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

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

Final Report

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Abbreviations

AC	Alternating Current
ACCC	Aluminum Conductor Composite Core
ACER	Agency for the Cooperation of Energy Regulators
ACSR	Aluminum Cable Steel Reinforced
ADB	Asian Development Bank
AEDP	Alternative Energy Development Plan
AFTA	ASEAN Free Trade Area
ALS	Automatic Load Shedding
ASEAN	Association of Southeast Asian Nations
BOO	Build Own Operate
BOT	Build Operate Transfer
B to B	Back to Back
CA	Concession Agreement
CB	Circuit Breaker
COD	Commercial Operation Date
CPI	Consumer Price Index
CSG	China Southern Power Grid
DC	Direct Current
DEB	Department of Energy Business
DEM	Department of Energy Management
DEPP	Department of Energy Policy and Planning
DMM	Department of Mining Management
DOF	Department of Forestry
DOL	Department of Law
DONRE	District Office of Natural Resources and Environment
DPC	Department of Planning and Cooperation
DPO	Days Payable Outstanding
DR	Demand Response
DSO	Days Sales Outstanding
EBIT	Earnings Before Interest and Taxes
ECC	Environmental Compliance Certificate
EDL	Electricité du Laos
EDL-Gen	EDL-Generation Public Company
EDLTC	EDL Training Center
EGAT	Electricity Generating Authority of Thailand
EGPD	Electricity Generation Planning Division
EIA	Environmental Impact Assessment
EPD	Energy Planning Division (DEPP , MEM)
EPPO	Energy Policy and Planning Office (Thailand)
EPPEI	Electric Power Planning & Engineering Institute
ENTSO-E	European Network of Transmission System Operators for Electricity
ESIA	Environmental and Social Impact Assessment
EVN	Electricity of Vietnam
EY	Ernst & Young Lao Co. Ltd.
FCP	Frequency Containment Process
FFC	Flat Frequency Control
FS	Feasibility Study
GDP	Gross domestic product

GMS	Greater Mekong Sub-region
HPCC	Hydro Power Control Center
HVDC	High Voltage Direct Current
IE	Institute of Energy (Vietnam)
IPP	Independent Power Producer
IREP	Institute of Renewable Energy Promotion
ISO	Independent System Operator
ITO	Independent Transmission Operators
JCC	Joint Coordination Committee
JEPX	Japan Electric Power Exchange
JICA	Japan International Corporation Agency
JV	Joint Venture
LEPTS	Lao Electric Power Technical Standard
LFC	Load Frequency Control
LDC	Least Developed Countries
LHSE	Lao Holding State Enterprise
M&A	Mergers and Acquisitions
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mines
MLS	Manual Load Shedding
MOE	Ministry of Energy (Thailand)
MOEE	Ministry of Electricity and Energy (Myanmar)
MoF	Ministry of Finance
MoH	Ministry of Health
MOIT	Ministry of Industry and Trade of the Socialist republic of Vietnam
MoNRE	Ministry of Natural Resources and Environment
MOU	Memorandum of Understanding
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
NCC	National Control Center
NGO	Non-Governmental Organization
NGPES	National Growth and Poverty Eradication Strategy
NPDP	National Power Development Plan
NSEDP	National Socio-Economic Development Plan
OCCTO	Organization of Cross-regional Coordination of Transmission Operators, Japan
OCR	Over Current Relay
O&M	Operation and Maintenance
OJT	On the Job Training
OLR	Over Load Relay
PCI	Projects of Common Interest
PDA	Power Development Agreement
PDP	Power Development Plan
PPDP	Provincial Power Development Plan
PLC	Power Line Communication
PPA	Power Purchase Agreement
PPS	Power Purchase Supplier
PSHD	Policy on Sustainable Hydropower Development
PSS	Power System Stabilizer

PwC	Price waterhouse Coopers
RCC	Regional Control Center
REDS	Renewable Energy Development Strategy
REDD+	Reduction of Emissions from Deforestation and forest Degradation +
RPCC	Regional Power Coordination Centre
RPTCC	Regional Power Trade Coordination Committee
SAPP	Southern Africa Power Pool
SCADA	Supervisory Control And Data Acquisition
SEA	Strategic Environmental Assessment
SEIA	Social and Environmental Impact Assessment
SPP	Small Power Producer
SS	Substation
SVC	Static VAR Compensators
TA	Technical Assistance
TBC	Tie-line Bias Control
TL	Transmission Line
TNB	Tenaga Nasional Berhad (Malaysia)
TSO	Transmission System Operator
TYNDP	Ten-year Network Development Plan
UFLS	Under Frequency Load Shedding
UNESCO	United Nations Educational, Scientific and Cultural Organization
VSPP	Very Small Power Producer
WAPP	West Africa Power Pool
WB	World Bank
WGRI	Working Group on Regulatory Issues

Chapter 0. Abstract

0.1. Background to the survey

Laos is a landlocked country located in the center of the Indochina Peninsula, bordering China, Vietnam, Myanmar, Thailand and Cambodia. Mountains and plateaus occupy almost 70% of its land, and the Mekong River flows through over 1,900 km of the country from north to south. The Lao PDR has harnessed its geographical resources, such as its potential for hydraulic power, for economic growth. In 2018, Laos had a generation capacity of 7,367 MW, of which 2,901 MW was supplied in its domestic system with a maximum power demand of 1,000 MW. The development potential of hydroelectric power plants in Laos is significant. The Government of Lao PDR aims to establish a "System to System" scheme (interconnections between Lao system and neighboring countries) to expand power trades with neighboring countries and to enhance electric power exports.

This project was implemented in cooperation with the Ministry of Energy and Mines (MEM) and Electricité du Laos (EDL) from January to March 2020 in order to contribute to the provision of a stable electric power supply in Laos and expand the amount of power interchanges with neighboring countries. The purpose was to provide support for the creation of power system development plans, roadmaps, and rules for power system operation, such as Grid Codes, by 2030.

0.2. Separation of Power System for Export-dedicated Transmission Lines and Domestic Power Supply System

The power system of Laos has been divided into transmission lines which are directly connected to the power systems of neighboring countries from dedicated power plants, and those for domestic supply. The domestic power supply system is synchronized with the electric power system of Thailand via 115 kV transmission lines in six places. Through those lines, electric power was imported from Thailand during the dry season and exported during the rainy season from 2010 to 2015. In the northernmost part of the region, there is a 115 kV interconnection with China, and power has been supplied from China to some regions at times when power shortages were expected.

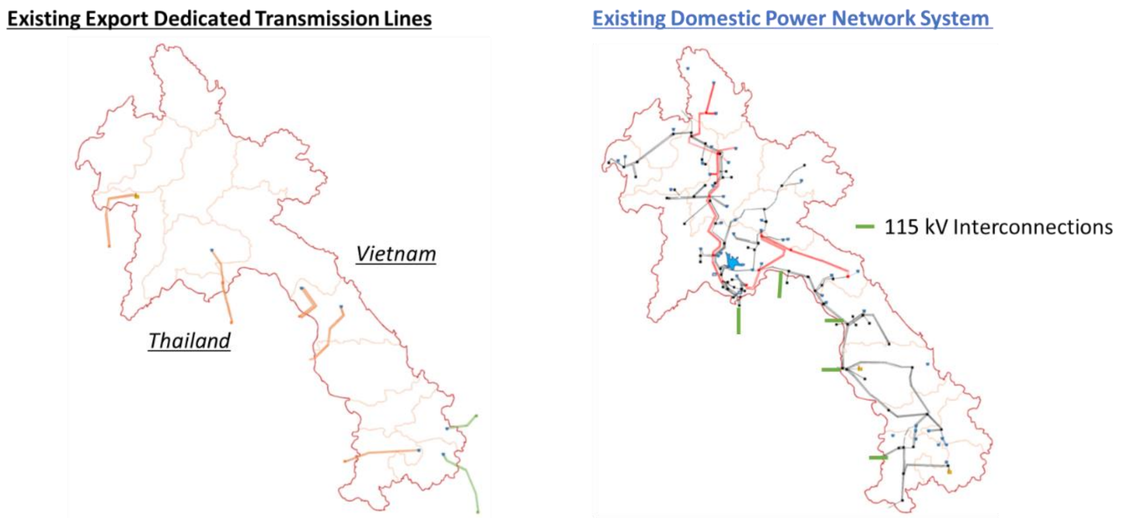


Figure 0.2-1 Export-Dedicated Transmission Lines and Domestic Power Supply System

At the beginning of the study, there were plans to make all the export-oriented power plants to be developed connected to the domestic power system and then export from them with the power plants developed in the domestic system to expand flexibility through System to System. However, the study plans to continue to separate the export-dedicated transmission lines from the domestic power supply system until 2030. This is due to there being insufficient system operation functions, such as securing supply-demand balance within the power system for domestic supply in Laos, control of generators, and the maintenance of domestic power system facilities, and it being difficult for the time being to build a reliable power transmission system in combination with the power plants of power generation companies dedicated to export.

0.3. Review of demand assumptions

At the beginning of the survey, the official domestic power demand forecasts for Laos were 1,728 MW in 2017 at maximum power demand, 2,097 MW in 2018, 2,401 MW in 2019, 2,723 MW in 2020 and 5,892 MW by 2030. The maximum power demand for 2016 to 2017 was only about 1,000 MW, which was far from expectations. During this period, construction of power plants for domestic use was carried out based on the initial power demand forecast, and it was expected that there would be a significant oversupply if this situation continued. For this reason, MEM and EDL revised their power demand forecast in 2018 reflecting the actual situation. The results of comparing the old and new power demand forecasts are shown in the following figure. It is expected to be around 1,200 MW for 2020 and 2,700 MW in 2030.

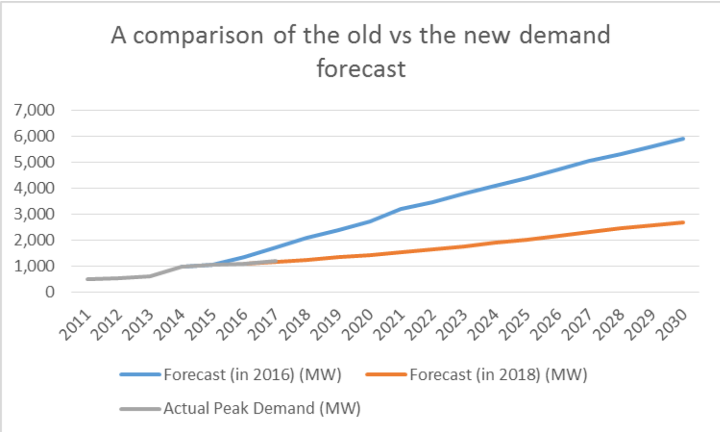


Figure 0.3-1 Comparison of New Demand Assumptions for 2009

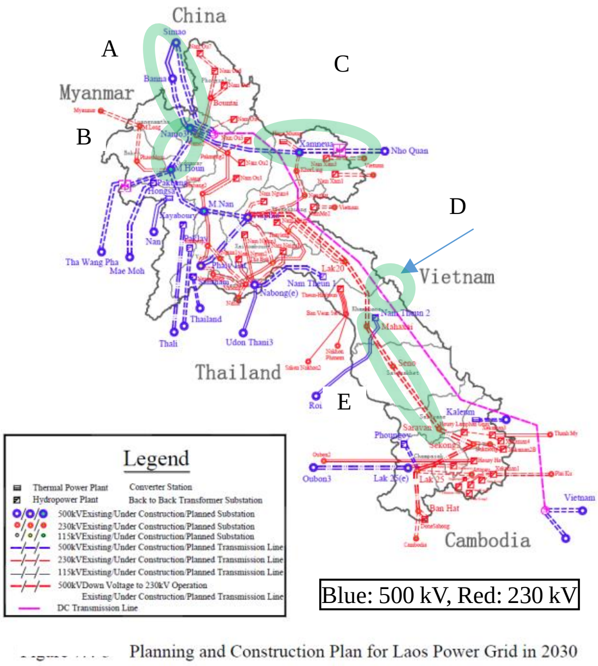
Power plants developed near the border can be designated for export or domestic supply, depending on their scale, location, and price of electricity. As a result, some of the power plants which had been under construction for Laos were switched to export use during their construction, and some of the power lines under construction in the domestic power system that could not be used for other reasons became useless. In addition, the sluggish power demand has eliminated the planned output of some of the power plants that have just been built for the domestic power demand. EDL had a significant financial burden due to contracts with power plants under full purchase conditions (Take or Pay). In both cases, the domestic power demand forecast at the time of development planning was excessive. In addition to reviewing the power demand forecast, it was also necessary to review the power supply plan.

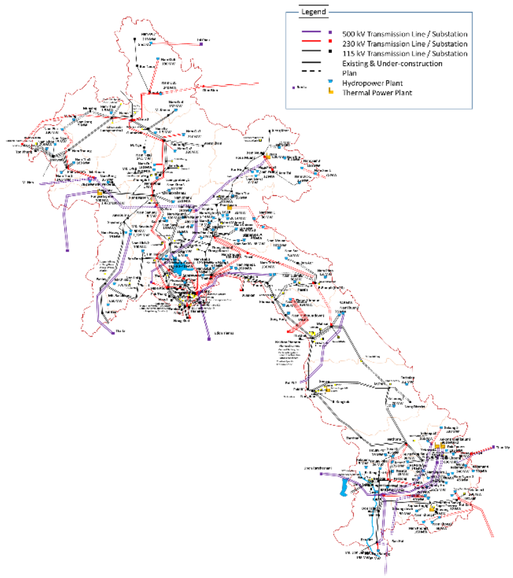
0.4. Study of Power Network System in Laos by China

In 2017, as part of China's "One Belt, One Road" initiative, a systematic investigation was launched with cooperation between Laos and China. In September 2017, a plan was considered to combine surplus power in Laos with power imported from China and export this to Thailand and Vietnam from Laos through a 500 kV transmission line or DC transmission line to be built in

Laos. However, this was based on the old demand forecast for Laos in 2016 (5,892 MW in 2030) and excessive exports from Vietnam to Lao PDR (4,000 MW from 2023), excluding export-dedicated power plants. For this reason, the power system facilities necessary in Laos were overestimated.

In 2019, China reviewed its plans for Laos, using the same power demand forecast used in the JICA Study. There is little difference from the Study for the domestic power system plan, such as the lack of necessity of the 500 kV backbone transmission lines until 2030. However, there still remains a difference in the method of thinking compared with the Study, which aims to expand the existing synchronous interconnections with Thailand, such as a plan to strengthen power trades between northern Laos and China and compensate for the supply-demand balance in Laos during the rainy and dry seasons with China.





Report by China　　　　　　　　　　　　　　JICA MP

	Main Project	Rpoet by China (2018-2019)	JICA MP
A	500 kV China - Norh of Laos iterconnection	With	Without
B	500 kV Nam mo - M. Houn	With	Without
C	500 kV Nam Mo - Nho Quan (Vietnam)	With	Without
	North-south 500 kV Bacck-bone transmission line	Without	Without
D	North of Laos - Central Vietnam DC line (Private)	With	Without
E	230 kV Mahaxai - Saravan transmission line	With	Without

Figure 0.4-1 Main differcence between the plan of China EPPI and JICA MP

At the same time, the establishment of EDL-T was proposed. This is an organization responsible for both power transmission and exports to neighboring countries, through the construction, operation, and management of bulk power transmission lines, which are expected to be needed in Laos. EDL-T's revenue is assumed to be the wheeling charge income from neighboring countries, and PPA agreements between neighboring countries and Laos are considered to be a condition of its establishment. One of the conditions for EDL-T's business to operate soundly is that neighboring Thailand, Vietnam and Cambodia import power from Laos as expected, and that power demand in Laos will increase as expected. Therefore, it is desirable to start the business of partial construction and operation of transmission lines according to the demand scale in Laos and the status of PPA agreements with neighboring countries after concluding PPAs with Thailand, Vietnam and Cambodia, including an agreement to establish EDL-T. The main power transmission lines in Laos will be used for power trades not only to China but also to other neighboring countries such as Thailand and Vietnam in the future and will have a significant impact on the power systems of other countries.

For this reason, if only China invests in this kind of business entity in Laos that manages the bulk power transmission lines, there is a risk that fair operation of the GMS grid will not be maintained in the future. Therefore, the participation of other countries such as Thailand and Vietnam should be considered.

0.5. Review of power plan

The MEM power development plan announced in 2017 has a total output of approximately 31.5 GW, including existing, under construction, and export power supplies, amounting to approximately 4.3 times' the power supply capacity of 7.4 GW that was operating in 2018.

One of the reasons for such a huge power generation plan was that when issuing a license for a power plant, the Lao government accepted the plans of the power generation company without properly ascertaining them or managing them based on the overall supply and demand. The Lao government also viewed such an excessive power supply plan as a problem. In March 2019, the Prime Minister's Secretariat issued a request to the Minister of Planning and Investment, the Minister of Energy and Mines, the Minister of Natural Resources and Environment, the mayors and the governors to review the power plan based on the revised demand forecast in Laos and the outlook for the amount of power exported to Thailand.

It was required to suspend planning and approval of inexpensive alternative energy power plants and power plants with a capacity of 5 MW or less for two years, and suspend development of projects that have no sales destination.

In April 2019, MEM EPD, EGPD and EDL compiled a power plan for 2030 in Laos. Under this, plans were kept to a minimum, and only five new power plants, excluding those already under construction, were newly developed. Since then, the plan has continued to be reviewed.

0.6. Measures to combat surplus power

In the domestic power supply system, the power generation capacity is larger than the capacity required for the domestic power supply, and a situation of oversupply continues. The amount of electricity generated by existing and under construction power plants will exceed electricity demand by 2027 even in the dry season when the least amount of electricity is generated. There is a surplus of power generation capacity that is not used throughout the year in the country, and this is putting pressure on EDL's finances, which have a large number of fixed-purchase contracts. In order to reduce surplus power and utilize the power generated by power plants, the following measures are given.

- Increase domestic power demand
- Increase exports from domestic power system
- Power plants for domestic power supply will be converted to export-dedicated power supplies

Some of the surplus power in the power system for domestic supply can be exported through the existing 115 kV interconnections with Thailand, but there is a limit to the power transmission capacity and restrictions regarding acceptance on the Thai side. Many of the existing and under-construction power plants in the domestic power supply system are located far away from the city of Vientiane, which is a demand center. Because the domestic power network system is insufficient, it has not been able to fully utilize the generated power. Also, supply and demand in the dry season are balanced when the demand reaches more than 2.5 times' the current demand, and waiting until this time will make EDL's financial situation worse.

Therefore, it is necessary to immediately convert surplus power from existing and under construction power plants to exports to neighboring countries in accordance with the location of the power plant, and to promptly restore EDL's finances. Specifically, of the existing and under construction power plants connected to the domestic grid, the following power plants close to neighboring countries have been converted for export. Nam Ou 5, 6 and 7 are in Vietnam and MK. Don Sahong is in Cambodia. Nam Kong 1 and 2 were initially supposed to be converted for exports to Vietnam, but could export to Cambodia.

Table 0.6-1 Existing and under construction power plants in domestic system to be converted for export

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

MK DonSahong (H) converts 3 of the 4 units for export.

Further, in order to utilize the surplus power generated in the power system for domestic supply, the method of increasing the amount of exports through the interconnections from the domestic power system is also effective. The power demand in Laos does not significantly differ between the rainy season and the dry season, so in Laos, where most power supplies are composed of hydropower, ensuring power output in the dry season in accordance with demand means that the amount of electricity generated in the rainy season creates surplus power. However, in neighboring countries such as Thailand and Vietnam, even in the rainy season, the effect of a reduction in thermal power can be expected. It is possible to utilize the power generated by hydroelectric power plants in Laos in both the rainy season and the dry season. By 2030, the following lines will be connected from the power system for domestic supply to neighboring countries.

With regard to exports to Vietnam, there are plans for the existing 230 kV power transmission lines of Sekaman 1 and 3 hydropower plants via G-to-System to be connected to nearby power plants for domestic use in Laos. However, if the power export volume to Vietnam increases, due to capacity limitations in the 230 kV power transmission lines of Sekaman 1 and 3 hydropower plants, there is also a plan for a new 500 kV transmission line from southern Laos to central Vietnam, with power to be exported from southern Laos.

Table 0.6-2 Interconnections from the Domestic Power Supply System to Neighboring Countries by 2030 (Draft)

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

0.7. Measures to ensure supply capacity during the dry season in the future

Since the power generated by hydropower in the dry season is small, it is necessary to install a considerably large capacity of hydropower in order to secure supply capacity during the dry season. In addition, since there is no need to generate power during the rainy season, the annual utilization rate of newly constructed hydroelectric power plants will be reduced. It is estimated that the annual equipment utilization rate will fall to around 20%. Current development methods (mainly hydropower) do not efficiently solve the shortage of supply capacity during the dry season. For this reason, it may be more economical to secure supply capacity during the dry season via imports from other types of power sources, such as thermal power plants, and from Thailand. Various power supplies were compared as a measure to secure the dry season supply capacity.

In Laos, in the rainy season, the supply will be sufficient solely from the output of existing and under construction hydropower plants. For this reason, the newly constructed power station does not need to be operated during the rainy season.With new coal-fired power plants, if power is secured in the dry season and plants are stopped during the rainy season, the annual utilization rate of coal-fired power will be as low as around 45%, and the economy will also decline. With solar power, when securing supply capacity during the dry season, the annual utilization rate is less than 10%. In addition, when combined with reservoir-type hydropower, capable of storing water during the day and night, the power from solar power generation can be utilized at night and can be used as supply power in the dry season.

Comparing the costs of securing power generation during the dry season in Laos gives the following, in descending order: solar power, coal-fired thermal power (Xekong Province), reservoir-type hydropower, coal-fired thermal power (Houaphan Province), and imports from EGAT. Therefore, imports from EGAT or Houaphan thermal power plants are economically dominant as a power supply for ensuring supply capacity during the dry season in Laos. The study considers the limitations of imports from EGAT and priority in the development of its own domestic power supply. The Houaphan thermal power plant was planned as a new power source starting in 2026.

It should be noted that, if it is possible to expand the number of lines connected with Thailand and increase the amount of imports from EGAT, this is considered to be effective as a supply measure for the dry season. In the future, it will be necessary to consider the most economical dry season supply capacity by combining power imports from Thailand, the development of thermal power plants using coal in Laos as fuel, and the dry season peak operation of the reservoir-type hydropower utilizing solar power generation. MEM and EDL need to consider examining economic dry season supply capacity, including power trades to neighboring countries.

0.8. Domestic power system planning

Domestic transmission lines and substations were planned, including the interconnections from the domestic power system to neighboring countries, based on the domestic power demand forecast and power supply plans. The main plans are as follows:

- 500 kV transmission lines
  - New power lines from Houaphan coal-fired power to M. Houn near the Thai border through southern Luang Prabang (Houaphan coal-fired power plant, supply to interconnection with Thailand)
  - M. Houn - Interconnection with Thailand (expansion of imports and exports with Thailand)
- 230 kV transmission lines
  - Near the northern Myanmar border (export to Myanmar, supply of northern industrial park)
  - Transmission lines surrounding Vientiane (measures to increase demand in Vientiane City)
  - East Vientiane – Interconnection with Thailand (expansion of imports and exports with Thailand with a back-to-back converter station)

- KM20 - Mahaxai (measures to increase the power flow to the Central area)
- Pakxong – Nathone (Houay Ho domestic return acceptance)

The cost of construction for the domestic power supply system is estimated to be approximately 1,900 million USD.

0.9. EDL's Financial Status

An analysis of EDL's financial status reveals that it is not good and continues to deteriorate from the perspectives of profitability, financial soundness, and solvency. Thus, EDL's financial status must be improved in order to proceed with its investment plans.

Essentially, it is necessary to create a positive cash flow from operating activities, and mobilize that in investment activities in order to generate additional cash flow from operating activities. However, EDL currently continues to invest via borrowings with business & financial structures which cannot generate cash flow from operating activities, and it continues to be caught in a vicious cycle financially, though EDL is able to increase its revenue level by developing export-oriented plants and increasing the sale of electricity for export, as simulated in the basic scenario.

EDL should conduct financial management as a public institution, and at the same time, operate its business, including the development of business strategy and investing activities etc., as a private company. Considering these characteristics and the above financial situation, it will be beneficial to support more inclusive business improvements, such as the development of a business strategy, introduction of a financial management system including optimization of financial management operations, capacity development in financial management, improvement of working capital, development of new revenue sources, and other areas.

0.10. Plan for Interconnections with Thailand

A power supply-demand balance simulation was conducted for the case of expansion of interconnections between Laos and Thailand. There is a large amount of surplus power from hydropower plants in the Laos north-central system in 2030. In the Thai system, the output from the northern coal-fired power plants will decrease due to aging and a decrease in Lignite reserves. As a result, the transmission capacity of the 500 kV transmission line used for power evacuation from the coal-fired power plants will have some room.

Given this, it is expected that interconnection between the Laos north-central system and the 500 kV system in the northern part of the Thai system will help improve the power generation efficiency of both systems. At an interconnection capacity of 1000 MW, the surplus power from hydropower in the Laos north-central system would be eliminated during peak times and on weekdays in the rainy season. However, during the off-peak daytime, the capacity of thermal power plants for curtailment in fuel consumption is reduced due to the increase in PV output in the Thai system, meaning that the amount of power transactions utilizing surplus power in the Laos system is reduced. Thermal power IPP contracts for the Thai system will decrease from 2030 onward, and the number of thermal power plants owned by EGAT will increase, so it is expected that the adjustment capacity for the curtailment of fuel consumption would increase. For this reason, it can be expected that the surplus hydropower in the Laos system would be used to reduce fuel consumption at thermal power plants in the Thai system even after 2030.

In addition, it is expected that power supply through Thailand to Myanmar and Cambodia will be accommodated, and Laos, whose demand is small, will be able to cope with large-scale demand fluctuations that exceed expectations.

For this reason, increasing the interconnection capacity with Thailand and strengthening the interconnection are considered to be advantageous for both Laos and Thailand.

0.11. Power System Operation and Grid Code

0.11.1. Operation of System-to-system-shaped Power Grid

In the future, establishment of a system-to-system structure by interconnecting between GMS countries' grids will have significant advantages in the following points:

- Energy resources can be effectively used throughout the region, and uneven distribution can be overcome.
- Promoting the connection of generators to the national grid will enable proper monitoring and control of the operation of generators and electricity trading, and will protect national interests such as a country's natural resources and energy sources.
- Mutual support in stabilizing the power grid becomes possible.
- Even in normal conditions, it is possible to pursue improved economic efficiency by activating electric power trading, importing and exporting cheaper power supplies.

In order to establish a system-to-system structure in the future and enjoy the benefits, it is important to establish the two aspects of "independence" and "coordination" in the management of electricity business.

In terms of "independence", management of the supply and demand balance and stabilization of the power system in the domestic country are to be undertaken with responsibility by each country's operators in order to maintain high quality and high reliability in the power supply.

In terms of mutual "coordination", it is necessary to contribute to the creation of common rules, revise the domestic rules according to the common rules, and establish a system of compliance with these rules by continuously monitoring and improving the gap between these rules and the actual situation.

It is extremely important to foster mutual trust in combination with these two aspects.

At present, the Lao power grid is synchronously connected to the Thai power grid, but this is achieved through multiple connections via 115 kV transmission lines. These should preferably be a 1-point-to-1-point connection via higher voltage interconnection. The reasons are as follows:

- Why is a high voltage class preferable?
  - Higher transmission capacity
  - Lower transmission losses
  - More stable system

- Why is a 1-point-to-1-point interconnection preferable?
  - Complex power flows such as loop flows can be avoided, simplifying management and control
  - In the event of system balancing-related trouble, it is possible to quickly and reliably disconnect the interconnection to avoid a spreading of the system disturbance and to protect the sound-side grid(s).

The JICA Study Team recommends the application of an OLR system as a measure to prevent transmission line overloading due to loop flow in the transitional period until a 1-point-to-1-point connection is achieved.

The Lao grid is not connected to the Vietnam grid, but in order to realize wide-area power trading, physical interconnection is required, such as synchronous interconnection using AC transmission lines, non-synchronous interconnection using DC transmission lines or Back-to-back facilities. However, too much synchronous interconnection will cause overloading of transmission lines due to loop flow, shortage of short-circuit current breaking capacity at CBs, and an increased risk of wide-area blackouts. Therefore, the JICA Study Team recommends non-synchronous interconnection for the time being.

Governor-free operation is expected to not only contribute to automatic fine adjustment of frequency fluctuations from the nominal value (50Hz) during normal conditions, but also to serve as FCR (Frequency Containment Reserves) for a large frequency drop when a large amount of generators are lost, if many generators can perform governor-free operation.

Therefore, in principle, it is desirable to make governor-free operation mandatory for all generators except for small-capacity generators.

LFC (Load-frequency Control) is a function for recovering the supply-demand imbalance in each domestic grid that could not be corrected by governor control. Since this function recovers deviations in frequency from 50Hz and power flow deviations from the scheduled import/export power on the international tie-lines due to a large amount of generators or demand loss due to operations in the disturbance-cause-side grid, it is essential for realizing power system operation “independent” from neighboring countries.

Therefore, it is necessary for the main generators to be equipped with an AGC function (a function that responds to the LFC from the EMS in NCC) as much as possible and to be connected online via communication channels with the EMS.

0.11.2. Grid Code

Laos's Grid Code is configured with a wide range of necessary items, but still remains within the domestic rules for system planning and operation.

The following measures are vital in order to establish the "System to System" structure which the Lao government is aiming for, and to promote the improvement of its financial conditions by exporting electricity:

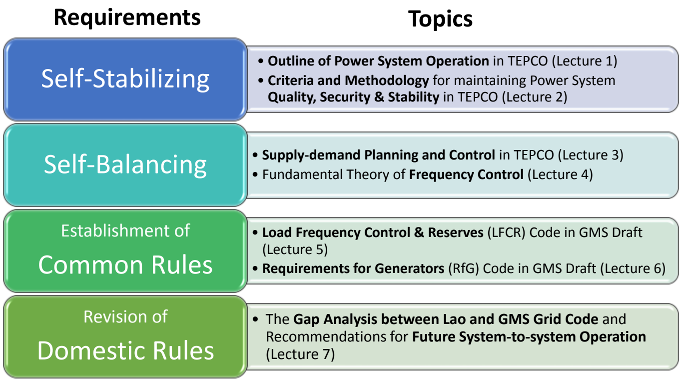
- Ensure that generators are connected to the EDL grid or the neighboring grids based on the power development plan
- Strengthen the authority of NCC to monitor and control the generators integrated with the EDL grid
- Provide stable, fair and transparent grid operation for all generators
- Establish a system of cooperation with neighboring countries

In order to proceed with the steady grid connection of generators, it is necessary to treat the generators that wish to connect fairly and transparently by specifying the necessary technical requirements. The Lao grid code has detailed procedures from the connection of the generator to the commencement of operations, but the provisions of technical requirements for the generators are too general and are not specific.

In order to establish independent monitoring and operation by the NCC, it is necessary not only to revise the current grid code, but also to fill the various gaps between the grid code and actual operational work.

In terms of the establishment of operational coordination with neighboring countries, there are almost no provisions in the current Lao Grid Code. Therefore, in order to improve this situation, it is necessary to proceed in harmony with the establishment of the GMS Regional Grid Code.

In this survey, the contents of the current Lao Grid Code were inspected based on the GMS Regional Grid Code (Draft) that was being investigated by ADB, but prior to that, gap analyses were also performed based on the Regulation Codes of the European Commission. Based on these analyses, the JICA Study Team proposed improvements to the Lao Grid Code and held a Power System Operation Seminar.



Source: JICA Study Team

Figure 0.11-1 Sub-Key Words for System Operation Seminar

0.12. Challenges for the expansion of wide-area connections

0.12.1. Steps to expand GMS connections

The realization of GMS wide-area interconnections is considered effective in order to improve the efficiency of energy consumption through power trades in the region and contribute to the development of the regional economy. For this purpose, hydroelectric power generation in Laos, where unutilized surplus power is generated, should be fully utilized throughout the year by embedding its power in networks within the GMS region.

0.12.2. Situation in neighboring countries

In order to utilize Laos's power to revitalize the region's economy, it is necessary to consider the supply-demand balance of the entire GMS region and the amount of electricity generated in Laos. Neighboring countries are in the following situations:

Thailand: Although there is a surplus in power generation due to slowing demand growth, the effect of reducing the amount of thermal power generation by EGAT can be anticipated. From a geographical aspect, it is possible to send the power received from Laos to Myanmar, Cambodia, and Malaysia.

Vietnam: Demand is on the rise, and in recent years, solar and wind power generation have greatly increased. On the other hand, there are cases where the development of coal-fired power plants has been delayed.

Cambodia and Myanmar: Rapid increase in power demand

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

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

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

Power demand in the GMS region is concentrated in Thailand and Vietnam. GMS wide-area interconnections are expected to take the form of expanding interconnections from Thailand and Vietnam to neighboring countries. However, since reliability levels in the power systems of Laos and Cambodia are low, and their system operation functions are inadequate, there is a possibility that Thailand and Vietnam will be cautious about expanding the synchronization relationship with Cambodia and Laos.

Thailand and Vietnam have Grid Codes and are compliant to some extent, but Cambodia and Myanmar do not have Grid Codes, and Laos has established EDLs, but their compliance is inadequate. The imbalance in grid code developments and compliance, as well as the lack of a grid code, among the countries is one of the reasons why grid interconnections have not progressed. In order to implement grid interconnections, it is necessary to indicate to the partner country the degree of tolerance of the power grid in the event of an accident in the home system and the method of recovery. However, Laos, Cambodia, and Myanmar have not been able to adequately ascertain the status of their national systems through power system analysis. It is also necessary to establish protocol rules with neighboring countries.

Laos and Cambodia are financially vulnerable, making it difficult to finance and construct larger transmission facilities to export or import their own energy. The transmission of power to Thailand or Vietnam, where power demand is high, is a large part of electricity business in Laos and Cambodia, where power demand is small, and the scale of interconnection lines is too large for the power companies and the size of their national finances. Investment in transmission lines used for interconnection in Laos and Cambodia cannot be covered via the normal finances of the electric utilities in either country.

Furthermore, if there is uncertainty about the need for interconnections, such as fluctuations in power demand forecast and fluctuations in power demand in neighboring countries, the risk of recovering the costs increases, making funding difficult. Risk assessment can be difficult in a single country in the first place. This is also considered to be a reason why interconnections between Thailand and Vietnam through Laos and Cambodia have not progressed.

0.12.4. Items to be prepared

The following items should be prepared to expand the amount of GMS interconnections.

- Establishment of an organization or ad hoc establishment within the region to share the results of studies on plans for specific projects (projects of a certain size or larger)
- Establishment of risk assessment methods for multilateral interconnection projects
- Attract private capital for investment in interconnections, set up multilateral government guarantees (by financially sound countries) in GMS, and improve the business risk assessment functions of each country
- Establishment of a regional interconnection operation organization in GMS
- Development of domestic grids
- Establish GMS Grid Code and revise Grid Code of each country according to the GMS Grid Code
- Enhancement of grid operation capacity and facility functions required to comply with the Grid Codes (particularly Laos, Myanmar, and Cambodia)
- Market design, setting of power wheeling charges

In order to implement inter-regional power exchanges, coordination of domestic IPP contracts and pricing contracts with neighboring power companies should be considered in the market institutional design. In addition, full liberalization increases the risk of power producers becoming unable to recover their investment, which may hinder their investment in the power generation business, so this should be carefully considered.

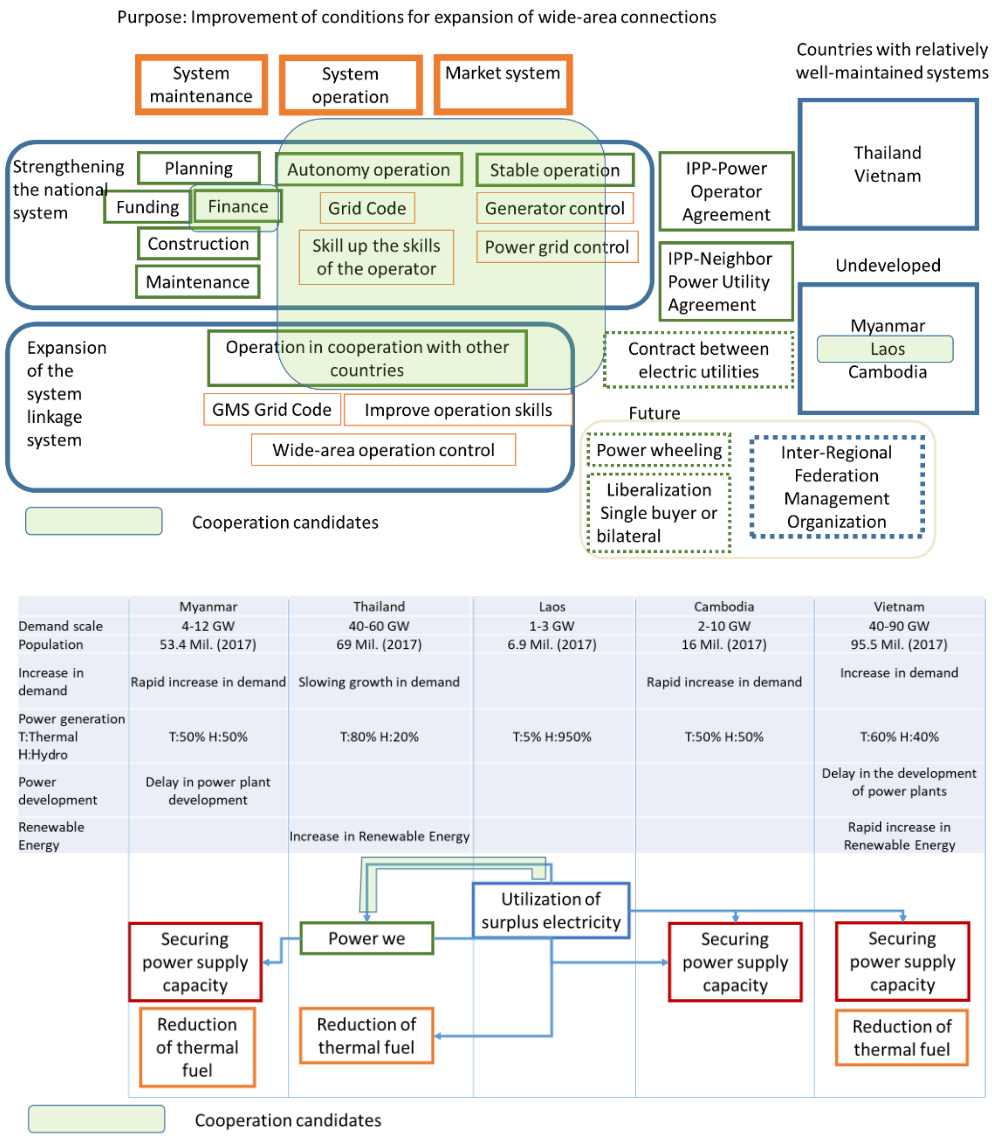


Figure 0.12-1 Improvement of conditions for expanding GMS wide area interconnection

0.13. Steps to expand interconnections, and roadmap

While maintaining a system configuration that is separated into export-only transmission lines and a domestic system with a small-capacity international interconnection line, we will gradually solve the issues preventing the realization of a System-to-System structure by 2030.

The 230 kV Thai-Lao domestic system, the 500 kV Thai-Lao PDR, and the 500 kV Thai-Myanmar (Myawaddy) are considered priority projects. MK. Pakbeng Hydro plans to share the 500 kV Thai-Northern Lao interconnection with exports from the Lao domestic grid.

The (500 kV Thailand-Northern Laos)-(500 kV Northern Laos-Vietnam) interconnection is based on the Lao PDR's 500 kV Hoa Pan Thermal Power Station power line and the 500 kV Napia-M. Houn transmission line. The concept is to connect the Lao-Vietnam connecting line with the Lao-Vietnam connecting line in Laos to create a Thai-Vietnam connecting line. In order to avoid synchronous interconnection between Vietnam and Thailand, DC facilities such as B2B will be required. Another possibility is a System-to-System interconnection via an interconnection between southern Laos and central Vietnam.

There is a future aim of connecting and integrating Lao PDR's domestic grid with export-only transmission lines, and establishing a System-to-System link with neighboring countries. Expanding wide-area interconnection within GMS by combining export-dedicated transmission lines and interconnections from domestic power system to export surplus power in Laos (after 2030) makes effective use of transmission lines and reduces their ROW. Therefore, basically, a step-by-step transition from G-to-System to System-to-System will be implemented.

0.14. Recommendations

The following are proposed as candidate projects for cooperation.

0.14.1. Strengthening of practical capacity, such as power supply command and system operation

- Grid Code
  - Adjustment of the Lao Grid Code to comply with GMS Regional Grid Code
  - Establishment of rules for cooperation between GSM countries, generation companies and EDL operators
  - Establishment of compliance system and PDCA cycle system

- Investigation of details regarding system operational work processes in EDL and Seminar for Capacity Development
  - Supply-demand balance planning/scheduling/grid monitoring and control
  - Process for outage planning
  - Skills for emergency restoration
  - Skill-certification system/operator training
  - Strategy, planning and management for protection relay/stabilizing system, etc.

0.14.2. Ideal method for electric power infrastructure development

- Fundamental research to realize LFC control
  - NCC system functions, data installation and maintenance
  - Communication infrastructure
  - Generator specifications/requirements
  - Measurement of electrical quantities of interconnection lines
  - Selection of generators for demonstration

- Fundamental research to realize GF control
  - Generator specifications/requirements
  - Selection of generators for demonstration

- Studies for countermeasures to improve steady state stability (power swing)
  - Power system analysis and tuning of PSSs

- Studies for mitigating overload via installation of OLR systems

0.14.3. Expansion of interconnections between northern Laos and Thailand

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

By transmitting the surplus in domestic power to Thailand, it is possible to reduce thermal fuel usage in Thailand and realize efficient power supply operation in the region. Increasing the capacity of the interconnection from Laos to Thailand and exporting Laos’s surplus energy to neighboring countries via Thailand can contribute to economic development in the region.

0.14.4. Cooperation in Financial Management

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

- Coopreation in development of business strategy (refer to examples of privatized electric power companies in other countries)
- Cooperation in introduction of financial management system with optimization of financial management operations and capacity development of financial management (apply the cooperation done in public financial management to EDL)
- Cooperation in improvement of cash flow from operating activities

Chapter 1. Introduction

1.1. Background to the Study

The Government of Lao PDR aims to establish a "System to System" scheme (interconnections between Lao system and neighboring countries) to expand power trades with neighboring countries and to enhance electric power exports. Although power exports are currently carried out by IPPs via dedicated transmission lines, the export-oriented power plants to be developed will be connected to the domestic power system. To stimulate the advancement of domestic industries and society, the Government of Laos aims to supply high-quality electricity, satisfying the domestic power demand, reducing power outage times, and stabilizing power system voltage and frequency.

To deal with this situation, it is necessary to clarify the power supply and demand structure of neighboring countries, together with their prospects, framework for power trading, technical problems and risks. For the power transmission system, it is essential to formulate a new master plan that will consider both facility planning and operational aspects. To expand power trades via a "System to System" structure, it is necessary to establish a power network system development plan and system operation rules that are harmonized with the level of the neighboring countries currently providing higher quality power supply than in Laos.

Under such circumstances, technical assistance has been requested by the Government of Laos regarding the establishment of a new power network system development plan, considering the plans of neighboring countries assuming regional power trading, and the development of rules for power system operation such as the establishment of a Grid Code.

1.2. Purpose of the Study

The following tasks are carried out to contribute to the provision of a stable electric power supply and steady progress in the power trading scheme with neighboring countries.

- Establish a roadmap to realize the expansion of power trades via a “System to System” structure
- Formulate a power network system development plan
- Provide support for the preparation of rules for power system operation, such as a Grid Code

Expected Accomplishments

- A roadmap is to be established, including recommendations on policies and systems to realize the expansion of power trades via a “System to System” structure. A power network system development plan is to be formulated.
- Power system operation rules required for the construction of a system for wide-area power trades are to be prepared.

1.3. Target Area

Target area: Whole of Laos (neighboring countries are included as study targets for power trading)

1.4. Related Authorities and Executing Agency

Related authority: Ministry of Energy and Mines (hereinafter referred to as “MEM”)

Executing agency: Electricité Du Laos (hereinafter referred to as “EDL”)

1.5. Joint Coordination Committee

To transfer technology via collaboration with MEM and EDL staff, MEM, EDL and the consultant form the “Joint Study Team”. The “Joint Coordination Committee” (hereinafter referred to as “JCC”), chaired by the Director of the Department of Energy Policy and Planning at MEM, is to be established as the joint study team’s top committee. Information/progress sharing, common understanding and consensus formation on this study were carefully considered at the JCC.

1.6. Study Items

The master plan study consists of the following two stages.

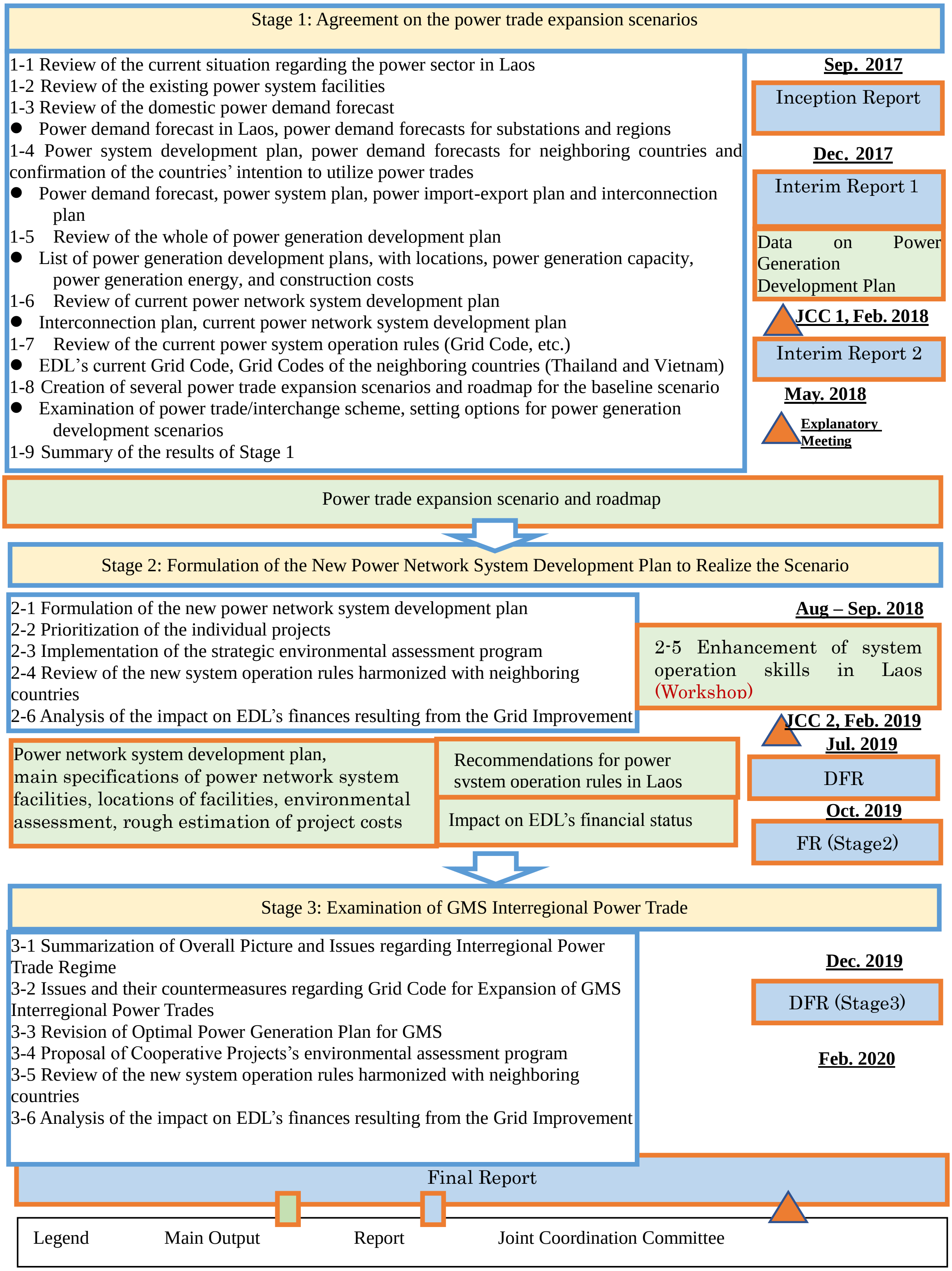
Stage 1: Agreement on the Power Trade Expansion Scenario and its Roadmap

Stage 2: Establishment of the Power Network System Plan to realize the Power Trade Expansion Scenario

Stage 3: Examination of GMS Interregional Power Trade

The power network system development plan is formulated in accordance with the baseline scenario that is agreed on with the Lao side and the countermeasures that should be urgently implemented. The target years are 2020, 2025, and 2030, consistent with the PDP. The individual projects are prioritized.

The flow for the whole of the work is shown in the below chart. Stage 1 is carried out to the end of May 2018 and Stage 2, to October 2019.



Source: JICA Study Team

Figure 1.6-1 Work Flow

Chapter 2. Lao People’s Democratic Republic Overview

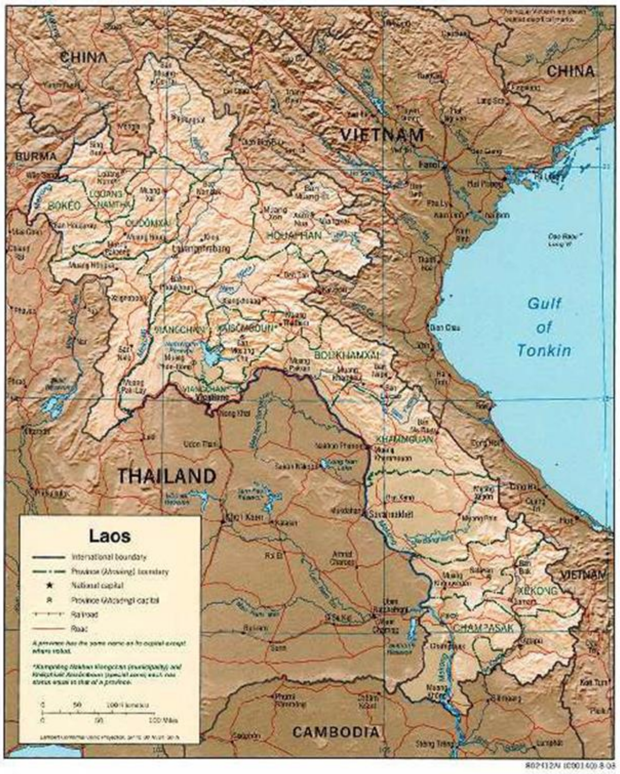
2.1. Social and Economic Conditions

2.1.1. Lao People’s Democratic Republic

1. Country Overview

The Lao People’s Democratic Republic (Lao PDR) is the only landlocked country in the Association of Southeast Asian Nations (ASEAN). It is located in the center of the Indochinese Peninsula, bordering China, Vietnam, Myanmar, Thailand and Cambodia.

In 1953, the Kingdom of Laos, independent from France after the Second World War, was established. The Kingdom of Laos was abolished in 1975, the Lao PDR was established, and the country has consistently maintained a single-party system led by the Lao PDR People's Revolutionary Party (LPRP). The land extends from north to south, and its area is almost equivalent to that of Honshu Island in Japan. Mountains and plateaus occupy almost 70% of its land, and the Mekong River flows through over 1,900 km of the country from north to south. The Lao PDR has harnessed its geographical resources, such as its potential for hydraulic power, for economic growth. The climate is tropical monsoon, having rainy and dry seasons, with high temperatures and humidity throughout the year. Figure 2.1-1 shows a country map of Lao PDR.



Source: United Nations

Figure 2.1-1 Country Map of Lao PDR

From an economic aspect, the Lao government introduced the New Economic Mechanism (NEM) in 1986 and has promoted economy-opening policies such as the introduction of market principles. As a result, the Gross Domestic Product (GDP) growth rate recorded was from 5% to 8% per year from 1992 to 1996. In the Asian economic crisis of 1997, the GDP growth rate of Lao PDR fell to 4% due to the influence of currency depreciation, inflation and the economic stalling of neighboring countries. Since that time, the Lao PDR has been successful in sustaining its own robust economic growth, with a GDP growth rate of 7.5% or more over the last 5 years. However, the Lao PDR is still one of the Least Developed Countries (LDC) because economic development has been delayed due to its geographical conditions of being a landlocked country and the influence of a past long-term civil war.

From a social aspect, more than 90% of citizens are estimated to be Buddhist and the character of its citizens is mild. Table 2.1-1 summarizes the country profile.

Table 2.1-1 Country Summary

Land	Area	:	236,800 square kilometers (Almost equivalent to Honshu Island in Japan)
	Capital	:	Vientiane
	Climate	:	Tropical monsoon having rainy and dry seasons. High temperature and humid through the year.
Population	Total	:	6.49 million people (2015)
	Growth rate	:	1.3 % per annum (2015)
	Population density	:	27 people per square kilometers (2015)
Ave. Life	Expectancy	:	67 years old (2015)
	Maternal mortality rate	:	197 people (0.20 %) per birth one hundred thousand people
	Infant mortality rates	:	50.7 (5.7 %) people per birth one thousand people
Labor	Force	:	3.47 million people (2015). Around 70 % of the force engages in agriculture.
Ethnic groups		:	Tai - Kadai 62.4 %
		:	Austro - Asiatic 23.7 %
		:	Mon - Yao 9.7%
		:	Sino - Tibet 2.9%
Religion		:	Buddhism
Language (official)		:	Lao
School enrollment		:	Primary enrollment 84 %, Junior high school enrollment 38 %, Literacy rate of adult 68.7 %
Currency		:	Kip
Exchange rate		:	1 USD = 8,129.06 Kip (2016, Bank of the Lao PDR)
GDP	Real	:	12.6 billion US dollars (2015)
	GDP/capita	:	1.85 thousand US dollars (2015)
	Growth average	:	7.6 % (2015)
Access to safe water		:	35 % (household base)
Physicians		:	1.3 per one thousand people
Hospital beds		:	1.18 per one thousand people

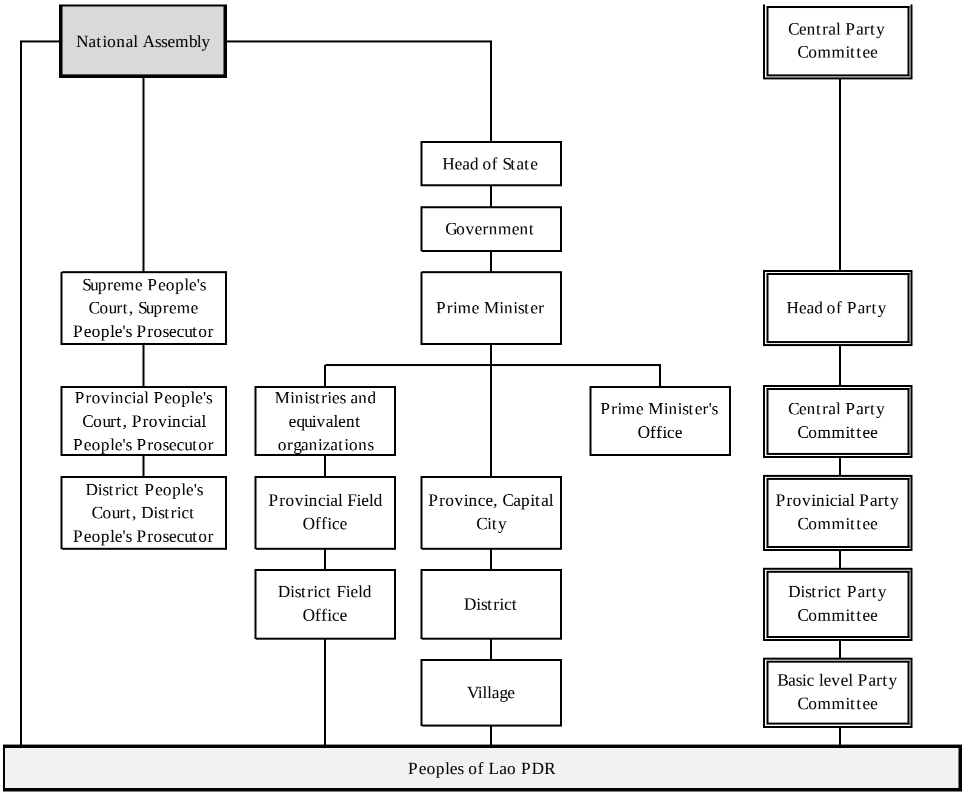
Source: prepared by JICA study team based on Ministry of Foreign Affairs website, "Results of Population and Housing Census 2015", "Lao's socio-economic base" and "UN, National Accounts Main Aggregates Database".

2. Political and Administrative Organizations

According to the present Constitution, Laos is stipulated as a People's Democratic Republic, and it has consistently maintained a single-party system led by the LPRP. The national governance organization is composed of the National Assembly, the Head of State, the government (which is the executing agency), the People's Court (which is the judicial body), and the People's Prosecutor Office.

The central government is composed of 18 ministries, including the Prime Minister's Office, and the Bank of Lao PDR.

According to the Constitution (Articles 75 – 78), local governments are divided into three categories - province, district and village – the details of which are prescribed by the Law on Local Administration (2003). There are 18 provinces, including the Vientiane Capital and 148 districts. Figure 2.1-2 shows the political and administrative structure.



Source: prepared by JICA study team based on "Outline of regional administration in Lao PDR (Public enterprise, 2010)"

Figure 2.1-2 Political and Administrative Structure

Table 2.1-2 shows the provinces and capitals of Lao PDR.

Table 2.1-2 Provinces and Capitals of Lao PDR

No.	Province	Capital
1	Vientiane Capital	Vientiane City
2	Phongsaly	Phongsali (Phongsaly District)
3	Luangnamtha	Luang Namtha (Namtha District)
4	Oudomxay	Muang Xay (Xay District)
5	Bokeo	Ban Houayxay (Houayxay District)
6	Luangprabang	Luang Prabang (Louangprabang District)
7	Huaphanh	Xam Neua (Xamneua District)
8	Xayabury	Sayabouly (Xayabury District)
9	Xiengkhuang	Phonsavan (Pek District)
10	Vientiane Province	Phonhong (Phonhong District)
11	Borikhamxay	Paksan (Paksane District)
12	Khammuane	Thakhek (Thakhek District)
13	Savannakhet	Savannakhet (Khanthabouly District)
14	Saravane	Salavan (Salavan District)
15	Sekong	Sekong (Lamarm District)
16	Champasack	Pakse (Pakse District)
17	Attapeu	Attapeu (Samakkhixay District)
18	Xaysomboon	Anouvong District.

Source: prepared by JICA study team based on "Results of Population and Housing Census 2015"

3. Geography

Mountains cover the northern and eastern parts of the country. Its square area is 236,800 km^2, almost equivalent to that of Honshu Island in Japan. The Mekong River, rising from the Tanggula Mountains in China, flows vertically through the country, transporting various natural bounties to the people. Its ample water resources help the country to earn foreign income by exporting electricity generated by the water flow. Table 2.1-3 shows the list of main rivers in Lao PDR.

