no poor household in this village

No. of Women Headed HHs: < 10 hhs (but they are not in poor condition)
No. of Disabled/Elderly Headed HHs: < 10 hhs (but they are not in poor condition)

<u>Main Income</u>
Agriculture: 70 %
Fish Farming: 0 %
Small scale Trading: 20%
Government Services: 10 %

- 50% of the households doing fishing seasonally, those for consumption in their hhs
- Riverbank garden: there are 12 households practice riverbank garden but the income from this activity is not their main income.

Main Crop: Vegetables (corns, cucumber, chilly etc,.)

Efficiency of Rain Rice: 3.5 ton/ha
Efficiency of Irrigation Rice: 3.5 ton/ha

<u>Community Assistance</u>

- ADB: construct and maintenance irrigation system

<u>Activities Related to the Nam Ngum River</u>

- 50 households that have agriculture land used irrigation system for their rice field and inland garden
- There are 12 households use the water from the Nan Ngum River for their river garden
- 12 households have water pump for their river garden for seasonal use

Water level

- 4-5 meters from the lowest point of river water to the plantation

Riverbank Ownership

- The permanent land use right certificate can be issued from the highest of riverbank to inland area and from the highest point to the riverside is belong to the government.

Impact from NN2 and Nam Lik 1-2

- Water level increased even in dry season
- As for irrigation system, it gives positive impact as the higher level of water could reduce the power use for pumping water into irrigation canal
- As for fishing, it gives positive impact as in past two years there were more fishes in the Nan Ngum River.

Predicted Impacts from NN1 Expansion Project

- Not very significant, it would reduce some productive land along the riverbank but the increasing of water level could support positive impact for irrigation system.

10. Cheng Village, Thoulakhom District

Interviewed Date: 24/05/2012
Village Head: Mr. Boualien, head of village

Village Area: 1,139.2 ha

- Construction Land 40 ha
- Rice field 293.95 ha (includes irrigation rice field 120 ha)
- Garden land 770.07 ha
- Grazing land 31 ha (for livestock raising)
- Community Land 4 ha

Total Population: 1,774 persons, Female: 825 persons
No. of Households: 368 HHs
No. of HHs own Agriculture Land: 95% (N/A for No. of HHs)
Ethnicity: 100% Lao Loum

Average Income: 700 USD/person/year
Average Income of Wealthiest: 2,200 USD/HH/year
No. of Regular Income: N/A
No. of Seasonal Income: N/A

No. of Vulnerable HH: N/A
Definition:
N/A

No. of Poor HHs: No poor hh in this villages
No. of Women Headed HHs: 1 HH (but they are not in poor condition)
No. of Disabled/Elderly Headed HHs: N/A

Main Income
Agriculture: 90 %
Fish Farming: 0.03 %
Small scale Trading: 3%
Government Services: 6.97 %

- Almost every househodls have river garden
- There is one households doing fish farming but at the present they stop doing it as they has been building new house

Main Crop: N/A

Efficiency of Rain Rice: 3.5 – 4 ton/ha
Efficiency of Irrigation Rice: 3.5-4 ton/ha
Upland Rice Field: 3-3.5 ton/ha (there are approx – 4-5 ha)

Community Assistance
N/A

Water level

- 2 meters of river garden buffer zone (from the lowest point of river water to the plantation)

Riverbank Ownership

- Normally the Permanent land use certificate can be issued 7 meters from the highest point of the riverbank to the main land
- In some cases e.g. the riverbank area is not steep and have been using by the family for generations, can be issued the permanent certificate even7 meters from highest point from the riverbank to the riverside

Activities Related to the Nam Ngum River

- 235 households using irrigation system for their rice and inland garden
- 150 households have water pump for their river garden, and those uses seasonally

Impact from NN2 and Nam Lik 1-2

- With the condition of heavy rain last year, increase of water level in the Nam Ngum River due to the operation of the Nam Lik and Nam Ngum 2, caused flooding for quite long period
- As for fishing, the increase of water gives positive impact as increase availability of fish catch

Predicted Impacts from NN1 Expansion Project

- Not very significant, however it is concerned that in case of having heavy rain, it may increase the scale of flooding

Annex 1.4: Monitoring Result on July 2011

Monitoring Sites	Temp ◦C	DO (mg/L)	pH	EC (µs/cm)	Remarks
Site 1: 0240636E, 2050445N	26.3	1.30	6.7	85.0	Quality of water is not good due to low DO, high turbidity, pH is in an acceptable scale
Site 2: 0237352E, 2049857N	26.8	1.20	6.6	84	Quality of water is not good due to low DO, high turbidity, pH is in an acceptable scale
Site 3: 0243704E, 2049500N	25.5	6.7	7.5	138	The quality of water is quite good high oxygen demand in the water
Site 4: 0243704E, 2049500N	25.9	3.6	7.44	138	Nam Ngum and Nam Lik joins at this site, DO is low while pH is in an acceptable scale
Site 5: 0243704E, 2049500N	26.5	1.7	6.72	83	DO is very low, high turbidity, pH is in an acceptable scale
Site 6: 0240198E, 2039877N	27.9	3.91	7.13	117	Low DO, pH is in an acceptable scale
Site 7: 0243433E, 2031801N	27.2	4.26	7.66	113	Low DO, pH is in an acceptable scale
Site 8: 0240103E, 2006827N	28.0	3.91	7.07	110	Low DO, pH is in an acceptable scale
Site 9: 0249064E, 2008508N	28.6	4.11	7.07	106	Low DO, pH is in an acceptable scale

Note: Standard scale for aquatic living things is: DO= 4-5 mg/l, pH= 6.5-9
Source: Attachment to the minutes of meeting on 6th February 2012 on fish died off incident

Site 1: Nam Ngum, upstream of the fish cage
Site 2: At the fish cage, 700 meters upstream of Thalat bridge
Site 3: Thalat bridge, Nam Lik side
Site 4: Thalat bridge, Central of the river
Site 5: Thalat bridge, Nam Ngum side
Site 6: Pakka-Nyoung ferry site
Site 7: Ban Keun ferry site
Site 8: Tha – Ggon Bridge, Ban Keun side
Site 9: Tha – Ggon Bridge, Ban Keun side