Table 2.1-3 List of Main Rivers

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

Source: Statistical Yearbook 2016

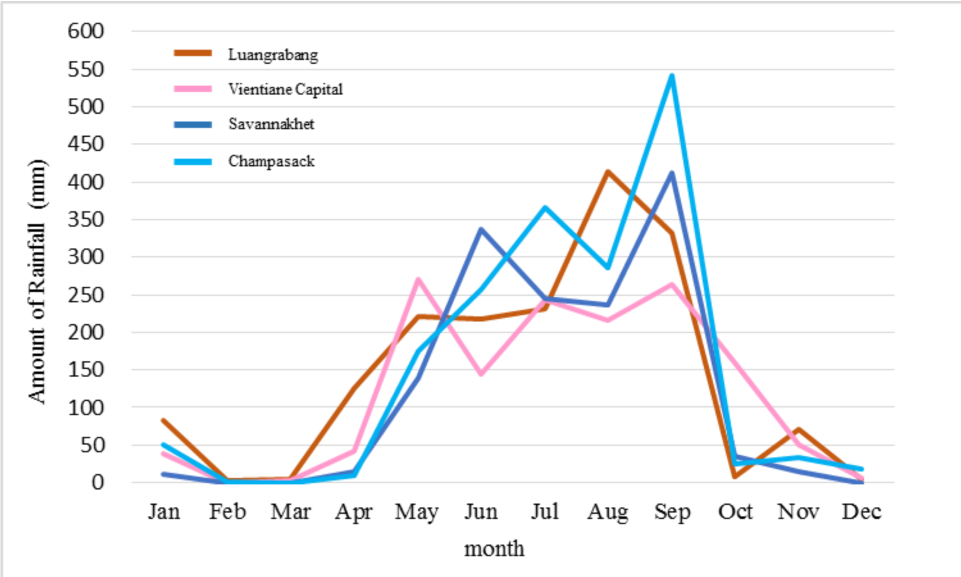
4. Climate

The climate of Lao PDR is of a typical tropical monsoon nature, with a rainy season from May to October and a dry season from November to April. Table 2.1-4 and Figure 2.1-3 show the meteorological data as well as the monthly rainfall data for four representative locations in Lao PDR, respectively. This data shows that the temperature of the country is mild all through the year, while some mountainous areas in the north record a relatively lower temperature. The records for the southern part of the Lao PDR show that this area receives more rain than other parts of the country.

Table 2.1-4 Meteorology Data in 2016

	Luangprabang (North)	Vientiane (Central 1)	Savannakhet (Central 2)	Champasack (South)
Average Temperature (℃)	25.3	27.3	27.1	28.2
Maximum Temperature (℃)	28.7	31.6	32.3	32.8
Minimum Temperature (℃)	18.5	22.8	21.7	25.2
Anuual Rainfall (mm)	1,525.1	1,438.1	1,445.3	1,991.1

Source: Statistical Yearbook 2016



Source: prepared by JICA study team based on "Statistical Yearbook 2016 Lao PDR"

Figure 2.1-3 Monthly Rainfall in 2016

5. Population

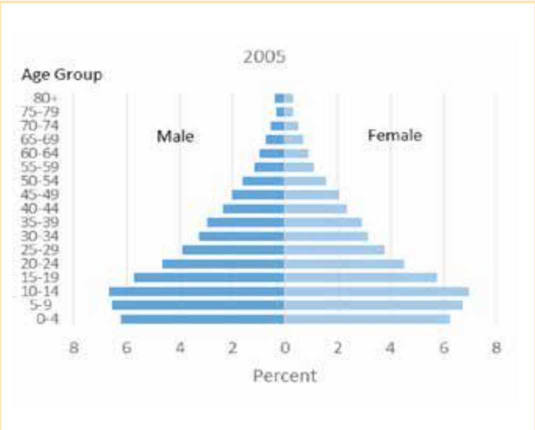
Table 2.1-5 and Figure 2.1-4 show the transition of key population indicators, and population pyramid structure in Lao PDR. The total population of Lao PDR is approximately 6.49 million people, with approximately 3.25 million males and approximately 3.24 million females, and the average number in a household is 5.3 people. The average population density is 27 people per km^2 nationwide, but in the Vientiane Capital it is approximately 8 times' that, at 209 people per km^2.

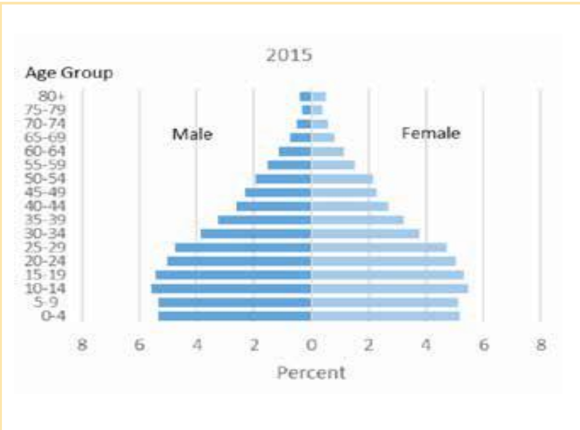
The Lao PDR will be able to benefit from a population bonus in the future because there are a lot of young people in the population pyramid. This means that Lao PDR has a huge potential labor force for future economic growth, and the rate of increase in the labor force population will be higher than the population growth rate with this population bonus.

Table 2.1-5 Transition of Key Population Indicators

Key population indicators	1995	2005	2015
Population scale			
Total (million people)	4.57	5.62	6.49
Female (million people)	2.31	2.82	3.24
Male (million people)	2.26	2.80	3.25
Male ratio to female (%)	98	99	101
Household numbers			
Collective households (%)	1.5	2.0	3.3
Independent households (%)	98.5	98.0	96.7
Average number of people (people)	6.0	5.8	5.3
Population density			
Population density (people per km^2)	19	24	27
Urban/rural area populations			
Urban area population ratio (%)	17.0	27.1	32.9
Rural area population ratio (%)	83.0	72.8	67.1
Villages with access road (%)	-	51.5	59.2
Villages without access road (%,)	-	21.3	7.9
Age structure of population			
0 – 14 years old (%)	44.0	39.0	32.0
15 – 64 years old (%)	52.0	57.0	63.7
65 years old and up (%)	4.0	4.0	4.2
Age dependency ratio	-	77.0	57.0

Source: prepared by JICA study team based on "Results of Population and Housing Census 2015"





Source: "Results of Population and Housing Census 2015"

Figure 2.1-4 Population Pyramid Structure (2005 and 2015)

Table 2.1-6 shows the population, area, and population density by province in 2015.

The population of Lao PDR is highest in Savannakhet (approximately 0.97 million people), followed by Vientiane Capital (approximately 0.80 million people) and Champasack (0.69 million people). The lowest population is in Xaysomboon (approximately 85 thousand people). Approximately 60% of the population is concentrated in the 6 provinces of Vientiane Capital, Borikhamxay, Khammuane, Savannakhet, Saravane and Champasack, facing the Mekong River in the south.

Table 2.1-6 Population, Area and Population Density by Province (2015)

	Province	Population (people)	Area (km^2)	Population density (people / km^2)
	Total	6,492,228	236,800	27.4
1	Vientiane Capital	820,940	3,920	209.4
2	Phongsaly	177,989	6,270	10.9
3	Luangnamtha	175,753	9,325	18.8
4	Oudomxay	307,622	15,370	20.0
5	Bokeo	179,243	6,196	28.9
6	Luangprabang	431,889	16,875	25.6
7	Huaphanh	289,393	16,500	17.5
8	Xayabury	381,376	16,389	23.3
9	Xiengkhuang	244,684	15,880	15.4
10	Vientiane Province	419,090	18,526	22.6
11	Borikhamxay	273,691	14,863	18.4
12	Khammuane	392,052	16,315	24.0
13	Savannakhet	969,697	21,774	44.5
14	Saravane	396,942	10,691	37.1
15	Sekong	113,048	7,665	14.7
16	Champasack	694,023	15,415	45.0
17	Attapeu	139,628	10,320	13.5
18	Xaysomboon	85,168	4,506	18.9

Source: Results of Population and Housing Census 2015

6. Infrastructure Development Status

Table 2.1-7 shows the transition of the penetration rate of social infrastructure services.

Table 2.1-7 Transition of Penetration rate of Social Infrastructure Services

	1995 (%)	2005 (%)	2015 (%)
Electricity supply	25	57	84.0
High quality water supply	15	35	61.0
Satisfactory sanitation facilities	29	49	73.2
Cooking fuel resources - firewood	93	79	66.9
Cooking fuel resources - charcoal	4	15	23.9
Cooking fuel resources - electricity	2	1	4.2

Source: Lao Statistics Bureau (2016) Results of Population and Housing Census 2015

a) Electricity supply

Approximately 84% of households nationwide are supplied with electricity through distribution lines. Approximately 9% of households are without an electricity supply, and these households use light oil, gas, candles etc. The electricity supply rates by each region are 97% in urban areas, 82% in rural areas with access roads, and 37% in rural areas without access roads. In addition, firewood is widely used as a fuel source for cooking at home. Its usage rate is 67% nationwide and 88% in rural areas without access roads, followed by charcoal at 36%, whilst electricity usage is as low as 4%. However, the use of firewood has been a cause of indoor air pollution.

b) Drinking water supply

At the national level, 61% of people obtain drinking water from safe water sources. However, supply via waterlines is approximately 7%, and approximately 36% of households purchase bottled drinking water. In addition, 20% of households use well-water and rainwater with simplified filtering. More than a third of households use river water and groundwater, where safety is not guaranteed for drinking water.

c) Education

Table 2.1-8 “Transition of School Attendance and Literacy Rate” shows the transition of school attendance and literacy rate.

The Lao PDR has a compulsory education system for elementary and junior high school students, and school attendance is obligatory for children aged 6 years and older. The school attendance rate for children between the ages of 6 and 16 is approximately 80% at the national level.

Table 2.1-8 Transition of School Attendance and Literacy Rate

	1995 (%)	2005 (%)	2015 (%)
Literacy rate	60	73	84.7
School attendance rate (6 – 16 years old, male)	66	75	80.6
School attendance rate (6 – 16 years old, female)	56	68	78.7

Source: Lao Statistics Bureau (2016) Results of Population and Housing Census 2015

2.1.2. Key Economic Indicators

In the Asian economic crisis of 1997, the GDP growth rate of Lao PDR fell to 4% due to the influence of currency depreciation, inflation and the economic stalling of neighboring countries. The GDP Growth of Lao PDR is stable now, and its value has reached a high level of 7.5% or more in recent years. Table 2.1-9 shows the transition of key economic indicators.

Table 2.1-9 Transition of Key Economic Indicators

	2010	2011	2012	2013	2014	2015
GDP (million USD)	6,743	8,060	9,397	10,759	11,853	12,585
GDP per capita (USD)	1,077	1,266	1,452	1,635	1,772	1,850
GDP growth rate (%)	8.1	8.0	7.9	8.0	7.6	7.6

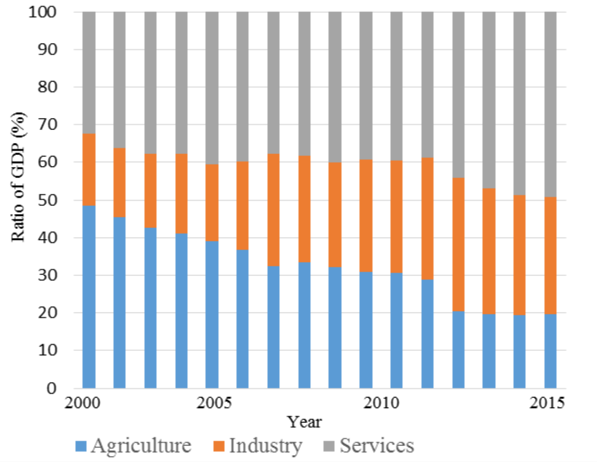
Source: prepared by JICA study team based on “UN, National Accounts Main Aggregates Database”

2.1.3. Industry Structure

Figure 2.1-5 and Figure 2.1-6 show the transition in GDP ratio by industry and the transition in Consumer Price Index (CPI) ratio for Lao PDR.

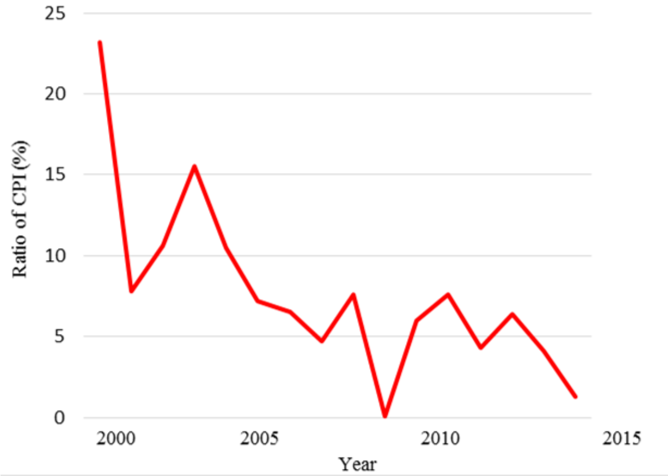
In the 1990s, wood products were the main export items for Lao PDR, but primary industry, including forestry, has been declining since the government implemented the policies of prohibition of bolt log exporting and limitations on tree logging. In the place of primary industry, the mining sector, one of the secondary industries, has been growing because two large-scale gold and copper mines began to operate with Australian capital (Sepon mine in 2003 and Phu Bia mine in 2006).

In recent years, electric power in Lao PDR has begun to be exported to neighboring countries (mainly Thailand), and this has led to growth in secondary industry. Tertiary industry is also growing due to the influence of commerce, such as the tourist and retail sectors, which have been growing with the recent World Heritage trend.



Source: prepared by JICA study team based on "ADB Key Indicators 2017"

Figure 2.1-5 Transition in GDP ratio by Industry



Source: prepared by JICA study team based on "ADB Key Indicators 2017"

Figure 2.1-6 Transition in CPI ratio

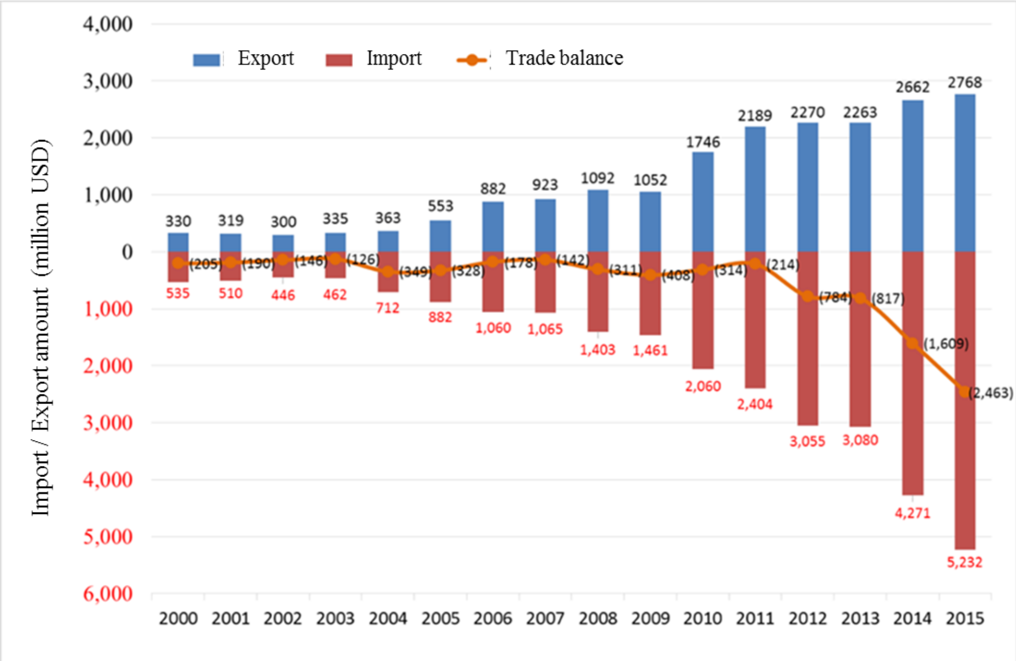
2.1.4. Trade

The Lao PDR has participated in the ASEAN Free Trade Area (AFTA) and the ADB – Greater Mekong Sub Region (ADB – GMS) and has actively engaged in the integration and cooperation of regional economies. Figure 2.1-7 shows the transition of the trade balance. This data shows that the import and export amounts for Lao PDR increased by approximately 9 times between 2000 and 2015.

The major export items in 2000 were wood products, charcoal, and clothing, which accounted for nearly 80%. From 2003 to 2008, metals such as gold and copper, refined via the progress in mining developments, began to be exported. Since then, mines such as tin, iron, lead, zinc and silicon have been newly developed and started to be exported in ore or refined form. In addition, from 2009 to 2012, hydro power stations such as Nam Theun 2 and Nam Ngum 2 were completed and electric power began to be exported.

On the other hand, the Lao PDR has imported petroleum products, such as gasoline, at a 100% level because there are no domestic oil fields, and approximately 90% of its imports are from Thailand.

The other major imported items are automobiles, machinery, electric products, etc. Along with the recent economic development, domestic investment and consumption have become active, and the import amount also shows high growth. The deficit in the trade balance has expanded due to this influence.



Source: prepared by JICA study team based on "ADB Key Indicators 2017"

Figure 2.1-7 Transition of Trade Balance

Thailand, which is close geographically and culturally, is the biggest trading partner for Lao PDR in imports and exports, followed by China and Vietnam.

2.1.5. National Development Plan

The Lao PDR has implemented economic development based on the National Growth and Poverty Eradication Strategy (NGPES) formulated in 2004, and the National Socio-Economic Development Plan (NSEDP) is formulated every five yewars. As a specific target, the Lao PDR set the "To leave the LDC by 2020" at the Sixth Party Congress in 1996. In the 8th NSEDP (2016-2020), the Lao PDR has mainly set three achievement goals and aims to leave the LDC through realization of these. For the economic targets of Lao PDR in 2020, GDP growth rate is 7.5% per capita, and GDP is 3,190 USD (as of 2015, 1,850 USD). Table 2.1-10Table 2.1-11 shows the 8th NSEDP overview.

Table 2.1-10 8th NSEDP Overview

	Achievement	Policy approach
Economic	Formation of strong economic base and reduction of economic vulnerability	・Promotion for integration in regional and international society (improvement of roads/bridges/power infrastructure) ・Promotion of capacity building for public and private labor force, reinforcement of overseas competitiveness for domestic companies ・Improvement of macro-economic stabilization mechanism ・Reinforcement of financial plan
Social	Human resource development, poverty reduction, high quality education, improvement of access to medical care, protection and development of culture unique in Lao PDR	・Reservation of food security and improvement of nutritional status ・Poverty reduction through improving living environment ・High quality education/Improvement of health care ・Improvement of access to social welfare
Environment	Protection and utilization of clean and sustainable natural resources and the environment; preparation for natural disasters and climate change	・Improvement of public transportation with impact of climate change ・Environmental conservation such as forest conservation and sustainable development in the Mekong River basin

Source: prepared by JICA study team based on "8th NSEDP" and Ministry of Foreign Affairs website

2.1.6. Government Finances

Table 2.1-11 shows the Government Finances in Lao PDR. The government's budgetary balance has long remained in a deficit. The underdevelopment of the private sector and weakness of structure for tax income create the background to such deficit. In recent years, the Government of Lao PDR has been frozen and public infrastructure projects with low urgency have been postponed for the purpose of curbing expenditure. Measures have also been taken to prohibit large-scale infrastructure development expenditure outside the budget centering on local governments that have not been approved by the National Assembly.

Table 2.1-11 Government Finances

(Unit: billion Kip)

Items	2010	2011	2012	2013	2014	2015
Revenue (incl. Grants)	12100.4	13890.0	16992.2	19586.8	22356.9	22719.6
Revenue (excl. Grants)	8538.4	10181.2	12427.7	14674.1	17186.5	18173.9
- tax income	7502.6	9108.6	10914.8	12651.8	14547.4	15675.8
- non-tax income	1035.8	1072.6	1512.8	2022.3	2639.0	2498.0
- Grant	3562.0	3708.8	4564.6	4912.7	5169.5	4545.8
Expenditure	13481.7	15102.8	18021.0	24665.0	26471.7	27508.8
Deficit	-1381.3	-1212.8	-1028.6	-5078.2	-4115.7	-4789.1

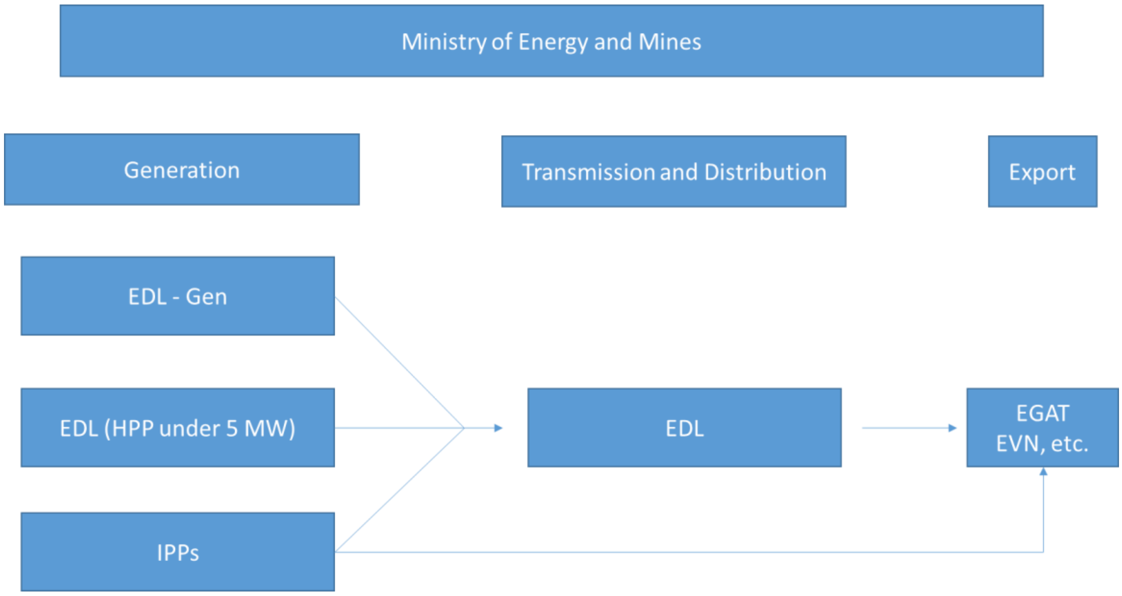
Source: prepared by JICA study team based on "ADB Key Indicators 2017"

Chapter 3. Energy Sector Overview

3.1. Organization of the Electricity Sector and Electricity Sector Policy

3.1.1. The Institutional Framework of the Laos Electricity Sector

The organizational structure of the electricity sector in Laos is shown in Figure 3.1-1 below.



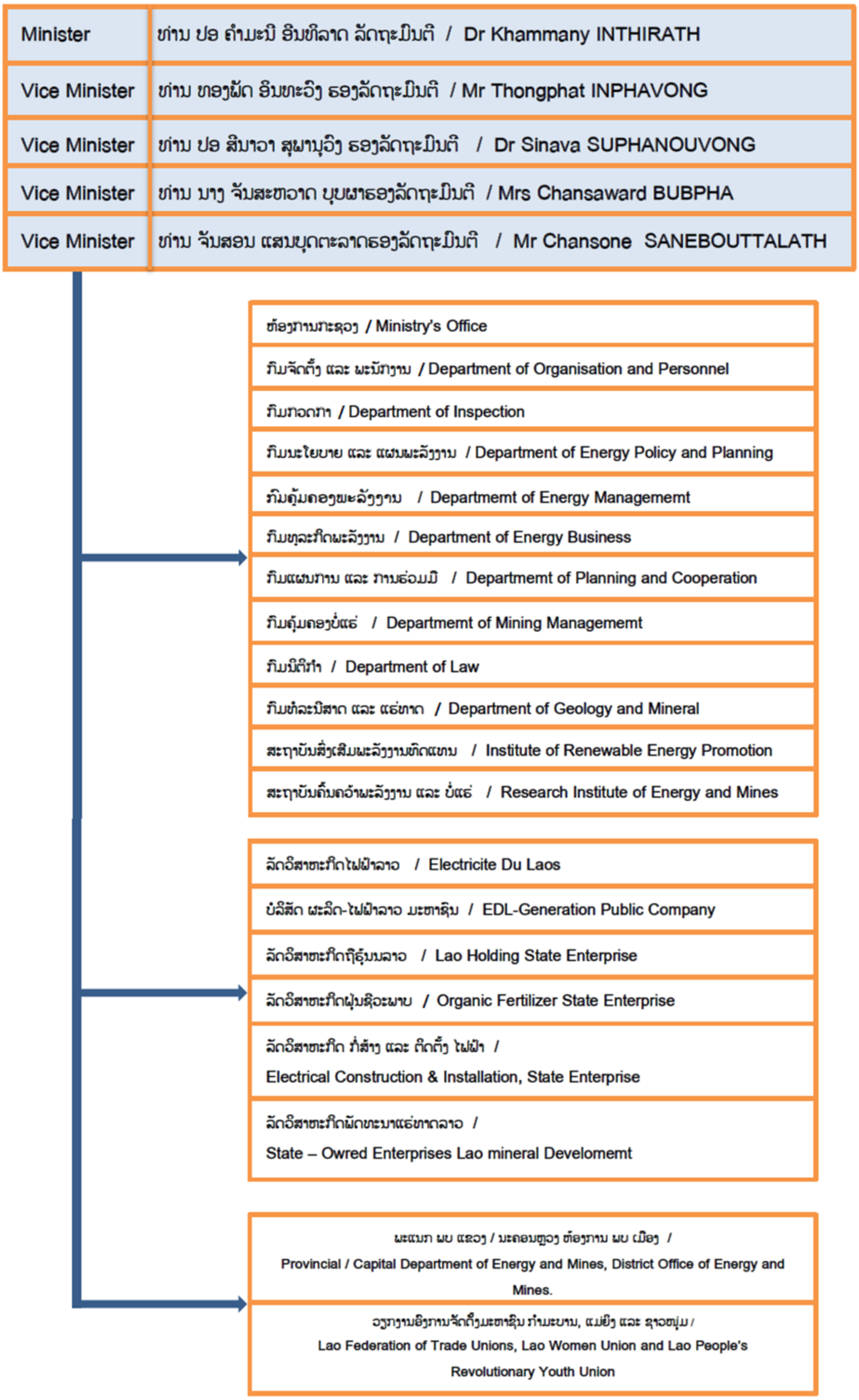
Source: JICA Study Team

Figure 3.1-1 Organizational Structure of the Electricity Sector

1. Ministry of Energy and Mines (MEM)

In Lao PDR, the Ministry of Energy and Mines (MEM) is the principal authority managing the electricity sector and it has the power to develop and implement laws and regulations governing the sector. Furthermore, in the absence of an independent power sector regulator, MEM also takes on the role of a regulator determining the electricity tariffs. The main departments under MEM are displayed in the following Figure 3.1-2.

Organization Chart of Ministry of Energy and Mines



Source: JICA Study Team

Figure 3.1-2 Organizational Structure of MEM (Overview)

Table 3.1-1 Organizational Structure of MEM (Overview)

Department of Energy Business (DEB)	DEB of MEM is in charge of private investment in the power sector. Its main role is to negotiate project development agreements with IPPs, conclude MoUs and sign power purchase agreements. The DEB deals with logistics and administration, project development, legal affairs, and project monitoring for electricity projects.
Department of Energy Policy and Planning (DEPP)	DEPP is responsible for policymaking and planning the Ministry's involvement in the energy sector.
Department of Energy Management (DEM)	DEM is the regulatory, monitoring and compliance entity within MEM. This department is in charge of drafting energy-related laws, regulations, guidelines and technical-safety standards. It also monitors both state-owned and private sector parties to ensure compliance.
Institute of Renewable Energy Promotion (IREP)	IREP is equivalent to a department of MEM and is responsible for renewable energy development, energy efficiency and conservation and rural electrification efforts in the country.

Source: JICA Study Team

2. Other Agencies and Stakeholders in the Energy Sector

The agencies and stakeholders playing specific roles in supplying electricity services in Lao PDR and managing the national power network are described in Table 3.1-2 below.

Table 3.1-2 Relevant Electricity Sector Agencies

Electricité du Laos (EDL)	EDL is a state-owned electric power utility, supplying electricity to domestic consumers through its transmission and distribution lines. EDL also manages the import and export of electricity. It buys power from a number of domestic IPPs, EDL-Gen and from abroad, as well as exports electricity to the neighboring countries.
EDL-Generation Public Company (EDL-Gen)	EDL-Gen is the electricity generation company and a subsidiary of EDL. The main objectives of EDL-Gen are (1) to generate energy for EDL from power plants with capacity above 5 MW; (2) to invest in or set up joint ventures with other electricity generation projects; and (3) to provide management and maintenance services for other electricity projects.
Lao Holding State Enterprise (LHSE)	The Lao Holding State Enterprise (LHSE) is a state-owned enterprise that holds, owns and manages on behalf of the Government its shares of four power project companies.
Ministry of Planning and Investment (MPI)	The main function of the MPI is to coordinate with the Government's line ministries in the preparation of their respective socio-economic development strategies. MPI is also responsible for implementing investment strategies, promoting regulation, and overall investment approvals.
The Ministry of Finance (MoF)	MoF defines the financial environment in the country. It determines policies that set the appropriate tax and duties for land use or equipment import.
Ministry of Natural Resources and Environment (MoNRE)	MoNRE has overall responsibility for the development and implementation of "Reduction of Emissions from Deforestation and forest Degradation" (REDD) and for overseeing the management of the forestry sector in Lao PDR.

Source: JICA Study Team

3.1.2. Regulatory Framework for the Energy Sector

There are several strategies, policies, laws and decrees that govern the power sector in Lao PDR, as summarized below.

1. Power Development Strategy, National Power Development Plan (NPDP) and Provincial Power Development Plan (PPDP)

The definition, composition and creation method for the above have been determined according to the "Law on Electricity" (details will be described later), amended in 2017. An overview of each is given below.

a) Power Development Strategy

A "Power Development Strategy" is a ten-year plan that determines policies and general road maps for the power sector and is a basis for the preparation of the NPDP and the PPDP. This strategy is consistent with the policies, visions and strategies in the National Socio-Economic development plan, natural resources development plans of other sectors and their shared usage and protection plans for forests. The content consists of a power demand forecast, development of power generation from different power resources, development of transmission and distribution systems, and power exports to neighboring countries. The MEM has prepared a draft of the Power Development Strategy in coordination with relevant ministries, departments and agencies. It has then been submitted to the Government for approval from the National Assembly but not been approved yet.

b) National Power Development Plan (NPDP)

An "NPDP" is a five-year plan which is consistent with the polices and strategies in the National Socio-Economic development plan, and it is summarized and created based on each Provincial Power Development Plan (details will be described later). The main contents are as follows.

- Power demand forecast for domestic and export markets
- Power generation resources, volumes of production, expansion of transmission and distribution lines to meet the demand and priority projects which integrate with other sectors' development plans, such as for natural resources and the environment, and so on.
- Budget and Financial Plan

The MEM prepares a draft of the NPDP in coordination with relevant ministries and local administrative bodies, and submits it to the Government. The Government implements the NPDP upon approval by the National Assembly. If necessary, the Government may review and amend the NPDP from time to time and submit it to the National Assembly for consideration. According to the MEM, the first draft of the NPDP hase been prepared (as of June 2019). It has been submitted to the Government with the aim of receiving approval from the National Assembly, but not approved yet.

c) Provincial Power Development Plan (PPDP)

A "PPDP" is a five-year plan which is established in conformity with provincial strategies, socio-economic development plans and the NPDP. The main contents are same as the NPDP. In order to prepare a new PPDP, six months before the expiry of the NPDP the Provincial Departments of Energy and Mines (PDEM) coordinate with the relevant provincial departments and line agencies in research and basic data collection relating to the preparation of the PPDPs for their respective provinces, and submit them to the MEM for preparation of the NPDP. The MEM prepares a draft of the NPDP based on the PPDPs submitted from the provinces and submits it to the Government. Upon approval of the NPDP from the National Assembly, PDEMs prepare drafts of PPDPs and submit them to the Provincial Governors for approval from the Provincial Assemblies.

2. Eighth Five Year National Socio-Economic Plan (2016-2020)

Lao PDR has a long-term goal for national development which is set out in the Eighth Five Year National Socio-Economic Plan (2016-2020), with a Vision to 2030. According to this vision, the goal is for Lao PDR to make the transition from a Least Developed Country (LDC) to a middle income country by 2020 supported by inclusive, stable and sustainable economic growth while alleviating poverty. In the energy sector, the plan puts focus on hydropower development, thermal electric power, solar energy and industrial plant energy in order to turn the power sector into a sustainable income-generating sector to support various types of production and solve the issue of poverty among the country's people. Furthermore, the plan focuses on developing large, medium and small hydropower dams along the Mekong River's tributary branches. Apart from these, there will be other projects to be implemented, such as the expansion of distribution substations and electrical networks and construction of transmission lines for remote rural electrification, and efforts will also concentrate on developing electrical power sources for export.

3. Law on Electricity (established 1997, amended 2008, 2011, 2017)

The "Law on Electricity" is the basic law on electricity business in Lao PDR, which defines the power development plan, permissions for electricity business and development, environmental and social considerations, electric technical standards compliance, power imports and exports, rural electricity, general principles of electricity tariff setting and so on. The latest version (amended in

2017) consists of 13 chapters with 119 articles. A composition comparison between the previous law and present law is given in Table 3.1-3 below.

Table 3.1-3 Composition Comparison between the previous law and the present one

(Previous) Law on Electricity		(Present) Law on Electricity	
Chapter 1	General Provisions (art 1-8)	Chapter 1	General Provisions (art 1-8)
Chapter 2	Electricity Activities (art 9-23)	Chapter 2	Power Development Plan (art 9-17)
Chapter 3	Electricity Business (art 24-42)	Chapter 3	Electricity Activities (art 18-35)
Chapter 4	Rural Electricity (art 43-46)	Chapter 4	Electricity Business (art 36-79)
Chapter 5	Electricity Tariff (art 47-49)	Chapter 5	Rural Electricity (art 80-82)
Chapter 6	Rights and Obligations of Electricity Producers, Distributors and Users (art 50-52)	Chapter 6	Alternative Electrical Power, Power Saving and Conservation of Electrical Power(art 83-85)
Chapter 7	Prohibitions (art 53-56)	Chapter 7	Electricity Tariff (art 86-89)
Chapter 8	Dispute Resolution (art 57-62)	Chapter 8	Rights and Obligations of Electricity Producers, Distributors and Users (art 90-92)
Chapter 9	Management and Inspection of Electricity Related Works (art 63-72)	Chapter 9	Prohibitions (art 93-96)
Chapter 10	Policies towards Persons with Outstanding Achievements and Measures against Violators (art 73-79)	Chapter 10	Dispute Resolution (art 97-102)
Chapter 11	Final Provisions (art 80-81)	Chapter 11	Management and Inspection of Electricity Related Works (art 103-110)
		Chapter 12	Policies towards Persons with Outstanding Achievements and Measures against Violators (art 111-117)
		Chapter 13	Final Provisions (art 118-119)

Source: Prepared by the JICA study team based on "(unofficial translation) Law on Electricity (dated May 9, 2017)", provided by Department of Law (DOL), MEM

In a major amendment, investment for BOT concessions by national or foreign private entities (the Law actually suggests a joint venture between the state and private entities) in a transmission line concession business has been newly added to the Law. (It may be noted that the previous Law had a provision for only BOT concession, which is more appropriate for large hydropower projects.)

The major amended points and articles related to this study are described in Table 3.1-4 below.

Table 3.1-4 Major amended points

Ch.	Title	Art	Sorting	Major content
2	Power Development Plan	9-17	New	Power Development Strategy, NPDP and PPDP
3	Electricity Business	26	New	- Investment by private entities in a transmission line concession business - Approval objects by the National Assembly Standing Committee (for 500 kV or above Transmission line projects)
		27	New	Description regarding Open Access (many power generation projects through the same transmission line). In this case, the owners of the transmission lines authorize other power generation projects to use their transmission lines subject to payment of wheeling charges, sharing the investment costs for construction.
		37	New	Definition, application and requirements for general electricity service business
		42-58	New	Description below regarding Independent Power Producers (IPP) - Authorization and forms (BOT and BOO etc.) of the IPP - Procurement of the IPP project developer and proposal forms (solicited and unsolicited) - Procedure for authorization from the Feasibility study (including the bidding)
		60	Change	- Composition for Social and Environmental Impact Assessment (SEIA) - Approval of SEIA by the MONRE etc.
		64	Change	Concession period on each project and extension method in operation phase are as follows. < In the case of BOT > - Power generation projects: shall not be more than 20 years. - Transmission line concession projects: determined by the Government and approved by the National Assembly Standing Committee. < In the case of BOO > - Small hydropower projects: shall not be more than 40 years. - Thermal power, solar and wind projects: shall not be more than 25 years - Other types of projects: determined by the Government. The concession period may be extended upon approval by the Government, whereby the project company shall submit a request for the extension 5 years prior to the end of the concession period.
		78-79	New	Description regarding the Transmission line concession business (BOT): - Government approval, entity formation - Proposal forms: solicited or unsolicited. (Same as for IPP)

Source: Prepared by the JICA study team based on "(unofficial translation) Law on Electricity (dated May 9, 2017)", provided from Department of Law (DOL), MEM

4. The Power Sector Policy Statement (2001)

The overall aims of power sector policy are to (i) maintain and expand an affordable, reliable sustainable electricity supply within the country to promote economic and social development; (ii) promote power generation for export (to provide revenues to meet the government's development objectives); (iii) and ensure sustainability.

5. Renewable Energy Development Strategy (REDS) (2011)

In recognition of the importance of renewable energy technology options in meeting Lao PDR's goal of providing energy services to rural households, the Renewable Energy Development Strategy (REDS) was announced in 2011. The Government aims to increase the share of renewable energies to 30% of the total energy consumption by 2025. REDS aims to develop new renewable energy resources, which are not yet widely used, to replace resources that will be depleted in the future - "non-renewable energy" such as fossil fuels, coal, natural gas etc. These renewable resources include biofuels (such as biomass and biogas), solar power, wind, small scale hydro and geothermal.

3.2. Electricity Tariffs (EDL, IPPs, Wheeling Charges)

The principles for setting electricity tariffs in the Lao PDR are defined in the Electricity Law. The law stipulates that it is necessary to reflect investment costs and operation and management (O&M) costs in the electricity tariffs, while also taking into consideration the consumers' purchasing power. Therefore, under the principles of the existing legislation, it is considered difficult to establish cost-reflective electricity tariffs, especially for individual consumers.

3.2.1. Electricity Tariffs of EDL

The EDL electricity tariffs are set every ten years, and there is no clear mechanism to update them during that period. The process of setting the EDL electricity tariffs in Laos is described below.

1. Electricity Tariff Study

MEM selects a consultant to conduct an electricity tariff study under an open procurement process. The selected consultant surveys the current status of the electricity sector and proposes optimal electricity tariffs. The last electricity fee study was carried out by SNC - Lavalin International Inc. in 2008 with the support of the IDA (International Development Association). The tariffs proposed as part of that study are presented Table 3.2-1.

Table 3.2-1 EDL Electricity Tariff Table (proposed in 2008)

Unit: Kip /kWh

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tariff										
Residential	443	416	478	598	748	934	1168	1460	1825	2080
International Organization	1070	1059	1112	134	1548	1734	1786	1839	1894	1951
General business	792	789	828	911	1002	1103	1169	1227	1301	1366
Entertainment	950	956	1004	1104	1215	1251	1289	1327	1367	1408
Government office	684	668	701	877	1026	1180	1239	1301	1366	1434
Irrigation	248	237	273	341	426	532	665	832	1040	1185
Industries	568	565	593	682	785	847	890	934	981	1030
Average	540	548	595	698	813	904	971	1064	1176	1274
Export Tariff	332	439	441	469	500	534	571	610	651	695
Average Sales Tariff										
Average Costs			959	946	978	1011	1075	1139	1203	1267

Source: Tariff Study Update Project Final Report (2008), IDA

It should be noted that in 2017 the World Bank commenced a new Electricity Tariff Study in order to support the development of the new ten-year tariff table. As no new tariff table had been approved by January 1, 2018, the validity of the tariffs for 2017 was extended by an additional six months.

2. Results of the study and proposed new tariffs

The DEM of MEM is currently reviewing the results of the power sector study, based on which the new electricity tariffs are expected to be determined. However, it should be noted that the current electricity fees were eventually set at a level of less than 50% of the level proposed in the 2008 study. The current electricity tariff table is shown in Table 3.2-2.

Table 3.2-2 Current EDL Electricity Tariff Table

	2011	2012											2013	2014	2015	2016	2017
Monthly		2	3	4	5	6	7	8-12	9	10	11	12	1-12	1-12	1-12	1-12	1-12
Low Voltage (Residential)	KIP Currency / kWh																
0 - 25 KWH	269	269	277	285	294	303	312	321	331	331	331	331	328	334	341	348	355
26 - 150 KWH	320	320	330	339	350	360	371	382	442	442	442	442	390	398	405	414	422
>150 KWH	773	773	796	820	845	870	896	923	780	780	780	780	941	960	979	999	1,019
Low Voltage (Non-Residential)																	
Embassies, Int'l Organization	1,077	1,077	1,109	1,143	1,177	1,212	1,249	1,286	1,152	1,152	1,152	1,152	1,312	1,338	1,365	1,392	1,420
Service Business, Temporary	835	835	860	886	912	940	968	997	998	998	998	998	1,017	1,037	1,058	1,079	1,101
Education Business and Sports			676	696	717	738	760	783	781	781	781	781	799	815	831	848	865
Entertainment Business	1,106	1,106	1,139	1,173	1,209	1,245	1,282	1,321	1,152	1,152	1,152	1,152	1,347	1,374	1,401	1,429	1,458
Government Organization	656	656	676	696	717	738	760	783	781	781	781	781	799	815	831	848	865
Agriculture, Irrigation	399	399	411	423	436	449	463	476	471	471	471	471	486	496	506	516	526
Industries	591	591	609	627	646	665	685	706	692	692	692	692	720	734	749	764	779
Medium Voltage																	
Service Business, Temporary	709	709	730	752	775	798	822	847	898	898	898	898	864	881	898	916	935
Education Business and Sports			574	591	609	627	646	665	703	703	703	703	678	692	706	720	734
Entertainment Business			1,082	1,115	1,148	1,183	1,218	1,255	1,094	1,094	1,094	1,094	1,280	1,305	1,331	1,358	1,385
Government Organization	557	557	574	591	609	627	646	665	703	703	703	703	678	692	706	720	734
Agriculture, Irrigation	340	340	350	361	372	383	394	406	424	424	424	424	414	422	431	439	448
Industries (less than 5 MW)	502	502	517	533	549	565	582	599	623	623	623	623	611	624	636	649	662
Industries (more than 5 MW)			647	647	647	647	647	647	647	647	647	647	660	673	687	700	714
High Voltage	647	647	647	647	647	647	647	647	647	647	647	647	660	673	687	700	714

Source: EDL

3. Electricity Tariff Revision

Currently, there is no mechanism for revision of the electricity tariffs during the period of their validity. Based on the outcomes of an interview with MEM representatives, it was confirmed that the Lao government manages the inflation rate, while the central bank controls the exchange rate fluctuations, which is considered to be the main reason for not having a formal tariff revision mechanism.

However, under exceptional circumstances, MEM can change the electricity tariffs even during their validity period. The most recent precedent was in 2016 when the tariffs for individual consumers were updated.

3.2.2. IPP Electricity Tariffs

The electricity tariffs for IPPs are determined in the PPA with IPP operators and are not disclosed publicly. The negotiations with IPPs are conducted by EBD of MEM, while the electricity tariffs are determined by DEM. IPP royalty is defined in a Prime Minister's decree, and the royalty is set as 5% for domestic sales and above 5% (no cap) for exports. However, the export royalty is decided according to deal-specific negotiations. According to MEM, the details cannot be disclosed. The royalty will not be charged during the construction period; it is set to be below 5% for 5 years after COD and will increase after this period.

3.2.3. Wheeling Charges

Currently, according to MEM, wheeling charges are set only for the Nabong Substation connecting to Thailand. The government and Nam Ngum2, which is developing the said substation, concludes a lease contract, and Nam Theun 1, Nam Ngiep 1, and Nam Ngum 2, which are connected to the substation, conclude ITAs with the government. They pay the charges to the government, and the government pays charges to Nam Ngum 2.

3.3. ODA Support by other donors

In Laos, support for the electric power sector is being implemented via three World Bank projects (source: Lao portfolio Factsheet, World Bank, March 2017).

- Power Grid Improvement Project
- The Power Grid Improvement Project aims at the improvement of distribution system reliability and its efficiency for the selected areas.

- Mekong Integrated Water Resources Management
- This large-scale program is being implemented with five relevant organizations and consists of eight areas of assistance, including support for the revision of the electric power law, optimal hydropower development in cooperation with local governments and the central government, and methodologies for hydropower development in consideration of the water system. The study of the interconnections between Laos and Vietnam is being carried out under this program.

- TA for Capacity Development in Hydropower and Mining Sector
- This TA aims at human capacity building for the staff of governmental organizations in hydropower development and the mining sector. "Financial Sustainability of the Power Sector in Lao PDR & Developing Suitable Power Tariff Regime" has been carried out under this program. The current tariff system had been effective until last year. The tariff system for the next ten years has since been studied.

The study "GMS Power Market Development" is being carried out until March 2018 for the purpose of supporting the Working Group of RPTCC, as described later. In this study, support for the establishment of a Regional Grid Code, and a study of the economic benefits brought by the regional interconnections are being implemented.

ADB has been supporting the studies on power trades in GMS and the conferences from the early 1990's. Table 3.3-1 shows the main studies and the support for the conferences in GMS by ADB.

Table 3.3-1 The Main Studies and the Support for the Conferences in GMS by ADB

1992	GMS Economic Cooperation Program
1995	Electric Power Forum
1995	Subregional Energy Sector Study for the Greater Mekong Subregion 1995 (Norconsult, ADB RETA 5535)
1999	Policy Statement on Regional Power Trade
1999	Power Trade Strategy Study, World Bank, 1999
2002	Regional Indicative Master Plan on Power Interconnection, 2002 (Norconsult, ADB RETA 5920)
2002	The Intergovernmental agreement (IGA) on regional power trade in the GMS is signed. The RPTCC is established.
2004	The first RPTCC
2009	Building a Sustainable Energy Future: The Greater Mekong Subregion, ADB, 2009
2010	Update of the Regional Indicative Master Plan on Power Interconnection, 2010 (RTE International et al., ADB RETA 6440)
2011	Discussion on the establishment of the Regional Power Coordination Center (RPCC)
2012	Two working groups are set up: (i) performance standards and grid code, and (ii) regulatory issues.

Source: Greater Mekong Subregion Power Trades and Interconnection - 2 Decades of Cooperation, ADB, 2012

"Technical Assistance (TA) for Harmonizing the Greater Mekong Sub-region (GMS) Power Systems to Facilitate Regional Power Trades TA-8830 REG" started in December 2014 to support the Working Groups for Performance Standards, Grid Code and Regulatory Issues at RPTCC. It provides technical assistance regarding harmonization of operation performance indicators, establishment of a Grid Code, the tariff system and an institutional power trade system.

ADB has supported the study and the construction of power transmission and distribution lines in the north of Laos, together with the environmental aspects of Nam Ngiep 1 including resettlement. The support for the transmission and distribution system in the north of Laos has almost finished. A feasibility study will be started from 2018 regarding the 230 kV transmission lines between Shan State in Myanmar and the north of Laos. The weakness of the power transmission system in Myanmar (to Mandalay and Yangon) may be one of the issues regarding power imports.

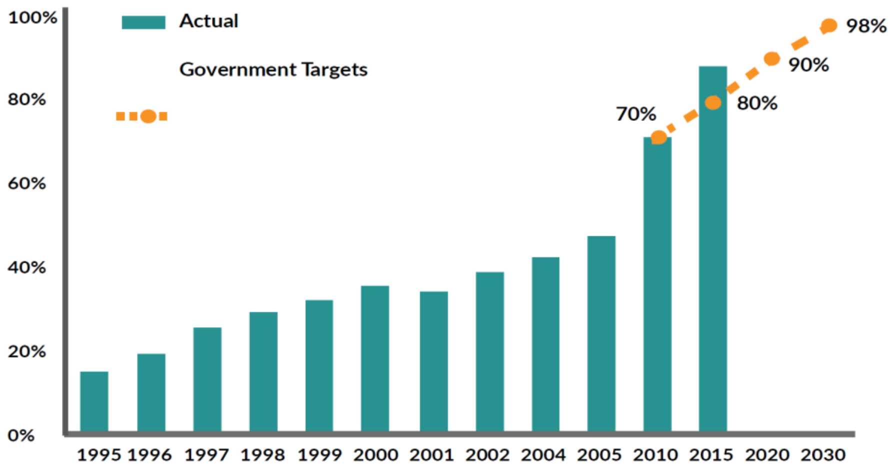
ADB will continue to provide support for regional interconnection, promote investment in small-scale distributed renewable energy sources, promote energy-saving investments, standardize rules for grid connection of storage batteries and distributed power sources, and to promote support for the development of building standards for efficient use. (RPTCC26, Evaluation of ADB Support to GMS Cooperation, November 2019)

A project for technical assistance and technology transfer on renewable energy in Lao PDR is being implemented with the support of the Ministry of Foreign Affairs and Trade of New Zealand (May 2013 to April 2018).

Since 2017, the "Vulnerability Assessment and Resilience Action Plan for the Lao Power Sector" has been implemented with the joint support of USAID CLEAN POWER ASIA and NREL (National Renewable Energy Laboratory). Possible risks in the power sector (hazards) are assessed in terms of climate change equivalents and other aspects (Technical aspects and Capacity building, etc.), and action plans are established for those at higher risk.

3.4. Rural Electrification

According to the National Socioeconomic Development Plan for rural electrification in Laos, the target is for the rate of electrification by household to reach 98% by 2030. As shown in the following figure, the rate of electrification by household in Laos has rapidly increased from 47% as of 2005 to 71% as of 2010 thanks to cooperation by the foreign donors that conducted the Rural Electrification Project, such as the World Bank.



Source: Worldwatch Institute for the LEDs GP Energy Working Group

Figure 3.4-1 Progress of Rate of Electrification by Household in Laos

Further, the rate of electrification by household after 2012 has also increased smoothly so as to achieve the same level as in the National Policy, as shown in the following table:

Table 3.4-1 Progress of Domestic Rate of Electrification from 2012 to 2017

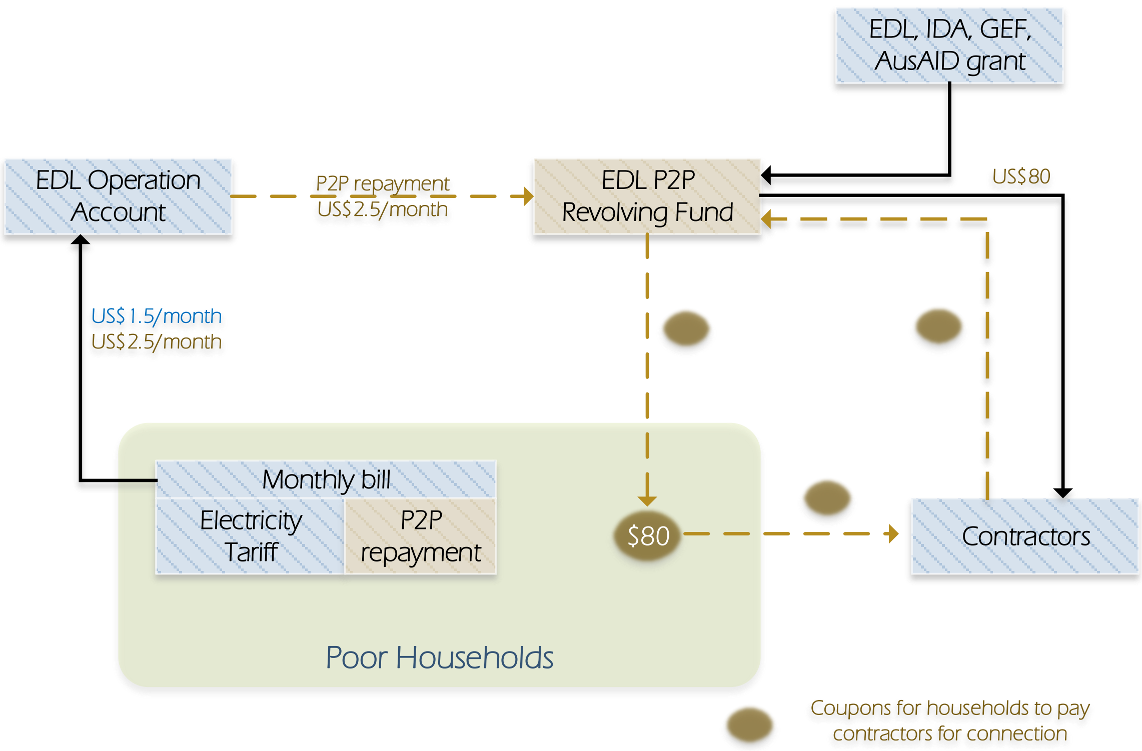
Year	Districts		Villages		Households	
	No.	Rate	No.	Rate	No.	Rate
2012	145	100%	6,448	74.49%	876,762	82.25%
2013	143	98.62%	6,924	80.32%	943,599	87.34%
2014	145	99.32%	7,203	84.04%	986,435	88.70%
2015	148	100%	7,373	85.90%	1,038,248	90.51%
2016	148	100%	7,554	88.41%	1,078,712	92.39%
2017	148	100%	7,667	90.15%	1,092,611	94.23%

Source: EDL Annual Report 2017

In terms of the background to the increased rate of electrification, the Australian Agency for International Development (AusAID), the Global Environment Facility (GEF), and the International Development Association (IDA) contributed by conducting two support programs: Power to the Poor (P2P, 2008 to 2014), which promoted the EDL grid power supply to female-headed households and impoverished households, and Solar Home System (SHS, 2004 to 2009), which promoted the installation of solar power facilities for households in off-grid areas. These programs were characterized by being interest-free and subsidized.

3.4.1. Power to the Poor (P2P)

The purpose of the P2P program is to increase the rate of electrification in villages from 85% to 95% by the provision of a subvention for female-headed households and households in poverty, who cannot bear the initial costs for connecting to the distribution line due to financial problems even though they reside in an electrified area. The cash flow in the P2P program is shown in the following figure:



Source: World Bank

Figure 3.4-2 Cash Flow in P2P Program

3.4.2. Solar Home System (SHS)

The SHS program was implemented by the Provincial Energy Service Companies (PESCOs), established in MEM from 2001, and installed home solar facilities on the roofs of 5,700 households in 50 off-grid villages up to 2004 in a pilot project. After this, it was expanded to more than 200 villages and 13,000 households up to 2009, supported by AusAID and IDA.

In the SHS program, the recipient could set the facility scale and payment period according to the income and ability of payment. After completion of payment, the recipient became the owner of the installed facilities. Home solar facilities installed in each household were equipped with battery chargers and batteries having the capacity to supply power for 4 hours.

The cost per scale of the facilities adopted in the SHS program is shown in the following figure:

Table 3.4-2 Cost of Home Solar Facilities in SHS Program

Capacity	Installation Fee	Monthly Payments for Solar Kit (kip/month)	
		5-year repayment period	10-year repayment period
20 W	160,000 kip	20,000 kip	10,000 kip
30 W	190,000 kip	30,000 kip	15,000 kip
40 W	220,000 kip	40,000 kip	20,000 kip
50W	250,000 kip	50,000 kip	25,000 kip

Source: World Bank

Chapter 4. Existing Power System Facilities

4.1. Current Power System Situation in Laos (incl. projects under construction)

4.1.1. Domestic Generating Facilities

Existing total generating power capacity in Laos is 6,917.3 MW as of the end of 2017, of which 2,451.3 MW is for domestic power supply within Laos and the remaining 4,466.0 MW is for power export to neighboring countries. Since some IPP power plants have generating and transformer facilities for both domestic supply and power exports, these IPP power plants are not only exporting to neighboring countries, but also supplying power to domestic demand. The generating power capacity for domestic power supply by each Area as of December 2017 is shown in Table 4.1-1 and almost all power for domestic supply is generated in the Northern, Central-1 and Southern Areas.

Table 4.1-1 Generating Power Capacity of Existing Power Stations for Domestic Supply

(Unit: MW)

Area	Northern	Central-1	Central-2	Southern	Total
Generating Capacity for domestic supply	891.7	954.8	177.8	427.0	2,451.3

Source: EDL

The generating power capacity for exporting power by IPPs in each Area as of December 2017 is shown in Table 4.1-2. Currently, IPPs for power exports have not been connecting to the domestic power grid and these IPPs are exporting power to Thailand and Vietnam via dedicated transmission lines (115 kV, 230 kV and 500 kV).

Table 4.1-2 Generating Power Capacity of Existing Power Stations (IPPs)

(Unit: MW)

Area	Northern	Central-1	Central-2	Southern	Total
Generating Capacity for export by IPPs	1,778.0	615.0	1,440.0	633.0	4,466

Source: EDL

The details of power plants, both existing and planned, which will be operating within the year 2018 are given in the power system for each area, as follows.

4.1.2. Domestic Transmission and Distribution System

Although the current power system in Lao PDR consists of transmission and distribution lines at 500 kV, 220 kV, 115 kV, 33 kV, 22 kV and low voltage, the domestic power supply system as of 2017 consists of under 230 kV transmission lines because the 500 kV transmission line is used only for power exporting to neighboring countries as a dedicated line.

Since Nam Ngum 1 power station was constructed in the 1970s and a 115 kV transmission line between Thailand and Lao PDR was constructed, power generated in Lao PDR has been exported to Thailand in the wet season, with the rich generating power via hydro power plants, while power is imported from Thailand in the dry season when the generating power is insufficient to meet domestic power demand. In addition, 115 kV Thakek substation (hereinafter referred to as “S/S”) and Pakbo S/S in Central-2 Area directly received power from Thailand because interconnection lines between each area (i.e. Northern, Central-1, Central-2 and Southern) had not been constructed. Therefore, the power grid in Lao PDR has been connected to the power grid in Thailand, and power output from power plants and the protection of power flow in the interconnection line between Thailand and Lao

PDR has been controlled by instructions from the national control center in Thailand.

Recently, extension of the 115 kV transmission line from the independent Northern area to the Central-1 area has taken place, and transmission and substation facilities for connecting Central-2 and Southern started operation in 2016. This means that a single national grid with 115 kV and 230 kV transmission lines was finally actualized by the interconnection line from the Northern Area to the Southern Area via the Central Area. Additionally, 230 kV transmission lines have been adapted for the domestic power supply system due to the increase in power demand and power development in the Northern Area, and a 230 kV transmission line between Vientiane, Luang Prabang and Namo substation has started operation. Furthermore, the national control center in Vientiane plays a role in the operation of the domestic power system in Lao PDR, and collaborates with Korn ken substation in Thailand.

The 500 kV transmission line between Na Bong S/S and Udon 3 S/S in Thailand is currently operating at 230 kV and exporting power from only Nam Ngum 2 power station (hereinafter referred to as “P/S”) to EGAT, in Thailand. Although this transmission line is owned by the Nam Ngum 2 P/S company, the power generated at Nam Ngiep 1 power plant was also connected to this T/L in 2019.

In order to interconnect with neighboring countries, currently, there are 500 kV and 230 kV transmission lines for direct export of power from IPPs and a 115 kV transmission line between the grids of EDL and EGAT. In addition, power trading between Lao PDR and neighboring countries is conducted by not only supplying from the domestic power grid but also 35 kV and 22 kV distribution lines, which are adopted in areas that are out of service of the domestic power grid and more than 115 kV T/L, such as areas located near the national border.

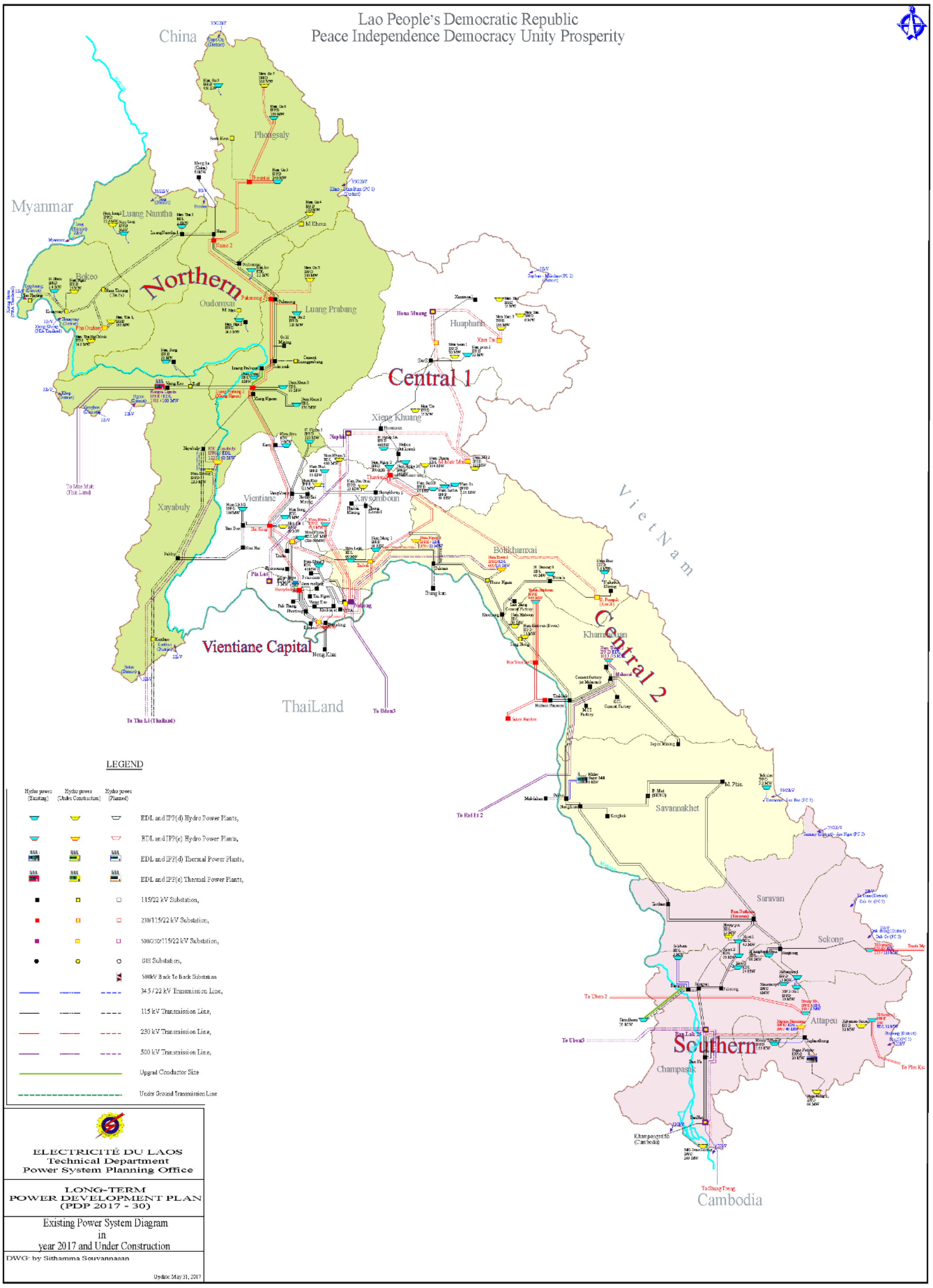
The list of distribution lines near the border for power trading and their peak power as of 2016 is shown in Table 4.1-3. Two distribution lines in this table, No. 1 and No. 13, will not be used after Houayxau S/S and Ton Pheung S/S (which are under construction in Bokeo province) have been constructed, because the power supply for demand via the distribution lines from Thailand will be changing over to the new substations.

Table 4.1-3 33 / 22 kV Distribution Lines near the Border for Power Trading with Neighboring Countries

No.	From	To	L (km)	V (kV)	Conductor (mm2)	Peak (MW)	Supplied by
				Northern Area			
1	Houayxai	Chiengkhong	0.7	22	ACSR 185	10.32	PEA
2	Khan Thao	Thali	0.4	22	ACSR 240	8.28	PEA
3	Pangthong	Mang District	28.6	22	ACSR 150	N/A	China
4	Khoub	Ban Houak	1.5	22	ACSR 150	1.25	PEA
5	Ngeun	Houay Kone	1.0	22	ACSR 150	N/A	PEA
6	Chiang Hon	Ban Mai	1.3	22	ACSR 150	1.58	PEA
7	Boten Dankham	Bohan	3.4	22	ACSR 90	N/A	China
8	M.Mai	Dienbien	25.0	35/22	ACSR 185	N/A	EVN
9	Ngot Ou	Jang Xeun	52,8	22	ACSR 120	2.83	China
10	Boten	Danxai	81.9	22	ACSR 150	2.62	PEA
11	Thon Pheng	Xieng Sen	3.0	22	ACSR 185	10.6	PEA
12	Long District	Xieng Kok	1.5	22	ACSR 150	N/A	Myanmar
				Central 1 Area			
13	Pahang	Mokchao	30.0	35/22	ACSR 150	3.51	EVN
				Central 2 Area			
14	Dansvan	Laobao	0.8	35/22	ACSR 95	7.84	EVN
				Southern Area			
15	Dakchung	Vietnam	10.0	35/22	ACSR 150	N/A	EVN
16	Lali (Samoua)	Are Ngor	2.0	35/22	ACSR 150	0.79	EVN
17	Vangtut Mining	Vietnam	50.0	35/22	ACSR 150	0.59	EVN

Source: EDL

Except for the distribution lines shown in Table 4.1-3, although power trading between Namo substation in the Northern Area and Menga LA power station in China had been conducted by a 115 kV transmission line, these power trades have recently been stopped due to over-generating in Lao PDR. A map of the power system and interconnection lines, including projects under construction, in Lao PDR as of October 2018 is shown in Figure 4.1-1.



Source: EDL

Figure 4.1-1 Power System and Interconnection Lines incl. projects under construction in Lao PDR as of May 2017

4.1.3. Power System in Northern Area

1. Generating Facilities in Northern Area

Many hydro power stations are being constructed in the Northern Area due to the topographical feature of it being a mountainous region. The existing generating facilities and the power generation projects under construction in the Northern Area are shown in Table 4.1-4.

Table 4.1-4 Power Stations Existing and Under Construction in Northern Area

No.	Name	Province	Capacity (MW)	Type	COD	Status
1	Nam Ko	Oudomxay	1.50	Run of river	1966	Existing
2	Nam Dong	Luangprabang	1.00	Run of river	1970	Existing
3	Nam Tha 3	Luangnamtha	1.30	Run of river	2010	Existing
4	Nam Nhon***	Borkeo	2.40	Run of river	2011	Existing
5	Nam Long***	Luangnamtha	5.00	Run of river	2013	Existing
6	Hongsa Lignite*	Xayaboury	1,778/100**	Thermal	2015	Existing
7	Nam Khan 2	Luangprabang	130.00	Reservoir	2015	Existing
8	Nam Beng	Oudomxay	36.00	Reservoir	2016	Existing
9	Nam Khan 3	Luangprabang	60.00	Reservoir	2016	Existing
10	Nam Ou 2	Luangprabang	120.00	Reservoir	2016	Existing
11	Nam Ou 5	Phongsaly	240.00	Reservoir	2016	Existing
12	Nam Ou 6	Phongsaly	180.00	Reservoir	2016	Existing
13	Nam Nga 2***	Oudomxay	14.50	Run of river	2017	Existing
14	Nam Tha 1	Borkeo	168.00	Reservoir	2018	Under Construction
15	Nam Houng Down	Xayaboury	12.50	Run of river	2019	Under Construction
16	MK. Xayaboury*	Xayaboury	1,260 / 60**	Run of river	2019	Under Construction
17	Nam Ou 1	Luangprabang	180.00	Run of river	2020	Under Construction
18	Nam Ou 3	Luangprabang	210.00	Run of river	2020	Under Construction
19	Nam Ou 4	Phongsaly	132.00	Reservoir	2020	Under Construction
20	Nam Ou 7	Phongsaly	210.00	Reservoir	2020	Under Construction
21	Nam Ngao	Borkeo	15.00	Reservoir	2020	Under Construction
Total			3,038 MW (IPP for Export)		1,879 MW (Domestic Supply)	

*IPP for Export **Domestic Power in IPP for Export ***Independent Power

Source: EDL

Nam Nhon P/S, having a capacity of 2.4 MW, Nam Long P/S, having a capacity of 5.0 MW, and Nam Nga 2 P/S, having a capacity of 14.5 MW, are not connected to the domestic power grid in EDL and exist as independent power sources for supplying power to the vicinity via 22 kV distribution lines.

Of the power stations in the Northern Area, it is planned for the power generated by Nam Ou 3 to Nam Ou 7 to be exported to the Northern Area of Vietnam.

2. Transmission and Substation Facilities in Northern Area

There are two IPPs for export in the Northern Area, Hongsa Coal-Fired Plant and Mekong Xayabuly Power Station, which is under construction. The power generated by these IPPs will be connected to EGAT, Thailand, via a 500 kV dedicated transmission line.

Furthermore, the power generated by the group of Nam Ou power stations, which has been constructed using Chinese funds in Phongsaly and Luang Prabang province, is supplied to Hin Heup substation in Central-1 Area by a 230 kV transmission line from Bountai S/S via Namo 2 S/S, Pakmong S/S and Luan Parabang 2 S/S. However, as mentioned above, there is an ongoing study for the interconnection transmission line to the Northern Area of Vietnam to export the power generated by the Nam Ou power station group.

For supplying the power generated in the Northern Area to Vientiane Capital and EGAT in Thailand, 115 kV transmission lines from Namo S/S in Northern Area are connected to Vientiane Capital via Kasi S/S in Central-1 Area.

3. Limits of Hydropower Transmission in the Northern Region

It is difficult to transmit power from hydroelectric power plants in the Nam Ou river system to Vientiane Capital via existing transmission lines. The rdairakueason is not a limitation in the heat capacity of transmission lines but the stability of the transmission lines.

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

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

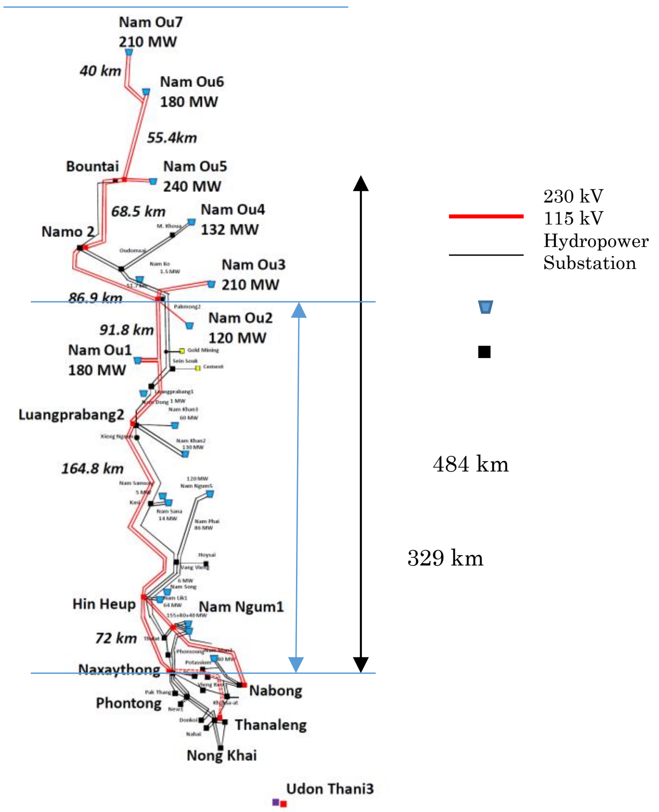


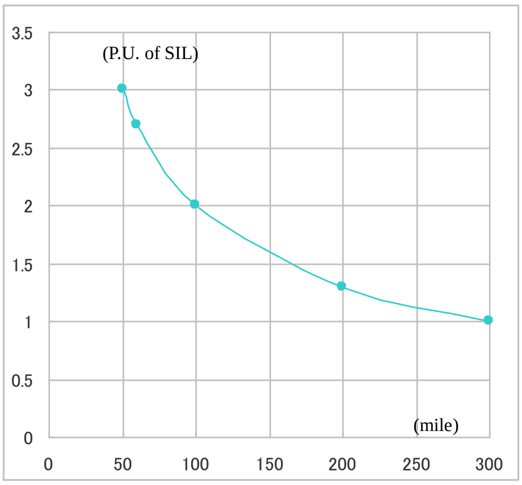
Figure 4.1-2 Power Transmission System of Hydroelectric Power Plants in Nam Ou River System

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

a) Estimation of Available Power

Method 1: The power transmission ability is simply estimated from the voltage phase difference between the sending and the receiving ends and the impedance between them. The distance is 480 km in 230 kV double circuit lines. Assuming that the transient impedance of the generators is 0.4 p.u., the impedance of the step-up transformer is 10%, and the phase difference is 44 degrees ($\sin\theta = 0.7$), the amount of power that can be stably transmitted through the 230 kV double circuits is approximately 312 MW.

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



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

Figure 4.1-3 Indication of Available Power Flow of a AC Transmission Line

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

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

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

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

	Case A	Case B	Case C
NOU7	105	105	0
NOU6	60	60	0
NOU5	120	240	0
NOU4	0	0	88
NOU3	0	0	210
NOU2	0	0	0
NOU1	0	0	0
Total	285	405	298

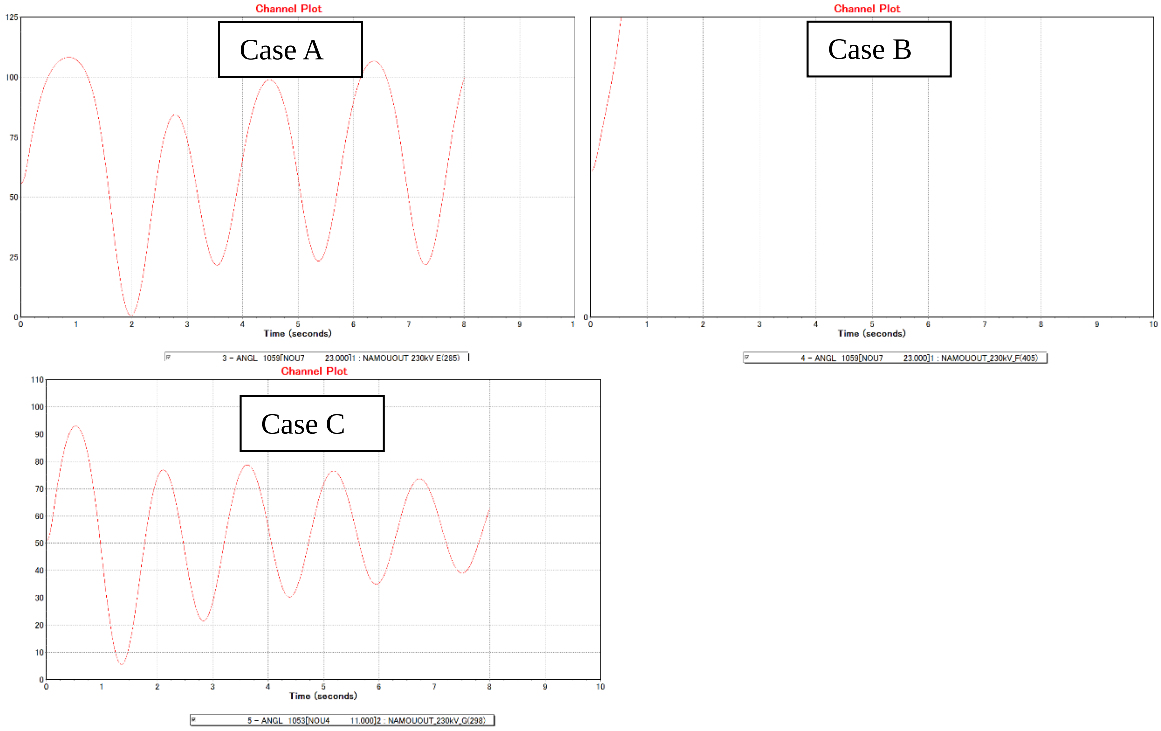


Figure 4.1-4 Results of stability calculations in each case with different Nam Ou outputs

b) Conclusion

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

4.1.4. Power System in Central-1 Area

1. Generating Facilities in Central-1 Area

Since Nam Ngum 1 P/S was constructed in 1971, hydropower stations have continued to be constructed along the Nam Ngum River system in the Central-1 Area. Additionally, Nam Xam 3 P/S and Nam Peum 1 P/S are under construction in Huapanh province, which faces the national border with Vietnam.

The existing generating facilities and the power generation projects under construction in the Central-1 Area are shown in Table 4.1-5.

Table 4.1-5 Power Stations Existing and Under Construction in Central-1 Area

No.	Name	Province	Capacity (MW)	Type	COD	Status
1	Nam Ngum 1	Vientiane Pro	155.00	Reservoir	1971	Existing
2	Nam Luek	Saysomboun	60.00	Reservoir	2000	Existing
3	Nam Mang 3	Vientiane Pro	40.00	Reservoir	2004	Existing
4	Nam lik 1/2	Vientiane Pro	100.00	Reservoir	2010	Existing
5	Nam Ngum 2*	Saysomboun	615.00	Reservoir	2010	Existing
6	Nam Song	Vientiane Pro	6.00	Reservoir	2011	Existing
7	Nam Ngum 5	Vientiane Pro	120.00	Reservoir	2012	Existing
8	Nam Sana	Vientiane Pro	14.00	Run off river	2014	Existing
9	Nam Sien Tad Lang	Xieng Khuang	5.00	Run off river	2014	Existing
10	Nam Ngipe 3A	Xieng Khuang	44.00	Reservoir	2015	Existing
11	Nam Ngiep 2	Xieng khuang	180.00	Reservoir	2015	Existing
12	Nam San 3B	Saysomboun	45.00	Reservoir	2015	Existing
13	Nam San 3A	Saysomboun	69.00	Reservoir	2016	Existing
14	Nam Sor	Saysomboun	4.20	Renewable	2016	Existing
15	Nam Ngipe 2C	Xieng Khuang	14.55	Run off river	2017	Existing
16	Nam Phai	Saysomboun	86.00	Reservoir	2017	Existing
17	Nam Peun 2	Houaphanh	12.00	Run off river	2017	Existing
18	Nam Sim	Houaphanh	9.00	Run off river	2017	Under Construction
19	Nam Chiene	Saysomboun	104.00	Reservoir	2017	Under Construction
20	Naxaythong Solar Farm (S)	Vientiane Capital		Renewable	2017	Existing
21	Nam Hao	Houaphanh	15.00	Run off river	2018	Under Construction
22	NN 1 (Extension Phase 1)	Vientiane Pro	80.00	Reservoir	2018	Under Construction
23	Nam Peun 1	Houaphanh	25.00	Run off river	2018	Under Construction
24	Nam PhaGnai	Saysomboun	19.00	Reservoir	2018	Under Construction
25	Nam Aow (Nam Pot)	Xieng Khuang	15.00	Reservoir	2018	Under Construction
26	Nam Lik 1	Vientiane Pro	64.00	Run off river	2019	Under Construction
27	Nam Ngipe 2A	Xieng Khuang	12.55	Run off river	2019	Under Construction
28	Nam Ngipe 2B	Xieng Khuang	8.94	Run off river	2019	Under Construction
29	Nam The	Xieng khuang	15.00	Run off river	2019	Under Construction
30	Nam Dick 1	Houaphanh	15.00	Run off river	2020	Under Construction
31	Nam Ngum 3*	Saysomboun	480.00	Reservoir	2020	Under Construction
32	Nam Samuay	Vientiane Pro	5.00	Run off river	2020	Under Construction
33	Nam Xam 3	Houaphanh	156.00	Reservoir	2020	Under Construction
34	NN 1 (Extension Phase 1)	Vientiane Pro	40.00	Reservoir	2020	Under Construction
Total			1095.0 MW (IPP for Export)		1,538 MW (Domestic Supply)	

*IPP for Export **Domestic Power in IPP for Export ***Independent Power

Source: EDL

As shown in Table 4.1-5 above, the only IPP for power exports in the Central-1 Area is Nam Ngum 2 power station, having a capacity of 615.0 MW, and all other power stations are connected to EDL's grid. In addition, Nam Ngum 3 P/S is under construction and we have listed NN3 to export the power generated from NN3 P/S to Thailand. Apart from the power stations listed in Table 4.1-5, a solar power station with a capacity of 15 MW is under construction near Na Bong substation.

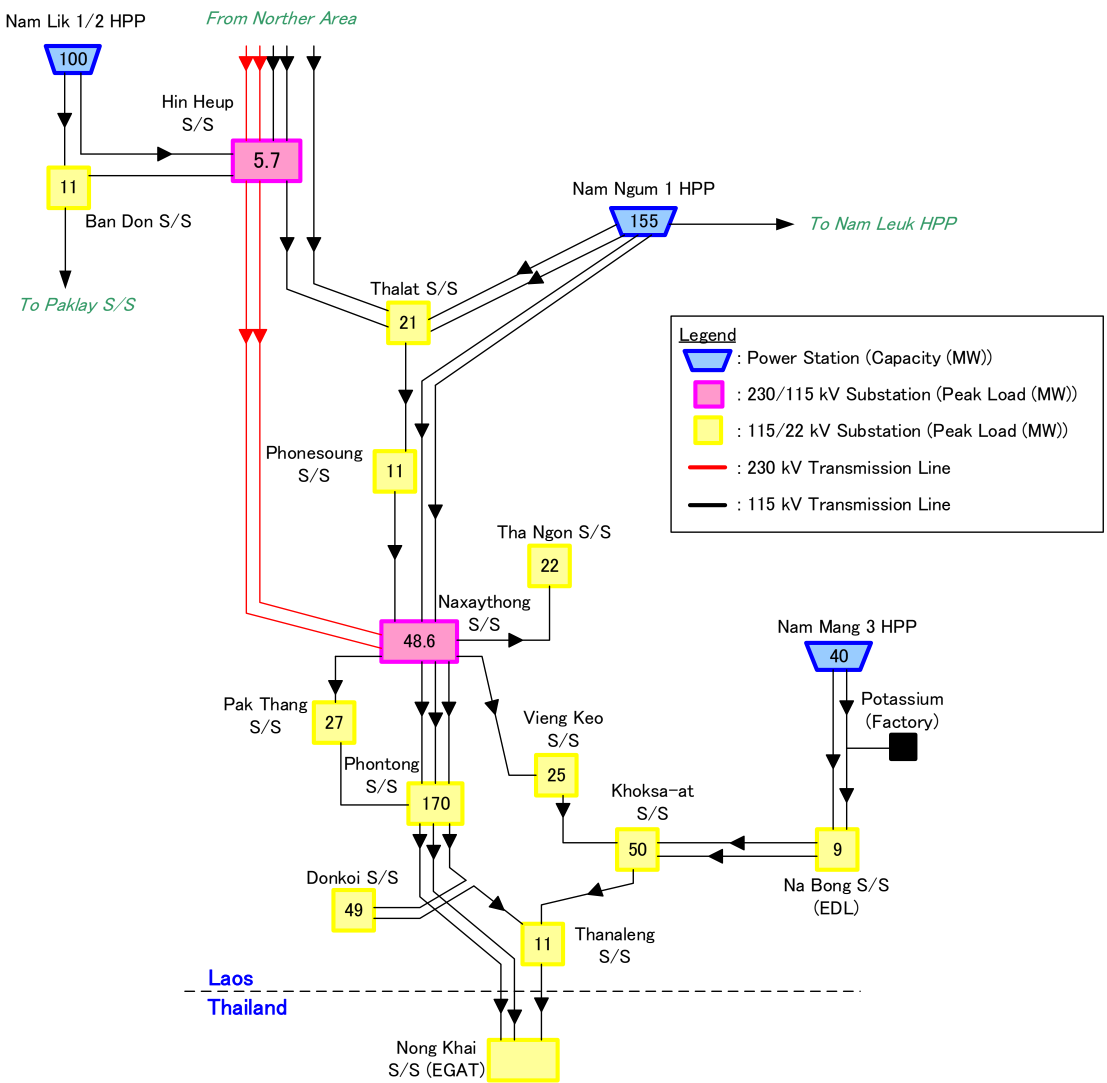
2. Transmission and Substation Facilities in Central-1 Area

Central-1 Area and Central-2 Area are connected by 230 kV and 115 kV transmission lines from Na Bong S/S to Pakxan S/S via Thabok S/S.

In the Central-1 Area, the power generated by the hydropower stations, except for IPPs for export located on the northern side, is supplied to Vientiane Capital and Thailand by 230 kV and 115 kV transmission lines. However, the countermeasures mentioned below are conducted, because the power flow of the 115 kV transmission line from the northern side to Vientiane Capital will be overloaded if the power generated by the hydropower stations is connected to EDL's grid.

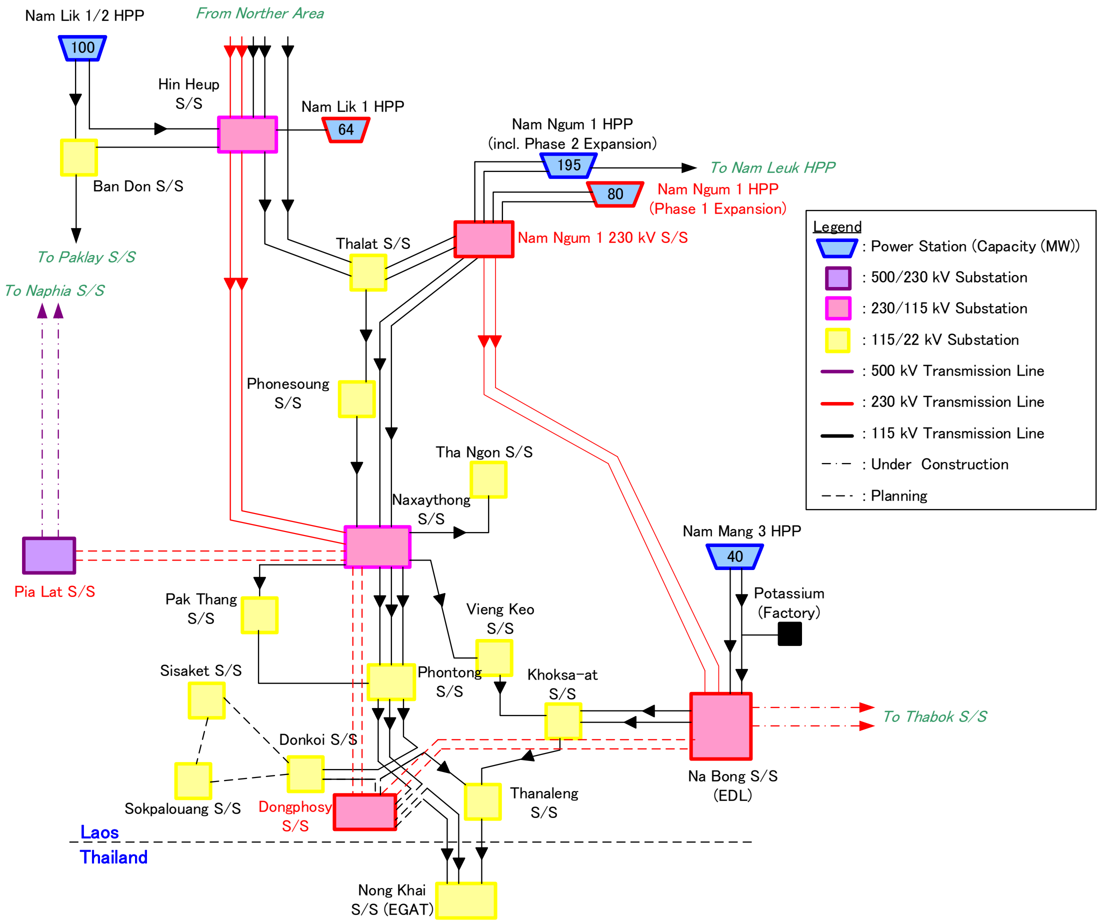
(a) Load Reduction for 115 kV Transmission Line in Vientiane Capital

As is conventionally done, the power from Nam Ngum 1 power station and the Northern Area has been supplied to Vientiane Capital by 230 kV and 115 kV transmission lines between Hin Heup S/S and Naxaythong S/S, but the existing transmission lines will become overloaded due to the expansion plan for Nam Ngum 1 P/S, which will add 80 MW in phase 1 and 40 MW in phase 2, and the construction of Nam Lik 1 P/S. Therefore, a 230 kV substation (called "Nam Ngum 1 230 kV substation"), located about 2 km downstream of Nam Ngum 1 P/S, was constructed and started operation in January 2018. After the 230 kV transmission line between Nam Ngum 1 230 kV S/S and Na Bong S/S is connected, the load of the 115 kV transmission line between Nam Ngum 1 P/S and Naxaythong S/S will be reduced, since it will be possible to transmit the power to Vientiane Capital via the 230 kV transmission line. On the other hand, although it is planned to construct a 230 kV transmission line from Pia Lat S/S to Dongphosy S/S via Naxaithong S/S, this should be studied carefully because it will overload the 230 kV bus conductor in Naxaithong S/S and the 115 kV transmission lines around Naxaithong S/S.



Source: EDL

Figure 4.1-5 230/115 kV Transmission Lines around Vientiane Capital (As of 2016)



Source: EDL

Figure 4.1-6 230/115 kV Transmission Lines around Vientiane Capital including Those Planned

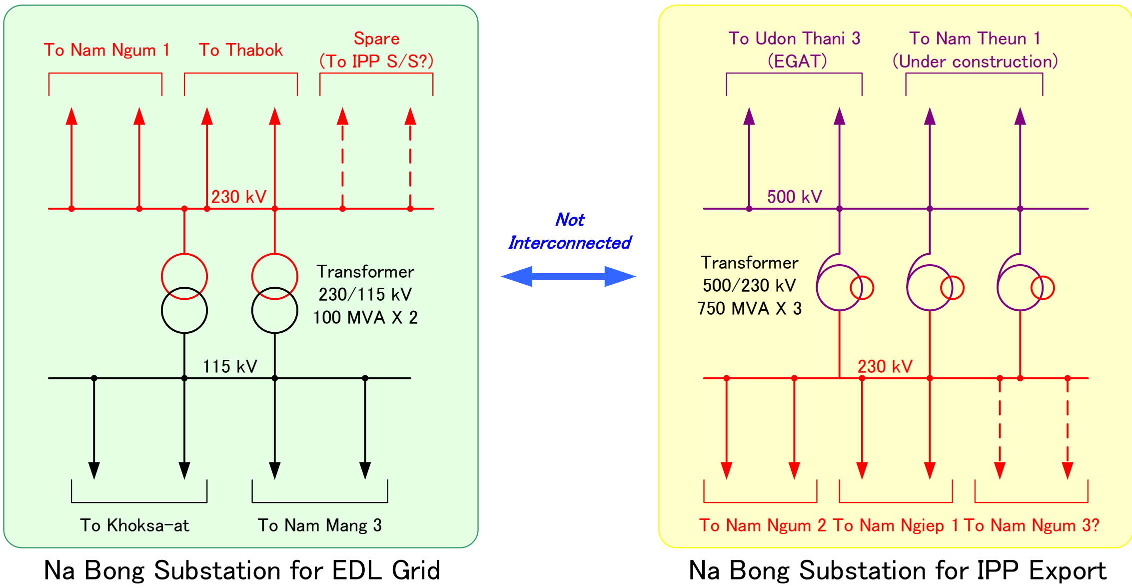
Source: JICA Study Team

Figure 4.1-7 Nam Ngum 1 230 kV Substation (As of September 2017)

(b) Operation of Na Bong Substation for IPP and EDL

In order to transmit the power from Nam Ngum 2 as an IPP for export to EGAT in Thailand, Na Bong S/S was constructed near the national border with Thailand. It has been operated at 230 kV to interconnect with Udon Thani 3 S/S in EGAT. In addition, it is planned for the Na Bong S/S and transmission line to EGAT to be upgraded to 500 kV after Nam Ngiep 1 P/S is connected to Na Bong S/S at 230 kV (2 cct) in 2019.

Furthermore, Na Bong S/S for EDL's grid was constructed next to Na Bong S/S for export IPP and is currently connected to Khoksa-at S/S and Nam Mang 3 P/S by 115 kV transmission lines. Na Bong S/S for EDL's grid and the export IPP are operating independently without interconnection, though each substation is close. The following figure shows the relationships of Na Bong S/S.



Source: JICA Study Team

Figure 4.1-8 Relationships of Na Bong S/S for EDL and Export IPP

EDL Grid Substation

IPP for Export Substation

Source: JICA Study Team

Figure 4.1-9 Na Bong Substation (As of November 2017)

4.1.5. Power System in Central-2 Area

1. Generating Facilities in Central-2 Area

The existing generating facilities and the power generation projects under construction in the Central-2 Area shown in Table 4.1-6.

Table 4.1-6 Power Stations Existing and Under Construction in Central-2 Area

No.	Name	Province	Capacity (MW)	Type	COD	Status
1	Theun-Hinboun*	Khammouan	440.00	Reservoir	1998	Existing
2	Nam Theun 2*	Khammouan	1,000.0/80.0**	Reservoir	2009	Existing
3	Nam Gnoug 8	Borikhamxai	60.00	Reservoir	2012	Existing
4	Nam Phao***	Borikhamxai	1.60	Run of river	2012	Existing
5	Sugar Mitlao Factory (T)	Savannakhet	3.00	Biomass	2012	Existing
6	Tadsalen***	Savannakhet	3.20	Run of river	2013	Existing
7	Nam Hinboun	Khammouan	30.00	Reservoir	2017	Under Construction
8	Nam Ngeip 1 (Off take)*	Borikhamxai	272.0/18.0**	Reservoir	2019	Under Construction
9	Nam Hinboun (Down)	Khammouan	15.00	Run of river	2020	Under Construction
10	Xelanong 1	Savannakhet	70.00	Reservoir	2021	Under Construction
11	Nam Theun 1*	Borikhamxai	650.0/130.0**	Reservoir	2020	Under Construction
Total			2,362.0 MW (IPP for Export)		437.8 MW (Domestic Supply)	

*IPP for Export **Domestic Power in IPP for Export ***Independent Power

Source: EDL

In the Central-2 Area, although there are relatively large hydropower stations such as the existing Theun-Hinboun P/S and Nam Theun 2 P/S, which is under construction, these P/Ss are IPP for export and the power for domestic supply is about 435 MW.

There are also some independent power sources, such as Nam Pho P/S and Tadsalen P/S, not connected to EDL's grid, and these amount to more than 115 kV. There are also some in other area.

2. Transmission and Substation Facilities in Central-2 Area

As mentioned above, the power system in the Central-2 Area is interconnected with that of the Central-1 Area at Thabok S/S and Pakxan S/S. In addition, the 115 kV transmission line from Pakxan S/S is also connected to Taothan S/S through the Central-2 Area.

Currently, a 230 kV transmission line between Thabieng S/S in the Central-1 Area and B. Pompik S/S in Central-2 is being constructed.

With regard to IPP for export in the Central-2 Area, 500 kV or 230 kV dedicated transmission lines from IPPs are directly connected to EGAT's grid for power trading. As shown in Figure 4.1-8, the power from Nam Ngiep 1 P/S and Nam Theun 1 P/S will be exported from Na Bong S/S for IPP export, constructed via the NN2 project, to EGAT via a 500 kV transmission line after connecting to Na Bong S/S via 2 circuits of 230 kV transmission lines from each power station.

4.1.6. Power System in Southern Area

1. Generating Facilities in Southern Area

Many hydropower stations are being constructed in the Southern Area due to the topographical feature of there being a mountainous region in Xekong and Attapeu province and rich water sources in the Mekong River System and Xekong River System. The existing generating facilities and the power generation projects under construction in the Southern Area are shown in Table 4.1-7.

Table 4.1-7 Power Stations Existing and Under Construction in Southern Area

No.	Name	Province	Capacity (MW)	Type	COD	Status
1	Xelabam	Champasak	5.00	Run of river	1970	Existing
2	Xeset 1	Saravan	45.00	Run of river	1990	Existing
3	Houay Ho*	Attapeu	150.0/2.0**	Reservoir	1999	Existing
4	Xeset 2	Saravan	76.00	Run of river	2009	Existing
5	Xekaman 3*	Sekong	225.0/25.0**	Reservoir	2013	Existing
6	Sugar Factory Attapeu	Attapeu	20.00	Biomass	2013	Existing
7	Xenamnoy 1	Sekong	15.00	Run of river	2014	Existing
8	Houaylamphanh Gnai	Sekong	88.00	Reservoir	2015	Existing
9	Xenamnoy 6	Champasak	5.00	Run of river	2016	Existing
10	Xeset 3	Champasak	23.00	Reservoir	2016	Existing
11	Houay por	Saravan	15.00		2018	Existing
12	Xekaman 1*	Attapeu	258.0/32.0**	Reservoir	2017	Existing
13	Xenamnoy 2 - Xekatam 1	Champasak	10.00	Run of river	2017	Existing
14	Nam Kong 2	Attapeu	66.00	Reservoir	2017	Existing
15	Houykapheu 1	Saravan	5.00	Run of river	2022	Under Construction
16	MK. Donsahong	Champasak	260.00	Run of river	2019	Under Construction
17	Xepien – Xenamnoy*	Champasak	370.0/40.0**	Reservoir	2019	Under Construction
18	Houay Chiae	Champasak	8.00	Run of river	2020	Under Construction
19	Houay Yoi - Houaykod	Champasak	11.20	Run of river	2019	Under Construction
20	Xekaman - Xanxai	Attapeu	32.00	Reservoir	2017	Under Construction
	Total		1,003.0 MW (IPP for Export)		783.2 MW (Domestic Supply)	

*IPP for Export **Domestic Power in IPP for Export ***Independent Power

Source: EDL

Within the power stations in the Southern Area, Xekaman 3 P/S, having a capacity of 250 MW, in Xekong province and Xekaman 1 P/S, having a capacity of 290.0 MW, in Attapeu province are operating as IPPs for export to EVN in Vietnam. Additionally, Xepian-Xenamnoy P/S, which is under construction, is planned to operate as an IPP for export to EGAT in Thailand.

(a) Dongsahong Power Station

Dongsahong P/S, whose total generated power of 260 MW (65 MW x 4 units) is planned to be exported to Cambodia, is under construction. The first unit started operation in May 2019, and other units will start operation every 2 months thereafter so that all units can be operated as of November 2019. It is planned that the power generated by Donsahong P/S will be transmitted by a 230 kV transmission line with 2 circuits via Ban Hat S/S.

Source: JICA Study Team

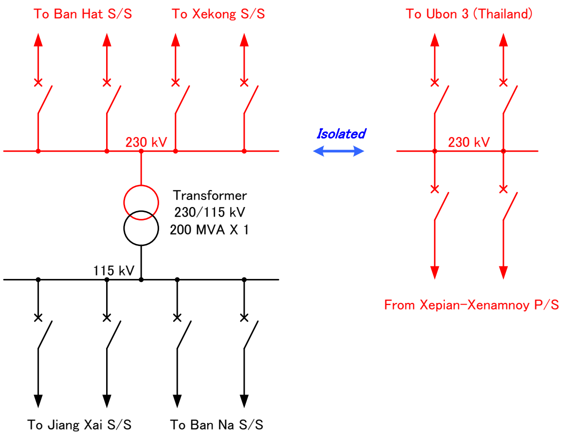
Figure 4.1-10 Dongsahong Power Station (As of June 2018)

2. Transmission and Substation Facilities in Southern Area

The power system in the Southern Area consists of only 115 kV transmission lines, except for the dedicated transmission lines of IPPs for export.

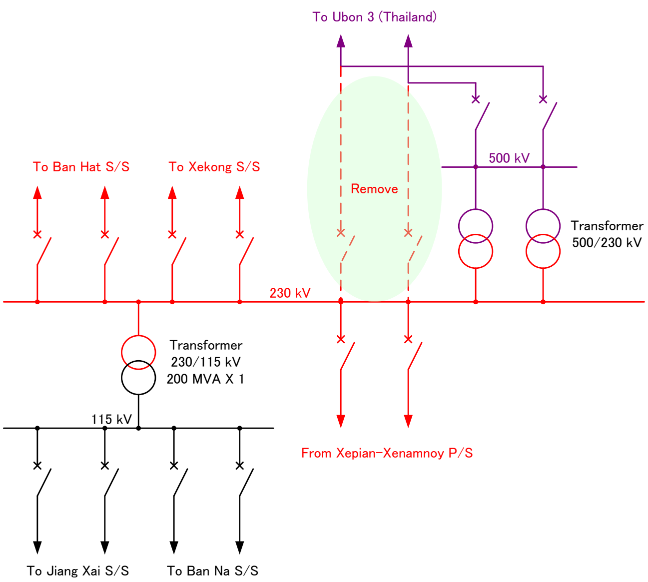
As mentioned above, Xekaman 3 P/S is connected to Thank My S/S in EVN's grid by two circuits of 230 kV transmission line and Xekaman 1 P/S is connected to Plei Ku S/S in EVN's Grid, because these power stations are IPPs for export.

Additionally, there are plans to export the power from Xepian-Xenamnoy P/S to EGAT via two circuits of 230 kV T/L between Xepian Xenamnoy P/S and Ban Lak 25 S/S. In addition, 230 kV transmission lines between Ban Hat S/S and Xekong S/S through Ban Lak 25 S/S, designed as 500 kV, are under construction and there are plans to upgrade to 500 kV in future. Therefore, the generating power of Xepian-Xenamnoy P/S will be transported to Ubon Ratchathani 3 S/S in EGAT after Ban Lak 25 S/S is upgraded to 500 kV.



Source: JICA Study Team

Figure 4.1-11 Connection Diagram at Ban Lak 25 Substation (Under Construction)



Source: JICA Study Team

Figure 4.1-12 Connection Diagram at Ban Lak 25 Substation (After Upgrading to 500 kV)

Furthermore, the interconnection line from Ban Hat S/S to Khampongsalao in EDC, Cambodia was operated at 22 kV as of December 2017 due to there being a small amount of power for trading, although it was constructed as a 115 kV transmission line.

a) Ban Lak 25 Substation

The 230 kV switching station named Pakse S/S, which has a one-and-a-half circuit breaker system, is under construction in order to connect the transmission line between Xepian-Xenamnoi P/S and Ubon 3 S/S in EGAT, of which the transmission line from Ban Lak 25 to Ubon 3 is designed as 500 kV. It is planned that the Pakse S/S will be operated as a 220 kV substation until 500 kV operation is started.

In the current plan, Ban Lak 25 S/S will be commissioned in 2019 in line with the construction schedule for the 230 kV transmission line from Ban Hat S/S to Ban Lak 25 S/S.

Source: JICA Study Team

Figure 4.1-13 Ban Lak 25 Substation (As of June 2018)

b) Ban Hat Substation

As mentioned above, power export from Ban Hat S/S to Cambodia is currently being conducted via the 115 kV transmission line (1 circuit, 66.6 km) and the 22 kV distribution line. However, the maximum amount of power that can be exported by the 115 kV transmission line was only 12 MW as of June 2018.

In addition, a 230/115 kV tie transformer with 90 MVA is now being installed in order to receive the power generated by Dongsahong P/S.

Source: JICA Study Team

Figure 4.1-14 Ban Hat Substation (As of June 2018)

c) Xekong Substation

The 230 kV transmission line with 2 circuits, designed as 500 kV, between Ban Lak 25 S/S and Xekong S/S is under construction. It will be commissioned in March 2020 in line with the construction schedule of Xekong S/S.

4.2. Transmission and Substations

4.2.1. Technical Standards for Transmission and Substation Facilities

The Lao Electric Power Technical Standards (LEPTS), which define technical articles to maintain safety for civil and electric hydropower plant facilities, substation facilities, transmission line facilities, distribution line facilities and users' sites' electrical facilities, were prepared in the "JICA Lao Electric Power Technical Standards Preparation Project" (2000-2003) and legislated as a ministerial ordinance in 2004. Since that time, all transmission lines and substation facilities in Lao PDR have been mandated to be constructed complying with the LEPTS.

In particular, the technical articles for transmission lines and substation facilities are as follows.

- General Electrical Facilities: 24 articles
- Overhead Transmission Line Facilities ("Conductors", "Insulators", "Dielectric Strength", "Supporting Structures", "Regulations for Installation", "Particulars of Installation Adjacent to and Crossing with Other Objects", "Protection against Lightning and Falling Trees"): 26 articles
- Substation Facilities ("Insulation", "Particularities of Equipment", "Protection, Monitoring and Control Systems", "Earthing Arrangement"): 18 articles

4.2.2. Outline of the Existing Transmission Lines

There are 230 kV and 115 kV transmission lines and the total distances of each voltage were 846.9 km and 4,761.9 km respectively as of December 2017. Their supporting structures mainly comprise double-circuits or single-circuit steel lattice towers and suspension type porcelain insulators are used. Regarding the type of conductors, ACSR (Aluminum Conductor Steel Reinforced) is used for almost all conductors but the conductors of one of the international interconnection lines with Thailand (115 kV Thakhek - Nakhon Phanom T/L) were replaced with ACCC (Aluminum Conductor Composite Core) in 2016.

4.2.3. Domestic Power Grid

As of December 2017, the main voltage classes of the domestic power grid are 230 kV and 115 kV. In the domestic power grid, there were four independent regional power grids, which are North, Central 1, Central 2 and South, in 2010. At present, these four regional power grids are interconnected.

Attachment 4-1 shows the existing transmission lines of 115 kV and over for the domestic power grid, including some IPP-dedicated lines, as of December 2017.

4.2.4. International Interconnections

The international interconnections in Lao PDR are categorized into transmission lines connected to the domestic power grid and IPP-dedicated lines for power export.

In terms of international interconnections connected to the domestic power grid, there are the 115 kV Phontong – Nong Khai and Thakhek – Nakhon Phanom double-circuit transmission lines and Thanaleng – Nong Khai, Pakxan – Bungkan, Pakbo – Mukdahan 2 and Bang Yo – Sirindhorn single-circuit transmission lines between Lao PDR and Thailand.

In addition, there are three interconnections for power imports from China to Luangnamtha and Phongsaly Provinces, seven interconnections for power imports from Thailand to Xayabuly and Bokeo, and six interconnections for power imports from Vietnam to Phongsaly, Savannakhet, Sekong, Saravan and Attapeu via 35 kV or 22 kV middle voltage distribution lines to supply electricity near the borders. There are also one interconnection for power exports from Luangnamtha to Myanmar and two interconnections for power exports from Champasak to Cambodia.

In terms of IPP-dedicated lines, there were seven export-oriented IPPs in Lao PDR as of December

2017. Five of them export electricity to Thailand, and there are four hydropower plants, Nam Ngum 2, Nam Theun 2, Theun Hinboun and Houay Ho, and one coal-fired thermal power plant, Hongsa Lignite. The remaining two IPPs export electricity to Vietnam and they are the Xekaman 1 and Xekaman 3 hydropower plants. They have 500 kV or 230 kV dedicated lines to export electricity to Thailand or Vietnam directly.

Attachment 4-2 shows the international interconnections as of December 2017.

4.2.5. Transmission Lines under Construction

As of December 2017, construction of the transmission lines, including domestic transmission lines and IPP-dedicated lines, listed in attachment 4-3 are in progress.

Regarding the 500 kV Naphia - Pia Lat T/L, tower erection on the Pia Lat side is in progress and the whole transmission line was estimated to be completed in October 2019. This transmission line will connect to hydro power plants such as Nam Mo 2 via M. Mok Mai from Naphia and will also connect to the Ban May (Ban Ang) - Naxaythong - Dongphosy transmission line from Pia Lat at 230 kV for power supply to Vientiane Capital. It is assumed that electricity generated in the Northern region would be carried to Vientiane Capital via M. Houn and M. Nan, and this would contribute to load reduction in the existing 230 kV and 115 kV transmission lines between North and Central-1. In addition, the construction of the 500 kV Ban Lak 25 Km - Ban Hat T/L is in progress. According to the feasibility study report for “Ban Hat - Ban Lak 25 - Xekong Transmission Line and Substation Project”, this transmission line will be operated at 230 kV initially and would be necessary in order to meet the load increase needs of the southern region, to supply sufficient and reliable power to an electrolytic aluminum project planned in Attapeu, to realize connection of a 230 kV power grid between the central and southern regions and to meet the needs of power transmission to neighboring countries. At present, 500 kV transmission lines are used for several export oriented IPP-dedicated lines but the establishment of a domestic 500 kV trunk line network has begun.

4.2.6. Existing Substations

The type of bus bar system is not standardized by the LEPTS. In most of the existing substations, the following bus bar system is adopted for each voltage level:

- 230 kV bus bar : 1 1/2 Circuit Breaker system
- 115 kV bus bar: Double bus (Main & Transfer) system

Only some of the substations have the double bus (Main & Transfer) system for the 230 kV bus bar and the single bus system for the 115 kV system.

EDL’s existing substations and switching stations which are connected to the power system are shown in attachment 4-4. The substation capacities of each region are summarized as Table 4.2-1.

Table 4.2-1 Substation Capacities of Each Region

No.	Name Substation	Province	Substation type			Power Transformer Capacity (MVA)			
			115 kV	230 kV	500 kV	115 kV	230 kV	500 kV	Total Capacity (MVA)
	Northern		13	3	-	441.0	440.0	-	881.0
	Central 1		24	3	-	939.5	800	-	1,739.5
	Central 2		13	-	-	432.0	300.0	-	732.0
	Southern		10	-	-	413.0	0.0	-	413.0
	Whole Country		60	6	-	2225.5	1540.0		3765.5

Source: EDL

4.2.7. Substations Under Construction

The following 500 kV substation constructions are in progress in each region.

- Central 1: Naphia substation, Pia Lat substation, and Houa Muang substation

Part of the building work at the Pia Lat substation has already been completed. In addition to said substation, construction of 115 kV and 230 kV substations is also in progress in the Northern, Central 1, and Southern regions. On the other hand, there are no construction projects at any voltage class in the Central 2 region.

4.3. Dispatching Control Center

4.3.1. Operation in NCC

1. Switching Operation

With the aim of completion by the end of 2018, system maintenance was under way to remotely control the CBs of 230 kV and 115 kV bus-bars in all substations and power stations (90 places) from NCC. Currently, CBs on the 230 kV side in 20 substations and hydropower stations can be remotely operated, but actual operations had not started at the moment of site investigation.

(Green: done, Red: on-going, Unmarked: not started yet)

Source: JICA Study Team

Figure 4.3-1 List of Stations that can be operated remotely

(230 kV bus-bar: 1+1/2 bus configuration, 115 kV bus-bar: Single-bus (main) and Transfer-bus)

Source: JICA Study Team

Figure 4.3-2One-line Diagram of Substation & Power Station

Substations are all manned. 3-4 people reside in each station with a 3-shift system, and switching operations are carried out based on instructions from the NCC.

2. Monitoring

According to the interviews and site survey, at least all generators connected to the EDL grid can be monitored. Telemetry data such as demand, frequency, power flow on the 400 kV and 230 kV etc. are displayed as per the following screen monitor, but due to a failure in the data acquisition and distribution system, accurate real-time demand is not displayed.

Source: JICA Study Team

Figure 4.3-3 Display of Demand, Power flow and Frequency

3. Shift Engineers

5 persons/team × 4 teams = 20 persons

Source: JICA Study Team

Figure 4.3-4 View of the NCC Control Room

4. Current Situation regarding Establishment of RCC (Regional Control Centers)

RCCs will be established in four regions (Northern, Central-1, Central-2, Southern) in 2018. Each control center is planned to be 4 persons/team, and NCC will also transfer 1 person to each shift team.

After the RCC operation has started, the NCC will mainly be responsible for operational instructions to the power stations and substations. The RCCs will perform switching operations according to the instructions from the NCC.

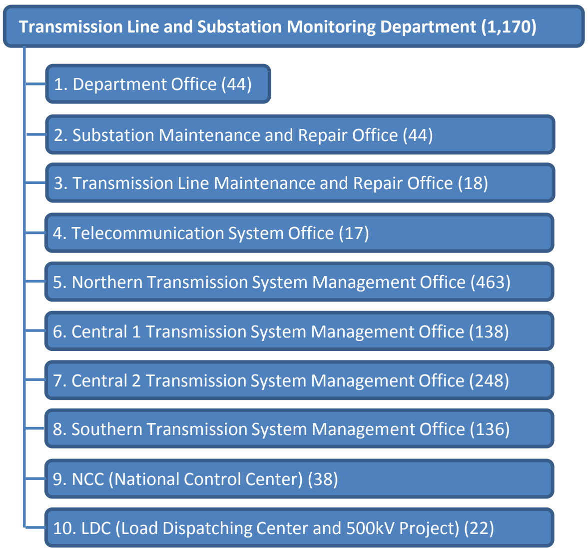
4.4. Operation and Maintenance

4.4.1. Present O&M Organization in EDL

The Transmission Line and Substation Monitoring Department is in charge of operation and maintenance for all transmission lines and substation facilities in EDL. It consists of eight offices and two centers.

Areas of responsibility for the Northern, Central-1, Central-2 and Southern Transmission System Management Offices are as follows - Northern: Phongsaly, Luang Namtha, Bokeo, Oudomxai, Xayabuly, Luangprabang, Huaphanh, Xiengkhuang, Xaysomboun and Vientiane Provinces; Central-1: Vientiane Capital; Central-2: Bolikhamxai, Khammuan and Savannakhet Provinces; Southern: Saravan, Champasak, Sekong and Attapeu Provinces. There are also Transmission System Divisions in each Province/Capital.

The current organization chart for the Transmission Line and Substation Monitoring Department is shown in Figure 4.4-1. The numbers in brackets show the number of staff as of March 2018.



(Source: Transmission Line and Substation Monitoring Dept., EDL)

Figure 4.4-1 Organization Chart for Transmission System O&M in EDL

The main duties of each department/office/center are as follows.

1. Transmission Line and Substation Monitoring Department

- Monitor the transmission lines and the substations across the whole country and secure a highly reliable domestic transmission system and power interchange system with the neighboring countries
- Manage and summarize transmission system work, including the LDC Phase II Project and RCC (Regional Control Centers)
- Maintain the transmission system and reduce the amount of forced outages
- Summarize the activities and budget of the Department and coordinate studies and designs for new transmission lines and substations with relevant departments
- Check and follow up with relevant offices, etc.

2. Substation Maintenance and Repair Office

- Collect technical data on substation equipment
- Study and research malfunctions involving substation equipment
- Prepare maintenance plans for substation equipment, and annual/emergency plans for

substation maintenance
- Prepare and propose budget for spare parts
- Prepare operation and maintenance reports
- Research new technology for substation system improvement
- Check the substation equipment based on the LEPTS, etc.

The Substation Maintenance and Repair Office is located at the Phontong SS. They repair substation equipment by themselves except for SCADA (Supervisory Control and Data Acquisition) and protection relays, which are difficult to handle because they are made by various Chinese manufacturers.

3. Transmission Line Maintenance and Repair Office

- Participate in operation and maintenance for the 230 kV and 115 kV transmission lines
- Collect technical data on transmission lines
- Study and research future power distribution strategies in consideration of transmission line and substation construction projects
- Research capacity of the existing transmission lines
- Prepare plans to check the transmission lines, etc.

The Transmission Line Maintenance and Repair Office dispatches trainers for training in transmission line operation and maintenance held by EDLTC as appropriate.

4. Telecommunication System Office

- Monitor the telecommunication and substation control systems
- Address problems regarding the telecommunication and substation control systems, such as PLC (Power Line Communication) and SCADA
- Plan and summarize extensions and installations for the telecommunication and substation control systems
- Arrange installation of telecommunication and substation control systems for hydro power plant projects and substation construction projects
- Participate in installation and commissioning tests

5. National Control Center (NCC)

- Monitor and conduct commissioning of new devices
- Find and address interruptions in the transmission system
- Enhance operators' skills and knowledge at NCC and RCC
- Study and consider information regarding substations and power sources before connection to EDL grid
- Study and consider construction of new RCCs and HPCC (Hydro Power Control Centers), etc.

4.4.2. Present O&M Items

The operation and maintenance items shown in Table 4.4-1 are conducted in the field mainly by the aforementioned four Transmission System Management Offices in EDL.

For transmission line tower inspections, EDL carries out visual inspections from the ground in a basic way and climbs towers for inspection when it's difficult to observe the upper part of a tower from the ground. Facility inspections using drones are already being carried out for the Nam Ngum 2 IPP dedicated line. EDL is planning to introduce drones for efficient patrol and inspection of transmission lines in mountainous areas that are difficult to access. For tree trimming, EDL checks the condition of trees adjacent to the ROW (right-of-way) of the transmission lines and they generally outsource almost all tree trimming to the local people.

For substation operation, EDL operates substations on two shifts and each shift is composed of two or three staff members. The members of each shift are arranged by the Personnel Department to combine both experienced and inexperienced staff. All substations in EDL are manned and visual inspections of substation facilities and checking of meters and gauges are conducted on a regular basis at each substation.

The staff who are in charge of the operation and maintenance of the transmission lines and substations receive training implemented by the EDL Training Center (EDLTC) as well as on-the-job training in the field. However, no standard EDL manual for O&M of transmission lines and substations has been prepared yet.

The Maintenance and Repair Offices and the Transmission System Management Offices send reports on operation and maintenance results to the Transmission Line and Substation Monitoring Department Office by e-mail on a weekly, monthly and annual basis.

Table 4.4-1 Major Transmission Line & Substation Maintenance Items in EDL

No.	Item	Basic Method	Time/Frequency	Office in Charge
1	T/L Patrol	By car/on foot	Annually (in dry season) & in an emergency	Transmission System Management Office
2	T/L Tower Inspection	Visual inspection from ground	Annually (in dry season) & in an emergency	Transmission System Management Office
3	Insulator Replacement	Visual inspection from ground (detection)	When a damaged disc is found	Transmission System Management Office
4	Tree Trimming	By car/on foot	Annually (in dry season)	Transmission System Management Office
5	SS Patrol	Visual inspection	Daily	Transmission System Management Office
6	SS Inspection	Visual inspection	Weekly, monthly & biannually	Transmission System Management Office
7	Regular Inspection	Visual inspection & resistance tests, etc.	Annually	Transmission System Management Office, SS Maintenance and Repair Office & TL Maintenance and Repair Office

(Source: Transmission Line and Substation Monitoring Dept., EDL)

4.4.3. Spare Parts

Spare parts had not been kept in EDL before 2016, but now it plans to purchase spare parts and store them in its own warehouses. The field staff submit a report to the Transmission Line and Substation Monitoring Department when the need for procurement or replenishment of a certain spare part arises. Then, after getting approval from MD, the Procurement Office, Business Department will put it out to tender in the standard way. In the case of an emergency, the Procurement Office will purchase the part without tendering.

4.4.4. Training for EDL Staff

The EDL Training Center (EDLTC) plans and implements training for hydropower generation, transmission lines, substations, distribution lines and house wiring in EDL. EDLTC is located at EDL's Headquarters. There are 51 staff, including trainers, and they sometimes invite trainers from the faculty of engineering.

There are currently fifty six training courses, as shown in Table 4.4-2, and these courses are provided to not only EDL staff but also IPPs. EDLTC charges a training fee to IPPs according to the scale of the project and provides training based on their requests. They have offered O&M training to IPPs such as Xeset HPP in 1989, Theun Hinboun HPP in 1995, Nam Ou HPP in 2014 and Xe-Pian Xe-Namnoy HPP in 2017.

The EDLTC utilizes training facilities such as training-purposes 115 kV transmission lines installed by a past JICA technical cooperation project, substation simulators introduced by Korea in 2017 and other simulators and models for generators and distribution lines.

Table 4.4-2 Training Courses at EDLTC

[illegible]	[illegible]	[illegible]	[illegible]
I. [illegible]			
1	[illegible]	Electricity Direct Current	
2	EL02	Electricity Alternative current	
3	[illegible]	Transformers, Alternator and Excitation	
4	[illegible]	[illegible] Voltage Regulator (AVR) and Speed Governor	
5	[illegible]	Electrical Protection System	
6	[illegible]	Electrical Diagram Motor Control	
7	EL07	Electrical Equipment	
8	[illegible]	Electrical [illegible]	
II. [illegible] SCADA [illegible] Computer			
1	[illegible]	Electronics	
2	[illegible]	PLC and SCADA for Hydropower Plant	
3	[illegible]	Microsoft Office [illegible]	
4	[illegible]	[illegible]	
5	[illegible]	[illegible] Google Sketch Up	
III. [illegible]			
1	[illegible]	Mechanical [illegible]	
2	[illegible]	[illegible]	
3	[illegible]	Mechanical Drawings	
4	[illegible]	Basic in Mechanical	
5	[illegible]	[illegible]	
6	[illegible]	Controlled Tightening	
7	[illegible]	[illegible]	
8	[illegible]	Hydropower plant [illegible]	
9	[illegible]	[illegible] Hydro-mechanical Equipment	
10	[illegible]	[illegible]	
IV. [illegible]			
1	[illegible]	Hydraulics [illegible]	
2	[illegible]	Hydrology and water management	
3	[illegible]	Civil work [illegible]	
4	[illegible]	Civil work [illegible]	

[illegible]	[illegible]	[illegible]	[illegible]
V. [illegible]			
1	[illegible]	[illegible]	
2	[illegible]	[illegible]	
3	[illegible]	PLC and SCADA for Substation	
VI. [illegible]			
1	[illegible]	[illegible]	
2	[illegible]	[illegible]	
3	[illegible]	[illegible] (Power Factor) [illegible]	
4	[illegible]	[illegible]	
5	[illegible]	[illegible]	
6	[illegible]	[illegible]	
7	[illegible]	[illegible]	
8	[illegible]	[illegible]	
9	[illegible]	[illegible]	
10	[illegible]	[illegible]	
11	[illegible]	[illegible]	
12	[illegible]	[illegible]	
13	[illegible]	[illegible]	
14	[illegible]	[illegible]	
VII. [illegible]			
Lao Electric Power Technical Standard (LEPTS)			
1	[illegible]	Civil Engineering of Hydropower plant (Basic course)	
2	[illegible]	Civil Engineering of Hydropower plant (Intermediate course)	
3	[illegible]	Hydropower plant (Basic course)	
4	[illegible]	Hydropower plant (Intermediate course)	
5	[illegible]	Transmission Line (Basic course)	
6	[illegible]	Transmission Line (Intermediate course)	
7	[illegible]	Substation (Basic course)	
8	[illegible]	Substation (Intermediate course)	
9	[illegible]	Distribution Line (Basic course)	
10	[illegible]	Distribution Line (Intermediate course)	
11	[illegible]	User [illegible] (Basic course)	
12	[illegible]	User [illegible] (Intermediate course)	

(Source: EDL Training Center)

(Source: EDL Training Center)

Figure 4.4-2 Training Facilities (Left: 115 kV Transmission Line, Right: Distribution Line)

For transmission lines and substations, EDLTC invites trainers from the Transmission Line/Substation Maintenance and Repair Offices and implements OJT for operation and maintenance using the actual facilities.

As described above, EDLTC fills an important role for capacity development and upskilling of EDL staff regarding electric power systems.

4.4.5. Issues regarding O&M for Transmission Systems

Based on the information gathered by the JICA Study Team, it seems that the following points are issues that should be considered.

- As pointed out in the Final Report for the “Study on Power Network System Plan in Lao People’s Democratic Republic” by JICA in 2010, EDL’s standard manual for transmission system O&M has not been prepared yet. Most of the existing transmission lines and substations in EDL were built after 2000 and so are relatively recent, but some were built in the 1960s and work to combat aging degradation will gradually become necessary. Moreover, construction of many transmission lines and substations is planned, so it is recommended to enhance O&M functions by optimizing O&M plans and standardizing their methods based on the manual.
- It seems that information on the existing facilities has not been shared in a cross-sectional manner interdepartmentally. It would be preferable to manage and operate facility information based on a common, interdepartmental database, not only to ensure adequate planning/upgrading of facilities and efficient O&M work but from the viewpoint of asset management.
- The voltage level of the domestic backbone transmission system has risen from 115 kV to 230 kV and will become 500 kV, but the training-purposes transmission line has not been upgraded and remains 115 kV. For proper facility O&M, it is recommended that the training facilities are upgraded/expanded in parallel with the actual facilities.

4.4.6. Recommendations for O&M of Transmission Systems

As described in Chapter 4.4.2, maintenance such as patrols and inspections for transmission lines and substation equipment is being implemented regularly based on defined rules and the results are being reported to the Headquarters in EDL. The amount of facilities is expected to increase in the future, so it is recommended to organize O&M manuals/guidelines, adding inspections using drones and considering regional environmental characteristics, in order to secure a steady, company-wide level of facility management quality and make O&M work more efficient.

According to an interview with the staff at EDLTC, the training facilities located at the side of the headquarters are planned to be relocated to Nathaythong SS in the near future. When they are relocated it is recommended to upgrade them to match the future system configuration, i.e. a 500 kV transmission system. This upgrade would provide staff of various technical levels with workable training and OJT using the actual facilities.

4.5. Power Supply/Demand Situations in Laos

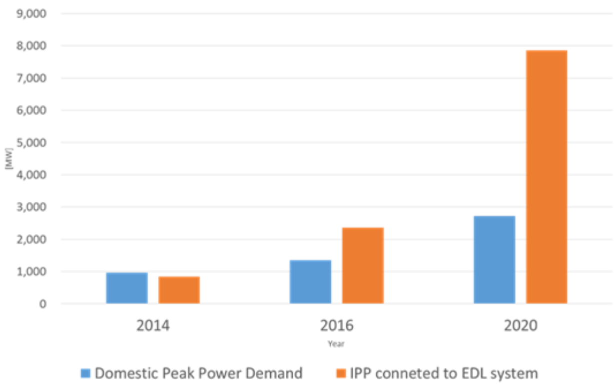
4.5.1. Power Demand

The peak demand for Laos in 2016 (May) was 904.76 MW. Among this, the demand supplied from the EDL grid was 865.93 MW, and the demand supplied from neighboring countries via distribution interconnections was 38.83 MW. The demand near the border is due to the long distance from the base substation and topographical constraints, making it difficult to install domestic distribution lines, but this will gradually be switched to EDL supply. Since the electrification rate in Laos reached 92.39% as of 2016, future trends in power demand are thought to be largely dependent on the large-scale power consumers. The current major power demand is mining demand, and in the future there will be a bauxite plant in the south. Railway construction with China has already begun. Therefore, although domestic demand may continue to increase, it is unclear whether the problem of surplus power can be solved.

4.5.2. Power Supply

With the exception of Hongsa Thermal Power Station (Fuel: Lignite coal, rated capacity of 1,800 MW, of which 100 MW is for domestic use, with the rest exported to Thailand), and small-capacity renewable energy generation (biomass power generation: sugar cane, solar - almost 99% except for wind power, etc.), nearly 99% of the power sources is hydropower.

Among this, the installed capacity of the generators connected to the EDL power system for EDL load supply is as shown in Figure 4.5-1.



Source: JICA Study Team

Figure 4.5-1 Power Generation Capacity connected to EDL Grid

The installed capacity of power generation is more than 2,000 MW as of 2016, and by 2020, it will be less than 8,000 MW, which is almost three times' the estimated demand, and excessive power development will continue. (Furthermore, there are power supplies that are directly sent to neighboring countries by dedicated transmission lines as export-only generators, and these developments have also advanced.)

Hydropower output largely depends on river flow and reservoir capacity. Figure 4.5-1 shows the average annual output of the 2016 wet season (August) and dry season (February).

Table 4.5-1 Record of Average Power Outputs during August (Wet Season) and February (Dry Season)

		Wet Season (August)			Dry Season (April)			Yearly		
Name of project	Install capacity (MW)	GWh	Average (MW)	Ratio of Average MW to Install MW	GWh	Average (MW)	Ratio of Average MW to Install MW	GWh	Average (MW)	Ratio of Average MW to Install MW
Nam Ou 5	240	131.2	179.7	74.9%	56.14	76.9	32.0%	1048.98	119.7	49.9%
Nam Ou 6	180	78	106.8	59.4%	49.85	68.3	37.9%	738.95	84.4	46.9%
Nam Ou 2	120	67.8	92.9	77.4%	29.57	40.5	33.8%	545.99	62.3	51.9%
Nam Khan 3	60	41.6	57.0	95.0%	10.21	14.0	23.3%	247.01	28.2	47.0%
Nam Ou 3	210	75.8	103.8	49.4%	43.7	59.9	28.5%	684.9	78.2	37.2%
Nam Ou7	210	77.2	105.8	50.4%	60.7	83.2	39.6%	810.9	92.6	44.1%
Nam Ou 1	180	90	123.3	68.5%	37.1	50.8	28.2%	709.7	81.0	45.0%
Nam Ou 4	132	57.6	78.9	59.8%	33.7	46.2	35.0%	523.9	59.8	45.3%
total	1,332	619.2	848.2	63.7%	320.97	439.7	33.0%	619.2	606.2	45.5%

Source: JICA Study Team

Especially in the dry season, the average output was about 33% of the rated output, but there is also the problem of power system capacity shortage besides the restriction of the power generation facilities mentioned above. Because of this situation, power flows in EDL from April to May 2016 via the 115 kV international interconnection line (synchronized interconnection by AC) with Thailand. On the other hand, during the rainy season, electricity flows out to Thailand, and according to EGAT, power transmission congestion is occurring in Thailand's domestic grid due to inadequate power flow control.

4.5.3. Power Supply/Demand Balance

Before 2015, the amount of power generation in the dry season was less than the demand for domestic power, and the power shortage amount was imported from Thailand through the 115 kV interconnection line. In the rainy season, surplus electricity was exported to Thailand. Source: prepared by JICA study team based on MEM and EDL data

Figure 4.5-2 shows the domestic power demand for each month of 2010 and 2015 and the amount of energy generated by domestic power plants. The orange lines are the domestic demand for electricity in each month, and the blue lines are the generated energy; their difference is balanced by imports from or exports to Thailand. However, since the power flow of the international interconnections between Thailand and Laos is not properly controlled, the National Power Dispatching Center in Thailand dispatches power adjustment commands to the Laos power plants, and the remaining imbalance is adjusted via the output of generators in Thailand. This situation had not changed even at the time of this survey, and is a factor that impedes the implementation of appropriate power transactions between the two countries.

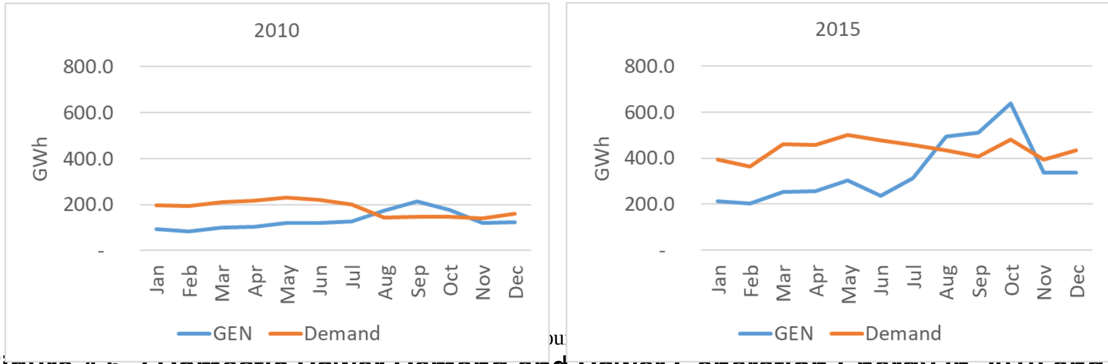
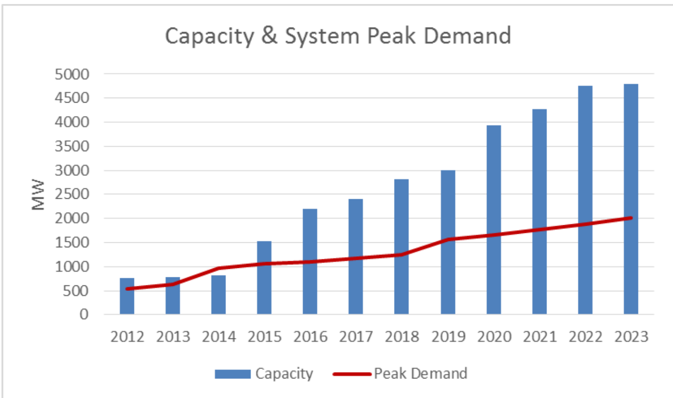


Figure 4.5-2 Domestic Power Demand and Power Generation Energy in 2010 and 2015

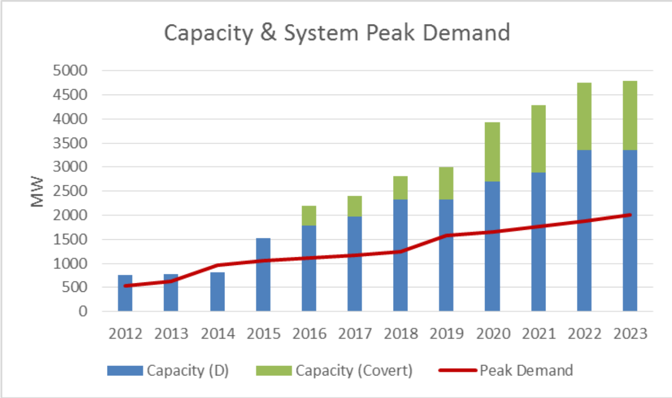
The power generation capacity of the domestic grid and the maximum power of the domestic grid will be as shown in the figure below from 2010 to 2023.



Source: prepared by JICA study team based on MEM and EDL data

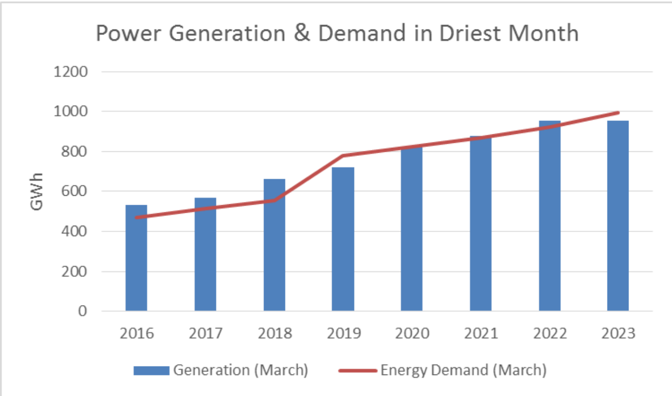
Figure 4.5-3 Power Generation Capacity of Existing and Under-construction Power Plants (2018) for Domestic Grid as of 2015

The red line is the maximum power demand in the entire domestic grid, and the actual value until 2015 is the expected value after 2016. As can be seen from the graph, the power generation capacity in 2022 and 2023 is about four times' the maximum power demand, and it is assumed to be excessive. As will be described later, by converting some of the power plants operating and under construction for the domestic grid into those for export, it is possible to balance the domestic power demand with the amount of power generated by the domestic power grid. The figure below shows the power generation capacity and maximum power of the domestic grid when some power stations are converted to export. The amount of power generated in the dry season in March left in the domestic grid is shown to balance the power demand. Even in the driest season, domestic demand can be supplied by expecting some imports.



Source: prepared by JICA study team based on MEM and EDL data

Figure 4.5-4 Power Generation Capacity and Maximum Power Demand of Domestic Grid when some plants are converted to export

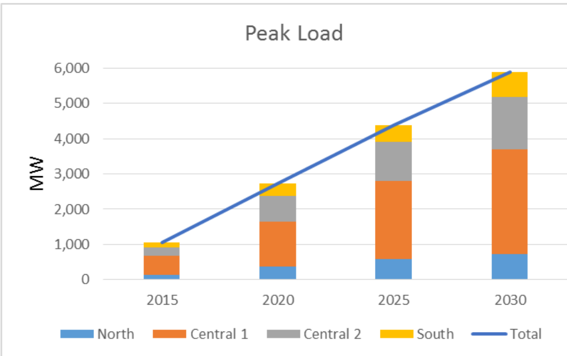


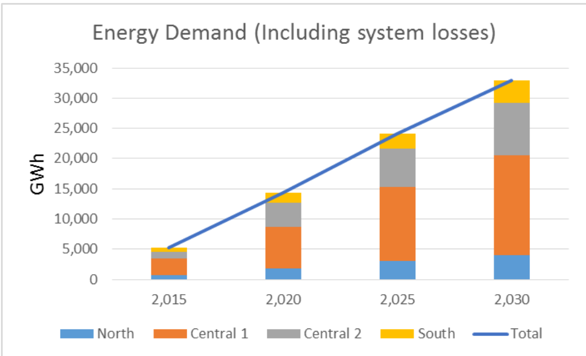
Source: prepared by JICA study team based on MEM and EDL data

Figure 4.5-5 Balance of Power Generation and Demand for the Power Generation Plants left in the Domestic System in Dry Season in March

4.5.4. Laos' Power Supply and Demand Forecasting Officially Announced in 2016

The report on demand forecasting and power plant plans officially announced by Laos is the "Demand Forecast and Supply Plan" (Lao language), published by MEM and EDL in February 2016. The Lao maximum demand forecast described in this report is shown in Figure 4.5-6. It is expected to reach 1,055 MW in 2015, 2,723 MW in 2020, and 5,893 MW in 2030.





Source: prepared by JICA study team based on MEM and EDL data

Figure 4.5-6 Demand Forecast by MEM as of 2016

The balance between generated power and electricity demand for the domestic supply system is shown in Figure 4.5-7.

Source: prepared by JICA study team based on MEM and EDL data

Figure 4.5-7 Power Demand Forecast by MEM as of 2016 and Planned Power Generation Capacity and Generated energy

According to this demand forecast, it should be around 2,000 MW in 2018, but it is about 1,000 MW of maximum demand as of 2018, and about twice as large as the actual figure. In addition, if the power supply plan at that time was implemented as it is, significant surplus for the supply amount against the demand would be generated.

Therefore, it is necessary to review both the demand forecast and the power supply plan.

Chapter 5. Review of Domestic Demand Forecast in Lao PDR

This chapter presents the current methods used to estimate domestic power demand in Laos, the deviation between the forecast and actual situation and its causes, and the new demand forecasting method introduced by Japanese consultants in 2013 and its problems.

The formulation of a realistic power system plan is vital for successful utilization of the abundant hydro power potential in Laos and the expansion of electric power exports to neighboring countries. The forecasting of domestic demand and supply is an important element in this process, and it is necessary to verify the adequacy of both the current method and the results of the demand forecasting.

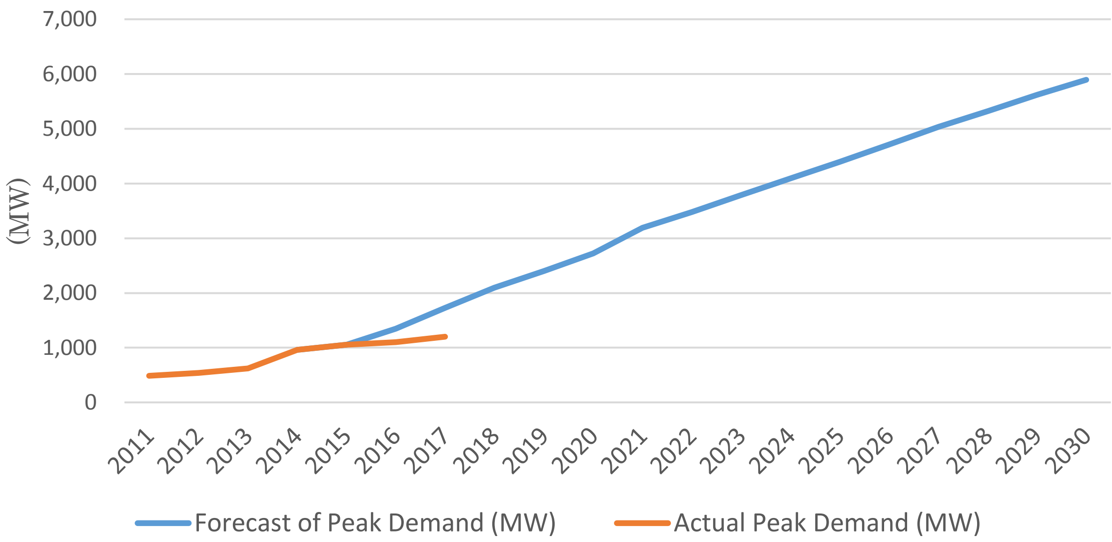
5.1. Review of the Demand Forecast Published in 2016

The electricity demand forecast for Laos is updated every year, and the latest published one was conducted in 2016 covering the period up to 2030. In this section, the power demand forecast conducted in 2016 is compared with the actual values received from EDL as of November 2017, and the deviation between the power demand forecast and the actual results is verified.

It is noted that the term "total of peak demand" used in this chapter means "the total value of peak demand of substations and large-scale customers throughout the year". Even in the power demand forecast announced in 2016, MEM and EDL calculated the value of the “total of peak demand”, and have forecast this figure also in the current EDL demand forecast; therefore, this chapter also follows the aforementioned definition.

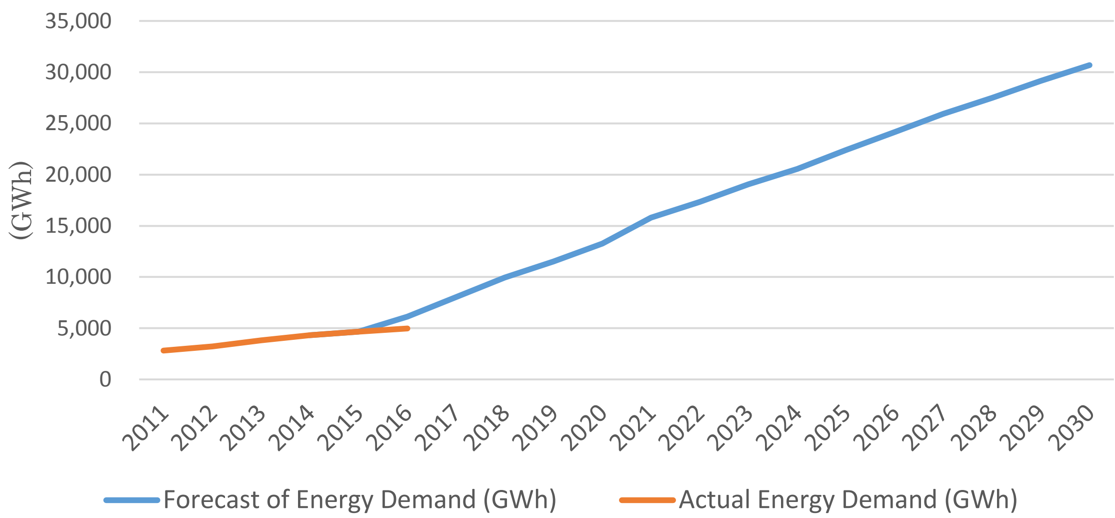
5.1.1. Deviation between Demand Forecast 2016-2030 and the Actual Values in 2016-2030

Figure 5.1-1 and Figure 5.1-2 show demand forecast results and actual demand. In 2016, the actual amount of electricity consumption was 5,062 GWh, against a forecasted electricity consumption of 6,131 GWh. In other words, the actual consumption is 1,167 GWh less than the forecast. As for the total peak demand, the actual value was 1,349 MW, against a forecasted demand of 1,103 MW, which is a difference of 246 MW.



(Source: prepared by JICA Study Team based on Demand Forecast 2016 and actual data provided by EDL)

Figure 5.1-1 Comparison of demand forecast 2016-2030 and actual results (total of peak demand)



(Source: prepared by JICA Study Team based on Demand Forecast 2016 and actual data provided by EDL)

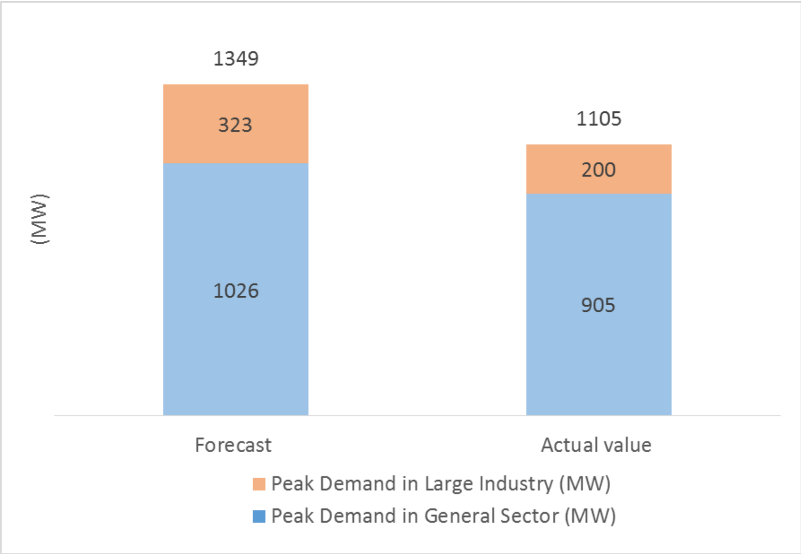
Figure 5.1-2 Comparison of demand forecast 2016-2030 and actual results (demand estimate)

5.1.2. Analysis of the Causes of Deviation between Demand Forecast and Actual Demand

In the process of demand forecasting, EDL divides its customers into Large Industry and General Sector. Customers categorized as Large Industry receive power from transmission lines with a capacity of 115 kV, and customers categorized as General Sector receive power from lines with a capacity lower than 115 kV.

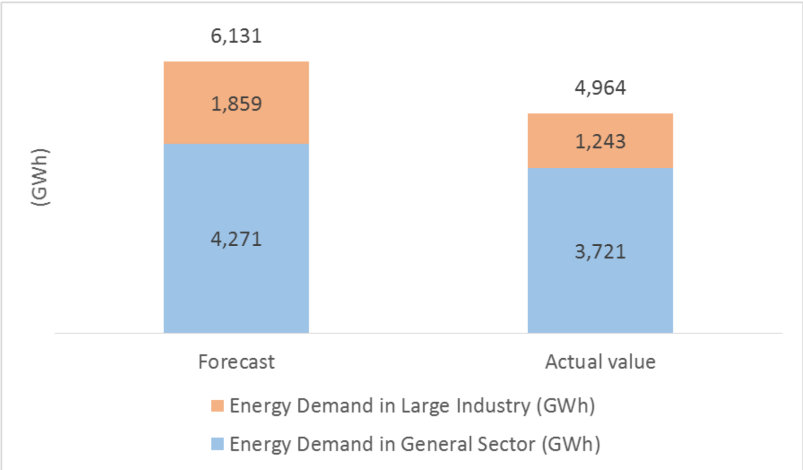
Figure 5.1-3 shows the assumed and actual values for the total peak demand in the General Sector and Large Industry in 2016 and 2017. Among the causes for the difference of 246 MW between the forecast and actual results in 2016, 123 MW is found to be due to excessive assumptions for Large Industry even though the percentage of demand from Large Industry is less than 20% of the total demand.

Figure 5.1-4 compares the forecasted electric energy in the General Sector and Large Industry with the actual values in 2016. The actual value for the General Sector is 12% less than the estimate, and the actual value for Large Industry is 38% less than the estimate. It is considered that excessive assumptions for Large Industry are a relatively big problem. In interviews with EDL staff conducted as part of this survey, it was confirmed that excessive assumptions for Large Industry have caused the divergence in the total demand forecast and this has been identified as an issue in the report to MEM on the current demand forecasting.



Source: prepared by JICA Study Team based on Demand Forecast 2016 and actual data provided by EDL

Figure 5.1-3 Estimated and Actual Values of Total of Peak Demand for Large Industry and General Sector in 2016



Source: prepared by JICA Study Team based on Demand Forecast 2016 and actual data provided by EDL

Figure 5.1-4 Estimated and Actual Electric Power in Large Industry and General Sector in 2016

5.1.3. Estimations and Actual Situation regarding Large Industry

Based on interviews with EDL staff, it was confirmed that EDL conducts electricity forecasting for Large Industry by using values such as the requested consumption on Power Purchase Agreements (PPA) with the customer. The Study Team confirmed that there is a three-year demand forecast included in PPAs. For example, a PPA concluded in 2014 includes the demand forecast from 2015 to 2018. After those three years, the demand is estimated by EDL by taking into consideration the rate of increase for the demand within those three years. As for projects for which a PPA has not been concluded yet, the personnel in charge of demand forecasting confirms the values for the demand negotiated with the Financial Department. However, the data from these sources is not always reliable, as there are many cases when the actual consumption is lower than the amount applied for, or reductions occur when plans for new facilities are cancelled or postponed.

The categories in Large Industry are Special Economic Zone (SEZ), mining, factory, railway construction, railway operation and hydro power construction. EDL had 77 Large Industry projects as of 2016, and estimated that 31 of these would consume electricity in 2016. However, among those 31 projects, 25 did not consume electricity as expected.

Table 5.1-1 provides examples of the projects at Large Industry consumers that were supposed to consume electricity in 2016. From the table, it is clear that EDL experienced challenges not only in long term forecasting but also in short term forecasting, such as one year-forecasting. There are large differences between the forecasted and actual values.

Table 5.1-1 Large Industry Assumptions and Actual Values in 2016

	Province	Industry	Forecast (MW)	Actual (MW)	Difference (GWh)
Northern	Luangnamtha	Railway Construction	3	0	-3
	Oudomxai	Railway Construction	9	0	-9
	Luangprabang	Special Economic Zone	0	1	1
		Railway Construction	7	0	-7
	Sayabouly	Hydroelectric Power Plant Construction	10	6	4
Central-1	Xiengkhuang	Mine	15	0	-15
	Saysomboun	Mine	70	57	-13
	Vientiane Province	Mine	20	18	-2
		Factory	6	7	0
		Railway construction	5	0	-5
	Vientiane Capital	Factory	5	0	-5
		Mine	3	2	-1
		Special Economic Zone	5	2	-3
		Special Economic Zone	2	0	-2
		Special Economic Zone	5	0	-5
		Special Economic Zone	15	0	-15
		Railway Construction	3	0	-3
Central-2	Borikhamxai	Mine	13	45	32
		Factory	10	0	-10
	Khammouan	Factory	17	17	0
		Mine	7	7	0
		Mine	10	0	-10
		Mine	5	0	-5
		Factory	5	0	-5
		Special Economic Zone	5	0	-5
	Savannakhet	Mine	45	35	-10
		Special Economic Zone	2	0	-2
		Special Economic Zone	3	0	-3
		Special Economic Zone	3	0	-3
Southern	Champasack	Special Economic Zone	3	0	-3
	Attapue	Factory	12	3	-10

Source: Prepared by JICA Study Team based on Actual Value Data provided by EDL

5.2. Demand Forecast in Laos (Energy Demand, Peak Demand and Load Factor)

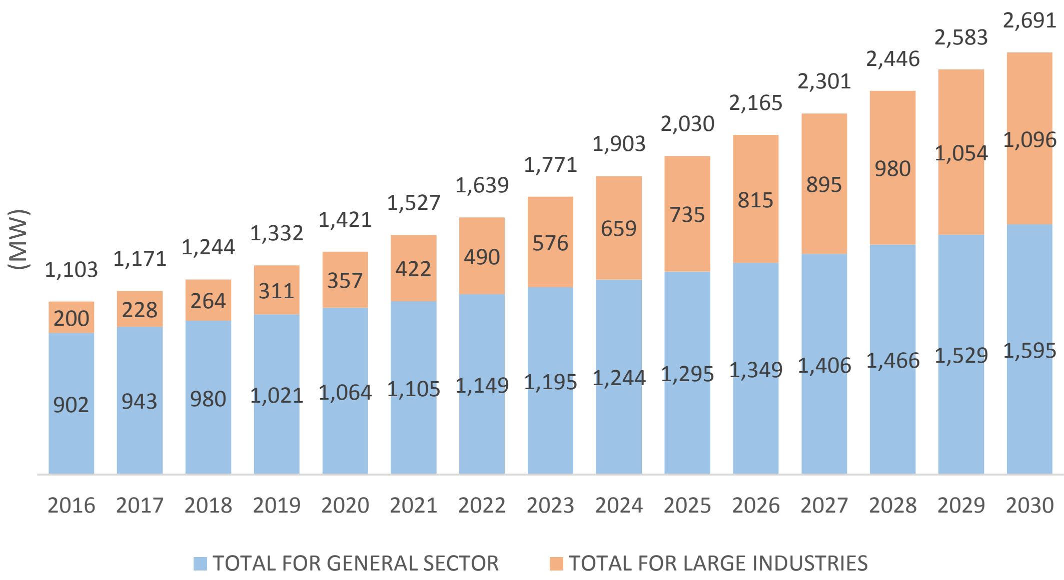
5.2.1. Review of the Latest Demand Forecast by EDL (Unpublished)

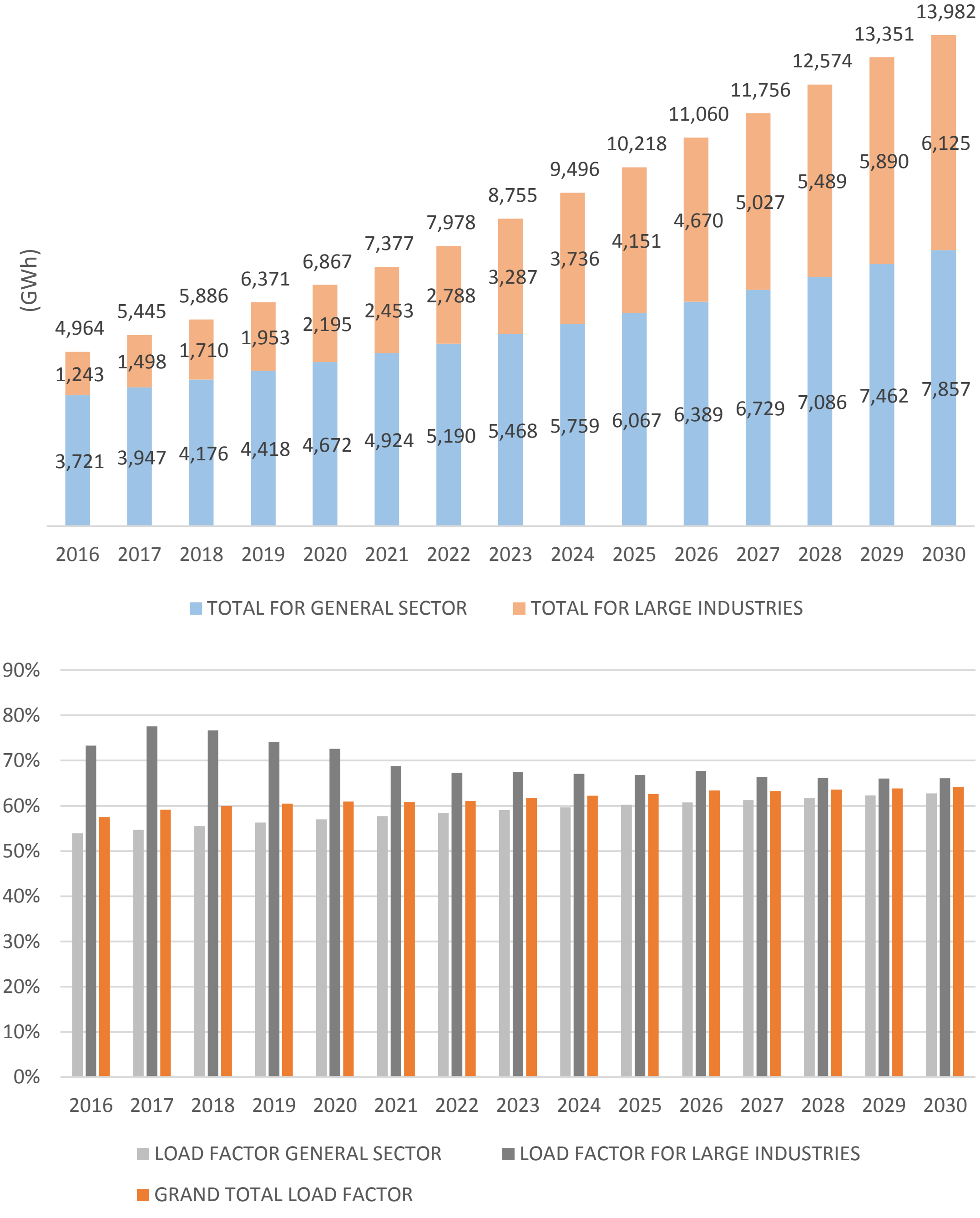
1. Results of the latest demand forecast for Lao PDR (as of February 2018)

In this section, the outcomes of the domestic demand forecast in Laos by 2030 provided in the latest demand forecast by EDL are covered. In the demand forecast for 2016, demand is assumed for three cases - Low, Base and High. In this report, only the Base case is covered, assuming a GDP growth rate of 7%, because the JICA survey team had only received data for the Base case by the time of preparation of this version of the report.

EDL forecasts demand by looking at three sectors - Residential Sector, Non-Residential Sector and Large Industry. The Residential Sector and Non-Residential Sector receive power via lines of less than 115 kV, and are collectively called the General Sector. Large Industry includes customers who receive power at 115 kV or higher. The "Grand Total" for the load factor refers to the total load factor regardless of the voltage. These conditions have not been changed since the previous forecast.

Below is a graph showing the forecast results for the total of peak demand, the amount of electricity, and the load factor up to 2030. The amount of electricity on a kWh basis is lower than that in 2017. The reason is that the values in 2016 are the actual amounts while those in 2017 are calculated by multiplying the maximum demand by the arbitrary load factor set relatively lower.

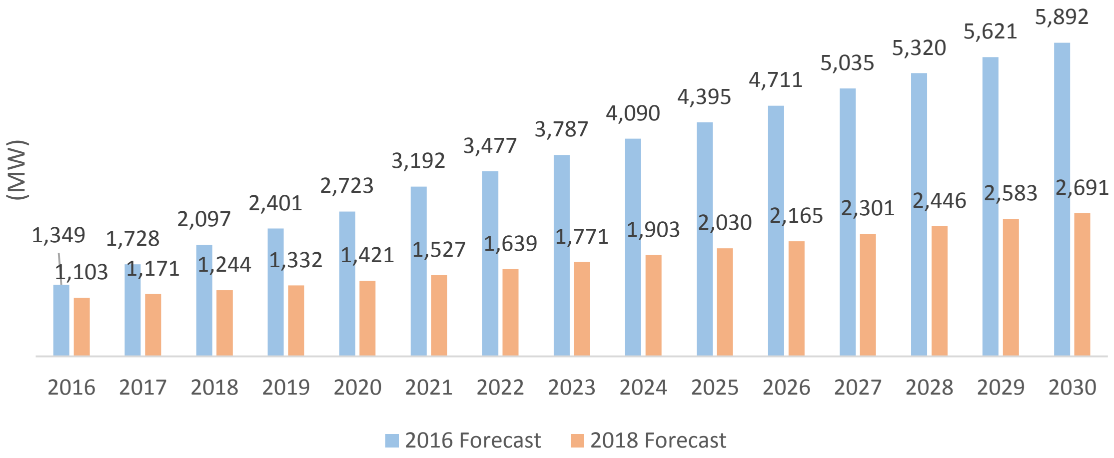




(Upper: sum of peak demand, Middle: amount of electricity, Lower: load factor)
Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

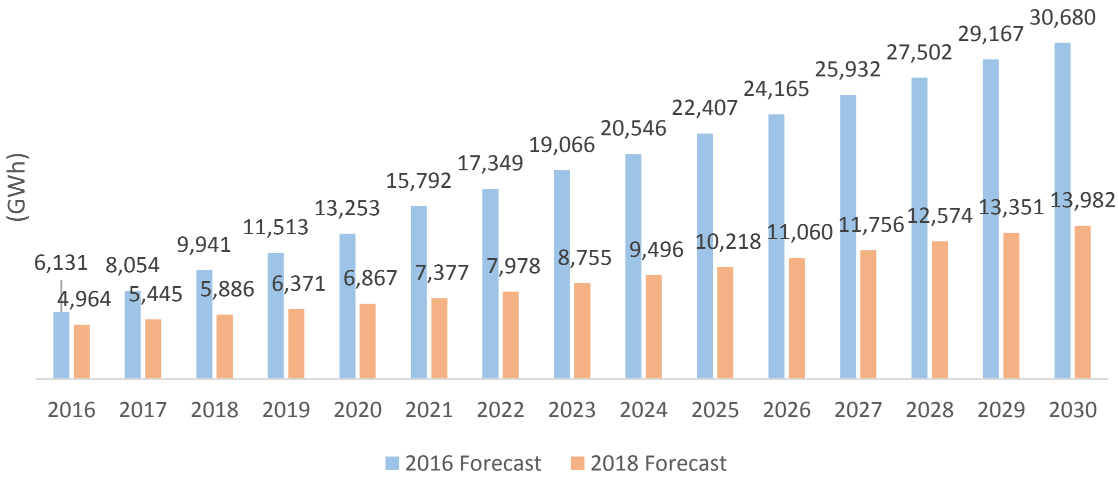
Figure 5.2-1 Demand Forecast up to 2030

Furthermore, as mentioned in the previous section, the demand forecast conducted in 2016 resulted in a large gap between the demand forecast results and the actual values in 2017. Due to this fact, the JICA Study Team compared the two demand forecasts by 2030 for the total of peak demand and electric energy amount, conducted in 2016 and 2017 respectively, in order to analyze the differences and the improvements to the demand forecast conducted in 2017.



Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

Figure 5.2-2 Difference between the Peak Demand Forecasts assumed in 2016 and 2017



Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

Figure 5.2-3 Difference between the Electricity Demand Forecasts assumed in 2016 and 2017

As shown in Figure 5.2-2 and Figure 5.2-3, the total peak demand in 2030 in the demand forecast announced in 2016 is 5,892 MW. On the other hand, the total peak demand in 2030 in the demand forecast announced in 2018 is 2,691 MW, which is less than half the previous forecast. The amount of electricity also decreased to less than half: 13,982 GWh in 2017 forecasted against 30,680 GWh in the 2016 forecast. The above results confirm that EDL reviewed not only the plans of Large Customers but also the demand of the General Sector. The forecast for the entire demand including general customers was reduced to less than half.

2. Methodology of EDL's Demand Forecast

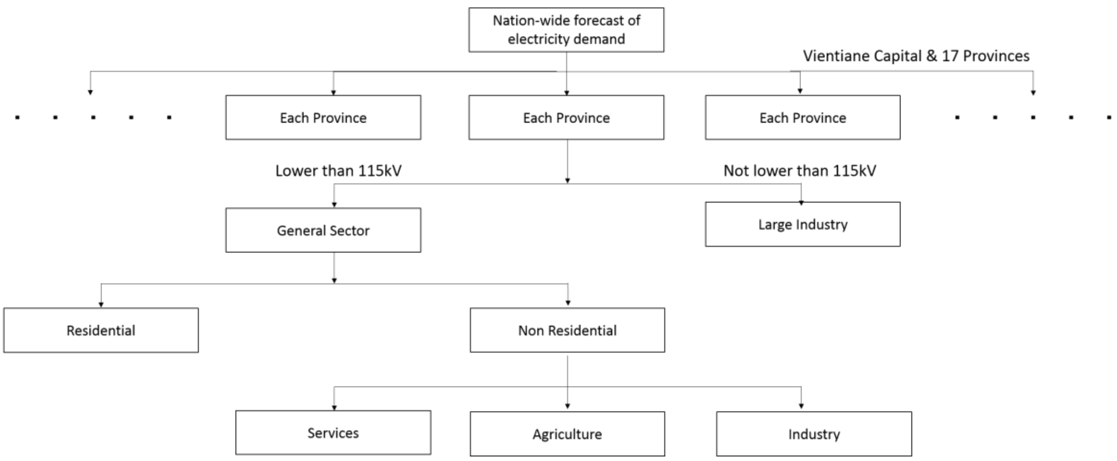
As part of a 2013 JICA Project, "Technical Support Project for Improvement of Lao National Power Sector Governance Function", a demand forecasting method using an econometric model was proposed. It is reported that a model based on Japanese econometric software was introduced and a one week training course at EDL was conducted in April 2013. However, in the interview with EDL it was confirmed that the staff at EDL did not master the practical method of operating the software, and returned to using the previously applied method. In other words, both demand forecasts estimated in 2016 and 2017 used the same method as the one applied before the introduction of the econometric model.

Compared with the demand forecast in 2016, it can be said that the demand forecast in 2018 has improved, in that past data is being considered more. As a result, the demand in the 2018 forecast has been revised downward significantly. For instance, for Large Industry, the amount of projects included in the demand forecast has been reduced in light of their actual progress. Therefore, the demand forecast in 2018 is considered to be closer to the actual situation than that of 2016. The following is a detailed description of the EDL demand forecasting procedure.

a) Flow of Demand Forecast

As shown in Figure 5.2-4, EDL forecasts power demand in Vientiane Special City and each of the 17 provinces, based on which a nationwide demand forecast is carried out by accumulating the values for each prefecture.

While the peak demand for the General Sector is obtained by multiplying the amount of electricity by the inverse of the load factor, the energy demand for Large Industry is calculated by multiplying the customer's maximum demand power applied by the load factor.

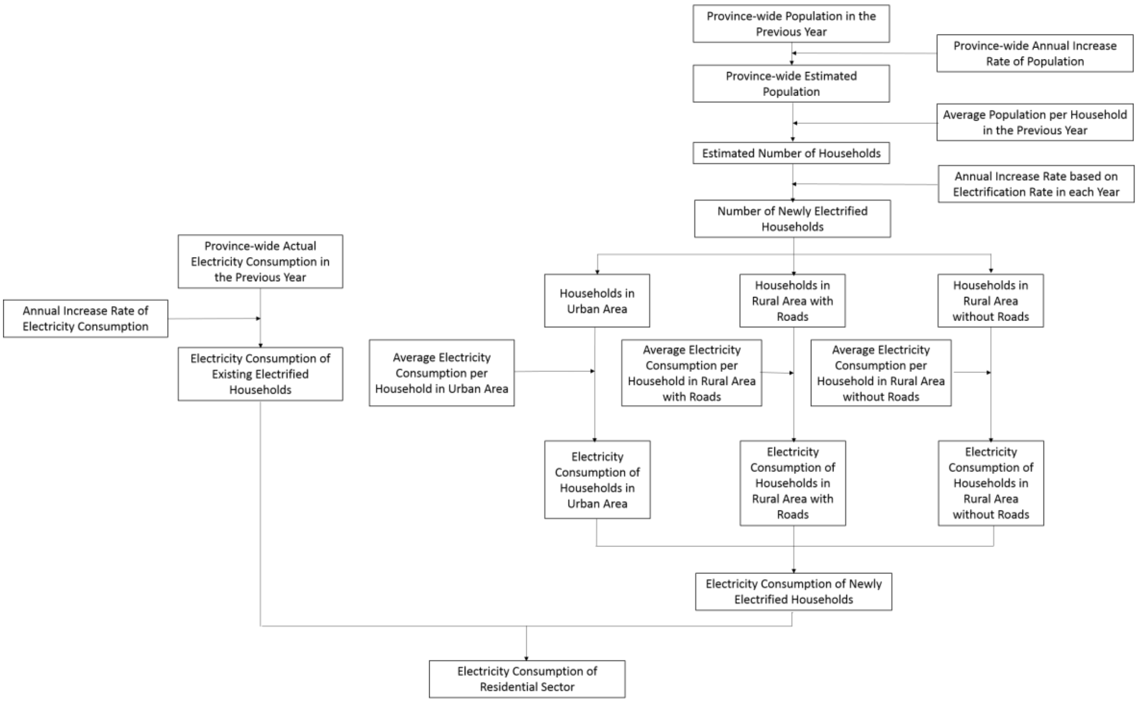


Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

Figure 5.2-4 Overall Flow Chart for Demand Forecast

b) Residential Demand Forecast

As shown in Figure 5.2-5, the electricity demand for residential users is forecasted for electrified and non-electrified households. For electrified households, the electricity consumption is assumed to increase by 5% every year. At the same time, for non-electrified households, EDL first estimates the increase in the number of households based on the population growth, and then assumes the number of electrified households with reference to the target value in the 8th National Socio-Economic Development Plan 2016-2020. Additionally, the forecast assumes that electrification progresses first in the urban areas, followed by areas with road access, then areas without road access, based on which the number of electrified households in each category is determined. By multiplying the number of electrified households in each category by the average electricity usage per household in the three categories from 2012 to 2016, the total amount of electricity demand is calculated.

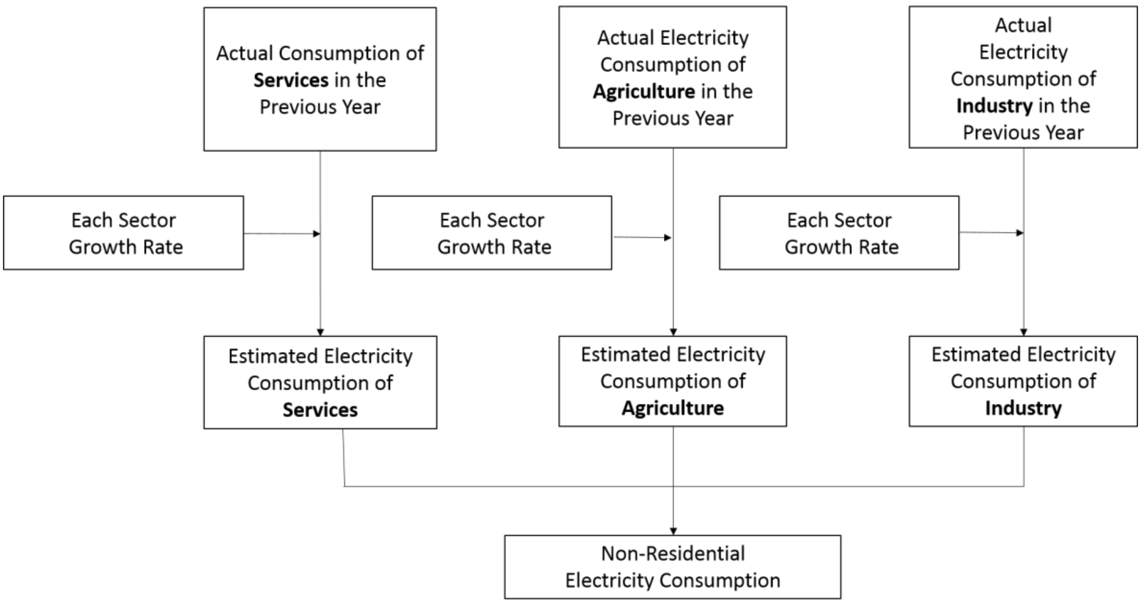


Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

Figure 5.2-5 Flow Chart for Residential Demand Forecast

c) Demand Forecast Method for Non-Residential consumers receiving power at less than 115 kV

The demand of non-residential customers receiving power at less than 115 kV is calculated by multiplying the actual energy demand in 2016 by the annual demand growth rate by region and industry. The growth rate is shown in Table 5.2-1. The growth rate of electricity demand is determined from the target of GDP growth rate for industry, agriculture and services set in the 8th Five-year National Socio-Economic Development Plan 2016-2020.



Source: Prepared by JICA Study Team based on Excel File of Demand Forecast Calculations provided by EDL

Figure 5.2-6 Flow Chart for Demand Forecast of Non-Residential Sector

Table 5.2-1 Demand Growth Rate for 115 kV Non-Residential Use used in 2018 Forecast (%)

	2016-2020			2020-2030		
	Industry	Agriculture	Service	Industry	Agriculture	Service
North	7.0	5.9	6.3	6.3	5.3	5.6
Central 1	6.8	5.9	6.3	6.6	6.4	6.1
Central 2	6.9	6.0	5.7	7.1	6.2	5.9
South	7.1	7.3	7.4	6.1	6.5	6.3

Source: Prepared by JICA Study Team based on the materials provided by EDL

Table 5.2-2 Demand Growth Rate for 115 kV Non-Residential Use used in 2016 Forecast (%)

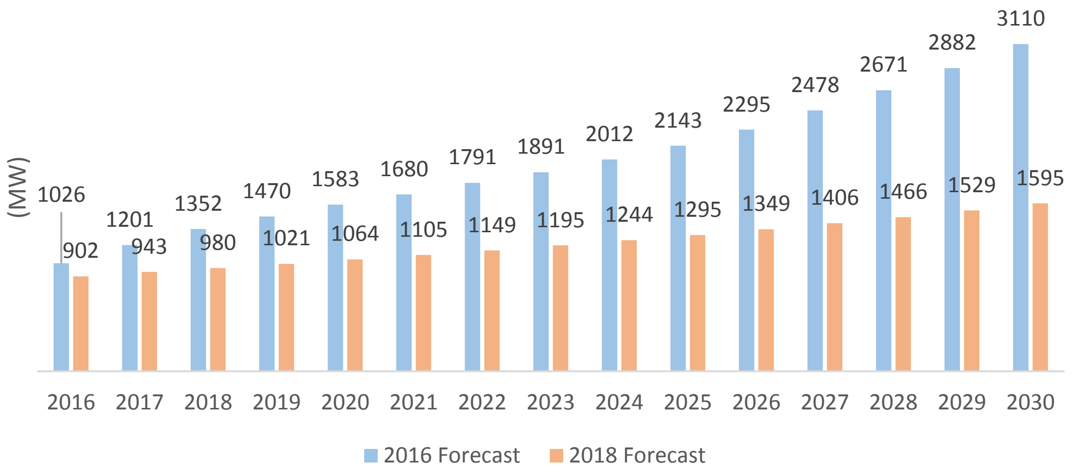
	2016-2020			2020-2030		
	Industry	Agriculture	Service	Industry	Agriculture	Service
North	12.4	5.9	11.4	11.2	5.3	10.3
Central 1	12.6	6.0	10.4	11.3	5.4	9.3
Central 2	12.6	6.0	10.4	11.3	5.4	9.3
South	13.7	7.3	13.9	12.4	6.5	12.5

Source: Prepared by JICA Study Team based on the materials provided by EDL

d) Demand Forecast Method for General Sector

As mentioned above, the total demand calculated in the 2018 forecast is significantly lower than that in the 2016 forecast, as the demands for both Large Industry and the General Sector were lowered. Figure 5.2-8 compares the maximum demand for the General Sector in 2030 in the two forecasts. The demand in 2030 estimated in 2018 is less than half of what was estimated in 2016. The reason for this is that the growth rate for the electricity demand calculated based on the GDP growth rate target has been changed. According to EDL, the growth rate for the electricity demand is adjusted every year based on the actual demand.

EDL does not calculate peak demand for non-residential use alone. The peak demand for the General Sector is calculated by multiplying the total electric energy for residential and non-residential use by the inverse of the load factor. The load factor in 2037 is set at 65%. The difference between the load factor in 2037 and in 2016 is divided by 21 years to calculate the annual increase in the load factor. However, in areas where electricity is insufficient, like the Ponsary Province in the north of Lao PDR, the load factor in 2016 is higher than 65%, and conversely, it is assumed that the load factor will decrease year by year.



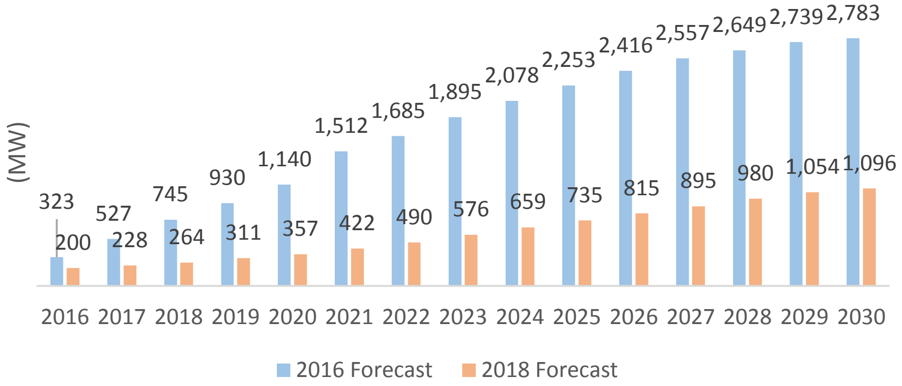
Source: Prepared by JICA Study Team based on the materials provided by EDL

Figure 5.2-7 Maximum Demand Forecast for General Sector (2016 and 2018)

e) Demand Forecast Method for Large Industry Consumers

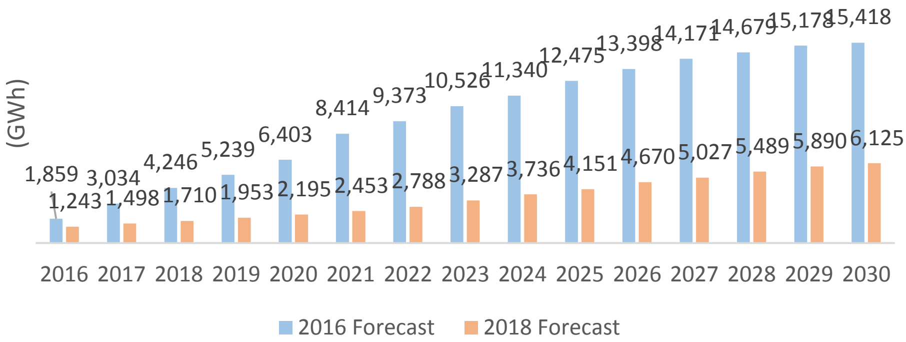
With regard to Large Industry, EDL estimates demand for 77 projects individually, based on information on electricity in applications from customers, MEM and MPI projects. The amount of electricity is calculated by multiplying the assumed maximum power by a load factor of 60 to 70%. Demand for Large Industry is compared between the 2016 forecast and 2018 forecast in Figure 5.2-9 and Figure 5.2-10. The estimated demand after 2020 has been lowered.

Among the 77 projects, the demand in 23 is assumed to be zero, and 52 projects have been downsized. The Study Team confirmed how EDL estimates the demand for Large Industry by interviewing the staff in charge of demand forecasting. There are several reasons for the decrease. Firstly, the demand for railway construction work is excluded as 22 kV will be used for railway construction. Secondly, EDL set priorities for projects in line with their progress. They excluded from the forecast projects for which the progress is slow. The growth rate for the demand from the projects included in the forecast has been reviewed based on actual data from similar projects. EDL also contacted the customers and it is possible that short term forecasting has been improved, such as two to three-year forecasting. However, EDL also realized that there was still room for improvement in the mid and long term forecasting. Since future demands are affected by various factors such as the perception of investors and government approvals, confirming the precise demand with customers is not, on its own, enough to increase the credibility of the forecast.



Source: Prepared by JICA Study Team based on the materials provided by EDL

Figure 5.2-8 Comparison of Peak Demand for Large Industry in 2016's Assumptions and 2017's



Source: Prepared by JICA Study Team based on the materials provided by EDL

Figure 5.2-9 Comparison of Energy Demand for Large Industry in 2016's Assumptions and 2017's

5.2.2. Identified Issues

Difference between actual usage and applied demand by 115 kV Large Industry customers

As mentioned in the previous sections, the demand forecast for Large Industry has led to overestimates so far, but this has been greatly reduced in the latest demand forecast by confirming the progress of each project with the customers and by it being based on actual data. Communicating closely with customers is effective for short term forecasting. However, mid and long term forecasting may not improve via this alone, as this method presents a number of problems because there are many uncertainty factors. Therefore, it is preferable to introduce top-down approaches, as mentioned below.

1. Lack of a top-down demand forecasting approach

As shown in Table 5.2-3, the electricity demand forecast approach can be classified into two main methods. Many governments implement both methods, benchmarking both, while examining the energy supply and demand plan.

Table 5.2-3 Demand Forecasting Approaches

	Description	Specific Characteristics
Bottom-up Approach	This model, in addition to making assumptions about individual customers (at regional and industrial levels) to obtain the total demand, estimates simultaneously the demand of the whole country through interviews with major electric power companies and other stakeholders.	This approach is suitable for short-term forecasting because it tends to reflect the trends of large-scale customers who make large-scale production adjustments in the short term, such as the iron and steel and nonferrous metal industries, which consume large volumes of electric power.
Top-Down Approach	This approach considers the influence of the real economy such as demographics, resource prices and exchange rates, while disregarding the influence of individual customers, to estimate electricity demand and prices simultaneously with GDP, employment and other parameters based on economic theory and models. Key approaches include (1) a macro econometric model that statistically analyzes and forecasts data over a period of 20 - 30 years, and (2) a general equilibrium model that forecasts the values by modeling economic conditions at a certain point in time.	Energy demand and price can be forecast while assuming changes in the long-term industrial structure. In this case, the influence of specific assumptions or parameters is relatively small, allowing one to easily remove arbitrariness in assumption. This approach is suitable for long-term forecasting.

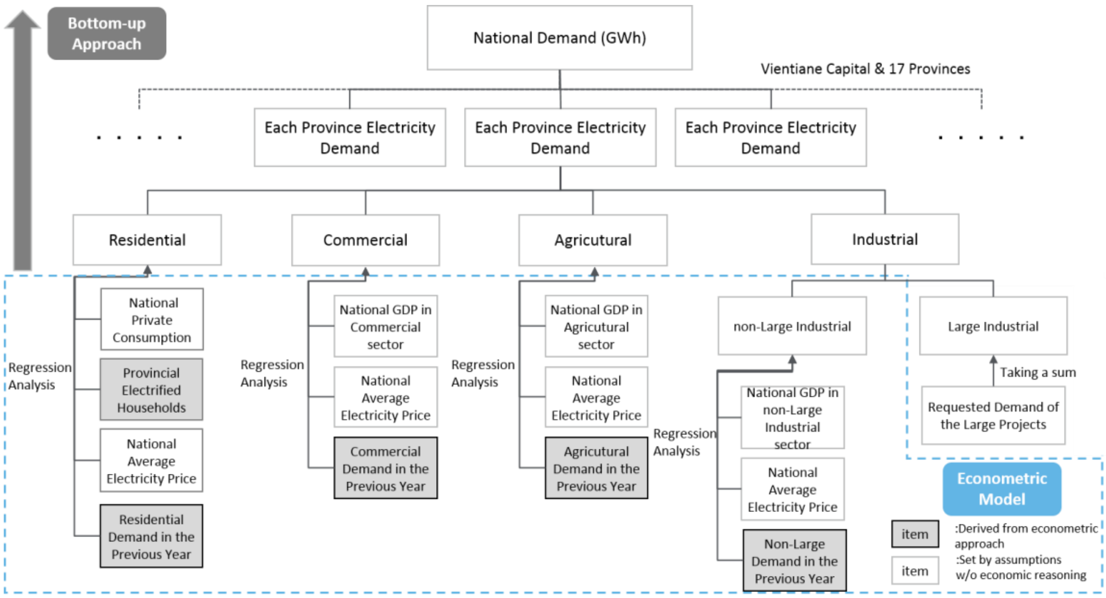
Source: Prepared by JICA Study Team

The EDL demand prediction method introduced in this chapter is classified as a bottom-up approach, built using individual data from residential users and large industries.

As explained above, an electric power demand forecasting model with Japanese-developed dedicated software was introduced as part of a past JICA project in 2013 (hereafter, this model is referred to as the “2013 model”). However, the 2013 model is not a top-down approach in a strict sense and it experiences similar issues to the EDL 2016 forecasting method. As a result, it overestimates the future demand.

In addition, the 2013 model assumes a 2% annual increase in economic growth rate in the industrial sector and in the average electricity price (EDL’s average annual unit price per kWh) published by MPI. The model depends strongly on this type of assumption but is not backed by an analysis of the real economy; thus, the results of the electric power demand forecast are greatly influenced by the reliability of these assumptions.

Figure 5.2-11 shows an outline of the 2013 model. This model breaks down the total national demand into provincial sectoral (residential, commercial, agricultural and industrial) demands and forecasts each by employing regression analysis with data from 2001 to 2011, and some other future values from other forecasts. It cannot estimate the peak demand forecast due to the lack of provincial peak demand data before 2009. It should be noted that the demands forecasted with the 2013 model are calculated by econometric methods (mainly regression analysis) based on limited economic indicators such as the electrification rate or previous year's demand at the provincial level, and the results depend heavily on the EDL and MPI assumptions regarding the real economy indicators (GDP, domestic household consumption, electricity price).



Source: Prepared by JICA Study Team based on the materials provided by EDL

Figure 5.2-10 Overview of the Demand Forecasting Model introduced in 2013

Furthermore, it is observed that in this model the top-down approach is only used to determine demand for residential, commercial, agricultural and non-large-scale industries in each province, and the nationwide demand is forecasted by applying a bottom-up approach. In particular, this model simply adopts the demand forecast for large industries by EDL. Therefore, this model is not a purely top-down approach model, but it can be said that it incorporates elements of econometric economics to some extent in the current EDL demand prediction method.

For the reasons described below, it is considered that there are also issues related to the combination of the current EDL demand model with the bottom-up approach.

- The GDP forecast data is based on the five-year plan by the Ministry of Planning and Investment (MPI) of Laos, and assumptions for economic sectors such as agriculture, industry or services are based on the government plans. In this way, arbitrary assumptions can easily influence the economic growth rate forecast, which is the basic data for the demand forecast. As mentioned above, some of the MPI plans are not feasible, thus contributing to overestimates of electricity demand. In general, the current demand forecast by EDL depends on the MPI assumptions on economic growth. Overestimates of the GDP growth rate can easily lead to overestimates in electricity demand.
- Table 5.2-4 compares the actual electricity consumption of each sector in 2016 with the forecasted value of each sector in 2016 according to the model introduced in 2013. Demand for residential users is close to the actual situation, yet in the case of Large Industry, as already mentioned above, there is a significant overestimate. It seems that this approach has also been followed to some extent in the model currently used by EDL.

Table 5.2-4 Sectoral electricity consumption in 2016 and deviations from the 2016 values estimated under the model introduced in 2013

	Residential	Agriculture	Service	non-Large Industry	Large Industry	Total
Actual (GWh)	1,735	36	991	960	1,342	5,064
Forecasted by the model (GWh)	1,653	61	1,327	1,175	2,285	6,501
Ratio of forecast to actual (%)	95%	169%	134%	122%	170%	128%

Source: Prepared by JICA Study Team based on the materials provided by EDL

- An interview with the staff in charge at EDL revealed that the new demand forecasting model introduced in 2013 was developed based on EDL's request to have a tool for continuous electricity demand forecasting on a provincial level. However, the number of economic variables, such as labor force or fixed capital, available at the provincial level is small due to the current status of the national statistics in Laos. In reality, the only variables in the model reflecting the situation in the real economy are the economic growth rate, final consumption expenditure, and inflation rate, thus limiting the way real economic developments influence the electricity demand forecast.
- As per the EDL demand forecast for February 2018, the consumption of large customers receiving electricity at 115 KV accounts for 26.5% as of 2016 and this is expected to grow to around 40% in 2030. However, the actual operations and electricity demand in mining and special economic zones is greatly influenced by the macroeconomic environment, including trade with neighboring countries and resource prices, which are not reflected in the existing model.

5.2.3. Proposals for Improvement

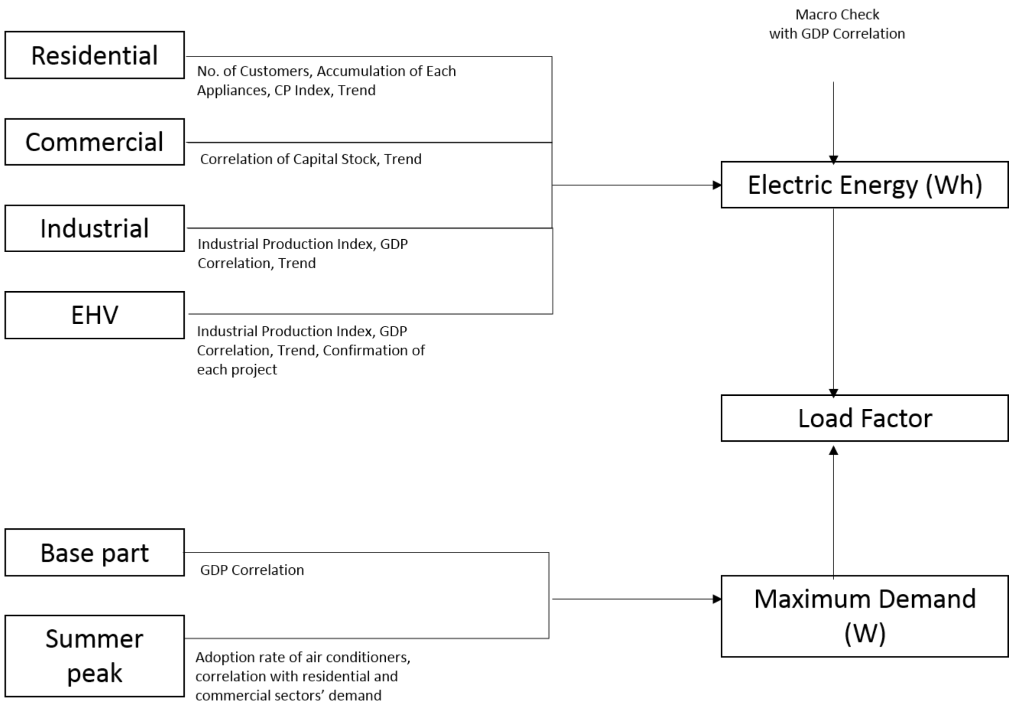
In this section, the Study Team proposes improvement measures for the challenges identified in previous sections.

1. Improvements for Bottom-Up Approaches

Figure 5.2-12 shows the work flow for a Bottom-Up Approach used in Japanese utilities. The Japanese utilities accumulate the demand for each class of customer: residential, commercial, industrial and Extra High Voltage (EHV) customers. They also check the correlation with economic indices such as the GDP. EDL could adopt a process during which it would check the correlation of electricity demands with economic indices, which it does not do currently.

In addition, EDL estimates the maximum demand by multiplying electricity consumption amounts with the inverse of the load factor. However, it is common to estimate the peak demand and electric consumption first and then calculate the load factor by using the amount (Wh) and demand (W). Since more methodologies for peak demand forecasting have been proposed than those for load factor, the accuracy may increase if EDL forecasts the peak demand first, rather than the load factor.

Table 5.2-5 shows improvement measures for each customer class. In general, the accuracy of the forecast in EDL would improve by using time series trends and economic indices. Forecasting the electricity demand in an accurate manner is difficult not only for EDL but also for all other electric utilities. However, it is important to build a rigorous logic for demand forecasting, and avoid relying on a rule of thumb. Doing so enables utilities to precisely analyze the causes of gaps between the forecast and actual data and improve the accuracy of demand forecasting by accumulating these analyses.



Source: Prepared by JICA Study Team based on "Interpretation of Calculation Method for Demand Forecast and Supply Plan in the Report of Japanese Utilities Survey" (Japan Electric Power Information Center)

Figure 5.2-11 Work Flow for Bottom-Up Approach

Table 5.2-5 Improvement Measures for Each Sector

Sector	Methodologies used in Japanese Electric Utilities	Improvement measures for EDL
Residential	Utilities estimate the demand from the number of customers and the energy demand per customer. The number of customers is estimated by population. The energy demand per customer is estimated by the adoption rate for home appliances.	EDL estimates that the energy demand increases every year by 5%. The accuracy of the forecast will increase by considering the adoption rate for home appliances. In addition, the number of electrified households is predicted based on the target value in the National Socio Economic Development Plan, and the actual data is not taken into consideration. The prediction accuracy is improved by considering the trends in the past data on the electrification rate.
Commercial	Utilities estimate the number of customers and the energy demand per customer. The number of customers is forecasted considering the gross capital stock index of the commercial sector and past trends. The amount for each customer is estimated based on actual trends.	EDL forecasts the demand by using the actual demand from the previous year. Using past long trends is an effective way to improve the accuracy of the demand forecast. However, it is necessary to be careful when using past trends when drastic socio economic changes are estimated, as the practice of using past trends is based on the assumption that similar trends will continue in the future. At this moment, EDL does not have accurate actual data for maximum demand and electric energy. Using past trends would considerably improve demand forecasting after EDL starts to accumulate precise past records.
Industrial	Utilities estimate the demand by using Indices of Industrial Production (IIP), GDP and past trends.	The industrial demand is proportional to IIP and it is recommended to use IIP. For the commercial sector, it is effective to use past trends.
Extra High Voltage	Utilities estimate the demand by using IIP correlation, GDP correlation, past trends and the status of each project. Similar to EDL, Japanese utilities also estimate the demand for Large Industry by interviewing the customers about their three-year demand forecast. Customers tend to provide positive information such as expansions and new constructions, but not negative information such as factory shutdowns. Therefore, there is always a risk of overestimation.	EDL estimates the demand for 115 kV by interviewing customers. It is better to use IIP correlation, GDP correlation and past trends as the information from the interviews is imprecise.

Source: Prepared by JICA Study Team based on "Interpretation of Calculation Method for Demand Forecast and Supply Plan in the Report of Japanese Utilities Survey" (Japan Electric Power Information Center)

2. Improvements for 2013 model

As explained above, while the present EDL forecasting method does not take time-series trends into account, the 2013 model utilizes socio-economic and provincial sectoral energy data from 2001. Utilizing time-series data might mitigate the weaknesses in the present EDL forecasting method.

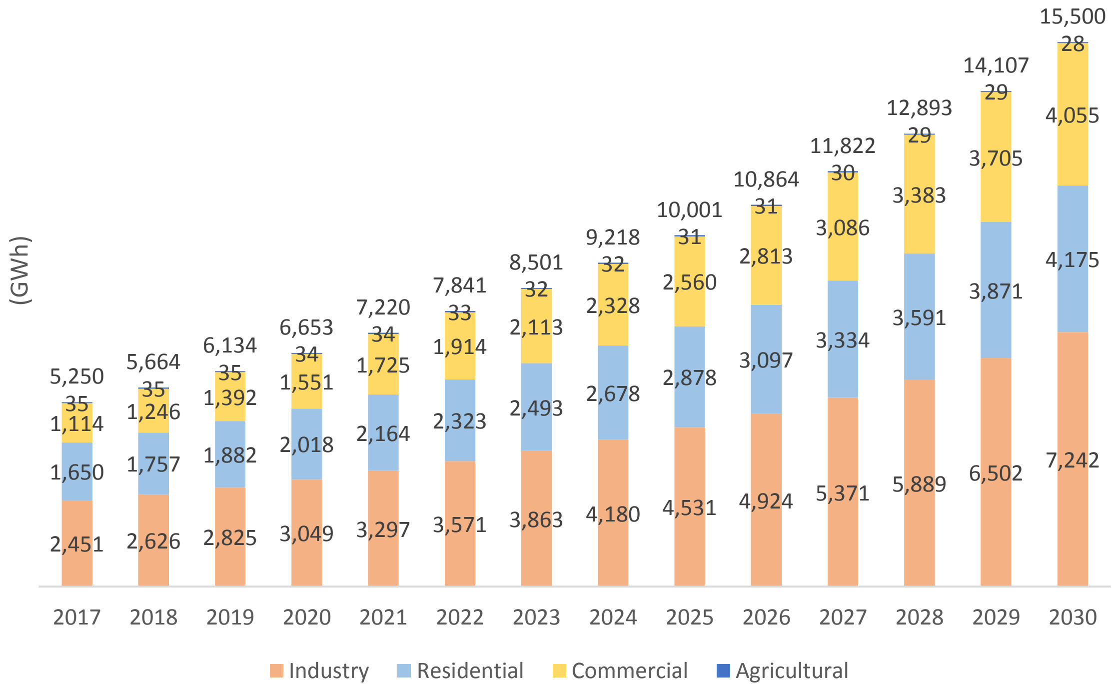
The Laos statistical yearbook contains GDP data for the agricultural, industrial, and service sectors. The 2013 model forecasts the demand for each province and sector according to this categorization and by using this data. However, the industrial GDP is used only for the forecast for non-large industry and the forecast for large industry does not take into account past GDP growth rates. This means the effect of industrial economic growth is taken into account in a different manner at the same time, which might lead to overestimation of the industrial power demand.

Thus, consolidating the large and non-large industry power demand as total industrial demand might improve the estimation of the relationship between sectoral economic growth and power demand and thus lead to the improvement of estimations and fewer over-estimations.

In this study, the data and program for the 2013 model was revised and updated until 2016, and a prototype of a revised model was developed (hereafter this model is referred to as the "prototype model"). In addition, certain data was also corrected as some inconsistencies were found in the previous dataset.

Although the prototype model still contains several inconsistencies in provincial and sectoral level forecasts (e.g., in the original data, agricultural demand has always been zero in some provinces, and electrified household demand decreases for some periods), these inconsistent results represent only a minor part of the total power demand and the overall results are consistent with the latest EDL forecast.

The results of the prototype model are summarized in Figure 5.2-13.



Source: Prepared by JICA Study Team based on power consumption data provided by EDL, "Statistical Yearbook Lao PDR", and "IMF Economic Outlook"

Figure 5.2-12 Sectoral Demand Forecast up to 2030 by prototype model

While the total power demand in 2030 forecasted by EDL is 13,982 GWh, the results of the calculation via the prototype model are slightly larger. The forecast for large industry in 2030 by EDL is 6,125 GWh, and that via the prototype model (7,242 GWh) also exceeds this value. These figures are consistent with each other.

Although there is still room for improvement, one merit is that it is possible to forecast the total demand without making any assumptions on the load factor for large industry. As explained in section 5.1.2, EDL recognizes the difficulty of making reasonable assumptions based on the long-term load factor for large industry. However, the prototype model can forecast the total demand without making requests to customers or assumptions regarding the load factor, which EDL uses to calculate the demand for large industry.

Although the prototype model cannot take into account the distribution losses caused by the difference in voltage, accumulating data and experience with model building and corrections will help to develop more accurate large industry load factor assumptions.

It should also be noted that external experts are required to operate the prototype model as it is still at the trial stage and many data inconsistencies remain. EDL does not possess enough resources to deal with such a task.

3. Capacity building to enable a top-down approach to forecasting

Despite the few advantages discussed above, the prototype model also relies on various rough assumptions including the GDP growth, electricity price and inflation rate. For example, the above forecast was carried out with a 7% GDP growth until 2030 assumption, even though assumptions on the macro economy should be more developed.

In addition, the impossibility of forecasting peak demand based on economic conditions is a significant issue which needs to be addressed, and there is still a need for a top-down approach model with more economic variables.

However, because building and maintaining a pure top-down approach model requires significant expertise, it is necessary to create a specialist training program and build capacity over several years.

Although there is room for improvement even in EDL's latest demand forecast, it can be said that the over-estimate issue has been somewhat resolved by considering the past data more than in the 2016 demand forecast. In addition, the demand estimated by using the economic model is generally consistent with that in the latest EDL forecast. Therefore, the study team considers that the latest demand forecast done by EDL, which predicts the maximum demand in 2030 to be 2,691 MW, and the amount of power to be 13,982 GWh, is reasonable, and has decided to apply the values in EDL's latest demand forecast in further studies.

5.3. Peak Demand Forecast for Each Substation

5.3.1. Forecast Methodology

In this section, peak demand supplied from each substation owned by EDL was forecasted up to 2030, and the required substation scale was also studied in the manner described below:

1. Load for the forecast

The forecast basically includes only the peak demand for the general sector, which is supplied from EDL's substations. The peak demand for large industry, which is supplied from EDL's 115 kV system, is not included in the forecast because it does not affect transformer capacity and the substation scale study.

2. Recorded peak demand and its growth rates

The latest EDL forecast shows total peak demand in each province up to 2030. The peak demand forecast for each substation shall be calculated by multiplying recorded peak demand in each substation by the forecasted annual growth rates in peak demand in each province.

Recorded peak demands for each substation in 2017 are applied for the forecast as base year peak demand. If there are deviations between the recorded peak demand and EDL's forecast, the ratio of the recorded peak demand and the forecasted peak demand by EDL in each province are calculated. Then, the ratio is multiplied with the recorded peak demand to obtain consistency for the study.

3. Transformer capacity for new installations

If the peak demand forecasted in the abovementioned manner exceeds the total capacity of the existing transformer, an additional transformer or new substation that would take part of the load of an existing substation is planned.

The unit capacity of an additional or new substation transformer is planned to be the same as the existing transformer in the overloaded substation. The number of transformer banks is planned on the basis of a maximum of 3 banks.

However, further detailed study on transformer capacity is necessary at the feasibility study stage.

4. Allocation rates for power demand to the new substations

The allocation rate of the peak demand to the new substations is assumed to be 30% of the nearest substation.

5. Temporary substations

Most of the temporary substations exist to supply electricity for power plant construction projects. The purpose of each temporary substation after the completion of construction has not been decided. Therefore, temporary substations are not included in this forecast.

6. Assumption of unknown loads

Peak demand in 2017 for Nam Lik 1/2 is assumed as 5 MW due to a lack of data.

5.3.2. Results of Peak Demand Forecasting for Each Substation

Table 5.3-3 to Table 5.3-6 show the results of the peak demand forecasting for each substation. In the following substations, the transformers are overloaded.

Table 5.3-1 Overloaded substations

No.	Substation	Year of Overload	Additional transformer required	Remarks
1	Viengkeo (Xayabuly)	2020	20 MVA x 1	Additional
2	Nam Mang 3	2017	5 MVA x 1	Additional
3	Pakthang	2017	50 MVA x 2	Additional (move schedule forward)
4	Phontong	2026	50 MVA x 2	New substation
5	Tha Ngon	2027	30 MVA x 1	Additional
6	Viengkeo (Nongviengkeo)	2023	50 MVA x 2	Additional (move schedule forward)
7	Thakhek	2017 2030	30 MVA x1 30 MVA x 1	Additional New substation
8	Song Hong	2022	30 MVA x 1	Additional
9	Pakbo	2023	Load relocation	To Nongdeun S/S
10	Nongdeun	2025	50 MVA x 1	Additional
11	Bang yo	2030	30 MVA x1	New substation
12	Ban Hat	2029	20 MVA x 1	Additional

Source: Prepared by JICA Study Team

1. Viengkeo (Xayabuly) substation

The result shows that the peak demand will exceed the existing transformer capacity (20 MVA x 1) in 2020. So, an additional transformer which takes part of the load is planned.

2. Nam Mang 3 hydro power station

The result shows that the peak demand will exceed the existing transformer capacity (5 MVA x 1) in base year 2017. So, an additional transformer which takes part of the load is planned. The additional transformer should be procured promptly. It is assumed that procurement will commence in 2019 and take two years in the earliest case. The additional transformer would then start operation in 2021.

3. Pakthang substation

The result shows that the peak demand will exceed the existing transformer capacity (30 MVA x 1) in base year 2017. Although there is a transformer extension plan for the substation in 2025, an additional transformer should be procured promptly, so earlier procurement is recommended. It is assumed that procurement will commence in 2019 and take two years in the earliest case. The additional transformer would then start operation in 2021.

4. Phontong substation

The result shows that the peak demand will exceed the existing transformer capacity (50 MVA x 4) in 2026. So, a new substation which takes part of the load is planned.

5. Tha Ngon substation

The result shows that the peak demand will exceed the existing transformer capacity (30 MVA x 1) in 2027. So, an additional transformer which takes part of the load is planned.

6. Viengkeo (Nongviengkham) substation

The result shows that the peak demand will exceed the existing transformer capacity (30 MVA x 1) in 2023. Although there is a transformer extension plan for the substation in 2025, earlier procurement is recommended. It is assumed that the additional transformer will start operation in 2023 to avoid overloads.

7. Thakhek substation

The result shows that the peak demand will exceed the existing transformer capacity (30 MVA x 2) in base year 2017. So, an additional transformer which takes part of the load is planned. The additional transformer should be procured promptly. It is assumed that procurement will commence in 2019 and take two years in the earliest case. The additional transformer would then start operation in 2021.

Even with the addition of the abovementioned transformer, the result shows that peak demand will exceed the total transformer capacity again in 2030. So, a new substation which takes part of the load is planned.

8. Song Hong substation

Although the substation is planned to start operation in 2020, the result shows that the peak demand will exceed the existing transformer capacity (30 MVA x 1) in 2022. So, an additional transformer which takes part of the load is planned.

9. Pakbo substation

The result shows that the peak demand will exceed the existing transformer capacity (20 MVA x 2) in 2023. There is the Nongdeun substation near the Pakbo substation. The existing transformer capacity at the Nongdeun substation has available space. So, a load relocation from Pakbo to Nongdeun is planned. If there are any distribution development plans around this area in the future, supplying them from the Nongdeun substation is recommended.

10. Nongdeun substation

The result shows that the peak demand will exceed the existing transformer capacity (50 MVA x 1) in 2025. So, an additional transformer which takes part of the load is planned.

11. Bang yo substation

The result shows that the peak demand will exceed the existing transformer capacity (25 MVA x 2) in 2030. However, there is no available space for the installation of an additional transformer in the substation. So, a new substation which takes part of the load is planned.

12. Ban Hat substation

The result shows that the peak demand will exceed the existing transformer capacity (20 MVA x 2) in 2029. So, an additional transformer which takes part of the load is planned.

Table 5.3-2 Peak demand growth rate in each province

General Sector Provincial Peak Power Demand

		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
WHOLE COUNTRY	Peak Power (MW)	**987.06**	**1,028.22**	**1,071.57**	**1,116.36**	**1,159.74**	**1,204.96**	**1,251.82**	**1,300.72**	**1,351.82**	**1,405.09**	**1,460.70**	**1,518.88**	**1,579.68**	**1,643.26**
NORTHERN	Peak Power (MW)	**136.77**	**143.48**	**150.61**	**157.84**	**164.72**	**171.91**	**179.43**	**187.28**	**195.55**	**204.22**	**213.34**	**222.89**	**232.94**	**243.53**
PHONGSALY	Peak Power (MW)	3.10	3.50	3.93	4.41	4.91	5.46	6.13	6.80	7.54	8.34	9.22	10.17	11.22	12.37
	Annual Growth Rate (%)		12.8%	12.5%	12.0%	11.5%	11.2%	12.3%	10.9%	10.8%	10.7%	10.6%	10.3%	10.3%	10.3%
OUDOMXAY	Peak Power (MW)	18.08	19.07	20.19	21.27	22.19	23.16	24.13	25.14	26.19	27.27	28.41	29.57	30.77	32.03
	Annual Growth Rate (%)		5.5%	5.9%	5.3%	4.3%	4.4%	4.2%	4.2%	4.2%	4.2%	4.1%	4.1%	4.1%	4.1%
LUANGNAMTHA	Peak Power (MW)	17.03	17.77	18.50	19.17	19.78	20.37	20.97	21.59	22.24	22.92	23.64	24.37	25.15	25.95
	Annual Growth Rate (%)		4.4%	4.1%	3.6%	3.2%	3.0%	2.9%	3.0%	3.0%	3.1%	3.1%	3.1%	3.2%	3.2%
BOKEO	Peak Power (MW)	20.59	21.80	23.07	24.42	25.74	27.12	28.55	30.06	31.64	33.29	35.03	36.84	38.74	40.73
	Annual Growth Rate (%)		5.9%	5.9%	5.9%	5.4%	5.4%	5.3%	5.3%	5.3%	5.2%	5.2%	5.2%	5.2%	5.2%
XAYABULY	Peak Power (MW)	38.44	39.59	40.78	41.94	43.03	44.18	45.40	46.68	48.02	49.43	50.91	52.46	54.08	55.79
	Annual Growth Rate (%)		3.0%	3.0%	2.9%	2.6%	2.7%	2.7%	2.8%	2.9%	2.9%	3.0%	3.0%	3.1%	3.2%
LUANGPRABANG	Peak Power (MW)	39.54	41.76	44.13	46.63	49.07	51.60	54.25	57.02	59.93	62.96	66.14	69.48	72.98	76.66
	Annual Growth Rate (%)		5.6%	5.7%	5.7%	5.2%	5.2%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.0%	5.0%
CENTRAL 1	Peak Power (MW)	**520.22**	**537.15**	**554.76**	**573.16**	**591.19**	**609.87**	**629.11**	**649.12**	**669.93**	**691.52**	**713.90**	**737.29**	**761.60**	**786.90**
HUAPHANH	Peak Power (MW)	10.62	11.19	11.78	12.42	13.09	13.78	14.54	15.33	16.15	17.01	17.91	18.95	20.04	21.17
	Annual Growth Rate (%)		5.4%	5.3%	5.4%	5.4%	5.3%	5.5%	5.4%	5.3%	5.3%	5.3%	5.8%	5.7%	5.7%
XIENGKHUANG	Peak Power (MW)	19.52	20.05	20.58	21.18	21.75	22.35	22.77	23.21	23.67	24.16	24.67	25.22	25.80	26.40
	Annual Growth Rate (%)		2.7%	2.6%	2.9%	2.7%	2.8%	1.9%	1.9%	2.0%	2.1%	2.1%	2.2%	2.3%	2.3%
XAYSOMBOUN	Peak Power (MW)	5.45	5.89	6.35	6.86	7.33	7.84	8.38	8.97	9.59	10.27	10.99	11.78	12.62	13.54
	Annual Growth Rate (%)		7.9%	8.0%	8.0%	6.9%	6.9%	6.9%	6.9%	7.0%	7.0%	7.1%	7.1%	7.2%	7.2%
VIETIANE PROVINCE	Peak Power (MW)	65.79	68.47	71.26	74.18	76.75	79.42	82.19	85.07	88.06	91.17	94.40	97.75	101.23	104.85
	Annual Growth Rate (%)		4.1%	4.1%	4.1%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.6%	3.6%
VIENTIANE CAPITAL	Peak Power (MW)	418.83	431.56	444.78	458.51	472.27	486.48	501.23	516.55	532.45	548.92	565.93	583.59	601.91	620.94
	Annual Growth Rate (%)		3.0%	3.1%	3.1%	3.0%	3.0%	3.0%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.2%
CENTRAL 2	Peak Power (MW)	**183.18**	**192.92**	**203.20**	**213.91**	**224.37**	**235.36**	**246.73**	**258.64**	**271.11**	**284.14**	**297.79**	**312.07**	**327.03**	**342.71**
BOLIKHAMXAY	Peak Power (MW)	41.27	43.04	44.92	46.87	48.72	50.65	52.64	54.70	56.86	59.09	61.41	63.80	66.30	68.90
	Annual Growth Rate (%)		4.3%	4.4%	4.3%	4.0%	4.0%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
KHAMMOUAN	Peak Power (MW)	56.84	60.34	64.07	68.03	71.90	75.98	80.25	84.76	89.50	94.50	99.77	105.31	111.16	117.32
	Annual Growth Rate (%)		6.2%	6.2%	6.2%	5.7%	5.7%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.5%
SAVANNAKHET	Peak Power (MW)	85.08	89.53	94.21	99.02	103.75	108.73	113.84	119.18	124.75	130.55	136.61	142.95	149.57	156.49
	Annual Growth Rate (%)		5.2%	5.2%	5.1%	4.8%	4.8%	4.7%	4.7%	4.7%	4.7%	4.6%	4.6%	4.6%	4.6%
SOUTHERN	Peak Power (MW)	**146.89**	**154.67**	**163.00**	**171.45**	**179.46**	**187.82**	**196.55**	**205.67**	**215.23**	**225.21**	**235.67**	**246.64**	**258.11**	**270.12**
CHAMPASAK	Peak Power (MW)	88.31	93.14	98.27	103.68	108.77	114.10	119.67	125.52	131.64	138.04	144.75	151.78	159.15	166.87
	Annual Growth Rate (%)		5.5%	5.5%	5.5%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%
SARAVAN	Peak Power (MW)	31.70	33.31	34.86	36.50	38.03	39.64	41.29	43.00	44.78	46.64	48.59	50.66	52.83	55.09
	Annual Growth Rate (%)		5.1%	4.7%	4.7%	4.2%	4.2%	4.2%	4.1%	4.2%	4.2%	4.2%	4.3%	4.3%	4.3%
ATTAPEU	Peak Power (MW)	20.45	21.31	22.34	23.20	24.08	24.98	25.91	26.87	27.87	28.92	30.02	31.15	32.33	33.56
	Annual Growth Rate (%)		4.2%	4.8%	3.8%	3.8%	3.7%	3.7%	3.7%	3.7%	3.8%	3.8%	3.7%	3.8%	3.8%
XEKONG	Peak Power (MW)	6.43	6.91	7.53	8.08	8.58	9.11	9.68	10.29	10.93	11.60	12.31	13.05	13.80	14.60
	Annual Growth Rate (%)		7.4%	9.0%	7.2%	6.2%	6.2%	6.3%	6.3%	6.2%	6.2%	6.1%	6.0%	5.8%	5.8%

Source: Prepared by JICA Study Team based on materials provided by EDL

Table 5.3-3 Peak demand forecast for each substation in Northern region

Unit: MW

Province	District	Station	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NORTHERN																
PHONGSALY			**3.09**	**3.49**	**3.92**	**4.39**	**4.90**	**5.45**	**6.12**	**6.79**	**7.52**	**8.32**	**9.21**	**10.16**	**11.20**	**12.35**
				12.8%	12.5%	12.0%	11.5%	11.2%	12.3%	10.9%	10.8%	10.7%	10.6%	10.3%	10.3%	10.3%
	1	Bountai (SwS)	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	U/C	Boun Neua SS	**0.00**	0.00	3.92	3.07	3.43	3.81	4.28	4.75	5.26	5.82	6.45	7.12	7.85	8.66
	U/C	M. Khoua SS	**0.00**	0.00	0.00	1.32	1.47	1.64	1.84	2.04	2.26	2.50	2.76	3.04	3.35	3.69
OUDOMXAY			**13.57**	**14.54**	**15.64**	**16.74**	**17.73**	**18.79**	**19.87**	**21.01**	**22.20**	**23.46**	**24.79**	**26.17**	**27.63**	**29.16**
				7.2%	7.6%	7.0%	6.0%	5.9%	5.8%	5.7%	5.7%	5.7%	5.7%	5.6%	5.6%	5.5%
	1	Na Mo 1 SS	**6.40**	6.86	7.38	7.90	8.36	8.86	9.37	9.90	10.46	11.06	11.68	12.33	13.02	13.74
	2	Oudomxai SS	**3.61**	3.87	4.16	4.45	4.71	5.00	5.29	5.59	4.14	4.38	4.63	4.89	5.16	5.44
	3	Na Mo 2 SS	**3.56**	3.82	4.11	4.40	4.65	4.93	5.22	5.52	5.83	6.16	6.50	6.86	7.24	7.65
	4	Pak Beng SS	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	Meuang Nga SS	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MOU	M. Houn SS									1.77	1.87	1.98	2.09	2.21	2.33
LUANGNAMTHA			**13.22**	**14.04**	**14.87**	**15.66**	**16.41**	**17.17**	**17.93**	**18.72**	**19.54**	**20.40**	**21.30**	**22.23**	**23.20**	**24.22**
				6.2%	5.9%	5.3%	4.8%	4.6%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%
	1	Luangnamtha 1 SS	**13.22**	14.04	14.87	15.66	16.41	17.17	17.93	18.72	13.68	14.28	14.91	15.56	16.24	16.95
	MOU	M. Long SS									5.86	6.12	6.39	6.67	6.96	7.27
BOKEO			**21.53**	**22.74**	**24.02**	**25.37**	**26.67**	**28.04**	**29.45**	**30.93**	**32.48**	**34.10**	**35.80**	**37.56**	**39.41**	**41.36**
				5.6%	5.6%	5.6%	5.1%	5.1%	5.0%	5.0%	5.0%	5.0%	5.0%	4.9%	4.9%	4.9%
	1	Thafar (Nam Thoung) SS	**5.25**	5.55	5.86	4.33	4.55	4.79	5.03	5.28	5.54	5.82	6.11	6.41	6.72	7.05
	2	Houayxay SS	**16.28**	17.19	18.16	13.43	14.11	14.84	15.58	16.37	17.19	18.05	18.95	19.88	20.85	21.88
	U/C	Tonfeung SS				5.75	6.05	6.36	6.68	7.01	7.36	7.73	8.12	8.52	8.94	9.39
	U/C	Pha Oudom SS				1.86	1.96	2.06	2.16	2.27	2.38	2.50	2.63	2.75	2.89	3.03

Source: Prepared by JICA Study Team based on materials provided by EDL

Unit: MW

		year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
XAYABULY			**42.16**	**43.17**	**44.23**	**45.26**	**46.21**	**47.24**	**48.33**	**49.49**	**50.72**	**52.01**	**53.39**	**54.83**	**56.36**	**57.96**
				2.4%	2.4%	2.3%	2.1%	2.2%	2.3%	2.4%	2.5%	2.6%	2.6%	2.7%	2.8%	2.8%
1	Xayabuly SS		**13.09**	13.40	13.73	14.05	14.35	14.67	15.01	15.37	11.02	11.31	11.61	11.92	12.25	12.59
2	Viengkeo SS		**16.15**	16.54	16.95	8.67	8.85	9.04	9.25	9.47	9.71	9.96	10.22	10.50	10.80	11.10
3	Paklay SS		**12.92**	13.23	13.56	9.71	9.91	10.13	10.36	10.61	10.88	11.16	11.45	11.77	12.10	12.44
U/C	M. Kenthao SS					4.16	4.25	4.35	4.45	4.56	4.67	4.78	4.91	5.04	5.18	5.32
MOU	230 kV Xayabuly SS										4.73	4.84	4.98	5.11	5.25	5.40
Add	Viengkeo Extension					8.67	8.85	9.04	9.25	9.47	9.71	9.96	10.22	10.50	10.80	11.10
LUANGPRABANG			**36.59**	**38.81**	**41.19**	**43.70**	**46.18**	**48.76**	**51.47**	**54.32**	**57.31**	**60.45**	**63.75**	**67.23**	**70.89**	**74.74**
				6.1%	6.1%	6.1%	5.7%	5.6%	5.6%	5.5%	5.5%	5.5%	5.5%	5.5%	5.4%	5.4%
1	Luang Prabang 1 SS		**10.59**	11.23	11.92	8.85	9.35	9.87	10.41	10.98	11.59	12.22	12.89	13.60	14.33	15.10
2	T-off Xieng Ngeun (SwS)		**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Luang Prabang 2 SS		**12.91**	13.70	14.54	15.43	16.30	17.21	18.17	19.17	14.16	14.93	15.75	16.61	17.52	18.47
4	Pakmong 1 SS		**6.18**	6.55	6.95	7.37	7.79	8.23	8.68	9.16	9.67	10.19	10.75	11.34	11.95	12.60
5	Sensouk (Siensouk) SS		**6.92**	7.34	7.79	8.27	8.74	9.23	9.74	10.28	10.86	11.45	12.08	12.74	13.43	14.16
6	Pak Mong 2 SS		**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOU	M. Nan										6.07	6.40	6.74	7.11	7.50	7.91
MOU	M. Chomphet					3.79	4.01	4.23	4.47	4.72	4.98	5.25	5.54	5.83	6.16	6.49
Province Total			**130.16**	**136.79**	**143.87**	**151.12**	**158.10**	**165.45**	**173.17**	**181.26**	**189.77**	**198.74**	**208.24**	**218.18**	**228.69**	**239.79**

Source: Prepared by JICA Study Team based on materials provided by EDL

Table 5.3-4 Peak demand forecast for each substation in Central 1 region

Unit: MW

Province	District	Station	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CENTRAL 1																
HUAPHANH			**7.57**	**8.13**	**8.73**	**9.38**	**10.06**	**10.79**	**11.59**	**12.44**	**13.33**	**14.28**	**15.29**	**16.45**	**17.69**	**18.99**
				7.4%	7.3%	7.4%	7.3%	7.2%	7.4%	7.3%	7.2%	7.1%	7.1%	7.6%	7.5%	7.4%
	1	Xamneua SS	**7.57**	8.13	8.73	3.75	4.02	4.31	4.63	4.97	3.73	3.99	4.28	4.60	4.94	5.30
	U/C	Xam Tai SS				2.81	3.02	3.24	3.48	3.73	4.00	4.28	4.59	4.94	5.31	5.70
	U/C	Houa Muang SS				2.81	3.02	3.24	3.48	3.73	2.80	3.00	3.21	3.46	3.72	3.99
	MOU	Xieng Khor SS									1.60	1.71	1.83	1.97	2.12	2.28
	MOU	Kor Hing SS									1.20	1.29	1.38	1.48	1.59	1.71
XIENGKHUANG			**11.19**	**11.91**	**12.66**	**13.48**	**14.30**	**15.17**	**15.94**	**16.74**	**17.58**	**18.45**	**19.37**	**20.34**	**21.36**	**22.43**
				6.5%	6.3%	6.5%	6.1%	6.1%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
	1	Phonsavan SS	**8.69**	9.25	9.83	4.19	4.45	4.72	4.96	5.21	5.47	5.73	6.02	6.32	6.63	6.97
	2	Nam Ngum 5	**2.50**	2.66	2.83	3.01	3.19	3.38	3.55	3.73	3.92	4.12	4.32	4.54	4.77	5.01
	3	T-off Na hor (SwS)	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	U/C	Naphia SS				3.14	3.33	3.53	3.71	3.90	4.10	4.31	4.52	4.75	4.99	5.24
	U/C	Nong Het SS									1.23	1.29	1.35	1.42	1.49	1.56
	MOU	M. Kham				3.14	3.33	3.53	3.71	3.90	2.87	3.01	3.16	3.31	3.48	3.65
XAYSOMBOUN			**0.93**	**1.03**	**1.14**	**1.27**	**1.40**	**1.55**	**1.73**	**1.92**	**2.15**	**2.42**	**2.74**	**3.12**	**3.58**	**4.14**
				10.8%	11.1%	11.3%	10.4%	10.8%	11.0%	11.5%	11.9%	12.5%	13.1%	13.8%	14.7%	15.8%
	1	Tongkoun 2 SS	**0.77**	0.86	0.95	1.06	1.17	1.30	1.45	1.61	1.80	2.03	2.30	2.62	3.01	3.48
	2	Thavieng SS	**0.16**	0.17	0.19	0.21	0.23	0.25	0.28	0.31	0.35	0.39	0.44	0.50	0.57	0.66
	3	T-off Tongkong 1 (SwS)	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Unit: MW

	year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VIENTIANE PROVINCE		**122.16**	**120.89**	**120.08**	**119.65**	**118.82**	**118.30**	**118.05**	**118.06**	**118.29**	**118.73**	**119.36**	**120.17**	**121.15**	**122.30**
			-1.0%	-0.7%	-0.4%	-0.7%	-0.4%	-0.2%	0.0%	0.2%	0.4%	0.5%	0.7%	0.8%	0.9%
1	Nam Ngum 1	**1.25**	1.24	1.23	1.23	1.22	1.22	1.22	1.22	1.22	1.22	1.23	1.24	1.25	1.26
2	Thalat SS	**25.20**	24.94	24.77	24.68	24.51	24.40	24.35	24.35	24.39	24.49	24.62	24.78	24.99	25.23
3	Phonsoung SS	**16.43**	16.25	16.15	16.09	15.98	15.91	15.88	15.88	15.91	15.97	16.05	16.16	16.29	16.45
4	Ban Don SS	**3.23**	3.19	3.17	3.16	3.14	3.13	3.12	3.12	3.13	3.14	3.16	3.18	3.21	3.24
5	Non hai SS	**8.65**	8.56	8.50	8.47	8.41	8.38	8.36	8.36	8.37	8.40	8.45	8.50	8.58	8.66
6	Nam Mang 3 SS	**5.81**	5.75	5.71	5.69	2.83	2.82	2.81	2.81	2.82	2.83	2.84	2.86	2.88	2.91
7	Nam Leuk	**5.68**	5.62	5.58	5.56	5.52	5.50	5.49	5.49	5.50	5.52	5.55	5.59	5.63	5.68
8	Vang Vieng SS	**20.78**	20.56	20.42	20.35	20.21	20.12	20.08	20.08	20.12	20.19	20.30	20.43	20.60	20.80
9	Nam Lik 1/2	**9.29**	9.20	9.14	9.10	9.04	8.99	8.97	8.98	8.99	9.03	9.08	9.14	9.22	9.30
10	Hinheup SS	**15.67**	15.50	15.40	15.34	15.23	15.16	15.13	15.13	15.16	15.22	15.30	15.41	15.53	15.68
11	Kasi SS	**10.19**	10.09	10.02	9.98	9.91	9.86	9.84	9.84	9.86	9.90	9.95	10.02	10.10	10.20
Add	Nam Mang 3 Extension					2.83	2.82	2.81	2.81	2.82	2.83	2.84	2.86	2.88	2.91
VIENTIANE CAPITAL		**361.69**	**375.96**	**390.82**	**406.29**	**421.94**	**438.16**	**455.04**	**472.60**	**490.88**	**509.85**	**529.52**	**549.99**	**571.29**	**593.45**
			3.9%	4.0%	4.0%	3.9%	3.8%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
1	Phontong SS	**123.39**	128.26	133.33	138.61	143.95	149.48	155.24	161.23	169.32	123.10	127.84	132.78	137.93	143.28
2	Tha Ngon SS	**18.04**	18.76	19.50	20.27	21.05	21.86	22.70	23.58	24.76	25.72	13.35	13.87	14.41	14.98
3	Thanaleng SS	**67.60**	70.26	73.04	53.15	55.19	57.32	59.53	61.82	64.92	67.43	70.03	72.74	75.55	78.48
4	Khoksa ad SS	**34.42**	35.79	37.20	38.67	40.17	41.71	43.32	44.99	23.62	24.53	25.48	26.47	27.49	28.55
5	Naxaythong SS	**25.78**	26.79	27.85	20.26	21.04	21.85	22.69	23.57	24.75	25.71	26.70	27.73	28.80	29.91
6	Donkoi SS	**40.24**	41.83	43.48	31.64	32.85	34.12	35.43	36.79	11.59	12.04	12.51	12.99	13.49	14.01
7	Pakthang SS	**26.44**	27.48	28.57	29.70	15.42	16.01	16.63	17.27	5.44	5.65	5.87	6.10	6.34	6.59
8	Viengkeo (Nongviengkham) SS	**20.54**	21.35	22.19	23.07	23.96	24.88	12.92	13.41	14.08	14.62	15.19	15.78	16.39	17.02
9	Nabong SS	**5.24**	5.44	5.66	5.89	6.11	6.35	6.59	6.85	7.20	7.48	7.77	8.07	8.38	8.70
U/C	230kV Dongphosy SS				22.78	23.66	24.57	25.52	26.51	27.84	28.92	30.04	31.20	32.41	33.66
U/C	Na Hai SS				13.56	14.09	14.63	15.20	15.78	16.58	17.22	17.88	18.57	19.29	20.05
U/C	Pia Lat SS				8.69	9.02	9.37	9.73	10.11	10.61	11.02	11.45	11.89	12.35	12.83
MOU	Donkoi Extension									11.59	12.04	12.51	12.99	13.49	14.01
MOU	Sokpaluang Extension									15.45	16.05	16.67	17.31	17.98	18.69
MOU	Sissaket Extension									7.26	7.54	7.83	8.13	8.44	8.77
MOU	Khoksa ad Extension									23.62	24.53	25.48	26.47	27.49	28.55
MOU	Pakthang Extension					15.42	16.01	16.63	17.27	18.13	18.83	19.56	20.32	21.11	21.93
MOU	Viengkeo Extension							12.92	13.41	14.08	14.62	15.19	15.78	16.39	17.02
Add	New 1 SS (From Phontong)										52.76	54.79	56.91	59.11	61.41
Add	Tha Ngon Extension											13.35	13.87	14.41	14.98
Province Total		**503.54**	**517.92**	**533.43**	**550.07**	**566.52**	**583.97**	**602.35**	**621.76**	**642.23**	**663.73**	**686.28**	**710.07**	**735.07**	**761.31**

Source: Prepared by JICA Study Team based on materials provided by EDL

Table 5.3-5 Peak demand forecast for each substation in Central 2 region

Unit: MW

Province	District	Station	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CENTRAL 2																
Province	**District**	**Station**														
Deviation			**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**-0.03**	**-0.04**	**-0.06**	**-0.06**	**-0.08**	**-0.08**	**-0.09**	**-0.12**	**-0.13**
				5.8%	**5.9%**	**5.8%**	**5.4%**	**5.4%**	**5.3%**	**5.3%**	**5.2%**	**5.2%**	**5.2%**	**5.1%**	**5.1%**	**5.1%**
	1	Pakxan SS	**14.82**	15.69	16.61	17.57	18.52	19.51	20.53	21.61	15.92	16.74	17.61	18.51	19.45	20.44
	2	Thasala SS	**2.44**	2.58	2.73	2.02	2.13	2.25	2.37	2.50	2.63	2.77	2.91	3.06	3.21	3.37
	3	Konsong SS	**3.80**	4.02	4.26	4.51	4.75	5.01	5.28	5.55	5.84	6.14	6.46	6.79	7.14	7.49
	4	Thabok SS	**2.38**	2.51	2.66	2.81	2.96	3.12	3.29	3.46	3.64	3.82	4.02	4.23	4.45	4.68
	5	Luk 20 (Pompik) SS	**9.09**	9.63	10.19	10.78	11.36	11.96	12.59	13.25	13.94	14.67	15.43	16.21	17.04	17.90
	6	Phone Ngam SS	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MOU	Thasi SS									6.82	7.18	7.55	7.94	8.34	8.77
	Plan	B. Aor SS				0.87	0.92	0.97	1.02	1.07	1.13	1.19	1.25	1.31	1.38	1.45
KHAMMOUAN			**91.22**	**94.09**	**97.11**	**100.30**	**103.19**	**106.22**	**109.35**	**112.62**	**116.04**	**119.60**	**123.33**	**127.22**	**131.28**	**135.52**
				3.1%	**3.2%**	**3.3%**	**2.9%**	**2.9%**	**2.9%**	**3.0%**	**3.0%**	**3.1%**	**3.1%**	**3.2%**	**3.2%**	**3.2%**
	1	Thakhek SS	**75.36**	77.73	80.23	58.01	41.77	43.00	44.27	45.59	46.97	48.40	49.91	51.49	53.13	38.39
	2	Mahaxai SS	**7.84**	8.09	8.35	8.63	8.88	9.14	9.42	9.70	7.00	7.21	7.43	7.67	7.92	8.17
	3	Nam Theun 2	**8.01**	8.26	8.52	8.80	9.06	9.32	9.60	9.89	10.19	10.51	10.84	11.18	11.54	11.91
	MOU	Song Hong SS				24.86	25.57	13.16	13.55	13.96	14.38	14.83	15.29	15.77	16.27	16.80
	MOU	500 kV Mahaxai SS									2.99	3.08	3.18	3.28	3.38	3.49
	Add	Thakhek Extension					17.90	18.43	18.97	19.53	20.13	20.74	21.38	22.05	22.76	16.45
	Add	Song Hong Extension						13.16	13.55	13.96	14.38	14.83	15.29	15.77	16.27	16.80
	Add	New 2 SS (from Thakhek)														23.51
SAVANNAKHET			**67.12**	**71.51**	**76.16**	**81.03**	**85.93**	**91.15**	**96.59**	**102.33**	**108.40**	**114.80**	**121.56**	**128.71**	**136.27**	**144.26**
				6.5%	**6.5%**	**6.4%**	**6.1%**	**6.1%**	**6.0%**	**5.9%**	**5.9%**	**5.9%**	**5.9%**	**5.9%**	**5.9%**	**5.9%**
	1	Pakbo SS	**23.14**	24.66	26.26	27.94	29.63	31.43	16.65	17.63	18.68	19.78	20.94	22.18	23.48	24.86
	2	Kengkok SS	**11.83**	12.61	13.43	14.29	15.15	16.06	17.02	18.02	7.64	8.09	8.57	9.08	9.61	10.18
	3	Nongdeun SS	**15.45**	16.46	17.53	18.65	19.78	20.98	38.89	41.20	21.82	23.11	24.46	25.90	27.42	29.03
	4	Muang Phin SS	**6.47**	6.89	7.34	7.81	8.29	6.16	6.53	6.92	7.33	7.76	8.22	8.70	9.20	9.74
	5	Banmat (Seno) SS	**10.23**	10.89	11.60	12.34	13.09	13.88	14.71	15.59	16.51	17.48	18.51	19.59	20.75	21.96
	MOU	Nong District SS						2.64	2.80	2.97	3.15	3.34	3.54	3.75	3.97	4.20
	MOU	500 kV Banmat (Seno) SS									5.73	6.07	6.43	6.81	7.21	7.63
	MOU	Songkhon SS									5.73	6.07	6.43	6.81	7.21	7.63
	Add	Nongdeun Extension									21.82	23.11	24.46	25.90	27.42	29.03
Province Total			**190.87**	**200.03**	**209.72**	**219.89**	**229.76**	**240.18**	**251.01**	**262.39**	**274.36**	**286.91**	**300.12**	**313.98**	**328.56**	**343.89**

Source: Prepared by JICA Study Team based on materials provided by EDL

Table 5.3-6 Peak demand forecast for each substation in Southern region

Unit: MW

SOUTHERN		year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Province	District	Station														
Deviation			**0.00**	**-0.01**	**0.00**	**0.01**	**0.00**	**-0.03**	**-0.08**	**-0.03**	**0.02**	**0.02**	**0.02**	**0.00**	**-0.03**	**-0.06**
				6.2%	**6.2%**	**6.2%**	**5.6%**	**5.6%**	**5.6%**	**5.5%**	**5.5%**	**5.5%**	**5.5%**	**5.5%**	**5.5%**	**5.5%**
	1	Bang yo SS	**30.59**	32.48	34.49	25.64	27.08	28.59	30.18	31.85	33.62	35.47	37.42	39.47	41.63	30.74
	2	Jiengxai SS	**12.45**	13.23	14.05	14.92	11.03	11.65	12.29	12.98	13.69	14.44	15.23	16.07	16.95	17.87
	3	Ban Na SS	**9.19**	9.76	7.26	7.71	8.14	8.60	9.07	9.58	7.07	7.46	7.87	8.30	8.76	9.24
	4	Ban Hat SS	**17.95**	19.06	20.24	21.49	22.69	23.95	25.28	26.68	28.16	29.71	31.34	33.06	24.41	25.74
	5	Pak Xong SS	**8.01**	8.51	9.04	9.60	5.07	5.35	5.65	5.96	6.29	6.64	7.01	7.40	7.81	8.24
	U/C	Ban Lak 25 SS			3.11	3.30	3.48	3.67	3.88	4.09	4.31	4.55	4.80	5.06	5.34	5.63
	MOU	Vang Tao SS				10.99	11.61	12.26	12.94	13.66	14.41	15.20	16.04	16.92	17.85	18.82
	MOU	Pak Xong Extension					5.07	5.35	5.65	5.96	6.29	6.64	7.01	7.40	7.81	8.24
	MOU	Ba Jiang District SS					4.73	4.99	5.27	5.56	5.87	6.19	6.53	6.89	7.27	7.67
	MOU	Don Talad SS									3.03	3.20	3.38	3.57	3.77	3.98
	Add	New 3 (From Bang yo)														13.18
	Add	Ban Hat Extension													10.46	11.04
SARAVAN			**16.68**	**18.11**	**19.60**	**21.21**	**22.83**	**24.58**	**26.44**	**28.44**	**30.59**	**32.89**	**35.37**	**38.07**	**40.97**	**44.10**
				8.6%	**8.2%**	**8.2%**	**7.7%**	**7.7%**	**7.6%**	**7.5%**	**7.5%**	**7.5%**	**7.5%**	**7.6%**	**7.6%**	**7.6%**
	1	Xeset 1	**3.58**	3.89	4.21	4.56	4.91	5.29	5.68	6.12	6.58	7.07	7.60	8.18	8.80	9.48
	2	Nathone (Saravan) SS	**8.91**	9.67	10.47	11.33	12.19	13.13	14.12	15.19	16.33	17.56	18.89	20.34	21.89	23.56
	3	Taothan SS	**4.19**	4.55	4.92	5.32	5.73	6.16	6.63	7.13	7.68	8.26	8.88	9.55	10.28	11.07
ATTAPEU			**18.10**	**19.03**	**20.13**	**21.08**	**22.05**	**23.05**	**24.08**	**25.14**	**26.26**	**27.42**	**28.63**	**29.87**	**31.17**	**32.53**
				5.2%	**5.7%**	**4.7%**	**4.6%**	**4.5%**	**4.5%**	**4.4%**	**4.4%**	**4.4%**	**4.4%**	**4.3%**	**4.4%**	**4.4%**
	1	Saphaothong SS	**18.10**	19.03	20.13	14.76	15.44	16.13	16.86	17.60	12.86	13.43	14.03	14.63	15.27	15.93
	MOU	Phuvong District SS				6.32	6.61	6.92	7.22	7.54	7.88	8.23	8.59	8.96	9.35	9.76
	MOU	B. Hat Xan SS									5.52	5.76	6.01	6.27	6.55	6.84
XEKONG			**5.09**	**5.52**	**6.09**	**6.60**	**7.08**	**7.60**	**8.17**	**8.79**	**9.44**	**10.13**	**10.88**	**11.66**	**12.49**	**13.37**
				8.5%	**10.2%**	**8.4%**	**7.4%**	**7.4%**	**7.5%**	**7.5%**	**7.4%**	**7.4%**	**7.3%**	**7.2%**	**7.0%**	**7.0%**
	1	Nongbong SS	**5.09**	5.52	6.09	4.62	4.95	5.31	5.71	6.14	6.60	7.08	7.60	8.14	8.73	9.34
	MOU	Ban Dakmong Gnai SS						0.69	0.74	0.80	0.86	0.92	0.99	1.06	1.13	1.21
	MOU	Dak Choung District SS				1.98	2.13	1.60	1.72	1.85	1.99	2.13	2.29	2.46	2.64	2.82
Province Total			**118.07**	**125.69**	**134.01**	**142.55**	**150.86**	**159.63**	**168.89**	**178.68**	**189.04**	**199.95**	**211.52**	**223.74**	**236.67**	**250.37**
TOTAL of Whole Country			**942.6**	**980.4**	**1,021.0**	**1,063.6**	**1,105.2**	**1,149.2**	**1,195.4**	**1,244.1**	**1,295.4**	**1,349.3**	**1,406.2**	**1,466.0**	**1,529.0**	**1,595.4**

Source: Prepared by JICA Study Team based on materials provided by EDL

5.3.3. Large-scale customers

Table 5.3-7 and Table 5.3-8 show the forecast of the maximum power demand of large-scale customers (power receiving at 115 kV) by EDL. This table is a forecast for June 2018.After this forecast, a 240 MW data center will start operating in Luangprabang Province from 2019. In examining the power supply plan and system plan, in addition to the demand in this table, the demand for this data center is expected.

Table 5.3-7 Maximum power demand forecast for large customers (North, Central 1)

			2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Phongsaly	Copper Mining 2 at Yot Ou District	(MW)					2.0	3.0	3.1	5.0	5.1	5.3	5.4	6.0	6.2	6.3	6.5	8.0	8.2
Bokeo	Dokngiewkham	(MW)						2.0	3.0	5.0	5.1	5.3	7.0	7.2	7.4	15.0	15.4	15.8	16.2
Luangnamtha	Economic Spicial Zone (Boten)	(MW)						2.0	2.1	2.1	2.2	5.0	5.1	5.3	5.4	7.0	7.2	7.4	7.5
Luangnamtha	Railway station	(MW)								2.4	2.6	3.0	3.6	4.2	5.4	6.0	6.0	6.0	6.0
Oudomxai	Railway station	(MW)								2.4	3.8	5.8	7.2	8.2	9.6	12.0	12.0	12.0	12.0
Oudomxai	Na Mo Industry Zone	(MW)						-	3.0	3.1	3.2	3.2	5.0	5.1	7.0	7.2	7.4	7.5	7.7
Luangprabang	Chomphet town development plan	(MW)	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0	2.5	3.0	3.5	4.0	4.0	4.0
Luangprabang	Railway station	(MW)								2.4	3.8	5.8	7.2	8.2	9.6	12.0	12.0	12.0	12.0
Luangprabang	Gold Mining at Phapon Village, Pak Ou District	(MW)				2.0	3.0	4.0	4.1	4.2	5.0	5.1	5.3	5.4	7.0	7.2	7.4	7.5	7.7
Luangprabang	Total Load during Construction of Hydro Power Plants	(MW)			10.0	12.0	12.3	12.6	12.9	13.2	15.0	15.4	15.4	17.0	20.0	25.0	25.0	25.0	25.0
Sayabouly	Copper Mining at Pang Kham Village, Paklay District	(MW)					2.0	3.0	3.1	4.5	5.0	5.1	5.3	5.4	8.0	8.2	8.4	8.6	8.8
Sayabouly	Total Load during Construction of Hydro Power Plants	(MW)	6.1	6.7	6.9	6.8													
Houaphan	Gold Mining at Phiangum District	(MW)					3.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0
XiengKhuang	Silicon factory. At Xai village. Pukuad District (Max Green lao company)	(MW)			3.0	5.0	7.0	9.0	12.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	55.0
XiengKhuang	Silicon factory. At Nahor village. Khouan District (Phongsapthavy company)	(MW)				3.0	5.0	7.0	9.0	12.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	50.0
Saysomboun	Phubia Gold/copper Mining, PouKham Village, AnouVong District, Sayxomboun Provice, (Existing 115KV at Thongkhuan Substation)	(MW)	56.9	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3
Viengtiane Province	Houaysai Gold/copper Mining, Na Mon Village, Vangvieng District (Existing, 115KV at Vangvieng Substation)	(MW)	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
Viengtiane Province	Cement Factory No.3 at PhonSu Village, Vangvieng Dist (Existing, 115 KV at Vangvieng Substation)	(MW)	6.6	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.3	13.7
Viengtiane Province	Cement Factory at Hinheup Village	(MW)			10.0	15.0	20.0	25.0	27.0	30.0	35.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Viengtiane Province	NongKhon Specific Economic Zone (Industries Zone) at Phonehong District, (Plan, 115KV at F1, 49 Substation)	(MW)								3.0	5.0	6.0	7.0	8.0	8.2	8.4	8.6	8.8	10.0
Viengtiane Province	Gold/Copper Mining at Maipakphoun Village, Sanakham District, (F2 Nonhai Substation)	(MW)						3.0	5.0	7.0	9.0	10.0	15.0	20.0	20.0	20.0	30.0	30.0	30.0
Viengtiane Province	Railway station	(MW)								6.0	9.6	12.0	14.4	16.8	19.2	21.6	21.6	21.6	21.6
Vientiane Capital	Kea Potash Factory at Thongmang Village, Saythany District, (Existing 115KV, NamMang 3-Khoksaat Substation)	(MW)	2.2	2.4	2.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.1	3.2
Vientiane Capital	Vientian Industrial and Trad Area (VITA PARK), NolThong village , Xaythany District, (22KV, KhokSaat Substation)	(MW)	1.6	1.9	2.0	3.5	5.0	6.5	8.0	9.5	11.0	12.5	14.0	15.5	17.0	18.5	20.0	65.0	70.0
Vientiane Capital	EZC Vientiane Nelamit at DongPhoXee Village, Hatxaifong District	(MW)				2.0	4.0	6.0	8.0	10.0	10.3	10.5	10.8	11.0	11.3	11.6	11.9	12.2	12.5
Vientiane Capital	Thatluang Lake Natural and Cultural Tourism Specific Economic Zone at ThatLuang Village, Sayshettha District, (Plan)	(MW)			1.0	3.0	5.0	7.0	9.0	9.2	9.5	9.7	15.0	20.0	30.0	30.8	31.5	32.3	33.1
Vientiane Capital	Saysettha Development Zone at Nano village, Saythany District	(MW)			3.0	5.0	7.0	8.0	9.0	10.0	15.0	20.0	25.0	30.0	50.0	50.0	50.0	70.0	70.0
Vientiane Capital	Nongchan World Trad Center at Ban Fai, Chanthabuly District	(MW)				2.0	5.0	7.0	9.0	9.2	9.5	9.7	9.9	10.2	10.4	10.7	11.0	11.2	11.5
Vientiane Capital	Long- Thanh Vientiane EZC at Dongphosy, Hatxaifont District, (Existing 22KV, MSS 6.2 at Thanaleng Substation)	(MW)				2.0	4.0	8.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	60.0	60.0	70.0	70.0
Vientiane Capital	DoneChan development Zone at , Chanthabuly District	(MW)				2.0	2.1	2.1	3.0	3.1	3.2	3.2	5.0	5.1	5.3	5.4	5.5	5.7	5.8
Vientiane Capital	Railway station	(MW)								2.4	2.9	4.8	7.2	8.4	9.6	10.8	10.8	10.8	10.8

Source: EDL

Table 5.3-8 Maximum power demand forecast for large customers (Central 1, South)

Province	Name	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Bolikhamxai	Nagadok gold mining, at Lak 20	(MW)	44.9	50.7	53.2	55.9	58.7	61.6	64.7	67.9	71.3	74.9	78.7	82.6	86.7	91.1	98.6	110.0	120.0
Bolikhamxai	Cement Factory, Lanchang Conpany at KhounNguen Village, Khounkham district	(MW)	7.3	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.4	15.8
Bolikhamxai	No.1 Iron melting factory, at Phonsi Village PakXan District (sinhouang) will construct 115KV, TR (63MVAx3+40MVAX1)	(MW)					3.0	5.0	7.0	9.0	12.0	15.0	20.0	25.0	25.6	26.3	26.9	27.6	28.3
Khammouane	Lao Kai Yuan Potassium at Nam Ma LatVillage, Thakhek District, (Exisiting, 22KV at FD 9&FD 10 Thakek Substation)	(MW)						3.0	5.0	7.0	9.0	12.0	15.0	20.0	20.5	21.0	21.5	22.1	22.6
Khammouane	Cement Factory at Nakham Village, Mahaxay District, (Existing 115KV, at Mahaxay-Thakek Line)	(MW)	17.4	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	20.0	20.0
Khammouane	Phonesack Cement Company Limited (PSCC) at Ban Tham Village in Gnommalath district	(MW)				3.0	5.0	7.0	9.0	12.0	16.0	18.0	20.0	20.5	21.0	21.5	22.1	22.6	23.2
Khammouane	Cement Factory, Lao Pattana Xangkham Conpany at PhonKham-Namdik Village, Hinboun district	(MW)				3.0	5.0	7.0	9.0	10.0	15.0	20.0	25.0	25.6	26.3	26.9	27.6	28.3	29.0
Khammouane	Khammuan Cement Lao (KCL) at Ban Phova, Mahaxai distict	(MW)			3.0	5.0	7.0	9.0	15.0	17.0	20.0	20.5	21.0	21.5	22.1	22.6	23.2	23.8	24.4
Khammouane	Economic Spacial Zone Phoukyo	(MW)						3.0	5.0	7.0	9.0	12.0	12.3	12.6	12.9	13.2	13.6	13.9	14.3
Khammouane	Thakhek Specific Economic Zone	(MW)					3.0	5.0	8.0	10.0	10.3	10.5	10.8	15.0	15.4	15.8	16.2	16.6	17.0
Savannakhet	Xepon Gold/Copper Mining at NaLum, Vilabury District, (Existing 115KV, at Mahaxay Substation)	(MW)	35.0	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3
Savannakhet	Savan-Seno Economic Spacial Zone (Zone A)	(MW)					2.0	3.0	5.0	7.0	9.0	9.2	9.5	9.7	9.9	10.2	10.4	10.7	11.0
Savannakhet	Savan-Seno Economic Spacial Zone (Zone B)	(MW)				2.0	3.0	5.0	7.0	9.0	12.0	12.3	12.6	12.9	13.2	13.6	13.9	14.3	14.6
Savannakhet	Savan-Seno Economic Spacial Zone (Zone C)	(MW)			2.0	3.0	5.0	7.0	9.0	12.0	15.0	15.4	15.8	16.2	16.6	17.0	17.4	17.8	18.3
Savannakhet	Savan-Seno Economic Spacial Zone (Zone D)	(MW)				1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Savannakhet	Savan-Seno Economic Spacial Zone (Zone E)	(MW)				2.0	3.0	5.0	7.0	9.0	9.2	9.5	9.7	9.9	10.2	10.4	10.7	11.0	11.2
Champasak	Specific Economic Zone Vang Tao, Ban Vang Tao, PholThong Dist	(MW)				3.0	3.1	3.2	5.0	7.0	9.0	10.0	13.0	15.0	17.0	20.0	20.5	25.0	25.6
Champasak	Mahanaty Siphandon Special Economic Zone	(MW)					2.0	3.0	5.0	7.0	9.0	12.0	12.3	12.6	12.9	13.2	13.6	13.9	14.3
Saravanh	Phonesack Ligmite at Tongxa village Ta-oi District	(MW)							2.0	3.0	5.0	7.0	10.0	14.0	15.0	15.4	15.8	16.2	16.6
Sekong		(MW)							3.0	5.0	7.0	9.0	12.0	15.0	15.4	15.8	16.2	22.0	22.6
Attapeu	Industries Zone at Km18	(MW)						3.0	5.0	10.0	12.0	15.0	15.5	20.0	25.0	25.6	26.3	26.9	27.6
Attapeu	Hong Ang Ya lai Sugar factory at Palai village, PhouVong District, (Existng 115KV, at SaphaoThong Substation)	(MW)	2.8	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.4	3.4	3.4

Source: EDL

Chapter 6. Power Development Plans, Power Demand Forecasts and Power Trades in the Neighboring Countries

6.1. Thailand

6.1.1. Current Status of Power Development Plan

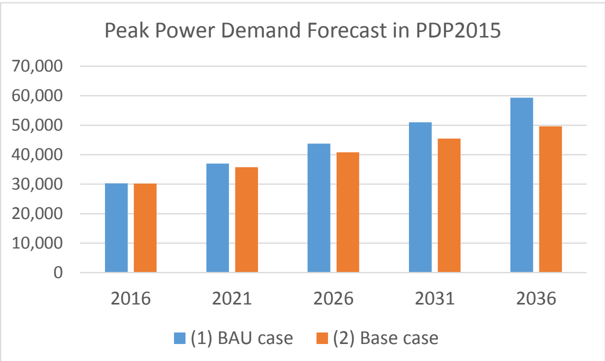
Thailand's Power Development Plan (PDP) is formulated by the Ministry of Energy (MOE) and the Energy Policy and Planning Office (EPPO), and approved by the cabinet. PDP2015 was enacted in June 2015. The new PDP was approved in February 2018 at the Thai Parliamentary Energy Policy Board (NESDB), chaired by the Prime Minister of Thailand. No PDP was formulated in 2016 or 2017. In May 2018, the new PDP was officially approved by the Cabinet. Hereinafter, the plan mainly described in the PDP 2015 is explained, and the outline of the PDP 2018 is described in the final section.

6.1.2. Power Demand Forecast in Thailand

The power demand forecast in Thailand's PDP2015 assumes two cases, the normal power demand forecast (Business as Usual) and the demand forecast reflecting the energy efficiency development plan (EEDP) (Base Case). The energy demand and the peak power demand in the latter case are less than in the former case by 9,645 MW and 67,216 GWh respectively.

The Energy Efficiency Development Plan predicts the amount of energy saving achieved via the adjustment of energy prices, provision of incentives for energy savings, obligations regarding energy saving targets, etc. The base case that includes the Energy Efficiency Development Plan is set as the power demand forecast for PDP2015.

In the base cases, peak power demands are forecasted at 30,218 MW in 2016 and at 49,655 MW in 2036. Energy demands are forecasted at 197, 891 GWh in 2016 and at 326,119 GWh in 2036.



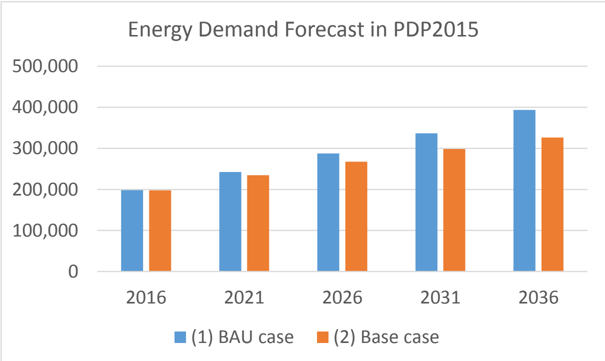
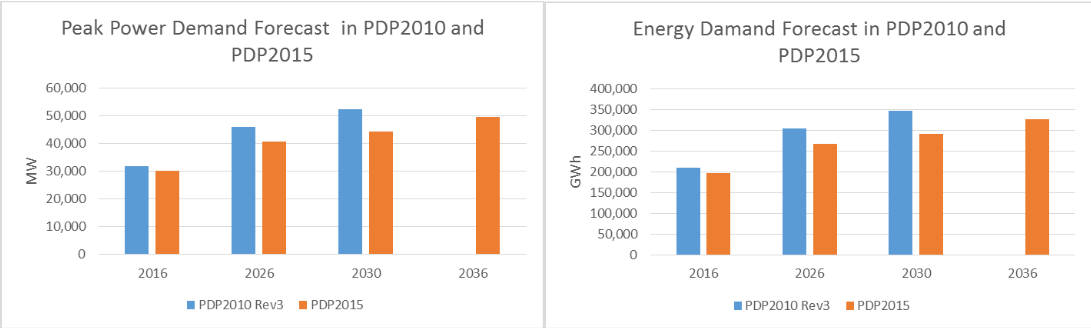


Figure 6.1-1 Comparison of power demand forecast between the "Business as Usual" case and "Base Case" reflecting EEDP

Figure 6.1-2 shows the power demand forecasts in PDP2010 and in PDP2015. The growth ratio for the power demand forecast in PDP2015 is 2.67% on average from 2014 to 2036. The peak power demand was forecasted at 52,256 MW in 2030 in PDP2010. However, the peak power demand is 44,424 MW in PDP2015, 7,832 MW lower.



(Source: PDP2015)

Figure 6.1-2 Comparison of Power Demand Forecasts between PDP 2010 and PDP2015

According to the information from EGAT in November 2017, the power demand forecast in the revised PDP is expected to be lower than that in the current PDP.

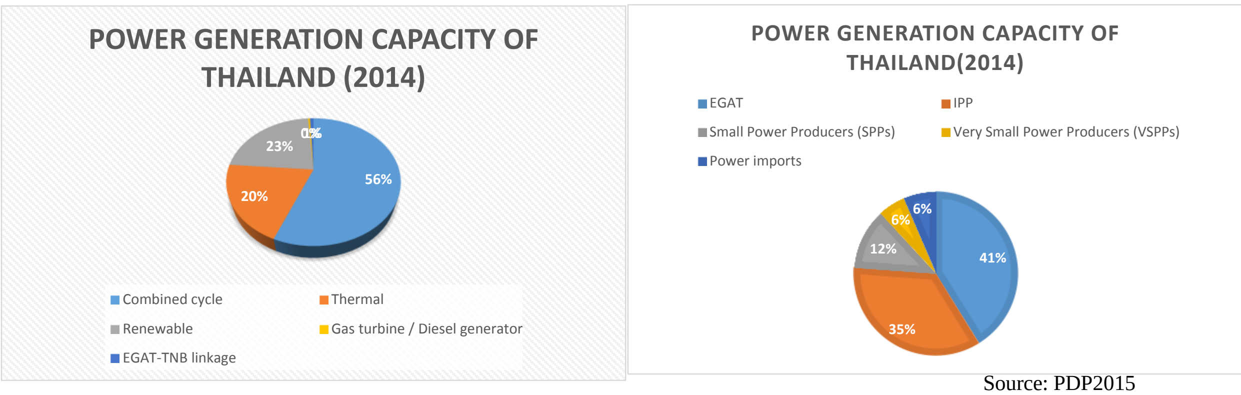
6.1.3. Power Generation Plans in Thailand

The capacity of power generation in February 2014 was 37,612 MW. EGAT and IPP produce 41% and 35%, respectively, and the remainder is made up of small power producers (called Small Power Producers and Very Small Power Producers) and electricity imports. By type of power generation, combined cycle is as high as 56%, ordinary thermal power using steam turbines is 20%, and renewable energy such as hydraulic power and sunlight is 23%.

Table 6.1-1 Power Generation Capacity in Thailand (December 2014)

Classified by power producer		Classified by technology	
	Contract Capacity		Contract Capacity
EGAT	15,482 MW	Combined cycle	21,145 MW
IPP	13,167 MW	Thermal	7,538 MW
Small Power Producers (SPPs)	4,530 MW	Renewable	8,476 MW
Very Small Power Producers (VSPPs)	2,029 MW	Gas turbine/Diesel generator	153 MW
Power imports	2,404 MW	EGAT-TNB linkage	300 MW
Total	37,612 MW	Total	37,612 MW

Source: PDP2015



Source: PDP2015

Figure 6.1-3 Power Generation Capacity in Thailand (December 2014)

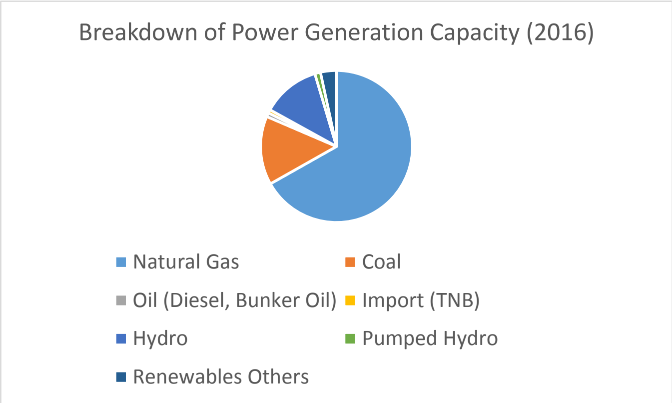
Table 6.1-2 shows a breakdown of fuel types and power generation capacity in 2015 and 2016. In 2016, natural gas thermal power was 67%, coal was 15%, and hydropower and pumped storage was 14%. Power generation by IPP from Laos to Thailand is transmitted through a dedicated transmission line directly connected to the EGAT system from the power plants. For this reason, this power generation is counted in coal and hydropower.

Table 6.1-2 Power Generation Capacity in 2015 and 2016

(Unit: MW)

	2015		2016	
Natural Gas	25,921.20	66.4%	27,581.00	66.8%
Coal	5,546.00	14.2%	6,037.00	14.6%
Oil (Diesel, Bunker Oil)	349.90	0.9%	349.90	0.8%
Import (TNB)	300.00	0.8%	300.00	0.7%
Hydro	5,100.98	13.1%	5,104.98	12.4%
Pumped Hydro	500.00	1.3%	500.00	1.2%
Renewables and Other	1,305.37	3.3%	1,403.37	3.4%
Total	39,023.45	100.0%	41,276.25	100.0%

Source: RPTCC23 Country Report, December 2017



Source: RPTCC23 Country Report, December 2017

Figure 6.1-4 Breakdown of Power Generation Capacity in 2016

The power generation plan in PDP2015 was made based on the following policies.

- Ensuring power system reliability for subsystem areas
- Focusing on fuel diversification
  - Reducing natural gas power generation
  - Increasing coal power generation via clean coal technology
  - Encouraging renewable power generation
  - Maintaining nuclear power plants at the end of the plan
- Ensuring an appropriate level of reserve margin, not less than 15 percent of the peak power demand
- Committed IPPs and SPPs would be maintained according to PPAs. SPPs with anticipated expiration of their PPA term located in high electricity and stream demand industrial zones would be encouraged to continue operation.

In Thailand, the target is to increase the share of renewable energy from the current 8% to 20% by 2036 in power supply energy. The planned capacity of renewable energy is shown in Table 6.1-3. The share of solar and biomass is relatively large.

Table 6.1-3 Plans for Renewable Energy Power Generation Capacity

(Unit: MW)

Year	Solar	Wind	Hydro	Waste	Biomass	Biogas	Energy Crops	Total
2016	3,390	66	70	100	337	1,842	-	5,805
2021	3,816	118	80	141	411	2,956	24	7,547
2026	4,237	224	115	264	491	3,687	259	9,279
2031	4,741	401	137	311	552	4,347	363	10,852
2036	5,262	1,069	168	321	600	5,050	630	13,100

The plans for the main power plants are as follows. The plans for thermal power plants are only a work in progress: existing contracts, replacement of existing thermal power, and new plans are not included in it. From Laos, Hong Sa Lignite, Xayaburi, Xepian, and Nam Ngiep 1, connecting to EGAT, and PPA are planned. The renewable energy of the new VSPP is dominated by home solar.

- Coal Fired Power Plants in south of Thailand: Krabi Coal (800 MW), Thepa Coal (2,000 MW)
- Replacement of South Bangkok, Bangkok, and Wan Noi Combined Cycle
  - South Bangkok (1,300 MW + 1,300 MW)
  - Bangkok (1,300 MW)
  - Wan Noi (1,300 MW +1,300 MW)
- 7 new IPPs already signed with EGAT (PPA) (8,070 MW)
- New SPPs already signed with EGAT
  - 41 Cogeneration: 3660 MW
  - 25 Expansion of Cogeneration: 424 MW
  - Renewable Energy: 1,828 MW
- New VSPP planned in AEDP
  - Renewable (largely shared by Home Solar) : 9,735.6 MW
  - Cogeneration: 34.6 MW
- Power Imports from the neighboring countries already signed with EGAT (PPA) (all from Laos)
  - Hong Sa Lignite: 3 x491 MW
  - Xayaburi: 1220 MW
  - Xepian: 354 MW
  - Nam Ngiep 1: 269 MW

The total for power generation capacities installed from 2015 to 2036 is 57,459 MW. Combined cycle power generation makes up 25% with 17,478 MW, and domestic renewable power makes up 17%, as per the breakdown by fuel type in Table 6.1-4. Power imports make up 14% of the total that is categorized as renewable energy. The power imports of 1,473 MW from neighboring countries, categorized as thermal power plants, is Hong Sa Lignite.

Pumped storage power plants are installed to level load curves or respond to the fluctuations in renewable energy power output. Their power sources are considered power generation that is not easily adjusted, such as coal thermal power plants.

Table 6.1-4 Breakdown of Power Generation Capacities from 2015 to 2036

Renewable Energy	21,648 MW		
--Domestic	12,105 MW		17%
--Power Purchases from neighboring countries	9,543 MW		14%
Pumped-storage power plants	2,101 MW		3%
Co-Generation	4,119 MW		6%
Combined Cycle	17,478 MW		25%
Thermal Power Plants	12,113 MW		17%
--Coal/Lignite power plants	7,390 MW		11%
--Nuclear power plants	2,000 MW		3%
--Gas turbine power plants	1,250 MW		2%
--Power purchases from neighboring countries	1,473 MW		2%
Total	57,459 MW		17%

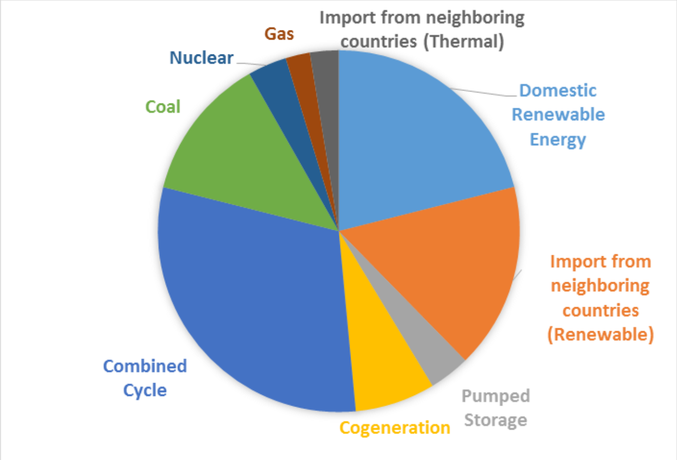


Figure 6.1-5 Breakdown of Power Generation installed from 2015 to 2036

Power generation amounting to 24,736 MW is planned to be retired from 2015 to 2036. As a result, the total power generation capacity in 2036 will be 70,355 MW as shown in Table 6.1-5.

Table 6.1-5 Power Generation Capacity in 2036

Power Generation in 2014	37,612 MW
Power generation newly installed from 2015 to 2036	57,459 MW
Power Generation retired from 2015 to 2036	-24,736 MW
Total power generation capacity in 2036	70,335 MW

Currently, in the revised PDP, emphasis will be placed on power supply via the development of renewable energy and mini grids. Therefore, the amount in the plans for large-scale power supply through the power grid system is expected to decrease.

Table 6.1-6 Power Generation Plan in PDP 2015 (2015-2020)

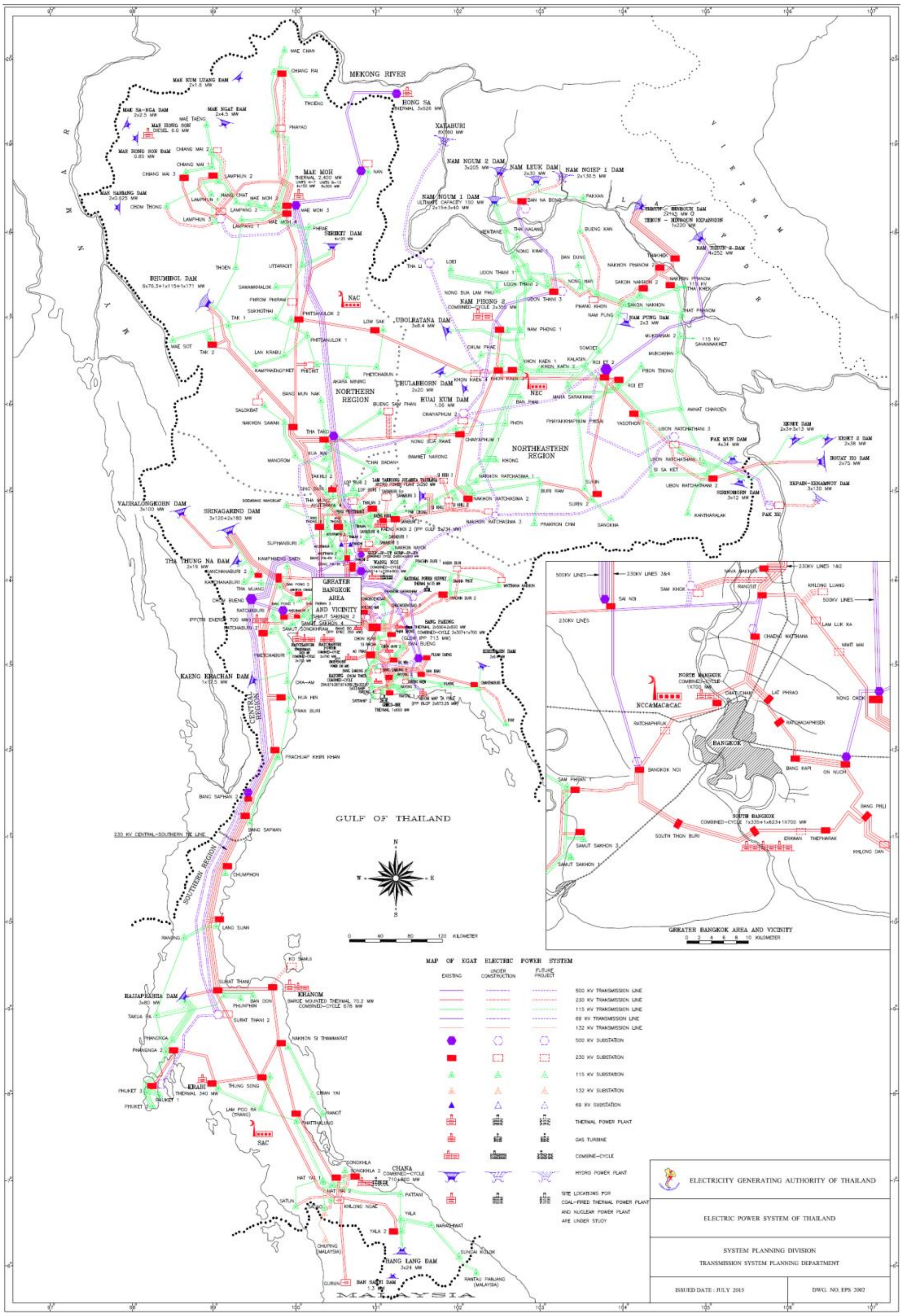
Year	Projects				Fuel Types	Contract Capacity (MW)
2014	Total Contract Capacity as of December 2014					37,612
2015	VSPP			2,377	-	
	SPP			988	-	
	Gulf JP UT CC #1-2 (Jun, Dec)	2	x	800	Gas	
	Kwae Noi Dam #1-2	2	x	15	Hydro	
	Thap Sakae Solar Cell			5	Solar	
	Khun Dan Prakarnchon Dam			10	Hydro	
	Pasak Jolasid Dam			6.7	Hydro	
	Mae Klong Dam #1-2	2	x	6	Hydro	
	Lao PDR (Hong Sa) TH #1-2 (Jun, Nov)	2	x	491	Lignite	43,623
2016	Retirement of Khanom TH #2 (Jun)			-70.2	Gas/Oil	
	Retirement of Khanom CC #1 (Jul)			-678	Gas	
	VSPP			271	-	
	SPP			1,240	-	
	North Bangkok CC #2 (Jan)			848.3	Gas	
	Khanom Replacement CC #1 (Jul)			930	Gas	
	National Power Supply TH #1-2 (Nov)			270	Coal	
	Bang Lang Dam (Refurbish)			12	Hydro	
	Sirindhorn Dam Solar Cell			0.3	Solar	
	EGAT Solar Cell			10	Solar	
	Lao PDR (Hong Sa) TH #3 (Mar)			491	Lignite	46,947
2017	Retirement of Bang Pakong CC #3 (Jan)			-314	Gas	
	Retirement of SPP			-180	-	
	VSPP			283	-	
	SPP			1,929	-	
	National Power Supply TH #3-4 (Mar)			270	Coal	
	Kiew Kormah Dam			5.5	Hydro	
	Lam Ta Khong Wind Turbine Phase2			24	Wind	48,965
2018	Retirement of Bang Pakong CC #4 (Jan)			-314	Gas	
	Retirement of Mae Moh TH #4-7 (Nov)			-560	Lignite	
	Retirement of SPP			-42	-	
	VSPP			288	-	
	SPP			733	-	
	Lam Ta Khong Pumped Storage #3-4 (Feb)	2	x	250	Hydro	
	Replacement of Mae Moh TH #4-7 (Nov)			600	Lignite	
	Klong Tron Dam			2.5	Hydro	
	Chulabhorn Dam Hydropower			1.3	Hydro	
	EGAT Biomass			4	Biomass	
	EGAT Biogas			5	Energy Crop	
	EGAT Solar Cell			10	Solar	
	Mae Moh Solar Cell			1	Solar	
	Krabi Power Plant Solar Cell			2	Solar	50,196
2019	Retirement of Wang Noi CC #1 2 (Jan)			-1,224	Gas	
	Retirement of SPP			-185	-	
	VSPP			330	-	
	SPP			532	-	
	Replacement of Bang Pakong TH #1 2 (Apr)			1,300	Gas	
	Replacement of South Bangkok TH #1-5 (Apr)			1,300	Gas	
	Krabi Coal-Fired TH #1 (Dec)			800	Coal	
	Huai Ped Solar Cell			2	Solar	
	Ban Chan Day Hydropower			18	Hydro	
	Napier Grass (Prachuabkirikhan)			4	Energy Crop	
	Phuket Wind Turbine			4	Wind	
	Lao PDR (Xe-Pian) (Feb)			354	Hydro	
	Lao PDR (Nam Nguep 1) (Jul)			269	Hydro	
	Lao PDR (Xaiaburi) (Oct)			1,220	Hydro	54,921
2020	Retirement of South Bangkok CC #1 (Jan)			-316	Gas	
	Retirement of Tri Energy Power Plant (Jun)			-700	Gas	
	Retirement of SPP			-242	-	
	VSPP			358	-	
	SPP			72	-	
	Pha Chuk Dam			14	Hydro	
	Nam Phung Dam Solar Cell			2	Solar	
	EGAT Blogas			5	Energy Crop	
	EGAT Solar Cell			10	Solar	
	Huai Sai Solar Cell			2	Solar	
	Mukdahan2 Substation Solar Cell			10	Solar	
	EGAT Wind Turbine			5	Wind	54,141

Year	Projects				Fuel Types	Contract Capacity (MW)
2021	Retirement of SPP			-213	-	
	VSPP			280	-	
	SPP			228	-	
	Gulf SRC CC #1-2 (Mar, Oct)			1250	Gas	
	Thepa Coal-Fired TH #1			1000	Coal	
	Lam Ta Khong Hydropower			1.5	Hydro	
	Chaiyaphum2 Substation Solar Cell			10	Solar	
	Surindhom Dam Solar Cell			2	Solar	
	EGAT Wind Turbine			2	Wind	56,701
2022	Retirement of Mae Moh TH #8-9 (Jan)			-540	Lignite	
	Retirement of South Bangkok CC #2 (Jan)			-562	Gas	
	Retirement of SPP			-150	-	
	VAPP			277	-	
	SPP			30	-	
	Gulf SRC CC #3-4 (Mar, Oct)			1,250	Gas	
	Replacement of Mae Moh TH #8-9			450	Lignite	
	Replace,emy of South Bangkok CC #1-2			1,300	Gas	
	Lam Pao Dam			1	Hydro	
	Yaso Thom - Phanom Prai Hydropower			4	Hydro	
	EGAT Solar Cell			10	Solar	
	Nam Pong Power Plant Solar Cell			2	Solar	
	Sirindhom Dam Solar Cell			10	Solar	
	EGAT Wind Turbine			5	Wind	58,788
2023	Retirement of Wang Noi CC #3 (Jan)			-686	Gas	
	Retirement of EPEC (Mar)			-350	Gas	
	Retirement of SPP			-41	-	
	VSPP			208	-	
	SPP			8	-	
	Gulf PD CC #1-2 (Mar, Oct)			1,250	Gas	
	Replacement of Wang Noi CC #1-2			1,300	Gas	
	Pranburi Dam			1.5	Hydro	
	Mahasarakam Hydropower			3	Hydor	
	Buriram Substation Solar Cell			2	Solar	
	South Khao Yai Thiang Wind Turbine			50	Wind	60,533
2024	Retirement of SPP			-680	-	
	VSPP			420	-	
	SPP			126	-	
	Gulf PD CC #3-4 (Mar, Oct)			1,250	Gas	
	Thepa Coal-Fired TH #2			1,000	Coal	
	Praya Man Hydropower			2	Hydro	
	Thart Noi Hydropower			2	Hydro	
	EGAT Biogas			5	Energy Crop	
	Lam Ta Plern Dam			1.2	Hydro	
	Thatako Solar Cell			2	Solar	62,261
2025	Retirement of Mae Moh TH #10-13 (Jan)			-1,080	Lignite	
	Retirement of Nam Pong CC #1-2 (Jan)			-650	Gas	
	Retirement of Global Power Energy (Aug)			-700	Gas	
	Retirement of Ratchaburi TH #1-2 (Oct)			-1,440	Gas/Oil	
	Retirement of SPP			-236	-	
	VSPP			490	-	
	SPP			36	-	
	Replacement of Wang Noi CC #3			1,300	Gas	
	Chonnabot Hydropower			1.5	Hydro	
	Ubonrat Dam Solar Cell			2	Solar	
	Bangpakong Hydropower			2	Hydro	
	EGAT Solar Cell			10	Solar	
	Nam Phung Dam Solar Cell			2	Solar	
	EGAT Wind Turbine			5	Wind	60,403

Table 6.1-7 Power Generation Plan in PDP2015 (2026-2036)

Year	Projects				Fuel Types	Contract Capacity (MW)
2026	Retirement of SPP			-5	-	
	VSPP			333	-	
	Chulabhorn Pumped Storage #1-2	2	x	400	Hydro	
	Tabsalao Dam			1.5	Hydro	
	EGAT Biogas			5	Energy Crop	
	Klong See Yud Dam			1.5	Hydro	
	EGAT Solar Cell			10	Solar	
	Ao Phai Wind Turbine			10	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	62,260
2027	Retirement of Bang Pakong CC #3 (Jan)			-576	Gas/Heavy	
	Retirement of Ratchaburi CC #1-2 (Apr)			-1,360	Gas	
	Retirement of Ratchaburi CC #3 (Oct)			-681	Gas	
	Retirement of SPP			-7	-	
	VSPP			303	-	
	Hua Na Hydropower			1	Hydro	
	EGAT Wind Turbine			5	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	60,645
2028	Retirement of Bang Pakong TH #4 (Jan)			-576	Gas/Heavy	
	Retirement of Glow IPP (Feb)			-713	Gas	
	Retirement of SPP			-103	-	
	VSPP			295	-	
	Srinagarind Pumped Storage #1-3	3	x	267	Hydro	
	Lam Dome Yai Hydropower			2	Hydro	
	EGAT Biogas			5	Energy Crop	
	Kamalasai Hydropower			1	Hydro	
	EGAT Solar Cell			10	Solar	
	Samutsakhon Wind Turbine			30	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	61,097
2029	Retirement of Lao PDR (Huay Ho) (Sep)			-126	Hydro	
	VSPP			313	-	
	Huai Samong Dam			1	Hydro	
	Kamphaeng Phet Substation Solar Cell			3	Solar	
	EGAT Wind Turbine			5	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	61,993
2030	VSPP			313	-	
	Mae Khan Dam			16	Hydro	
	EGAT Biogass			5	Energy Crop	
	EGAT Solar Cell			10	Solar	
	Power Purchase from Neighbouring Countries			700	Hydro	63,037

Year	Projects				Fuel Types	Contract Capacity (MW)
2031	Retirement of SPP			-40	-	
	VSPP			349	-	
	Klong Luang Dam			1	Hydro	
	EGAT Wind Turbine			5	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	64,052
2032	Retirement of BLCP TH #1 (Jan)			-673	Coal	
	Retirement of BLCP TH #2 (Feb)			-673	Coal	
	Retirement of GPG CC #1 (May)			-734	Gas	
	Retirement of SPP			-9	-	
	VSPP			356	-	
	Replacement of Bang Pakong CC #3-4			1,300	Gas	
	Mae Wong Dam			12	Hydro	
	EGAT Biogas			5	Energy Crop	
	EGAT Solar Cell			10	Solar	
	Power Purchase from Neighbouring Countries			700	Hydro	64,345
2033	Retirement of GPG CC #2 (Feb)			-734	Gas	
	Retirement of Ratchaburi Power CC #1 (Feb)			-700	Gas	
	Retirement of Ratchaburi Power CC #2 (May)			-700	Gas	
	VSPP			371	-	
	Replacement of Ban Pakon TH #3-4			1,300	Gas	
	Coal Fired Power Plant #4			1,000	Coal	
	EGAT Wind Turbine			5	Wind	
	EGAT Wind Turbine			5	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	65,592
2034	Retirement of Krabi TH #1 (Jan)			-315	Heavy Oil	
	Retirement of Chana CC #I (Jan)			-710	Gas	
	Retirement of SPP			-21	-	
	VSPP			453	-	
	Gas Turbine #I			250	Diesel	
	Coal-Fired Power Plant #5 (South)			1,000	Coal	
	EGAT Biogas			5	Ener Crop	
	EGAT Solar Cell			10	Solar	
	Power Purchase from Neighbouring Countries			700	Hydro	66,965
2035	Reitirement of South Bangkok CC #3 (Jan)			-710	Gas	
	Retriement of Bang Pakong CC #5 (Jan)			-710	Gas	
	Reitirement of Lao PDR (Nam Theun2) (Mar)			-948	Hydro	
	Retirement of SPP			-90	-	
	VSPP			489	-	
	Gas Turbine #2-4			750	Diesel	
	Coal Fired Power Plant #6			1,000	Coal	
	Nuclear Power Plant #I			1,000	Uranium	
	EGAT Wind Turbine			10	Wind	
	Power Purchase from Neighbouring Countries			700	Hydro	68,456
2036	Reitirement of North Bangkok CC #1 (Jan)			-670	Gas	
	VSPP			580	-	
	Gas Turbine #5			250	Diesel	
	Nuclear Power Plant #2			1,000	Uranium	
	EGAT Biogas			10	Ener Crop	
	EGAT Solar Cell			10	Solar	
	Power Purchase from Neighbouring Countries			700	Hydro	70,335



Source: PDP2015, Thailand

Figure 6.1-6 Power Network System Plan in Thailand (PDP2015)

6.1.4. Power Import Plan in Thailand

Thailand carries out power trades with Laos in the two manners of (1) power imports from export-oriented IPPs and (2) power exchanges through 115 kV interconnection lines. Table 6.1-8 shows the list of power imports from export-oriented IPPs. Capacities are indicated by the contracted values.

Table 6.1-8 Power Imports from Export-oriented IPPs

List of Project Capacities				
List of Projects		Capacity (MW)	COD	
Completed Projects (COD)	Theun-Hinboun	214	March	1998
	Theun-Hinboun Expansion	220	December	2012
	Houay Ho	126	September	1999
	Nam Thuan 2	948	April	2010
	Nam Ngum 2	597	March	2011
	Hong Sa Unit 1	491	June	2015
	Hong Sa	491	November	2015
	Hong Sa	491	March	2016
	Sub Total	3,578		
PPA (Signed Projects and those In Negotiation)	Xe-Pian Xe-Namnoy	354	February	2019
	Nam Ngiap 1	269	September	2019
	Xayaburi	1,220	October	2019
	Sub Total	1,843		
Tariff MOU Signed	Nam Thuan 1	514	January	2022
	Sub Total	514		
Total		5,935		

(Source: EPPO, MOI)

From the information obtained from MEM in Laos, the plant factors of export IPP for Thailand are as follows. Nam Theun 2, Hongsa Lignite and Xayaboury have high factors and are operated almost as base generation.

Theun-Hinboun	32%
Houay Ho	34%
Nam Theun 2	64%
Nam Ngum 2	41%
Hongsa Lignite (T)	76%
Xayaboury	67%
Nam Ngeip 1	59%
Nam Theun 1	44%

The MOUs regarding power development between the governments of Thailand and Laos were agreed in 1993, 1996, December 2006 and December 2007. Power exports of 9,000 MW from Laos to Thailand were agreed in the MOU in September 2016. Thus, the remaining 3,000 MW is expected to constitute a further amount of power imports from Laos.

Table 6.1-9 shows the plan for power imports from the neighboring countries according to the presentation material by EPPO in June 2017.

Table 6.1-9 Plans for Power Imports to Thailand from the Neighboring Countries

2015	Hong Sa Lignite: Unit #1 (491 MW), #2 (491 MW)
2016	Hong Sa Lignite: Unit #3 (491 MW)
2019	Xepian-Xenamnoi 354 MW, Nam Ngiep 1 (269 MW), Xayaburi (1,220 MW)
2022	Nam Thuen 1 514 MW
2026	Power Purchases from Neighboring Countries: 700 MW
2027	Power Purchases from Neighboring Countries: 700 MW
2028	Power Purchases from Neighboring Countries: 700 MW
2029	Power Purchases from Neighboring Countries: 700 MW, Decommission Hou Ho: -126 MW
2030	Power Purchases from Neighboring Countries: 700 MW

Source: the presentation materials by EPPO in June 2017

The power imports from neighboring countries of 700 MW each year from 2026 are not limited only to those from Laos, but include imports from Myanmar and Cambodia. Their breakdowns have not been decided. However, because low prices for hydropower generation in Laos are highly anticipated, Thailand intends to import from Laos preferentially.

Thailand has concluded MOUs with China, Myanmar, Laos and Cambodia, and sets the amounts for their future power imports. However, the MOU with China had a deadline of the end of 2017, and it seems that this has not been continued. The amount of power exchanges agreed with Myanmar and Cambodia are unclear.

Table 6.1-10 Power Imports from Thailand

Countries	Status	Amounts	
Thailand - China	MOU	3,000 MW	Until the end of 2017
Thailand - Myanmar	MOU	Unclear	Until the end of 2020
Thailand - Laos	MOU	9,000 MW	Signed in Sep. 2016
	Contracted	3,578 MW	
	Under Construction	1,848 MW	
Thailand - Cambodia	MOU	Unclear	No deadline

Source: Country Report of RPTCC 23, December 2017

6.1.5. Power Trades between Laos and Thailand

Currently, power trades are carried out through 115 kV interconnections. In Figure 6.1-7, the green lines indicate the interconnections between Laos and Thailand and the purple lines indicate 500 kV transmission lines.

The amount of power exchanges with EDL depends on the power supply demand balance in Laos. Because the energy prices of power imports from Laos are cheaper than power exports to Laos, economic benefits are brought to Thailand through power exchanges.

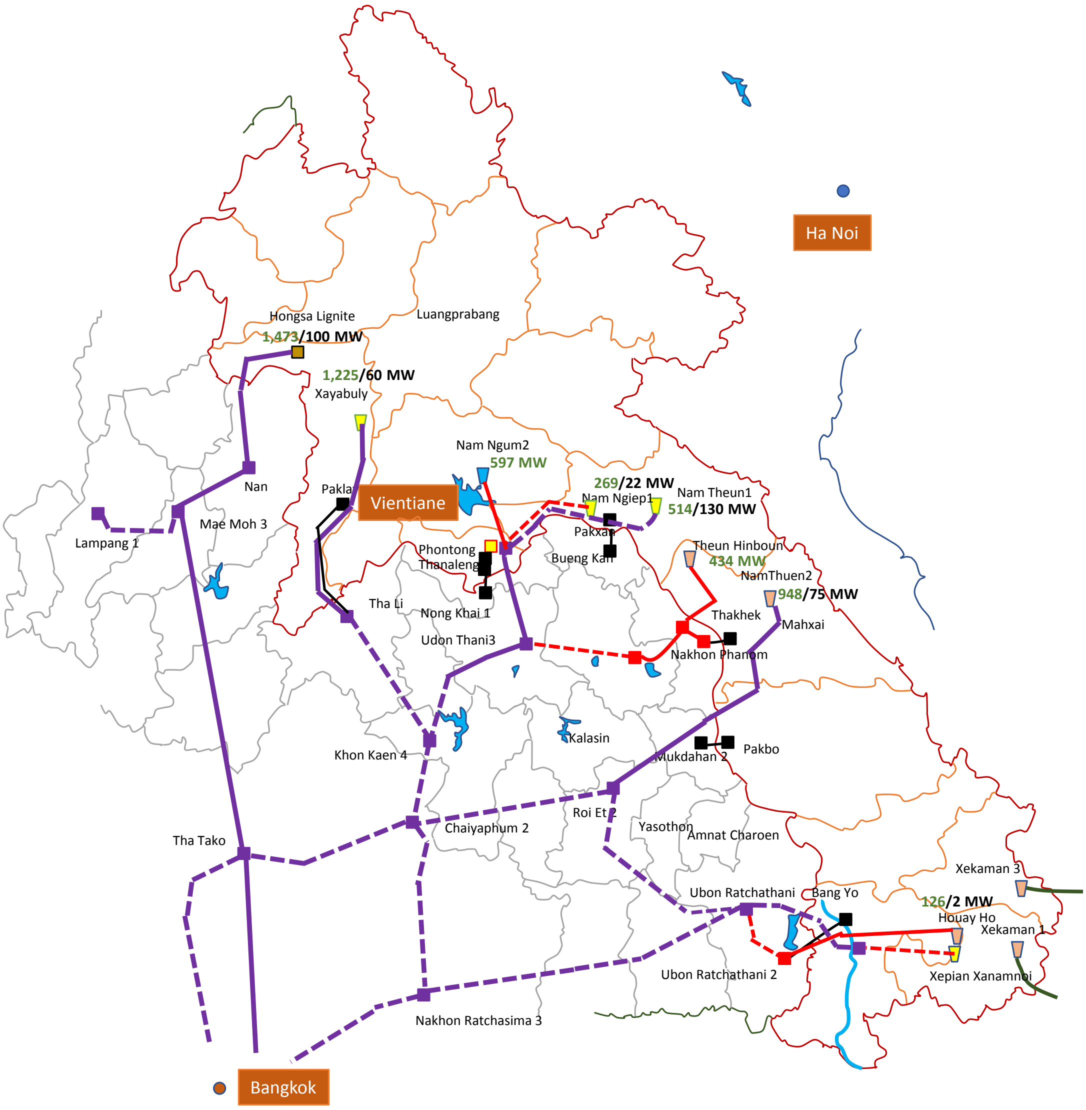


Figure 6.1-7 Interconnections between Laos and Thailand

(Source: Drawn by JICA Study Team based on the information in RPTCC 23 Country Reports)

Table 6.1-11 shows the amount of power trading through 115 kV transmission lines between EGAT and EDL in 2016 and 2017. Generally, power exports from Laos to Thailand are larger; however, power imports from Thailand are also recorded in some cases. Especially in the section between Phontong-Thanaleng in the Central 1 region and Nong Khai, power exports from Laos are very large.

Table 6.1-11 Records of Power Trades between Laos and Thailand

	Interconnection (Thailand – Laos)	Laos -> Thailand		Thailand -> Laos		Net Value	
2016	115 kV Nong Khai - Phontong	708.73	GWh	-70.56	GWh	638.17	GWh
	115 kV Nong Khi - Thanaleng	119.71	GWh	-145.34	GWh	-25.62	GWh
	115 kV Bueng Kan - Pakxan	177.38	GWh	-4.36	GWh	173.01	GWh
	115 kV Nakhon Phanom - Thakhek	164.8	GWh	-120.84	GWh	43.96	GWh
	115 kV Mukdahan 2 - Pak Bo	76.24	GWh	-115.67	GWh	-39.42	GWh
	115 kV Sirindon - Bang Yo	229.2	GWh	-109.43	GWh	119.76	GWh
		1476.09	GWh	-556.22	GWh	909.87	GWh
2017	Interconnection	Laos -> Thailand		Thailand -> Laos		Net Value	
	115 kV Nong Khai - Phontong	769.58	GWh	-28.99	GWh	740.59	GWh
	115 kV Nong Khi - Thanaleng	142.46	GWh	-74.28	GWh	68.18	GWh
	115 kV Bueng Kan - Pakxan	190.1	GWh	-12.54	GWh	177.55	GWh
	115 kV Nakhon Phanom - Thakhek	186.29	GWh	-111.48	GWh	74.8	GWh
	115 kV Mukdahan 2 - Pak Bo	115.38	GWh	-2.32	GWh	113.05	GWh
	115 kV Sirindon - Bang Yo	274.8	GWh	-62.74	GWh	212.06	GWh
		1678.44	GWh	-292.37	GWh	1386.27	GWh

(Source: RTCC 23 Country Report)

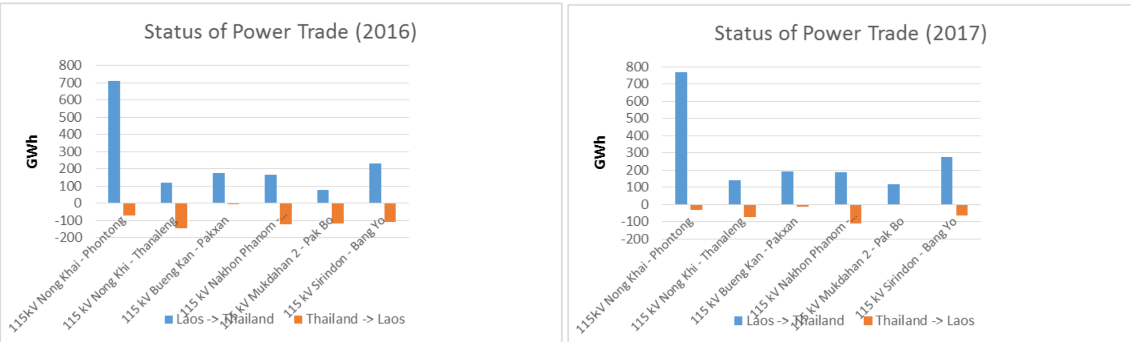


Figure 6.1-8 Records of Power Trades between Laos and Thailand

(Source: RTCC 23 Country Report)

Laos and Thailand carried out a joint study on power exchanges through 115 kV interconnections from Dec. 2016 to 2017. However, the results of the study in November 2017 are based on the power demand forecast and power generation plan as of 2015. Thus, the final results are expected to be summarized in the near future based on the power demand forecast and power generation plan. When study conditions such as the construction of transmission lines, power demand forecast and power generation plan are changed, the study will be carried out again.

The following are recommended in the interim reporting.

- The projects for hydropower stations at the stages of Concession Agreement (CA), Power Development Agreement (PDA) and Feasibility Study (FS) are to be re-examined, and their construction schedules should be adjusted to maintain the balance of power exchanges with Thailand and the power supply-demand balance in Laos.
- It is important to control both active and reactive power at the border between Laos and Thailand in the EDL system to secure power system reliability and stability in Laos and Thailand.
- Guidelines showing the appropriate generation dispatching in the North, Central 1, Central

2 and South areas of Laos should be established between EDL's dispatching control center and EGAT's dispatching control center.

- Power exchanges due to the development of IPPs in the Laos system after 2019 should be curtailed due to restrictions on the capacity of transmission lines in the EGAT system.

In 2019, discussions on power exchanges were underway between EGAT and EDL. According to EGAT, the top priority is to build an interconnection via a BTB conversion station between the north of Laos and Thailand.

6.1.6. Overview of PDPs in 2018

Power demand forecasts for PDP 2015 and PDP 2018 are shown in Figure 6.1-9. In the PDP 2018, the demand before 2030 has been slightly reduced, but this has been slightly corrected since 2030.

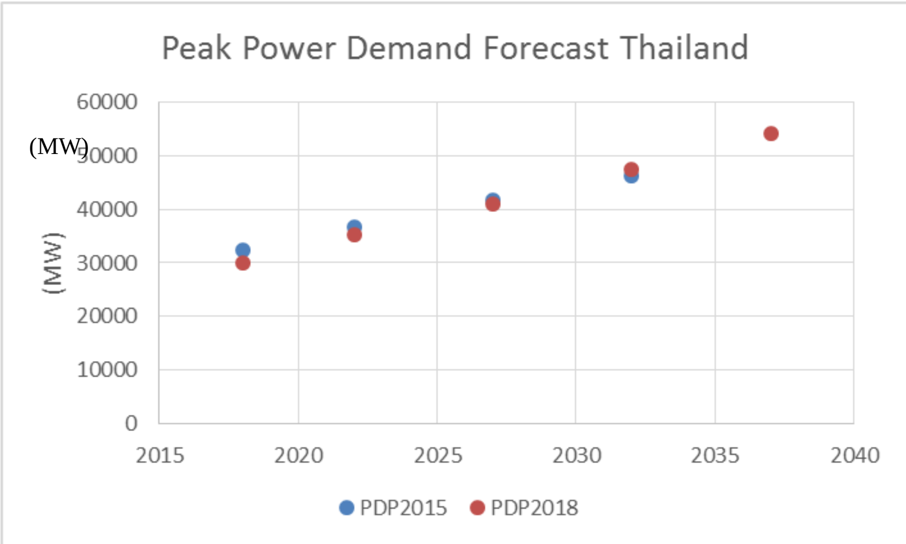


Figure 6.1-9 Comparison of Demand Forecasts for PDP 2015 and PDP 2018

Since the plans for imports in PDP 2018 affect the exports from Laos to Thailand, the differences between the plans for PDP 2015 and PDP 2018 are described below. Table 6 is a reposting of the generation capacity in 2036.

2014	37,612 MW
2015-2036	57,459 MW
2015-2036 (power supply retired)	-24,736 MW
2036	70,335 MW

Among this, the breakdown of new installed capacity of 57,459 MW from 2015 to 2036 is as follows.

- Domestic Renewable Energy: 12,105 MW
- Imports from neighboring countries (hydropower): 9,543 MW
- Pumped storage plants: 2,101 MW
- Cogeneration: 4,119 MW
- Combined cycle power generation: 17,478 MW
- Coal-fired power: 7,390 MW
- Nuclear power: 2,000 MW
- Gas turbine thermal power: 1,250 MW
- Imports from neighboring countries (thermal power): 1,473 MW
- Total 57,459 MW

The breakdown of the abovementioned imports from neighboring countries (hydropower) is as follows.

From 2026, imports from neighboring countries of 700 MW are expected each year until 2036.

- 2019, Xe-Pian: 354 MW
- 2019, Nam-Ngiep 1: 269 MW
- 2019, Xaiyaburi: 1,220 MW
- 2026-2036 Imports from neighboring countries (hydropower): 7,700 MW
- 9,543 MW in total

However, in the PDP 2018, the 7,700 MW (hydropower) from these neighboring countries is reduced to 3,500 MW. That is, the PDP 2018 expects 700 MW every two years as imports (hydro) from neighboring countries from 2026 to 2035.

The PDP 2018 does not specify import countries, but Laos, Myanmar and Cambodia can be considered. However, EGAT expects Laos to import a substantial proportion of 3,500 MW.

In Myanmar, there are trends in plans to export from hydropower plants in the northeastern part of Myanmar, such as Hutgy Hydropower (1,360 MW) and Upper Thanlwin Hydropower (3,000 MW), to Thailand, but according to information from EGAT in May 2019 it seems that there is no definite plan because the decision-making process on the other side is opaque and takes time. Rather, Thailand has plans to export from Thailand to the eastern part of Yangon.

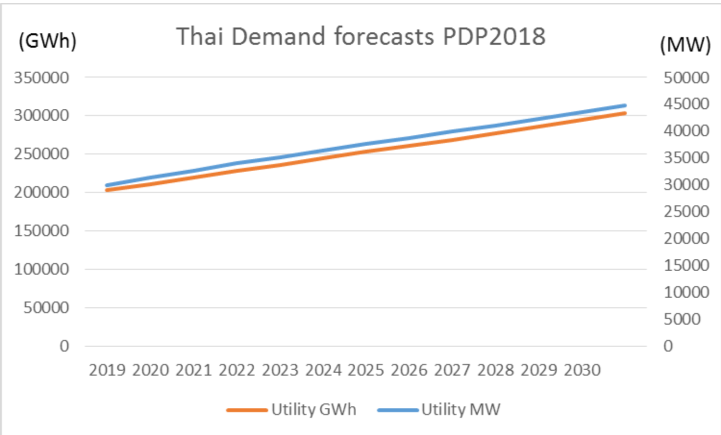
Also, the above-mentioned Lao-Thai power interchange is separate from the plans for imports in the PDP.

As described in Section 7.1.2, an LTMS project plan has been in progress, in which Thailand will entrust certain power to Malaysia via Laos to Thailand. Currently, 100 MW is being piloted and there are plans to increase the amount of flexibility, but the purchase price from Laos to Malaysia has not been agreed, and this stage is under consideration.

6.1.7. Power Development Plan for Thailand's EGAT (PDP 2018)

1. Demand forecast in Thailand

According to the latest Thailand PDP2018, the ratio of IPS (Independent Power Supply) is increasing due to an increase in self-generation and self-consumption in the industrial field, accounting for 17% on an energy basis. For this reason, in PDP 2018, unlike the conventional power demand forecast for PDP, the overall electric power demand including IPS is forecasted based on the demand forecast using the correlation with GDP as before. The utilities' demand, excluding IPS from the whole country's demand, is then calculated. The power development plan has been changed to secure supply capacity to meet utilities' demand.

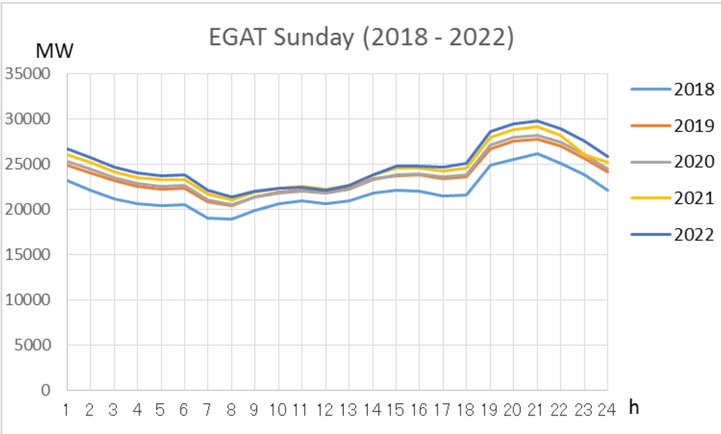


Source: EPPO

Figure 6.1-10 Demand forecast of Utilities (PDP2018)

The GDP growth rate forecast by NESDB is expected to reach 3.8%/year by 2027, 3.6%/year from 2028 to 2032, and to slow to 3.6%/year by 2037 thereafter. Accordingly, the electricity demand (GWh) is expected to grow 3.76%/year by 2027 and 2.83%/year from 2018 to 2037. The load factor is assumed to be 77%, with no significant change. For this reason, the maximum power (MW) is growing at the same rate as the power demand (GWh).

In 2030, electric power demand is expected to be 303,138 GWh and peak demand to be 44,781 MW. By 2030, the peak demand is expected to grow by 15 GW.On the other hand, the increase in PV penetration in IPS has affected the daily load curve. In particular, the effect is large during the weekend. The following figure shows the assumptions on the weekend load curve based on the actual records.



Source: JICA study team based on EGAT documents

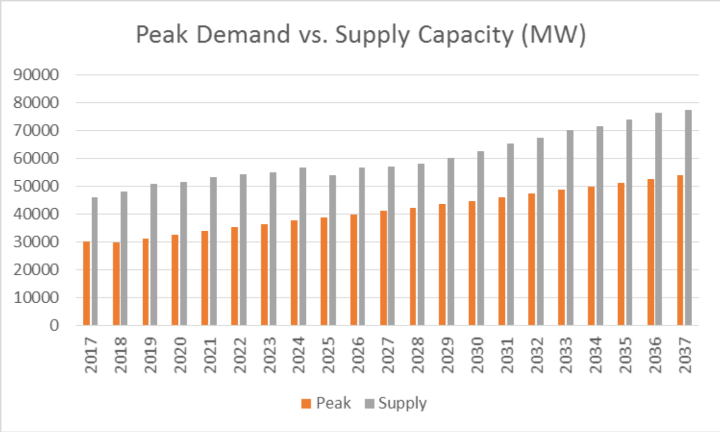
Figure 6.1-11 Daily load curve forecasts of EGAT (PDP2018)

2. Power Development Plan

According to the latest Thai PDP 2018, active introduction of renewable energy and state-of-the-art EMS technology, and micro grids minimize investment in power development and improve power supply system efficiency, thereby reducing electricity tariffs.

The Thai government aims to introduce 20% renewable energy by 2037. In addition, it will promote community power plants (mainly biomass power generation), and use micro grid technology to conduct local production for local consumption.

The contracted supply capacity (MW) at the end of 2030 is 62,554 MW, and at the end of 2037 it is 77,211 MW. The ratio of installed capacity to peak demand is 1.40 in 2030 and 1.42 in 2037, indicating that there is around 40% of reserve capacity.



Source: JICA study team based on PDP2018 and EPPO documents

Figure 6.1-12 Supply/Demand balance in Thai system (PDP2018)

a) Breakdown of power supply facilities at the end of 2017

Since the end of 2017, renewable energy, the output of which is difficult to control, has been introduced, with a capacity of 7,500 MW and PV amounting to around 16% of the peak demand.

- Installed power generation capacity by fuel type

- Combined cycle	20,398 MW	44.3%
- Steam turbine	8,567 MW	18.6%
- Co-generation	5,816 MW	12.6%
- Renewable Energy	10,949 MW	23.8%
- Diesel	60 MW	0.1%
- TNB interconnection	300 MW	0.6%
- Total	46,090 MW	

- Installed capacity by company

- EGAT	16,071 MW	34.9%
- IPP	14,949 MW	32.4%
- SPP	7,536 MW	16.4%
- VSPP	3,656 MW	7.9%
- Imported power	3,878 MW	8.4%
- Total	46,090 MW	

b) Power development plan 2018-2037

According to PDP2018, new power plants amounting to 56,431 MW are to be developed by 2018 through 2037, and facilities of 25,310 MW are to be abolished due to aging. In this way, power plant increases amount to 31,121 MW in comparison with the end of 2017, with power supply equipment becoming 77,211 MW at the end of 2037.

In line with the alternative energy development program (AEDP) by the Thai government, new renewable energy of 18,176 MW is to be introduced by 2037. In addition to floating solar developed by EGAT, a great deal of PV and wind power is to be introduced through SPP and VSPP. It plans to develop 12,725 MW of new PV and 1,485 MW of wind power.

i) Power plant Development by EGAT

EGAT will develop 2,867.2 MW of power plants during 2018-2023, once it has received cabinet approval. The breakdown is as follows.

Project	Capacity	COD
Mae Moh Replacement Units 4-7	600 MW	2018
Lam Takong (PSPP) Units 3-4	500 MW	2018
Lam Takong Wind	24 MW	2018
South Bangkok Replacement	1,220 MW	2019
Bang Pakong Replacement Units 1-2	1,386 MW	2020
Down Stream Hydro	67.95 MW	2018-2023
Siribdhorn Floating Solar	0.25 MW	2018
Floating Solar pilot projects	69 MW	2020-2023
Total	3,867.2 MW	

ii) Power Plant Development by IPP

There are four IPP projects that have a PPA with EGAT, with a total of 5,000 MW expected to be operational between 2021 - 2024.

Project	Capacity	COD
Gulf SRC Unit 1	1,250 MW	2021
Gulf SRC Unit 2	1,250 MW	2022
Gulf PD Unit 1	1,250 MW	2023
Gulf PD Unit 2	1,250 MW	2024
Total	5,000 MW	

iii) SPP

PPA for 85 projects, amounting to 3,665.46 MW, have been signed for development between 2018-2025. Of these, 26 projects, amounting to 1,269.96 MW, are government-subsidized renewable energy projects.

iv) VSPP

944.26 MW has been agreed for development between 2018-2022. Of this, 927.47 MW is renewable energy.

v) Power imports from neighboring countries

The PPA is linked to the following four projects, amounting to 357.3 MW. There are plans to import 700 MW every other year from 2026, with a total of 3,500 MW by 2037. No PPA has been agreed with regard to imports of electricity after 2026, and specific projects have not been clarified.

Project	Capacity	COD
Xayaburi	1,220 MW	2019
Xe Pian – Xe Nam Noi	354 MW	2019
Nam Ngeip 1	269 MW	2019
Nam Theun 1	514.3 MW	2022
Total	2,357.3 MW	

vi) Power supply facilities at the end of 2014

The power supply facilities in Thailand at the end of 2014 based on PDP2015 are shown below.

Table 6.1-12 Power development in Thai system at the end of 2014

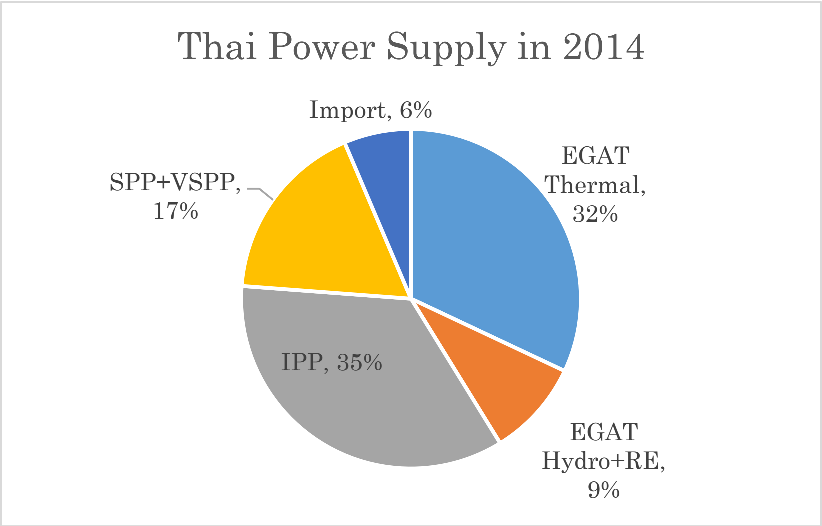
Source: JICA study team based on PDP2015 and EPPO documents

No	Power Plant		MW	Type	COD	Province
1	South Bangkok	Block 1	316.00	CCGT	1994	Samut Prakan
2	South Bangkok	Block 2	562.00	CCGT	2007	Samut Prakan
3	South Bangkok	Block 3	710.00	CCGT	2009	Sumut Prakan
4	Bang Pakong	Unit 3	576.00	Gas/H Oil	1992	Chachoengsao
5	Bang Pakong	Unit 4	576.00	Gas/H Oil	1992	Chachoengsao
6	Bang Pakong	Block 3	314.00	CCGT	1992	Chachoengsao
7	Bang Pakong	Block 4	314.00	CCGT	1992	Chachoengsao
8	Bang Pakong	Block 5	710.00	CCGT	1992	Chachoengsao
9	Mae Moh	Unit 4	140.00	Lignite	1984	Lampang
10	Mae Moh	Unit 5	140.00	Lignite	1984	Lampang
11	Mae Moh	Unit 6	140.00	Lignite	1985	Lampang
12	Mae Moh	Unit 7	140.00	Lignite	1985	Lampang
13	Mae Moh	Unit 8	270.00	Lignite	1989	Lampang
14	Mae Moh	Unit 9	270.00	Lignite	1990	Lampang
15	Mae Moh	Unit 10	270.00	Lignite	1991	Lampang
16	Mae Moh	Unit 11	270.00	Lignite	1991	Lampang
17	Mae Moh	Unit 12	270.00	Lignite	1995	Lampang
18	Mae Moh	Unit 13	270.00	Lignite	1995	Lampang
19	Krabi	Unit 1	315.00	H Oil	2003	Krabi
20	Nam Pong	Block 1	325.00	CCGT	1992	Khon Kaen
21	Nam Pong	Block 2	325.00	CCGT	1994	Khon Kaen
22	Wang Noi	Block 1	612.00	CCGT	1997	Ayutthaya
23	Wang Noi	Block 2	612.00	CCGT	1997	Ayutthaya
24	Wang Noi	Block 3	686.00	CCGT	1998	Ayutthaya
25	Wang Noi	Block 4	750.00	CCGT	2014	Ayutthaya
26	Chana	Block 1	710.00	CCGT	2008	Songkhla
27	Chana	Block 2	766.00	CCGT	2014	Songkhla
28	North Bangkok	Block 1	670.00	CCGT	2010	Nonthaburi
29	Mae Hong Son		4.40	Diesel	1993	Mae Hong Son
EGAT-Thermal			**12033.40**			
30	Bhumibol		779.20	Reservoir	1964	Tak
31	Sirikit		500.00	Reservoir	1977	Uttaradit
32	Sirindhorn		36.00	Reservoir	1972	Ubon Ratchathani
33	Chulaphorn		40.00	Reservoir	1973	Chaiyaphum
34	Ubol Ratana		25.20	Reservoir	1966	Khon Kaen
35	Srinagarind		720.00	Reservoir	1981	Kanchanaburi
36	Vajiralongkorn		300.00	Reservoir	1986	Kanchanaburi
37	Tha Thung Na		39.00	Reservoir	1978	Kanchanaburi
38	Kaeng Krachan		19.00	Reservoir	1974	Phetchaburi
39	Bang Lang		72.00	Reservoir	1981	Yala
40	Rajjaprabha		240.00	Reservoir	1987	Surat Thani
41	Pak Mun		136.00	Reservoir	1979	Ubon Ratchathani
42	Lam Ta Khong		500.00	PSPP	2013	Nakhon Ratchasima
43	Small Hydro		37.8	Run-of-river		
EGAT-Hydro			**3444.20**			
44	Fang		0.30	Geothermal	1989	Chiang Mai
45	Solar		1.60	Solar		
46	Wind		2.69	Wind		
EGAT-Total			**15482.19**			
Purchased Power						

No	Power Plants		MW	Type	COD	Owner
47	Khanom	Unit 2	70.20	Gas/H Oil	1989	EGCO
48	Khanom	Block 1	678.00	CCGT	1995	EGCO
49	Ratchaburi	Unit 1	720.00	Gas/H Oil	2000	Ratchaburi Power
50	Ratchaburi	Unit 2	720.00	Gas/H Oil	2000	Ratchaburi Power
51	Ratchaburi	Block 1	685.00	CCGT	2002	Ratchaburi Power
52	Ratchaburi	Block 2	675.00	CCGT	2002	Ratchaburi Power
53	Ratchaburi	Block 3	681.00	CCGT	2003	Ratchaburi Power
54	BLCP Power	Unit 1	673.30	Coal	2006	BLCP Power Co., Ltd.
55	BLCP Power	Unit 2	673.30	Coal	2007	BLCP Power Co., Ltd.
56	Gheco-One	Block 1	660.00	Coal	2012	Gheco-One Co., Ltd.
57	Tri Energy	Block 1	700.00	CCGT	2000	Tri Energy Co., Ltd.
58	GlobalPowerSyn.	Block 1	700.00	CCGT	2000	Global Power Synegy
59	Glow IPP	Block 1	356.50	CCGT	2003	Glow IPP Co., Ltd.
60	Glow IPP	Block 2	356.50	CCGT	2003	Glow IPP Co., Ltd.
61	Eastern P&E	Block 1	350.00	CCGT	2003	Eastern Power & Energy
62	Gulf Power Gen.	Block 1	734.00	CCGT	2006	Gulf Power Generation
63	Gulf Power Gen.	Block 2	734.00	CCGT	2008	Gulf Power Generation
64	RatchaburiPower	Block 1	700.00	CCGT	2008	Ratchaburi Power
65	RatchaburiPower	Block 2	700.00	CCGT	2008	Ratchaburi Power
66	Gulf JP NS	Block 1	800.00	CCGT	2015	Gulf JP NS Co., Ltd.
67	Gulf JP NS	Block 2	800.00	CCGT	2015	Gulf JP NS Co., Ltd.
68	SPP		369.50	Coal		
69	SPP		4.50	H Oil		
70	SPP		2807.00	Gas		
71	SPP		120.00	GT		
72	SPP		313.60	Biomass		
73	SPP non-firm		914.923			
74	VSPP		2029.00			
	Theun Hinboun		434.00	Reservoir	1999	Laos
75	Houay Ho		126.00	Reservoir	2000	Laos
76	Nam Theun 2		948.00	Reservoir	2006	Laos
77	Nam Ngum 2		596.60	Reservoir	2009	Laos
78	TNB Link		300.00			
Purchased Power-Total			**22129.92**			
Total			**37612.11**			

Since the maximum power of the power company's system in 2018 was 29,969 MW, the supply capacity at the end of 2014 already has a 25.5% reserve.

In addition, since power purchased from IPP and the like uses Take or Pay contracts, there is basically no margin for supply and demand adjustment. Therefore, reduction of thermal power by importing hydropower from Laos will be done via adjustment at the EGAT power plants. EGAT's thermal power generation capacity was 12,033.4 MW at the end of 2014, which is 40% of the maximum power in 2018, and is considered to have sufficient adjustment capacity.



Source: JICA study team

Figure 6.1-13 Installed capacity of power sources at the end of 2014

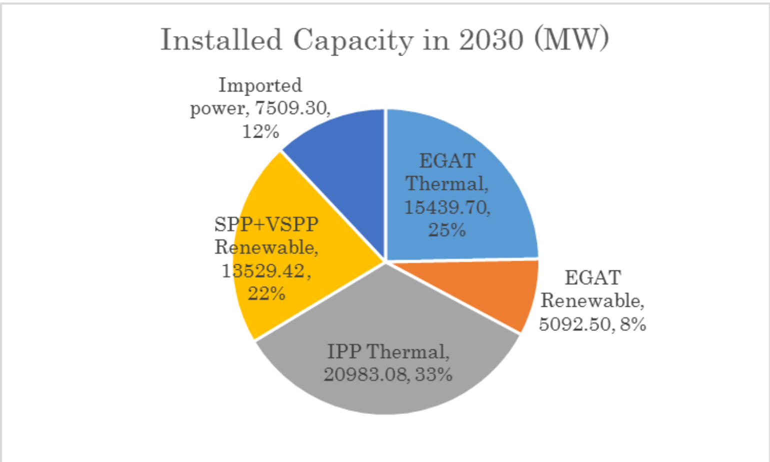
vii) Installed capacity at the end of 2030

The installed capacity of power plants at the end of 2030 is estimated by adding the developed power supply described in PDP2018 to the power supply equipment at the end of 2014 based on PDP2015.

The composition ratio of thermal power generation owned by EGAT is reduced to 25%, but it is still 15 GW, which can sufficiently absorb excess hydropower in Laos.

The share of renewable energy from SPP and VSPP has increased to 30%. The PV share is more than half of this, and there is a possibility that the securing of spinning reserve may cause issues.

In 2030, Thailand's electricity imports were 7509.3 MW, most of which came from Laos. Houay Ho (126 MW) will be returned to Laos after the PPA ends in 2029. Nam Thuen 2 (948 MW) will also end its PPA in 2031.



Source: JICA study team

Figure 6.1-14 Installed capacity of power plants in Thai system at the end of 2030

Table 6.1-13 Imported power in Thai system at the end of 2030

Project	Capacity (MW)	COD	Remarks
Back to back with TNB	300	1990	Thermal
Theun Hinboun	434	1999	Reservoir, PPA extended
Nam Theun 2	948	2006	Reservoir, PPA 2031
Nam Ngum 2	597	2009	Reservoir
Hongsa Lignite	1473	2012	Thermal
Xayaburi	1220	2019	Run of river
Xe Pian – Xe Nam Noi	354	2019	Reservoir
Nam Ngiep 1	269	2019	Reservoir
Nam Theun 1	514.3	2022	Reservoir
Power Purchase	700 x 2	2026, 2028	

6.2. Vietnam

6.2.1. Current Status of Power Development Plan Formulation

Vietnam's Power Development Plan has been formulated every 5 years and the latest one is the 7th Power Development Plan (PDP7). PDP7 was formulated in July 2011 as the plan for the years from 2011 to 2030 and it was revised on March 18th, 2016. The revised version focuses on power development for renewable energy.

From the end of 2018, IE began preparing to develop the next PDP (PDP 8). The following is a description based on the information on the PDP 7 revised edition.

6.2.2. Regional Categorization

Vietnam has a long north-south territory and eight north-south regions: Northwest, Northeast, Red River Delta, North Central, South Central Coast, Central Highlands, Southeast, and Mekong River Delta. The northern and central regions can be further divided into two regions based on the eight divisions. The northern part is divided into the northern part 1, which has a large hydropower ratio and large power demand, and the northern part 2, which has a large amount of power generation equipment such as coal-fired power generation but has a small power demand. In addition, the central part can be further divided into central part 1, in the central part of the north central part, and central part 2, in the central part of the south central part.[1]

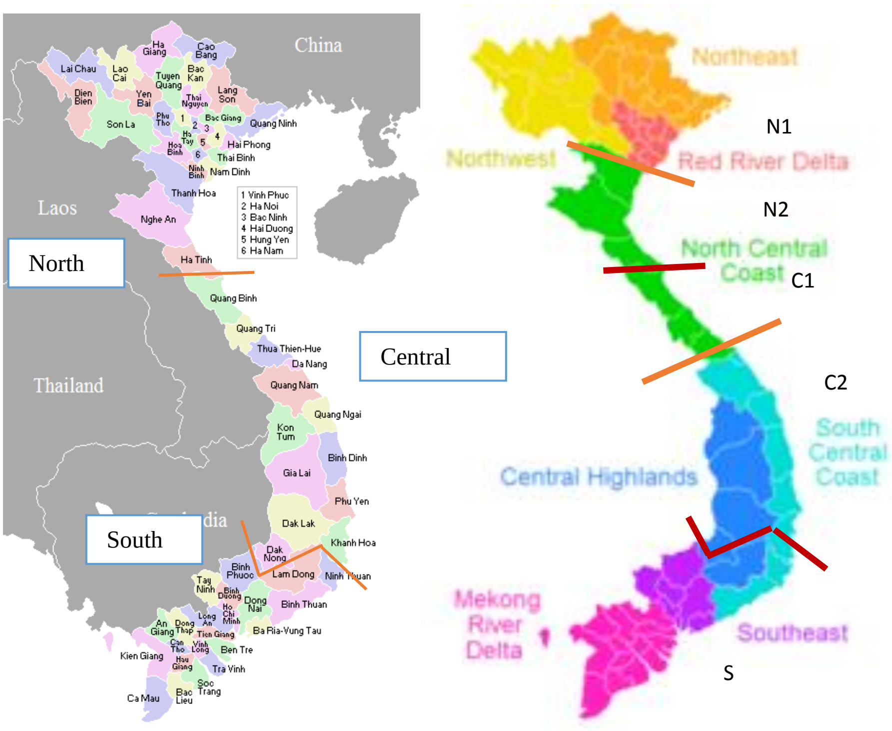


Figure 6.2-1 Region Classification in Vietnam System Development Plan

6.2.3. Power Demand Forecast in Vietnam

The regional breakdown for the power demand forecast assumed in PDP7 was obtained from IE in November 2017. Table 6.2-1 shows the power demand forecast for Vietnam.

The growth ratio for the power demand is assumed to be around 9% per year. The peak power

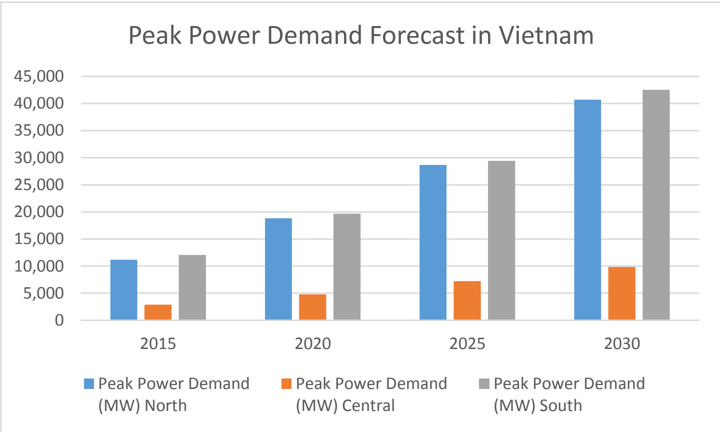
[1]This splitting method is used only in this chapter

demand is 11,150 MW for the North and 12,070 MW for the South in 2015. The peak power demand forecasts in 2030 are 40,704 MW for the North and 42,521 MW for the South.

Table 6.2-1 Power Demand Forecast in Vietnam

		2015	2020	2025	2030
Peak Power Demand (MW)	North	11,150	18,812	28,663	40,704
	Central	2,883	4,790	7,236	9,858
	South	12,070	19,666	29,415	42,521
Energy Demand (GWh)	North	63,623	107,753	165,719	237,472
	Central	15,579	26,057	39,837	54,919
	South	82,048	131,596	194,771	279,361
Load Factor	North	65%	65%	66%	67%
	Central	62%	62%	63%	64%
	South	78%	76%	76%	75%

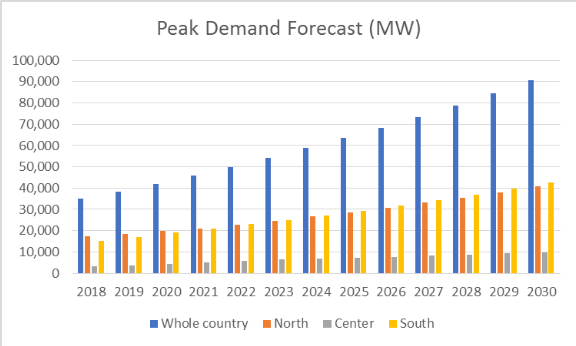
(Source: Information from IE, November 2017)

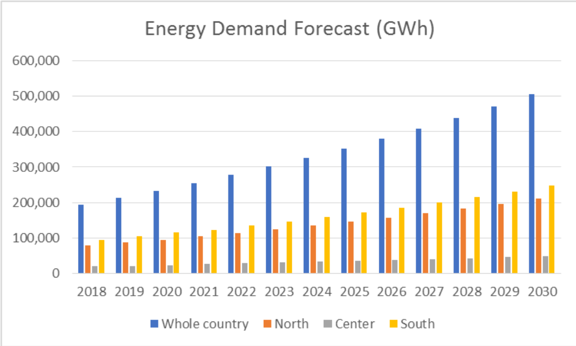


(Source: Information from IE, November 2017)

Figure 6.2-2 Power Demand Forecast in Vietnam

The forecast of the maximum power demand and the power demand energy is shown for each region. Power demand is concentrated in the north and south. The assumptions up to around 2025 have been slightly revised upward from the values obtained in 2018. The maximum power demand is currently around 35,000 to 40,000 MW, but it is expected to be about 90,000 MW in 2030.





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Changes in power generation capacity by region are shown below. Power generation capacity is concentrated in N1, C2 and S. However, N1 and S also have large power demands, so it is necessary to look at the supply and demand balance by region.

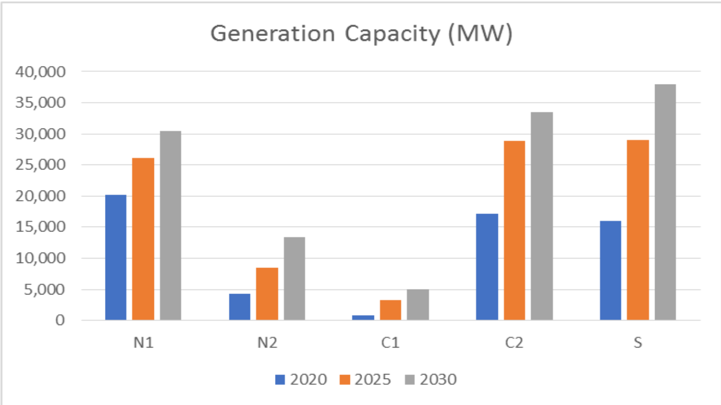


Figure 6.2-4 Trends in power generation capacity by region

6.2.4. Power Generation Plan in Vietnam

The existing power plants in Vietnam in 2015 are shown in Table 6.2-6. The total power generation capacity is 38,537 MW, and the available power generation capacity is 37,116 MW. The share of hydropower is 41%, coal fired power is 36%, and combined cycle is 20%. The sum of hydropower, coal fired power and combined cycle makes up 97% of the total.

The capacity of power generation facilities for enterprises other than EVN is 12,595 MW, accounting for 33% of the total.

Hydropower is mainly installed in the north and central regions, and especially in the northwest, with 5,971 MW of hydropower plants in total. Coal fired power is more prevalent in the north than other regions, and the south has many combined cycle plants.

The IPPs with existing contracts in Laos are reflected in Vietnam's current power generation plan, but other power imports from China and Laos are not included.

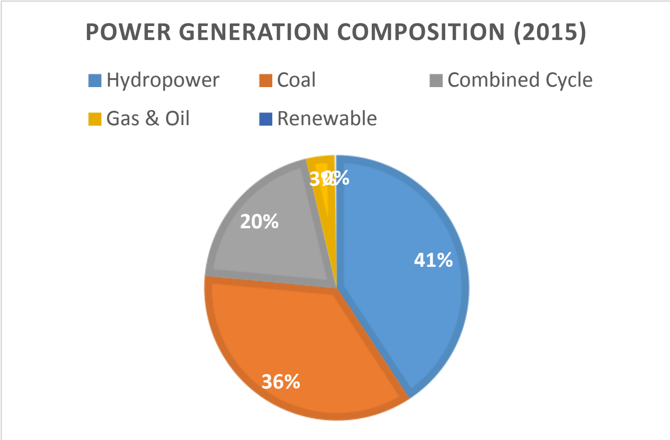


Figure 6.2-5 Composition of Power Generation in Vietnam in 2015

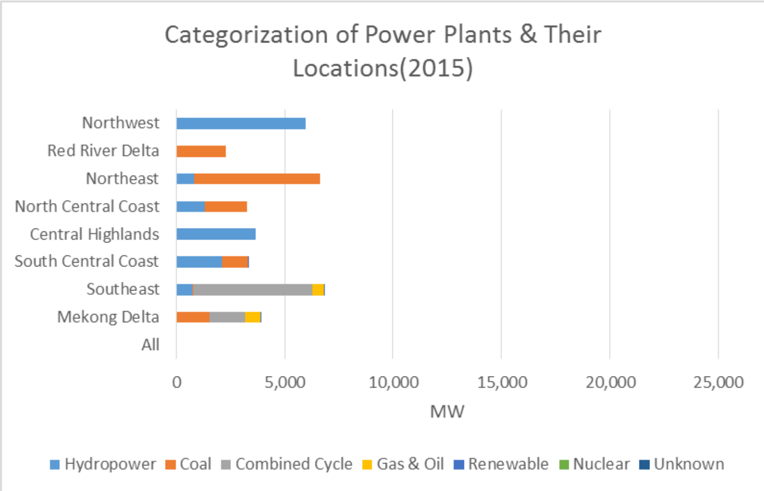


Figure 6.2-6 The Locations and Compositions of Power Generation in Vietnam in 2015

Table 6.2-2 The Locations and Compositions of Power Generation in Vietnam in 2015

2015	All	Mekong Delta	Southeast	South Central Coast	Central Highlands	North Central Coast	Northeast	Red River Delta	Northwest	Unknown	Total
Hydropower	1,320	0	721	2,110	3,670	1,306	849	0	5,971	0	15,947
Coal	0	1,544	72	1,200	0	1,950	5,785	2,280	0	0	12,831
Combined Cycle	0	1,632	5,471	0	0	0	0	0	0	0	7,103
Gas & Oil	0	693	549	0	0	0	0	0	0	0	1,242
Renewable	0	45	24	24	0	0	0	0	0	0	93
Nuclear	0	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0
Total	1,320	3,914	6,837	3,334	3,670	3,256	6,634	2,280	5,971	0	37,216

(Source: Made by JICA Study Team based on the information from IE)

The available power generation capacity in 2020 is 58,866 MW. The share of hydropower is 34%, coal fired power is 43%, combined cycle is 14% and renewable energy is 6%.

Renewable power of 3,600 MW is being developed mainly in the central and southern areas from 2016 to 2020. Coal-fired power plants are being developed almost equally in the regions, with 3,700 MW in the north, 4,350 MW in the central area and 4,470 MW in the south.

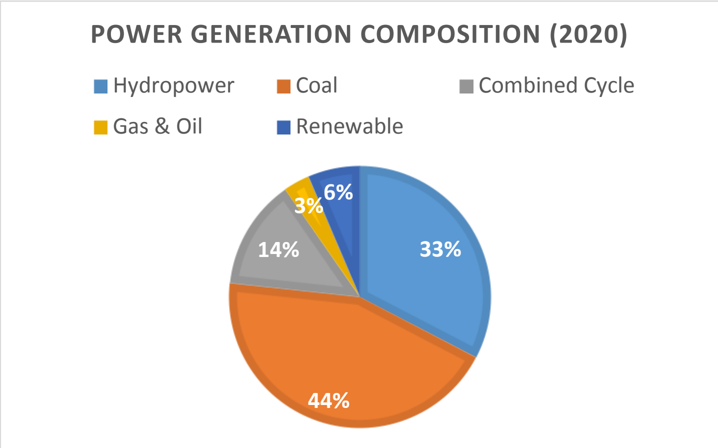


Figure 6.2-7 Composition of Power Generation in Vietnam in 2020

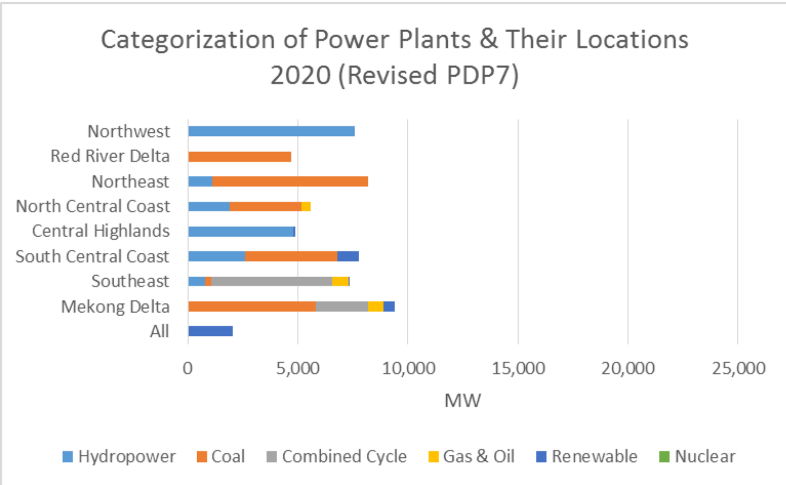


Figure 6.2-8 The Locations and Compositions of Power Generation in Vietnam in 2020

Table 6.2-3 The Locations and Compositions of Power Generation in Vietnam in 2020

2020	All	Northwest	Red River Delta	Northeast	North Central Coast	Central Highlands	South Central Coast	Southeast	Mekong Delta	Unknown	Total
Hydropower	1,320	7,580	0	1,126	1,890	4,798	2,589	796	0	0	20,099
Coal	0	0	4,680	7,085	3,300	0	4,200	282	5,804	0	25,351
Combined Cycle	0	0	0	0	0	0	0	5,471	2,382	0	7,853
Gas & Oil	0	0	0	0	400	0	0	774	693	0	1,867
Renewable	2,060	0	0	0	0	110	991	24	511	0	3,696
Nuclear	0	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0
Total	3,380	7,580	4,680	8,211	5,590	4,908	7,780	7,347	9,390	0	58,866

(Source: Made by JICA Study Team based on the information from IE)

The available power generation capacity in 2025 is 96,426 MW. The share of hydropower is 23%, coal fired power is 49%, combined cycle is 16% and renewable energy is 10%.

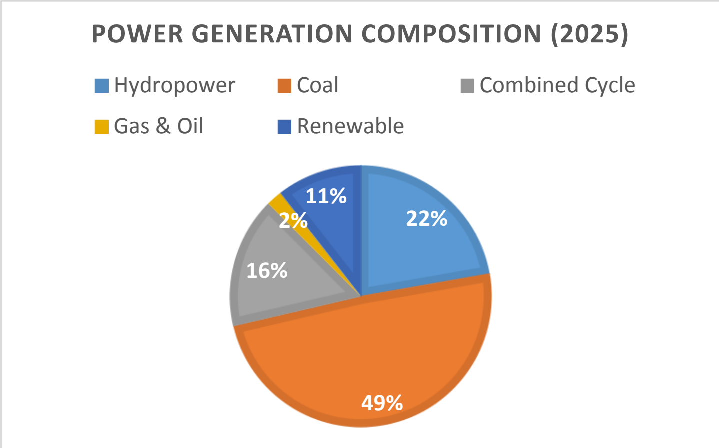


Figure 6.2-9 Composition of Power Generation in Vietnam in 2025

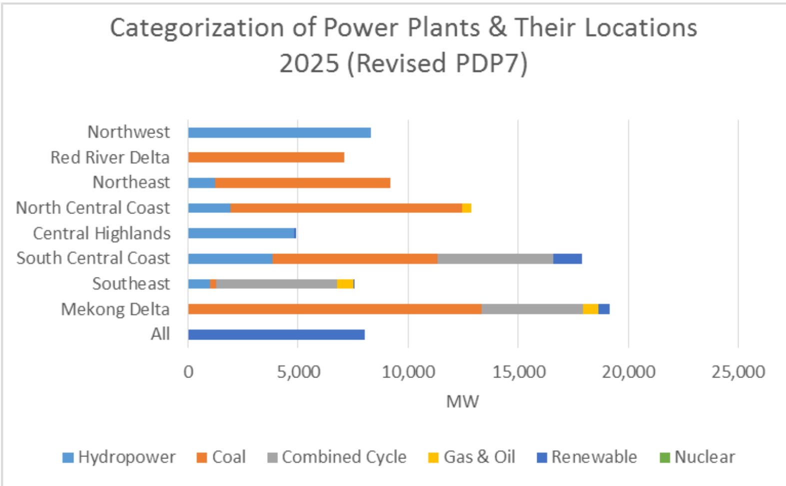


Figure 6.2-10 The Locations and Compositions of Power Generation in Vietnam in 2025

Table 6.2-4 The Locations and Compositions of Power Generation in Vietnam in 2025

2025	All	Mekong Delta	Southeast	South Central Coast	Central Highlands	North Central Coast	Northeast	Red River Delta	Northwest	Unknown	Total
Hydropower	1,320	0	996	3,849	4,798	1,950	1,231	0	8,310	0	22,454
Coal	0	13,324	282	7,500	0	10,500	7,980	7,080	0	0	46,666
Combined Cycle	0	4,632	5,471	5,250	0	0	0	0	0	0	15,353
Gas & Oil	0	693	774	0	0	400	0	0	0	0	1,867
Renewable	8,050	511	24	1,291	110	0	0	0	0	0	9,986
Nuclear	0	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	100	100
Total	9,370	19,160	7,547	17,890	4,908	12,850	9,211	7,080	8,310	100	96,426

(Source: Made by JICA Study Team based on the information from IE)

The available power generation capacity in 2030 is 132,618 MW. The share of hydropower is 18%, coal fired power is 44%, combined cycle is 13% and renewable energy is 19%.

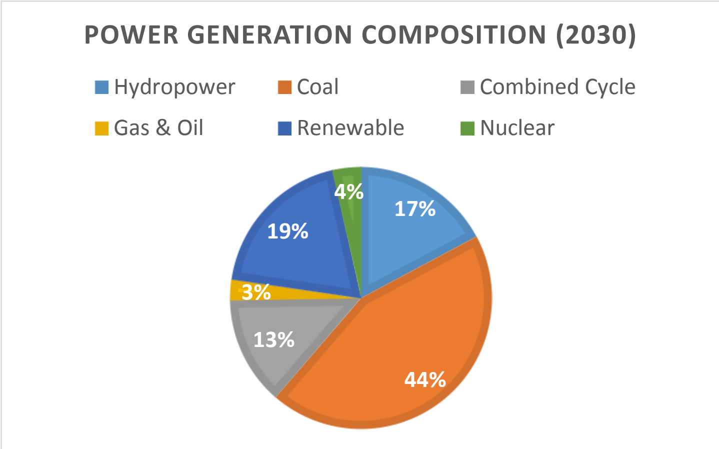


Figure 6.2-11 Composition of Power Generation in Vietnam in 2030

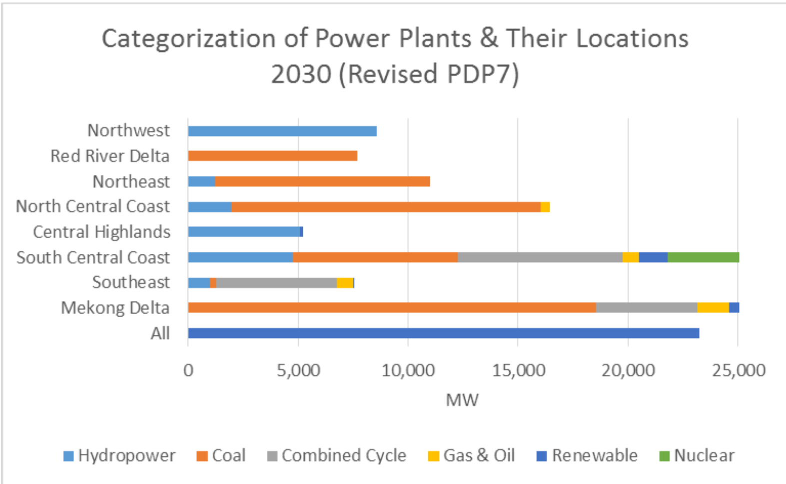


Figure 6.2-12 The Locations and Compositions of Power Generation in Vietnam in 2030

Table 6.2-5 The Locations and Compositions of Power Generation in Vietnam in 2030

2030	All	Mekong Delta	Southeast	South Central Coast	Central Highlands	North Central Coast	Northeast	Red River Delta	Northwest	Unknown	Total
Hydropower	1,320	0	996	4,749	5,098	1,950	1,231	0	8,562	0	23,906
Coal	0	18,524	282	7,500	0	14,100	9,780	7,680	0	0	57,866
Combined Cycle	0	4,632	5,471	7,500	0	0	0	0	0	0	17,603
Gas & Oil	0	1,443	774	750	0	400	0	0	0	0	3,367
Renewable	23,240	511	24	1,291	110	0	0	0	0	0	25,176
Nuclear	0	0	0	4,600	0	0	0	0	0	0	4,600
Unknown	0	0	0	0	0	0	0	0	0	100	100
Total	24,560	25,110	7,547	26,390	5,208	16,450	11,011	7,680	8,562	100	132,618

(Source: Made by JICA Study Team based on the information from IE)

Table 6.2-6 Existing Power Plants in Vietnam (2015)

				Unit	Install	Available	Owner
			EVN Hydropower Plant		**11424**	**11364**	
Northwest	Son La	Son La	Hydropower	6	2400	2400	EVN
Northwest	Hoa Binh	Hoa Binh	Hydropower	8	1960	1960	EVN
Northeast	Yen Bai	Thac Ba	Hydropower	3	120	120	GENCO 3
Northeast	Tuyen Quang	Tuyen Quang	Hydropower	3	342	342	EVN
North Central Coast	Nghe An	Ban Ve	Hydropower	2	320	320	GENCO 1
Northwest	Lai Chau	Ban Chat	Hydropower	2	220	220	GENCO 3
Northwest	Lai Chau	Huoi Quang	Hydropower	1	260	260	EVN
Northwest	Lai Chau	Lai Chau	Hydropower	1	400	400	EVN
North Central Coast	Thua Thien Hue	A Luoi	Hydropower	2	170	170	GENCO 1
North Central Coast	Quang Tri	Quang Tri	Hydropower	2	64	64	GENCO 2
South Central Coast	Quang Nam	A Vuong	Hydropower	2	210	210	GENCO 2
North Central Coast	Thanh Hoa	Vinh Son	Hydropower	2	66	66	GENCO 3
North Central Coast	Thanh Hoa	Song Hinh	Hydropower	2	70	70	GENCO 3
Central Highlands	Kon Tum	Plei Krong	Hydropower	2	100	100	EVN
Central Highlands	Gia Lai	Ialy	Hydropower	4	720	720	EVN
Central Highlands	Gia Lai	Se San 3	Hydropower	2	260	260	EVN
Central Highlands	Gia Lai	Se San 4	Hydropower	3	360	360	EVN
Central Highlands	Gia Lai	Se San 3A	Hydropower	2	108	108	EVN
Central Highlands	Dak Lak	Buon Tua Srah	Hydropower	2	86	86	GENCO 3
South Central Coast	Quang Nam	Song Tranh 2	Hydropower	2	190	190	GENCO 1
Central Highlands	Dak Lak	Srepok 3	Hydropower	2	220	220	GENCO 3
Central Highlands	Gia Lai	An Khe - Kanak	Hydropower	2+2	173	173	GENCO 2
Central Highlands	Dak Lak	Buon Kuop	Hydropower	2	280	280	GENCO 3
South Central Coast	Phu Yen	Song Ba Ha	Hydropower	2	220	220	GENCO 2
Central Highlands	Dak Nong	Dong Nai 3	Hydropower	2	180	180	GENCO 1
Central Highlands	Dak Nong	Dong Nai 4	Hydropower	2	340	340	GENCO 1
Southeast	Dong Nai	Tri An	Hydropower	4	400	440	EVN
Central Highlands	Lam Dong	Da Nhim	Hydropower	4	160	160	GENCO 1
Southeast	Binh Phuoc	Thac Mo	Hydropower	2	150	150	GENCO 2
South Central Coast	Binh Thuan	Ham Thuan	Hydropower	2	300	300	GENCO 1
South Central Coast	Binh Thuan	Da Mi	Hydropower	2	175	175	GENCO 1
South Central Coast	Binh Thuan	Dai Ninh	Hydropower	2	300	300	GENCO 1
North Central Coast	Nghe An	Khe Bo	Hydropower	2	100	100	GENCO 1
			EVN Coal Thermal Power Plant		**8459**	**8324**	
Red River Delta	Hai Duong	Pha Lai 1	Coal	4	440	400	GENCO 2
Red River Delta	Hai Duong	Pha Lai 2	Coal	2	600	580	GENCO 2
Northeast	Quang Ninh	Uong Bi	Coal	2	630	600	GENCO 1
Red River Delta	Ninh Binh	Ninh Binh	Coal	4	100	100	GENCO 3
Red River Delta	Hai Phong	Hai Phong	Coal	4	1200	1200	GENCO 2
Northeastern	Quang Ninh	Quang Ninh	Coal	4	1200	1200	GENCO 1
North Central Coast	Thanh Hoa	Nghi Son	Coal	2	600	600	GENCO 1
South Central Coast	Binh Thuan	Vinh Tan	Coal	2	1245	1200	GENCO 3
Mekong Delta	Tra Vinh	Duyen Hai 1	Coal	2	1244	1244	GENCO 1
Northeast	Quang Ninh	Mon Duong 1	Coal	2	1200	1200	GENCO 3
			Oil Thermal Power Plant		**867**	**846**	
Southeast	HCM	Thu Duc	Oil	3	169.5	153	GENCO 2
Mekong Delta	Can Tho	Can Tho	Oil	1	37	33	GENCO 2
Mekong Delta	Can Tho	O Mon	Oil	2	660	660	GENCO 2
			Gas Turbine & Combined Cycle Thermal Power Plant		**3209**	**2945**	
Southeast	Ba Ria- Vung Tau	Ba Ria	Combined Cycle	8GT +S9 +S1(	388	334	GENCO 3
Southeast	Ba Ria- Vung Tau	Phu My 2	Combined Cycle	4GT +ST23,2	949	860	GENCO 3
Southeast	Ba Ria- Vung Tau	Phu My 1	Combined Cycle	3GT +ST4	1140	1090	GENCO 3
Southeast	Ba Ria- Vung Tau	Phu My 4	Combined Cycle	2GT+ST3	468	440	GENCO 3
Southeast	HCM	Thu Duc	Combined Cycle	4GT	114	89	GENCO 2
Mekong Delta	Can Tho	Can Tho	Combined Cycle	4GT	150	132	GENCO 2
			Small Hydropower Plants		**1984**	**1320**	

				Other than EVN	**12595**	**12317**
Northwest	Son La	Nam Chien 2	Hydropower	2	32	32
Northwest	Lao Cai	Bac Ha	Hydropower	2	90	90
Northeast	Ha Giang	Nho Que	Hydropower	2	110	110
North Central Coast	Thanh Hoa	Cua Dat	Hydropower	2	97	97
Northeast	Tuyen Quang	Chiem Hoa	Hydropower	3	48	48
Northwest	Lao Cai	Su Pan	Hydropower	3	34.5	35
Northwest	Lao Cai	Nam Phang	Hydropower	2	36	36
Northwest	Lao Cai	Muong Hum	Hydropower	2	32	32
North Central Coast	Thanh Hoa	Ba Thuoc	Hydropower	4	80	80
North Central Coast	Nghe An	Hua Na	Hydropower	2	180	180
Northwest	Son La	Nam Chien 1	Hydropower	2	200	200
Northeast	Yen Bai	Van Chan	Hydropower	3	57	57
Northwest	Lao Cai	Ta Thang	Hydropower	2	60	60
Northeast	Ha Giang	Song Bac	Hydropower	2	42	42
Northwest	Lao Cai	Ngoi Phat	Hydropower	3	72	72
Northeast	Yen Bai	Ngoi Hut	Hydropower	2	48	48
Northwest	Lai Chau	Nam Na	Hydropower	3	66	66
Northwest	Dien Bien	Nam Muc 2	Hydropower	2	44	44
Northeast	Lang Son	Na Duong	Coal	2	110	110
Northeast	Thai Nguyen	Cao Ngan	Coal	2	115	115
Northeast	Quang Ninh	Cam Pha	Coal	2	660	600
Northeast	Bac Giang	Son Dong	Coal	2	220	200
Northeast	Quang Ninh	Mao Khe	Coal	2	440	440
Northeast	Quang Ninh	Mon Duong 2	Coal	2	1245	1200
North Central Coast	Ha Tinh	Vung Ang	Coal	2	1245	1200
North Central Coast	Ha Tinh	Formosa Ha Tinh	Coal	1	150	150
Northeast	Thai Nguyen	An Khanh	Coal	2	120	120
North Central Coast	Ha Tinh	Huong Son	Hydropower	2	34	34
Northeast	Ha Giang	Thai An	Hydropower	2	82	82
North Central Coast	Thua Thien Hue	Binh Dien	Hydropower	2	44	44
South Central Coast	Quang Nam	Song Con	Hydropower	3	63	63
South Central Coast	Quang Nam	Song Bung 5	Hydropower	2	57	57
South Central Coast	Quang Nam	Song Bung 4A	Hydropower	2	49	49
Central Highlands	Gia Lai	Se San 4A	Hydropower	3	63	63
Northwest	Lai Chau	Krong H'nang	Hydropower	2	64	64
Central Highlands	Dak Lak	Srepok 4	Hydropower	2	80	80
Central Highlands	Dak Lak	Srepok 4A	Hydropower	2	64	64
Central Highlands	Lam Dong	Dam Bri	Hydropower	2	75	75
North Central Coast	Thua Thien Hue	Huong Dien	Hydropower	3	81	81
Central Highlands	Dak Lak	Dak R'tih	Hydropower	4	144	144
South Central Coast	Quang Nam	Dak Mi 4	Hydropower	5	195	195
South Central Coast	Quang Nam	Song Bung 4A	Hydropower	2	156	156
South Central Coast	Khan Hoa	Song Giang 2	Hydropower	2	37	37
South Central Coast	Quang Ngai	Dak Drinh	Hydropower	2	125	125
Central Highlands	Dak Nong	Dong Nai 2	Hydropower	2	73	73
South Central Coast	Binh Thuan	Bac Binh	Hydropower	2	33	33
Central Highlands	Dak Nong	Dong Nai 5	Hydropower	2	150	150
Central Highlands	Lam Dong	Da Dang 2	Hydropower	2	34	34
Southeast	Binh Phuoc	Can Don	Hydropower	2	78	80
Southeast	Binh Phuoc	Srok Phu Mieng	Hydropower	2	51	51
Southeast	HCM	Hiep Phuoc	Oil	3	375	375
Mekong Delta	Long An	Formosa	Coal	2	310	300
Southeast	Ba Ria- Vung Tau	Phu My 3	Combined Cycle	2GT+ST3	740	743
Southeast	Ba Ria- Vung Tau	Phu My 22	Combined Cycle	2GT+ST3	740	715
Southeast	HCM	Nhon Trach 1	Combined Cycle	2GT+ST3	465	450
Southeast	HCM	Nhon Trach 2	Combined Cycle	2GT+ST3	750	750
Mekong Delta	Ca Mau	Ca Mau 1	Combined Cycle	2GT+ST1	771	750
Mekong Delta	Ca Mau	Ca Mau 2	Combined Cycle	2GT+ST4	771	750
Southeast	Dong Nai	Ve Dan	Coal	2	72	72
Southeast	Tay Ninh	Bourbon	Biomass	2	24	24
South Central Coast	Binh Thuan	Tuy Phong (Wind)	Wind		30	24
Mekong Delta	Bac Lieu	Bac Lieu (Wind)	Wind		60	45
Southeast	Ba Ria- Vung Tau	Dam Phu My	Gas	1	21	21
				Total	**38537**	**37116**

(Source: Information from IE, November 2017)

Table 6.2-7 Vietnam's Power Development Plan

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2016	Northeast	Ha Giang	Nho Que 2	Hydropower	48	48	IPP
2016	Northeast	Ha Giang	Nho Que 1	Hydropower	32	32	IPP
2016	Northwest	Lai Chau	Nam Na 3	Hydropower	84	84	IPP
2016	Northwest	Lao Cai	Nam Toong	Hydropower	34	34	IPP
2016	Northeast	Ha Giang	Bac Me	Hydropower	45	45	IPP
2016	North Central Coast	Thanh Hoa	Ba Thuoc 1	Hydropower	60	60	IPP
2016	South Central Coast	Quang Nam	Song Tranh 3	Hydropower	62	62	IPP
2016	Northwest	Lai Chau	Huoi Quang Unit2	Hydropower	260	260	EVN
2016	Northwest	Lai Chau	Lai Chau Unit 2 & 3	Hydropower	2x400	800	EVN
2016	North Central Coast	Thanh Hoa	Trung Son Unit 1 & 2	Hydropower	2x65	130	EVN
2016	North Central Coast	Nghe An	Nhan Hac	Hydropower	59	59	IPP
2016	South Central Coast	Quang Nam	Song Bung 2	Hydropower	100	100	EVN
2016	Central Highlands	Laos	Xekaman 1 (Laos)	Hydropower	290	290	Viet Lao Power Joint-stock Company
2016	South Central Coast	Quang Nam	Song Tranh 4	Hydropower	48	48	IPP
2016	South Central Coast	Quang Nam	Dak Mi 2	Hydropower	98	98	IPP
2016	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 2	Coal	150	150	IPP - coal based power
2016	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 3 & 4	Gas	2x100	200	IPP - blast furnace gas
2016	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 5	Coal	150	150	IPP - coal based power
2016	South Central Coast	Quang Nam	Dak Mi 3	Hydropower	45	45	IPP
2016	Southeast	Dong Nai	Formosa Dong Nai Unit 3	Coal	150	150	IPP
2016	Southeast	Dong Nai	Ve Dan	Coal	60	60	IPP (cogeneration)
2016	Mekong Delta	Tra Vinh	Duyen Hai III Unit 1	Coal	600	600	EVN
2016	South Central Coast	Phu Yen	KCP Unit 1	Biomass	30	30	IPP (Phu Yen)
2016	All	All	Renewable energy	Renewable	260	260	
2017	North Central Coast	Nghe An	Chi Khe	Hydropower	41	41	IPP

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2017	Northwest	Dien Bien	Long Tao	Hydropower	42	42	IPP
2017	North Central Coast	Thanh Hoa	Trung Son Unit 3 & 4	Hydropower	2x65	130	EVN
2017	Northeast	Tuyen Quang	Yen Son	Hydropower	70	70	Binh Minh Construction & Travel Group Joint-stock Company
2017	South Central Coast	Quang Ngai	Tra Khuc 1	Hydropower	36	36	IPP
2017	Central Highlands	Laos	Xekaman Xanxay 1 (Laos)	Hydropower	32	32	Viet Lao Power Joint-stock Company
2017	Southeast	Binh Phuoc	Thac Mo Expansion	Hydropower	75	75	EVN
2017	Red River Delta	Thai Binh	Thai Binh I Unit 1 & 2	Coal	2x300	600	EVN
2017	Red River Delta	Thai Binh	Thai Binh II Unit1	Coal	600	600	PVN
2017	Mekong Delta	Tra Vinh	Duyen Hai III Unit 2	Coal	600	600	EVN
2017	Southeast	Ba Ria- Vung Tau	Long Son Unit 1	Oil	75	75	IPP (cogeneration)
2017	Central Highlands	Gia Lai	An Khe Unit 1	Biomass	55	55	Quang Ngai Sugar Joint-stock Company
2017	All	All	Renewable energy	Renewable	360	360	
2018	Northeast	Ha Giang	Song Lo 6	Hydropower	44	44	Xuan Thien Ha Giang Co., Ltd
2018	North Central Coast	Thanh Hoa	Hoi Xuan	Hydropower	102	102	IPP
2018	Northeast	Ha Giang	Song Mien 4	Hydropower	38	38	IPP
2018	South Central Coast	Binh Thuan	La Ngau	Hydropower	36	36	La Ngau Hydropower Joint-stock Company
2018	South Central Coast	Quang Nam	Dak Mi 1	Hydropower	54	54	IPP
2018	Central Highlands	Lam Dong	Da Nhim Expansion	Hydropower	100	100	EVN
2018	Central Highlands	Laos	Xekaman 4 (Laos)	Hydropower	80	80	Viet Lao Power Joint-stock Company
2018	North Central Coast	Thua Thien Hue	A Lin	Hydropower	62	62	IPP
2018	Northeast	Quang Ninh	Thang Long Unit 1	Coal	300	300	Thang Long Thermal Power Joint-stock Company
2018	Red River Delta	Thai Binh	Thai Binh II Unit 2	Coal	600	600	PVN

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2018	South Central Coast	Binh Thuan	Vinh Tan IV Unit 1 & 2	Coal	2x600	1200	EVN
2018	Mekong Delta	Soc Trang	Long Phu I Unit 1	Coal	600	600	PVN
2018	Southeast	Ba Ria- Vung Tau	Long Son Unit 2 & 3	Oil	2x75	150	IPP (cogeneration)
2018	South Central Coast	Phu Yen	KCP Unit 2	Biomass	30	30	IPP (Phu Yen)
2018	Central Highlands	Gia Lai	An Khe Unit 2	Biomass	55	55	Quang Ngai Sugar Joint-stock Company
2018	Mekong Delta	Hau Giang	Lee & Man	Biomass	125	125	Lee & Man Paper Vietnam Co., Ltd (cogeneration)
2018	Mekong Delta	Ca Mau	Khai Long Wind (Ca Mau)	Wind	100	100	Cong Ly Construction - Trading - Tourism Co., Ltd
2018	Mekong Delta	Bac Lieu	Bac Lieu Wind Unit 3	Wind	142	142	Cong Ly Construction - Trading - Tourism Co., Ltd
2018	All	All	Renewable energy	Renewable	520	520	
2019	Central Highlands	Lam Dong	Bao Lam 3	Hydropower	46	46	IPP
2019	Northwest	Lai Chau	Pac Ma	Hydropower	140	140	Pac Ma Hydropower Joint-stock Company
2019	Central Highlands	Kon Tum	Upper Kon Unit 1 & 2	Hydropower	2x110	220	EVN
2019	Northeast	Quang Ninh	Thang Long Unit 2	Coal	300	300	Thang Long Thermal Power Joint-stock Company
2019	Northeast	Quang Ninh	Hai Ha 1 cogeneration plant	Coal	3x50	150	IPP (inside the industrial zone)
2019	Northeast	Lang Son	Na Duong II	Coal	110	110	Vinacomin
2019	Mekong Delta	Soc Trang	Long Phu I Unit 2	Coal	600	600	PVN
2019	Mekong Delta	Hau Giang	Song Hau I Unit 1 & 2	Coal	2x600	1200	PVN
2019	Mekong Delta	Tra Vinh	Duyen Hai III Expansion	Coal	660	660	EVN
2019	South Central Coast	Binh Thuan	Vinh Tan I Unit 1 & 2	Coal	2x600	1200	CSG - CPIH - Vinacomin (BOT)
2019	South Central Coast	Binh Thuan	Vinh Tan IV Expansion	Coal	600	600	EVN
2019	Northwest	Dien Bien	Nam Cum 1, 4, 5	Hydropower	65	65	IPP
2019	South Central Coast	Ninh Thuan	Trung - Nam wind	Wind	90	90	IPP (Ninh Thuan)

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2019	Mekong Delta	Soc Trang	Soc Trang wind	Wind	99	99	Cong Ly Construction - Trading - Tourism Co., Ltd
2019	South Central Coast	Ninh Thuan	Thien Tan 1 solar	Solar	300	300	IPP (Ninh Thuan)
2019	All	All	Renewable energy	Renewable	450	450	
2020	Northwest	Son La	Nam Pan 5	Hydropower	35	35	IPP
2020	Northwest	Lai Chau	Nam Mo (Vietnam)	Hydropower	95	95	IPP
2020	Central Highlands	Gia Lai	Ialy Expansion	Hydropower	360	360	EVN
2020	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 6 & 7	Coal	2x150	300	IPP - coal based power
2020	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 8 & 9	Gas	2x100	200	IPP - blast furnace gas
2020	North Central Coast	Ha Tinh	Formosa Ha Tinh Unit 10	Coal	150	150	IPP - coal based power
2020	Red River Delta	Hai Duong	Hai Duong Unit 1	Coal	600	600	Jaks Resources Berhad (BOT)
2020	Northeast	Quang Ninh	Cam Pha III Unit 1 & 2	Coal	2x220	440	Vinacomin
2020	North Central Coast	Thanh Hoa	Cong Thanh	Coal	600	600	Cong Thanh Thermal Power Joint-stock Company
2020	Mekong Delta	Can Tho	O Mon III	Combined Cycle	750	750	EVN
2020	Northwest	Dien Bien	Nam Cum 2, 3, 6	Hydropower	54	54	IPP
2020	South Central Coast	Ninh Thuan	Hanbaram Wind	Wind	117	117	IPP
2020	South Central Coast	Ninh Thuan	Thien Tan 2 solar	Solar	400	400	IPP (Ninh Thuan)
2020	All	All	Renewable energy	Renewable	470	470	
2021	Northwest	Lai Chau	My Ly	Hydropower	250	250	IPP
2021	Northwest	Hoa Binh	Hoa Binh Expansion Unit 1	Hydropower	240	240	EVN
2021	North Central Coast	Thanh Hoa	Nghi Son II Unit 1	Coal	600	600	Marubeni - Kepco (BOT)
2021	North Central Coast	Ha Tinh	Vung Ang II Unit 1	Coal	600	600	VAPCO (BOT)
2021	Red River Delta	Hai Duong	Hai Duong Unit 2	Coal	600	600	Jaks Resources Berhad (BOT)
2021	Red River Delta	Nam Dinh	Nam Dinh I Unit 1	Coal	600	600	Taekwang Power Holdings - ACWA Power (BOT)
2021	North Central Coast	Thanh Hoa	Quang Trach I Unit 1	Coal	600	600	PVN
2021	Mekong Delta	Kien Giang	Kien Giang 1	Combined Cycle	750	750	PVN
2021	Mekong Delta	Can Tho	O Mon IV	Combined Cycle	750	750	EVN

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2021	Mekong Delta	Tra Vinh	Duyen Hai II Unit 1 & 2	Coal	2x600	1200	Janakuasa Sdn. Bhd (BOT)
2021	Mekong Delta	Hau Giang	Song Hau II Unit 1	Coal	1000	1000	Toyo Ink (BOT)
2021	Mekong Delta	Soc Trang	Long Phu II Unit 1	Coal	660	660	TATA Power (BOT)
2021	Mekong Delta	Soc Trang	Long Phu III Unit 1	Coal	600	600	PVN
2021	Northeast	Quang Ninh	Uong Bi (Ceasing)	Coal	-105	-105	EVN
2021	South Central Coast	Ninh Thuan	Thien Tan 3 solar	Solar	300	300	IPP (Ninh Thuan)
2021	All	All	Renewable energy	Renewable	790	790	
2022	North Central Coast	Quang Tri	Ban Mong (Song Hieu)	Hydropower	60	60	IPP
2022	Northwest	Hoa Binh	Hoa Binh Expansion Unit 2	Hydropower	240	240	EVN
2022	South Central Coast	Quang Ngai	Dak Re	Hydropower	60	60	IPP
2022	Northeast	Quang Ninh	Hai Ha 2 cogeneration	Coal	5x150	300	IPP
2022	Northeast	Bac Giang	Luc Nam Unit 1	Coal	50	50	IPP
2022	North Central Coast	Nghe An	Quynh Lap I Unit 1	Coal	600	600	Vinacomin
2022	North Central Coast	Ha Tinh	Vung Ang II Unit 2	Coal	600	600	VAPCO (BOT)
2022	North Central Coast	Thanh Hoa	Nghi Son II Unit 2	Coal	600	600	Marubeni - Kepco (BOT)
2022	Red River Delta	Nam Dinh	Nam Dinh I Unit 2	Coal	600	600	Taekwang Power Holdings - ACWA Power (BOT)
2022	North Central Coast	Thanh Hoa	Quang Trach I Unit 2	Coal	600	600	PVN
2022	South Central Coast	Binh Thuan	Vinh Tan III Unit 1	Coal	660	660	VTEC (BOT)
2022	Mekong Delta	Hau Giang	Song Hau II Unit 2	Coal	1000	1000	Toyo Ink (BOT)
2022	Mekong Delta	Soc Trang	Long Phu II Unit 2	Coal	660	660	TATA Power (BOT)
2022	Mekong Delta	Soc Trang	Long Phu III Unit 2 & 3	Coal	2x600	1200	PVN
2022	South Central Coast	Khanh Hoa	Van Phong I Unit 1	Coal	660	660	Sumitomo (BOT)
2022	Mekong Delta	Kien Giang	Kien Giang II	Combined Cycle	750	750	PVN
2022	All	All	Renewable energy	Renewable	1200	1200	
2023	Northeast	Phu Tho	Phu Tho low head	Hydropower	105	105	Binh Minh Construction & Travel Group Joint-stock Company

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2023	North Central Coast	Nghe An	Quynh Lap I Unit 2	Coal	600	600	Vinacomin
2023	Northeast	Bac Giang	Luc Nam Unit 2	Coal	50	50	IPP
2023	North Central Coast	Quang Tri	Quang Tri Unit 1	Coal	600	600	EGATi (BOT)
2023	South Central Coast	Khanh Hoa	Mien Trung I	Combined Cycle	750	750	PVN
2023	South Central Coast	Quang Ngai	Dung Quat I	Combined Cycle	750	750	Sembcorp (BOT)
2023	South Central Coast	Binh Thuan	Vinh Tan III Unit 2 & 3	Coal	2x660	1320	VTEC (BOT)
2023	South Central Coast	Khanh Hoa	Van Phong I Unit 2	Coal	660	660	Sumitomo (BOT)
2023	South Central Coast	Binh Thuan	Son My II Unit 1	Combined Cycle	750	750	PVN
2023	South Central Coast	Ninh Thuan	Bac Ai pumped-storage Unit 1 & 2	Hydropower	2x300	600	EVN
2023	All	All	Renewable energy	Renewable	1000	1000	
2024	North Central Coast	Ha Tinh	Vung Ang III Unit 1	Coal	600	600	Samsung C&T (BOT)
2024	North Central Coast	Quang Tri	Quang Tri Unit 2	Coal	600	600	EGATi (BOT)
2024	South Central Coast	Khanh Hoa	Mien Trung II	Combined Cycle	750	750	PVN
2024	South Central Coast	Quang Ngai	Dung Quat II	Combined Cycle	750	750	Sembcorp (BOT)
2024	Mekong Delta	Long An	Long An I Unit 1	Coal	600	600	
2024	South Central Coast	Binh Thuan	Son My II Unit 2	Combined Cycle	750	750	PVN
2024	All	All	Renewable energy	Renewable	1200	1200	
2025	Southeast	Dong Nai	Tri An Expansion	Hydropower	200	200	EVN
2025	Red River Delta	Hai Phong	Hai Phong III Unit 1	Coal	600	600	Vinacomin
2025	Northeast	Quang Ninh	Hai Ha 3 cogeneration plant	Coal	2x300	600	IPP
2025	Unknown	Unknown	Rang Dong cogeneration plant	Unknown	100	100	IPP
2025	North Central Coast	Ha Tinh	Vung Ang III Unit 2	Coal	600	600	Samsung C&T (BOT)
2025	Mekong Delta	Long An	Long An I Unit 2	Coal	600	600	
2025	South Central Coast	Binh Thuan	Son My II Unit 3	Combined Cycle	750	750	PVN
2025	South Central Coast	Ninh Thuan	Bac Ai pumped-storage Unit 3 & 4	Hydropower	2x300	600	EVN
2025	All	All	Renewable energy	Renewable	1800	1800	
2026	Northwest	Laos	Nam Mo 1 (Laos)	Hydropower	72	72	IPP

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2026	Red River Delta	Hai Phong	Hai Phong III Unit 2	Coal	600	600	Vinacomin
2026	North Central Coast	Nghe An	Quynh Lap II Unit 1	Coal	600	600	BOT
2026	South Central Coast	Khanh Hoa	Mien Trung III	Combined Cycle	750	750	PVN
2026	Mekong Delta	Long An	Long An II Unit 1	Coal	800	800	
2026	Mekong Delta	Can Tho	O Mon II	Gas	750	750	
2026	South Central Coast	Binh Thuan	Son My I Unit 1	Gas	750	750	GDF SUEZ/Sojitz-Pacific (BOT)
2026	All	All	Renewable energy	Renewable	2160	2160	
2027	North Central Coast	Nghe An	Quynh Lap II Unit 2	Coal	600	600	BOT
2027	South Central Coast	Binh Thuan	Son My I Unit 2	Combined Cycle	750	750	GDF SUEZ/Sojitz-Pacific (BOT)
2027	Mekong Delta	Long An	Long An II Unit 2	Coal	800	800	
2027	Mekong Delta	Tien Giang	Tan Phuoc I Unit 1	Coal	600	600	
2027	All	All	Renewable energy	Renewable	2910	2910	
2028	South Central Coast	Phu Yen	Dong Phu Yen pumped-storage Unit 1	Hydropower	300	300	Xuan Thien Company
2028	Northeast	Quang Ninh	Hai Ha 4 cogeneration plant	Coal	2x300	600	IPP
2028	North Central Coast	Thanh Hoa	Quang Trach II Unit 1	Coal	600	600	
2028	South Central Coast	Binh Thuan	Ninh Thuan I Unit 1	Nuclear	1200	1200	EVN
2028	Mekong Delta	Tien Giang	Tan Phuoc I Unit 2	Coal	600	600	
2028	Mekong Delta	Tien Giang	Tan Phuoc II Unit 1	Coal	600	600	
2028	South Central Coast	Binh Thuan	Son My I Unit 3	Combined Cycle	750	750	GDF SUEZ/Sojitz-Pacific (BOT)
2028	All	All	Renewable energy	Renewable	3240	3240	
2029	South Central Coast	Phu Yen	Dong Phu Yen pumped-storage Unit 2	Hydropower	300	300	Xuan Thien Company
2029	Northeast	Quang Ninh	Quang Ninh III Unit 1	Coal	600	600	
2029	North Central Coast	Ha Tinh	Vung Ang III Unit 3	Coal	600	600	
2029	North Central Coast	Thanh Hoa	Quang Trach II Unit 2	Coal	600	600	
2029	Mekong Delta	Tien Giang	Tan Phuoc II Unit 2	Coal	600	600	
2029	Mekong Delta	Bac Lieu	Bac Lieu I Unit 1	Coal	600	600	

Year	Region	Province	Name		Install	Available (2015) /Install (2016-)	Owner
2029	South Central Coast	Binh Thuan	Ninh Thuan I Unit 2	Nuclear	1200	1200	EVN
2029	South Central Coast	Binh Thuan	Ninh Thuan II Unit 1	Nuclear	1100	1100	EVN
2029	All	All	Renewable energy	Renewable	3350	3350	
2030	Northwest	Son La	Huoi Tao	Hydropower	180	180	
2030	South Central Coast	Phu Yen	Dong Phu Yen pumped-storage Unit 3	Hydropower	300	300	Xuan Thien Company
2030	Central Highlands	Lam Dong	Don Duong pumped-storage Unit 1	Hydropower	300	300	EVN
2030	Northeast	Quang Ninh	Quang Ninh III Unit 2	Coal	600	600	
2030	North Central Coast	Ha Tinh	Vung Ang III Unit 4	Coal	600	600	
2030	Mekong Delta	Bac Lieu	Bac Lieu I Unit 2	Coal	600	600	
2030	South Central Coast	Binh Thuan	Ninh Thuan II Unit 2	Nuclear	1100	1100	EVN
2030	All	All	Renewable energy	Renewable	3530	3530	

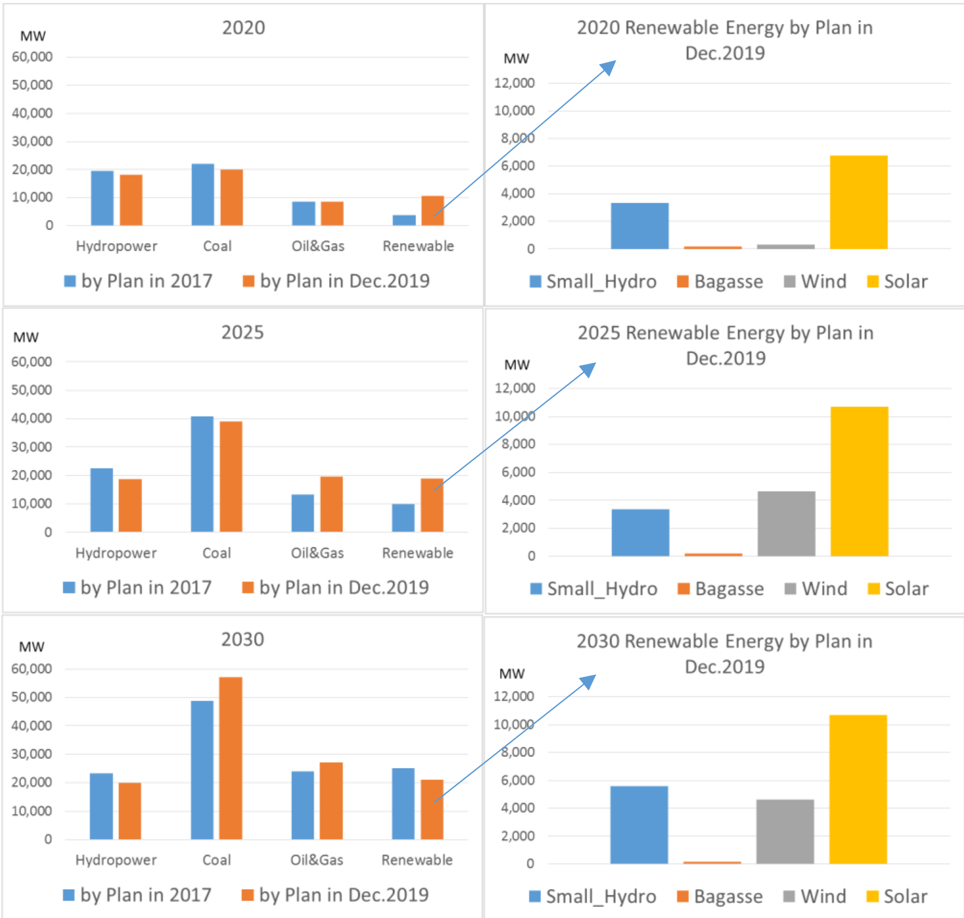
(Source: added to the locations by JICA Study Team based on the information from IE and PPDP7)

6.2.5. New Power Development Plan

From the end of 2018, IE began preparing to develop the next PDP (PDP8). The information below includes information obtained from IE in December 2019.

The new power plan obtained from IE in December 2019 was compared with the 2017 power plan based on the revised PDP7.

Renewable energies include solar, wind, biomass and small hydro. Solar power, which was rarely installed in 2018, increased its installed capacity significantly due to the application of FIT until June 2019, and installed capacity in 2019 reached approximately 4.5 GW. The installed capacity of renewable energy in the new power supply plan will be about three times in 2020 and about twice in 2025 compared to the old power supply plan. On the other hand, the installed capacity of hydropower plants and coal-fired power plants under the new power plan has been slightly reduced by 2025 compared to the old power plan. However, the installed capacity of coal-fired power plants by 2030 is higher than in the old plan.



Renewable energy includes small hydro, biomass, wind and solar

Figure 6.2-13 Comparison of the Old Power Plan and the New Power Plan in December 2019

The characteristics of power generation sources in Vietnam are as follows.

- Reduction of hydropower development
- Increasing share of thermal power plant capacity

- Rapid increase of solar power plants in recent years and uneven distribution of solar power plants

Changes in future power generation capacity are shown below. The development of hydropower plants has been saturated and the installed capacity of hydropower plants will not increase significantly in the future. Coal-fired and gas-fired thermal power will nearly triple by 2030.

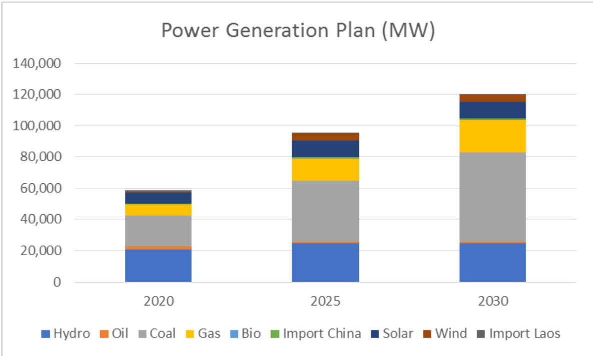


Figure 6.2-14 Changes in Future Power Generation Capacity

In the future, the ratio of thermal power plants to power generation capacity will increase.

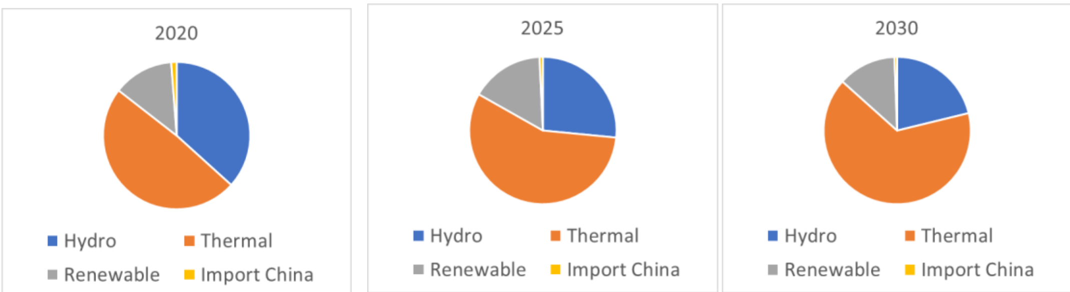


Figure 6.2-15 Changes in the Composition of Power Generation Capacity

The figure below shows the planned installed capacity of solar power and wind power by region. Solar power and wind power are concentrated in C2 and S.

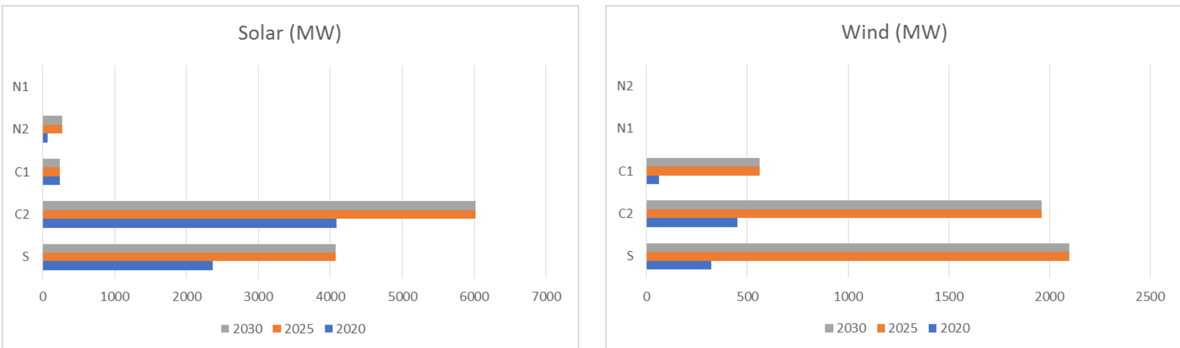


Figure 6.2-16 Planned Installed Capacity of Solar Power and Wind Power by Region

As shown in the figure, solar power is expected to increase sharply from 2019 to 2021, exceeding 10,000 MW, but is not expected to increase thereafter.

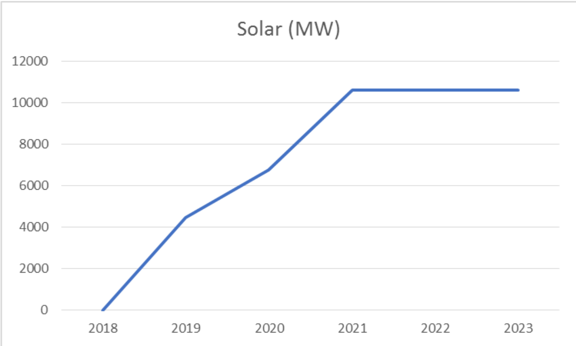


Figure 6.2-17 Trends in Development of Solar Power Plants in Vietnam

Hydropower plants are concentrated in N1 and C2. As shown in Figure 6.2-18, the installed capacity of hydropower plants is not expected to increase significantly in the future, and will be about 21,000 MW in 2020 and 25,000 MW in 2030.

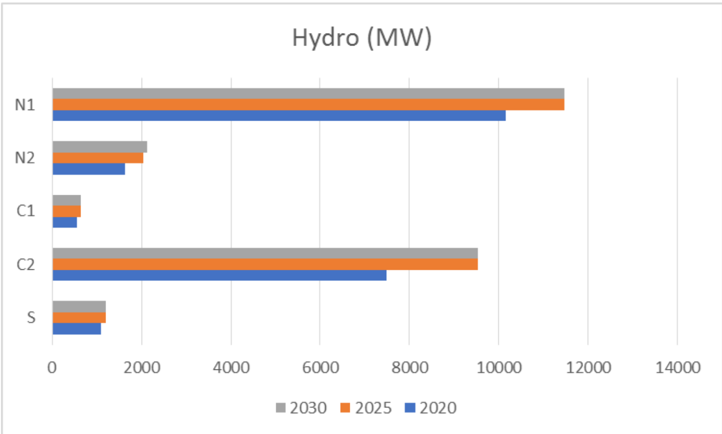


Figure 6.2-18 Planned Installed Capacity of Hydropower Plants by Region

Vietnam's hydropower plants have a large output difference between the rainy and dry seasons. Figure 6.2-19 Ratio of Installed Capacity of Hydropower Plants Operating in Vietnam to Average Monthly Output shows the ratio of the installed capacity of hydropower plants operating in Vietnam to the average monthly output. In the dry season, average power drops to around 25% of capacity.

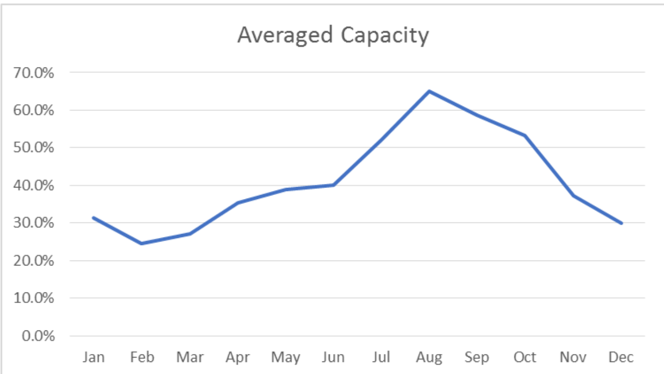


Figure 6.2-19 Ratio of Installed Capacity of Hydropower Plants Operating in Vietnam to Average Monthly Output

Figure 6.2-20 shows the supply and demand balance by region and by month. The N2 and C2 regions have a positive balance throughout the year due to low demand and large generation capacity. Area S has a negative balance for the whole year due to high demand. Since the N1 area has a lot of hydropower, the supply and demand balance changes significantly during the rainy and dry seasons. In 2020, the supply will be more positive in the rainy season, less in the dry season, and negative. After 2025, the N1 area will have a negative balance, with demand exceeding supply even in the rainy season.

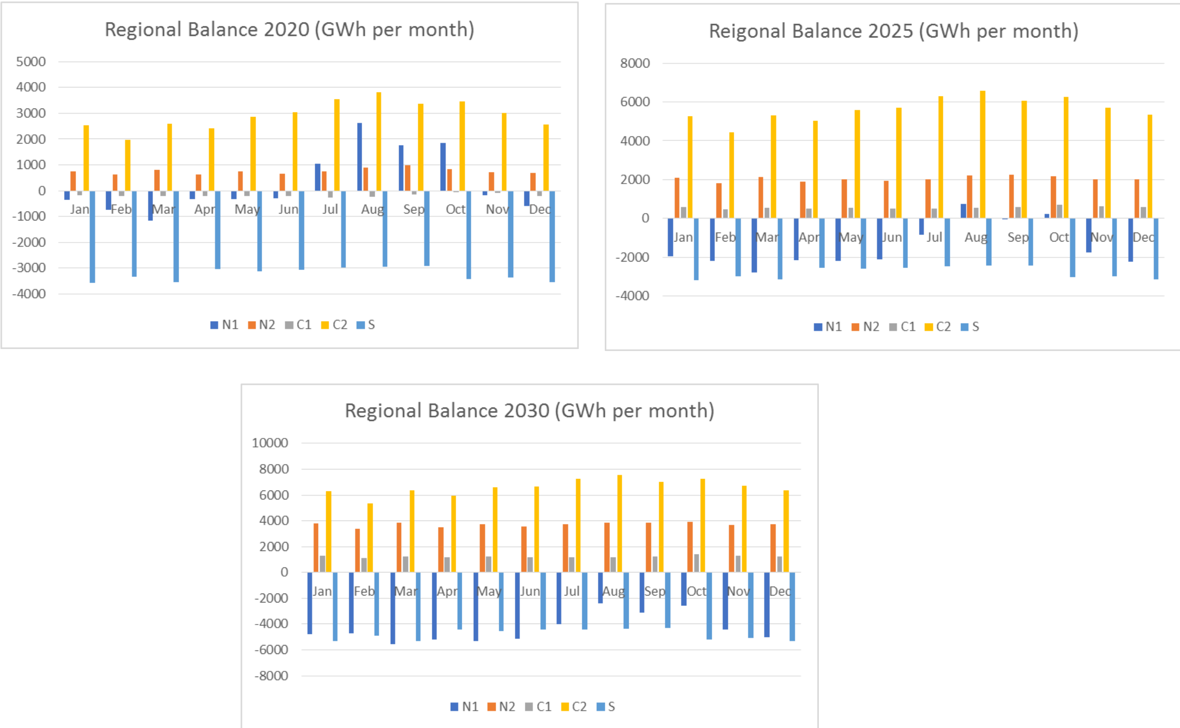
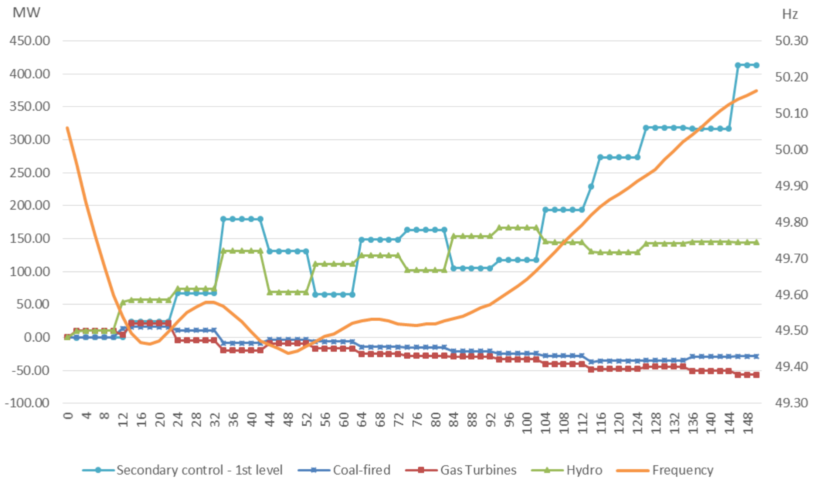


Figure 6.2-20 Supply and Demand Balance by Region/Month

6.2.6. Reservoir-type Hydropower Capacity Required for Solar Power Regulation

As shown in Figure 6.2-21, frequency adjustment on the order of a few seconds is currently being implemented at hydropower plants, and there is a concern that if the ratio of hydropower decreases in the future, adjustment power will be insufficient. For this reason, securing frequency adjustment power is an issue for the future, and implementation of primary frequency adjustment by thermal power plants, which is not currently being implemented, and measures to secure power adjustment by installing pumped storage power plants and storage batteries are being studied. It is also possible to develop a hydroelectric power plant in Laos specifically for the Vietnamese grid to ensure coordination.



Horizontal axis: seconds

Figure 6.2-21 Status of Frequency Adjustment in Vietnam

About 90% of Vietnam's hydropower is reservoir-type, so day and night output can be adjusted by hydropower. As shown in the frame below, if there is a reservoir-type hydropower plant that has approximately three times' the installed solar power capacity in Vietnam, it can be adjusted for the whole year using only reservoir-type hydropower. Therefore, if a solar power plant with a capacity of up to about 8,000 MW is estimated from the installed capacity of hydropower in 2030, it is considered that the output during the day and night can be sufficiently leveled by reservoir type hydropower. (8,000 MW is the maximum power output and a panel capacity of 10,000 MW can be accepted.)

<Capacity of reservoir-type hydroelectric power required for power generation adjustment due to fluctuations in day and night output of solar power generation>

Estimate how much storage-type hydroelectric power stations, if any, for the installed capacity of photovoltaic power generation, can be adjusted day and night with only reservoir-type hydropower. If the installed capacity of photovoltaic power generation is 1 MW and power is generated for 10 hours a day in fine weather, the amount of power generated per day will be approximately 6.4 MWh considering changes in the altitude of the sun. The 24-hour electric power of a 1 MW load is 24 MWh. If the remaining load of about 6.4 MWh is supplied by solar power generation and about 17.6 MWh supplied by reservoir-type hydroelectric power, 1 MW can be supplied constantly for 24 hours (24 MWh). In this case, the average daily output of solar power is 0.28 MW, and the average output of reservoir-type hydroelectric power is 0.73 MW. To obtain this amount of average output during the dry season through standard Vietnamese reservoir-type hydropower, approximately four times' the averaged power generation capacity of the reservoir-type hydropower plants during the dry season should be required in Vietnam in consideration of the decrease in average output during the dry season, meaning a reservoir hydropower station with a capacity of about 2.9 MW. As a result, this capacity is about three times' the installed capacity of solar power.

6.2.7. Power Supply-Demand Balance in Vietnam

Figure 6.2-11 shows the peak power demand and generation capacities in 2015, 2020, 2025 and 2030 based on the PDP7, categorized into regions. 80% of renewable energy is assumed to be allocated to the south and 20% to the central area because renewable energy is being planned without specifying its locations. Reserve margin for power generation capacity is secured at the ratio of 30 to 40%. In the central region, the power generation capacity has been far larger than the peak power demand for years. In the southern region, the power generation capacity becomes larger than the peak power demand from around 2025. Thus, the power flow tends to be from the central area to the south. In the north, power generation capacity becomes less than the peak power demand from around 2025. Thus, power flow is expected to increase from the central area to the south for the later years.

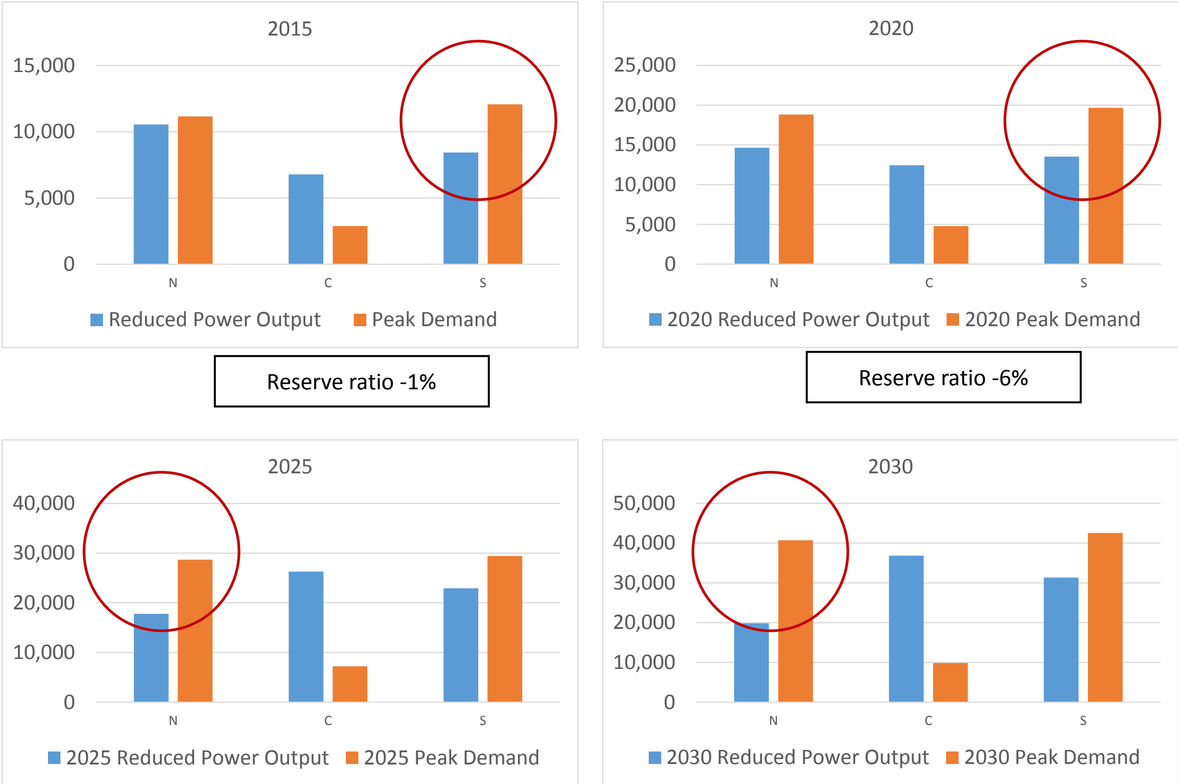
(Unit: MW)

Figure 6.2-22 Regional Peak Power Demand and Power Generation Capacity in Vietnam

(Source: made by JICA Study Team based on information from IE and PDP7)

However, in consideration of the severe conditions for the power supply and demand situations (such as cases with low power outputs in the dry season, where power outputs are assumed at 60% of the capacity for hydropower, 80% for thermal and nuclear, and 30% for renewable energy), the amount of power supply is slightly insufficient for the peak power demand.

In 2025, there is a 350 MW shortage for the whole system, 600 MW shortage in the north and 3,600 MW shortage in the south. In 2020, there is a 2,700 MW shortage in the whole system, 4,200 MW in the northern part and 6,100 MW in the south. After 2025, the shortage of power generation capacity in the north and south becomes prominent. In particular, the amount of capacity shortage in the north will increase. The amount for the shortages shall be taken from the central region, China and Laos.



(Unit: MW)

Red circles indicate a large shortage of power

(Source: made by JICA Study Team based on information from IE and PDP7)

Figure 6.2-23 Regional Peak Power Demand and Power Generation Outputs for severe Conditions in Power Supply-Demand Balance

Table 6.2-8 Regional Peak Power Demand and Power Generation Outputs for severe Conditions in Power Supply-Demand Balance

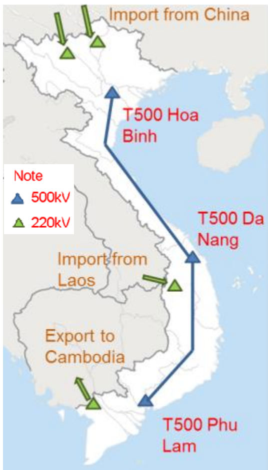
(Unit: MW)

		N	C	S	Total	
2015	Peak Demand	11,150	2,883	12,070	26,103	0%
	Reduced Power Output	10,544	6,779	8,434	25,757	-1%
	Affordability	-606	3,896	-3,636	-346	
2020	Peak Demand	18,812	4,790	19,666	43,268	0%
	Reduced Power Output	14,636	12,425	13,532	40,593	-6%
	Affordability	-4,176	7,635	-6,134	-2,676	
2025	Peak Demand	28,663	7,236	29,415	65,314	0%
	Reduced Power Output	17,773	26,267	22,905	66,945	2%
	Affordability	-10,890	19,031	-6,510	1,631	
2030	Peak Demand	40,704	9,858	42,521	93,083	0%
	Reduced Power Output	19,844	36,858	31,311	88,013	-5%
	Affordability	-20,860	27,000	-11,210	-5,070	

(Source: made by JICA Study Team based on information from IE and PDP7)

6.2.8. The Power Network System of Vietnam

The bulk power system in Vietnam is operated at the voltages of 500 kV and 220 kV, and 500 kV transmission lines have been constructed from north to south. A portion of the northern region system is supplied from China through three circuits of 220 kV transmission lines and four circuits of 110 kV lines. Power exports to Cambodia are carried out from the southern region. Power imports from Laos are carried out by connecting Xekaman 1 hydropower station in the south of Laos to the 500 kV Than My substation in the center of Vietnam, and Xekaman 3 hydropower station to the 500 kV Pleiku 2 substation in the center of Vietnam through 220 kV transmission lines.



GWh	2015	2016
Cambodia (220kV)	**1194**	**1141**
<110kV	388	401
220kV	806	740
Laos (220kV)	**-493**	**-1193**
<110kV	48	51
220kV	-540	-1244
China	**-1689**	**-1492**
110kV	-255	0
220kV	-1434	-1492

Source: RPTCC 23 Country Report

Figure 6.2-24 Power System of Vietnam and The Amount of Power Trades with neighboring Countries

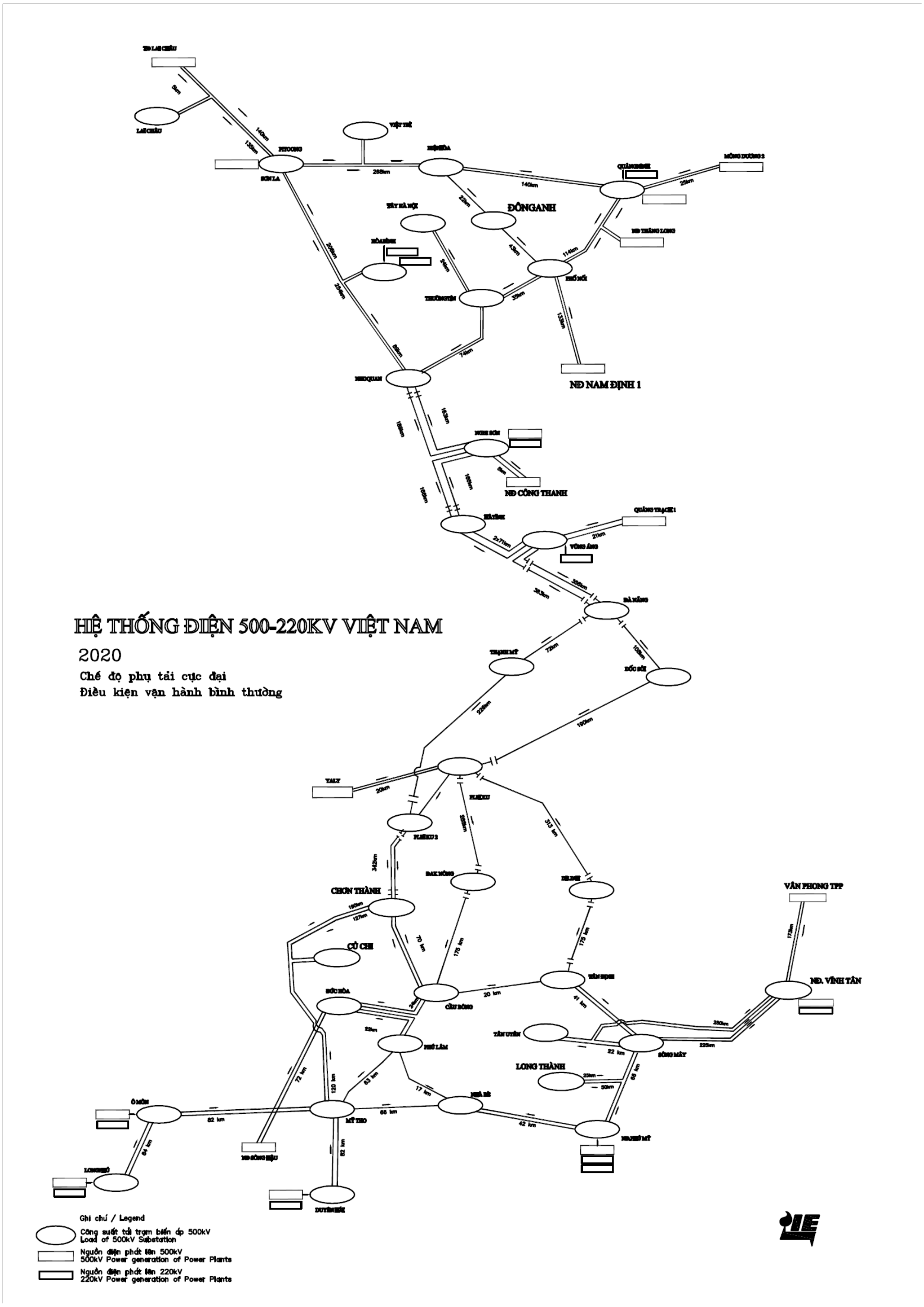


Figure 6.2-25 500 kV System in Vietnam (2020)

(Source: Information from IE, November 2017)

Figure 6.2-26 500 kV System in Vietnam (2025)

(Source: Information from IE, November 2017)

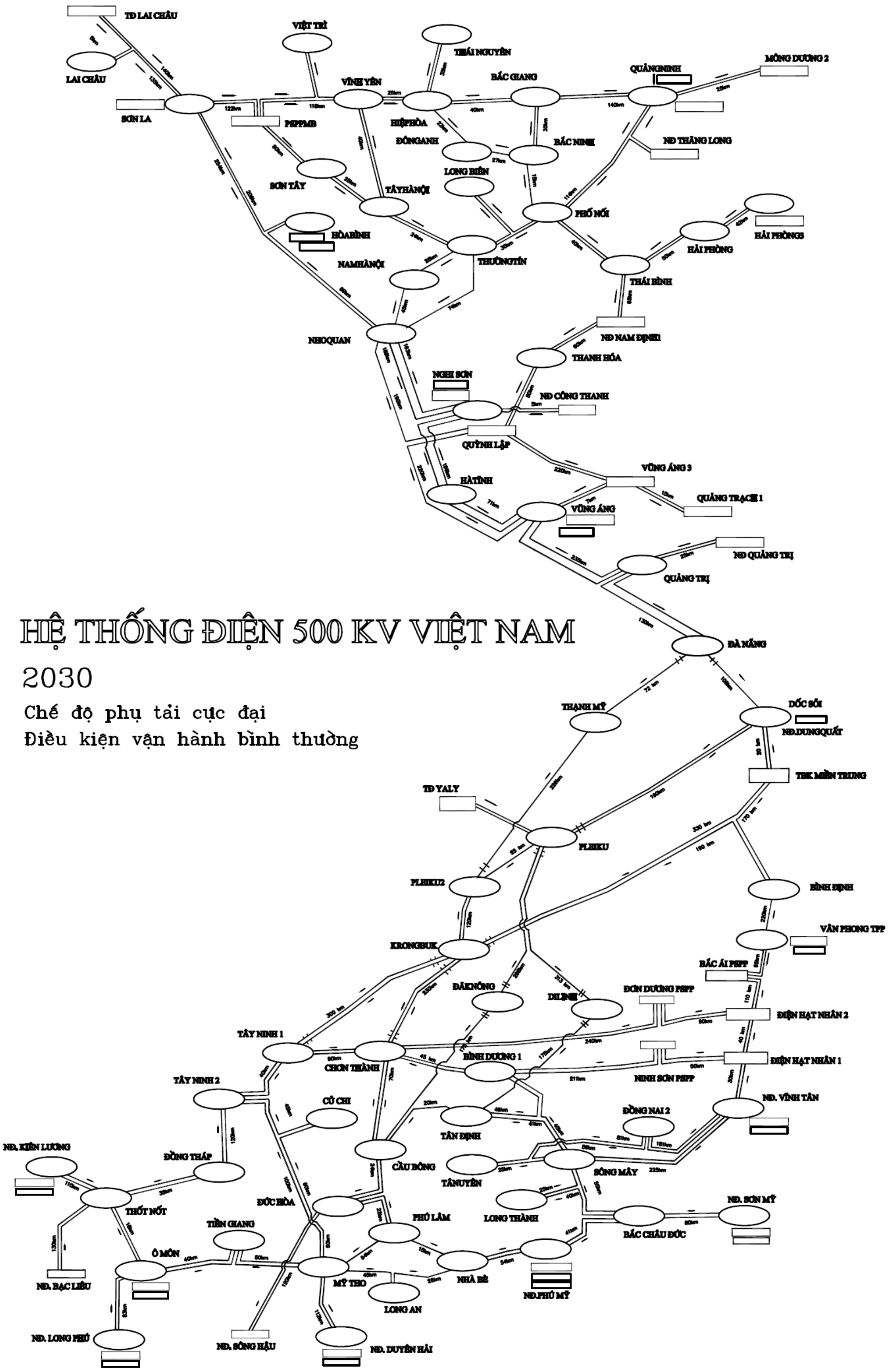


Figure 6.2-27 500 kV System in Vietnam (2030)

(Source: Information from IE, November 2017)

Table 6.2-9 Power Exchanges between the Vietnam system and neighboring countries through

220 kV transmission lines in 2016

Existing interconnections between China and Vietnam

Projects	Voltage level	Pmax (in contract)	Pmax (2016)
Guman – Lao Cai	220 kV	450 MW	300 MW
Malutang – Ha Giang	220 kV	350 MW	230 MW

Existing interconnections between Laos and Vietnam

Projects	Voltage level	Pmax
Xekaman 3 – Thanh My	220 kV	248 MW
Xekaman 1 – Pleiku 2	220 kV	290 MW

Existing interconnections between Cambodia and Vietnam

Projects	Voltage level	Pmax (in contract)	Pmax (2015)
Chau Doc – Takeo	220 kV	200 MW	200 MW

Source: RPTCC 23 Country Report

6.2.9. Power Import and Export Plan between Laos and Vietnam

An MOU was signed between the governments of Laos and Vietnam in October 2016. The generation capacities listed below were confirmed for possible export.

- Up to 2020, minimum capacity of around 1,000 MW
- From 2021 to 2025, minimum capacity of around 3,000 MW
- From 2026 to 2030, minimum capacity of around 5,000 MW

With regard to the interconnections between the systems of Laos and Vietnam, both parties agreed the following.

- The study will be continued with a 220 kV transmission line being constructed to connect Xekaman 3 to Xekaman 1 hydropower to increase the capacity of the 220 kV transmission lines of Xekaman 3-Than My and Xekaman 1 – Pleiku 2 up to 1,000 MW.
- For the long term, construction of 500 kV lines, and the 220 kV transmission lines connecting the Vietnamese system to Laos and a DC converter station, will be invested in by Laos and power sales and purchases between Laos and Vietnam will be carried out through interconnections.
- When importing power from China through the transmission lines from the north to the south of Laos, Laos should secure a capacity of around 3,000 MW from Yunnan.

Currently, the World Bank is conducting a study on power exports from hydropower stations in the south of Laos by utilizing the remaining capacities of the transmission lines from the export-oriented IPPs of Xekaman 1 and Xekaman 3. Table 6.2-10 shows the power plants to be connected to Xekaman 1 and 3 planned in October 2017. The total capacity is around 1,000 MW. However, many are at the CA, PDA, and FS stages and it seems it will be difficult to bring these to fruition.

Table 6.2-10 Power plants to be exported from via the transmission lines of Xekaman 3 and Xekaman 1 in the October 2017 plan

	Xekaman 3 Connecting Power Plants							
No.	Power Plant	Type	Province	(MW)	(GWh)	Plant Factor	COD	Status
1	Xekaman 3 (IPPe)	Reservoir	Sekong	250	982.9	45%	2013	Existing
2	Houay Lamphanyai (EDL-GEN)	Reservoir	Sekong	88	500	65%	2015	Existing
3	Xenammoy 1 (IPPd)	Run Off River	Sekong	14.8	80	62%	2015	Existing
4	Xenamnoy 6 (IPPd)	Run Off River	Sekong	5	27	62%	2017	Existing
5	Xenammoy 2-Xekatam 1 (IPPd)	Run Off River	Sekong	10	58	66%	2017	Existing
6	Dakcha Liew 1 (IPPd)	Run Off River	Sekong	11	54	43%	2020	CA
7	Dakcha Liew 2 (IPPd)	Run Off River	Sekong	13	51	40%	2020	CA
8	Houaylamphan Gnai (Down) (EDL-GEN)	Run Off River	Sekong	15	80	61%	2020	PDA
9	Nam PaGnoun (IPPd)	Run Off River	Sekong	15	60	46%	2020	PDA
10	Houay La Ngea (IPPd)	Reservoir	Sekong	60	293.8	42%	2020	FS
Total Potential Generation up to 2020				481.8	2,186.70			
	Xekaman 1 Connecting Power Plants							
No.	Power Plant	Type	Province	(MW)	(GWh)	Plant Factor	COD	Status
1	Sugar Factory (IPPd)	Bio-Thermal	Attapeu	20	123	70%	2013	Existing
2	Xekaman 1 (IPPe)	Reservoir	Attapeu	290	1,096.00	43%	2017	Existing
3	Xekaman - Xanxai (IPPe)	Run Off River	Attapeu	32	121	43%	2017	Existing
4	Nam Kong 2 (IPPd)	Reservoir	Attapeu	66	263.11	46%	2017	Under Construction
5	Nam Kong 3 (IPPd)	Reservoir	Attapeu	55	170.24	43%	2019	Under Construction
6	Xepian - Xenamnoy (IPPd)	Run Off River	Attapeu	40	229	56%	2019	Under Construction
7	Houay Ka Ouy (IPPd)	Run Off River	Attapeu	15	85	65%	2020	Under Construction
8	Nam Kong 1 (IPPd)	Run Off River	Attapeu	160	649	46%	2020	Under Construction
9	Xekong Down A (IPPd)	Run Off River	Attapeu	76	387.8	58%	2020	CA Negotiation
Total Potential Generation up to 2020				744	3,124.20			

Source: Presentation Material by EDL at the conference among Vietnam, Laos and the World Bank, October 2017

However, the country report presented by Vietnam at RPTCC 23, with support from ADB, in December 2017 presents the plan for power imports from Laos as shown in Table *, in comparison with the abovementioned list. The plan using the Xekaman 3 transmission line is not mentioned and the plan using the Xekaman 1 transmission line is included as the Xekaman 4 and Xekaman Xansay.

Table 6.2-11 Power Import/Export Plans from Laos in Future

Projects	Voltage level	COD
Xekaman Xansay – Xekaman 1 (32 MW)	110 kV	2018
Xekaman 4 – Xekaman 1 (80 MW)	220 kV	2022
Xe Kong 1 & 2 (1800 MW)	500 kV	2021-2022
Nam Xam 1 & 3 (220 MW)	220 kV	2021-2022

(Source: RPTCC 23 Country Report, December 2017)

Power imports of 3,000 MW from Laos to Vietnam are achieved up to 2025 via power imports of 1,000 MW utilizing Xekaman 1 & 3 and Xe Kong 1 & 2 (1800 MW) and Nam Xam 1 & 3 (220 MW).

As described below, Laos and Vietnam have been considering an export plan for the Nam Ou Hydropower Plant (1 ~ 7) since 2018.

The potential power projects that could be exported to Vietnam were compiled in light of the information on the PDP obtained from IE in December 2019 and the opinion of the Lao side. The list should include almost all exports that have been decided or are likely to be exported.

The following additional information was obtained from IE in January 2020.

- Power Import Plan from Laos
  - The developers/investors of Savannakhet Hydropower projects (total 300~500 MW) wanted to sell electricity to Vietnam (Quang Tri province) but the plan has not yet been finalized. It is said that, the investors seemed to agree on the selling price of US Cent 6.95/kWh (same as other hydropower projects selling to Vietnam) but the Laos Government wanted to collect more fee. It's not clear when this plan can be realized.
- Power Import Plan of Vietnam
  - Vietnam is planning to increase the power import from China but it's still under negotiation. Technically, the power grid plan has been studied and prepared but there're political and government policy issues that need approval of high-ranking level before the plan could be realized. At present, Vietnam is importing about 400 MW from China (Yunnan) to northern provinces in Vietnam (Ha Giang, Lao Cai). It's technically possible to increase the import capacity up to 1,500 MW~2,000 MW by additional construction of back-to-back 220kV substations. But it's waiting for approval of the Government and not clear of the timing.

The plans for imports from Laos by region base on the information in December 2019 are described below.

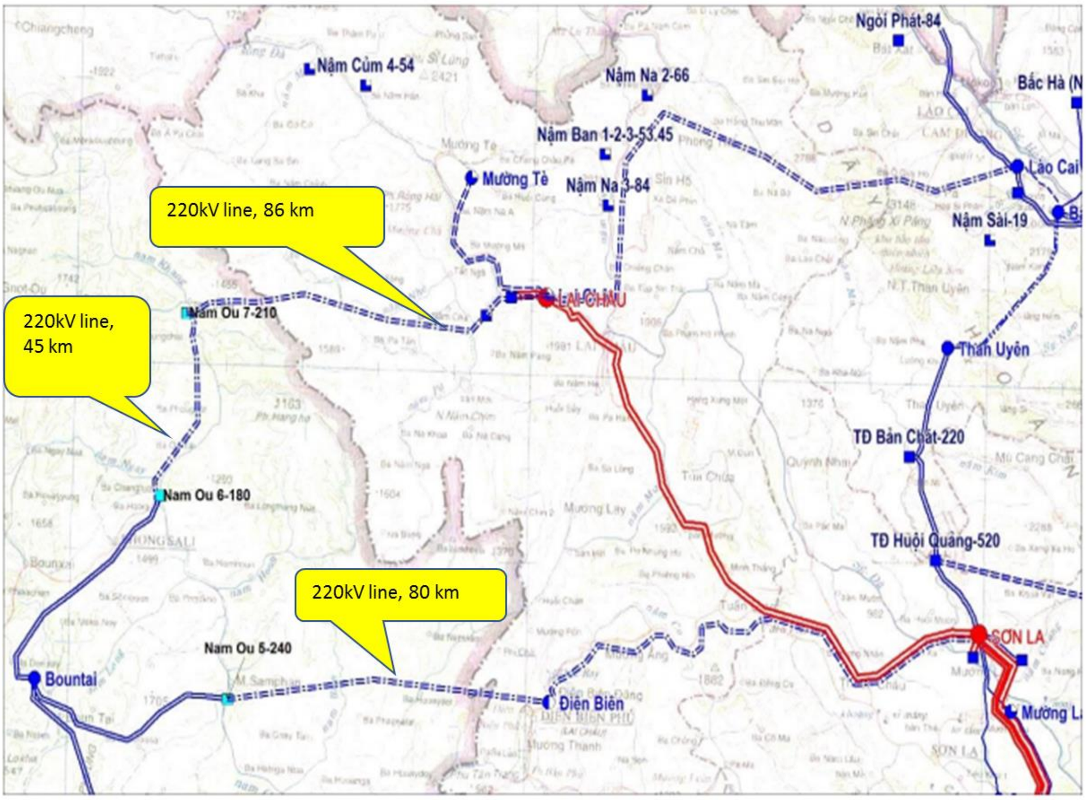
1. Export from Northern Laos to Northern Vietnam

The list of IE included Nam Ou1 2. But in Laos, Nam Ou1 2 is currently being considered for domestic use, so this was removed from the list. In addition to the method shown in Figure 6.2-28, there are plans to transmit power from Nam Ou from Xam Neua, to Nho Quan in Vietnam at 500 kV. MK. Prabang was also listed on the IE list, but was excluded on Laos's side in January 2020 on the grounds that it was being considered for Thailand.

Houaphan Coal is listed on the list from Vietnam as a potential export, but this master plan considers it for Laos.

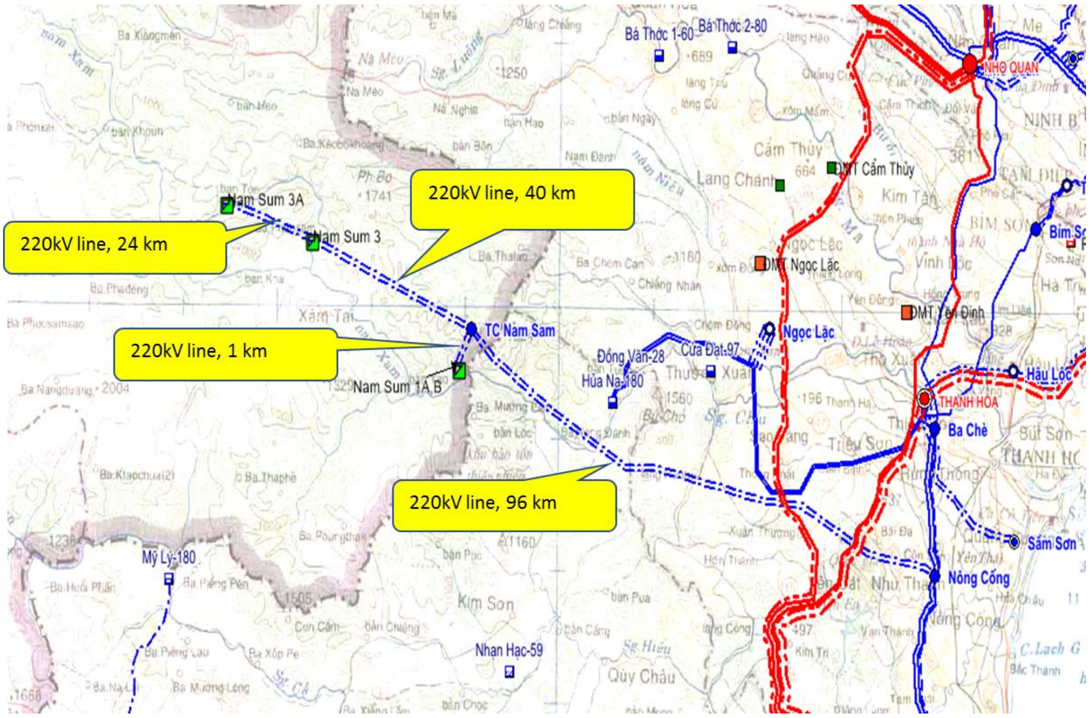
Table 6.2-12 Plans for Exports from Northern Laos to Vietnam

No	Name of projects	Capacity (MW)	Energy generation (GWh)	Type of source	Progress of project	Planning year to purchase to Vietnam
I	**Connect to the North**	**822**				
	HPP Nam Ou 7	210	811	Hydro	Constructing	2021-2025
	HPP Nam Ou 6	180	738	Hydro	Operating	2021-2025
	HPP Nam Ou 5	240	1048	Hydro	Operating	2021-2025
	HPP Nam Leng	60	232.2	Hydro	Studying for development	2021-2025
	HPP Nam Ou 4	132	523	Hydro	Constructing	2021-2025
	HPP Nam Ou 3	210	684	Hydro	Constructing	2021-2025
	Houaphan coal thermal	600		Coal thermal		
II	**Connect to the North Center**	**970**				
	Nam Sum 3	156	626	Hydro	Studying for development	2021-2025
	Nam Sum 1AB	64	229	Hydro	Studying for development	2021-2025
	Nam Sum 3A	45	169	Hydro	MOU	2021-2025
	Sam Neua	200		Hydro	Potential	Potential
	Nam Mo 1	60	356	Hydro	Studying for development	2021-2025
	Nam Mo 2	120	498	Hydro	Constructing	2021-2025
	Nam San 3A	69		Hydro	Operating	2022
	Nam San 3B	45		Hydro	Operating	2022
	Nam Tai	21		Hydro	Constructing	2022
	Nam Sannoi - Nam Xao 1	45		Hydro	MOU	2023-2025
	Nam Xao 2,3	17		Hydro	MOU	2023-2025
	Nam Sak, Nam Chao	28		Hydro	MOU	2023-2025
	Nam Mouan	100		Hydro	MOU	2024-2025
	Xieng Khoang coal thermal			Coal thermal	MOU	Potential



(Source: Materials obtained from IE)

Figure 6.2-28 Nam Ou Hydropower Connection (Connection to Northern Vietnam)



(Source: Materials obtained from IE)

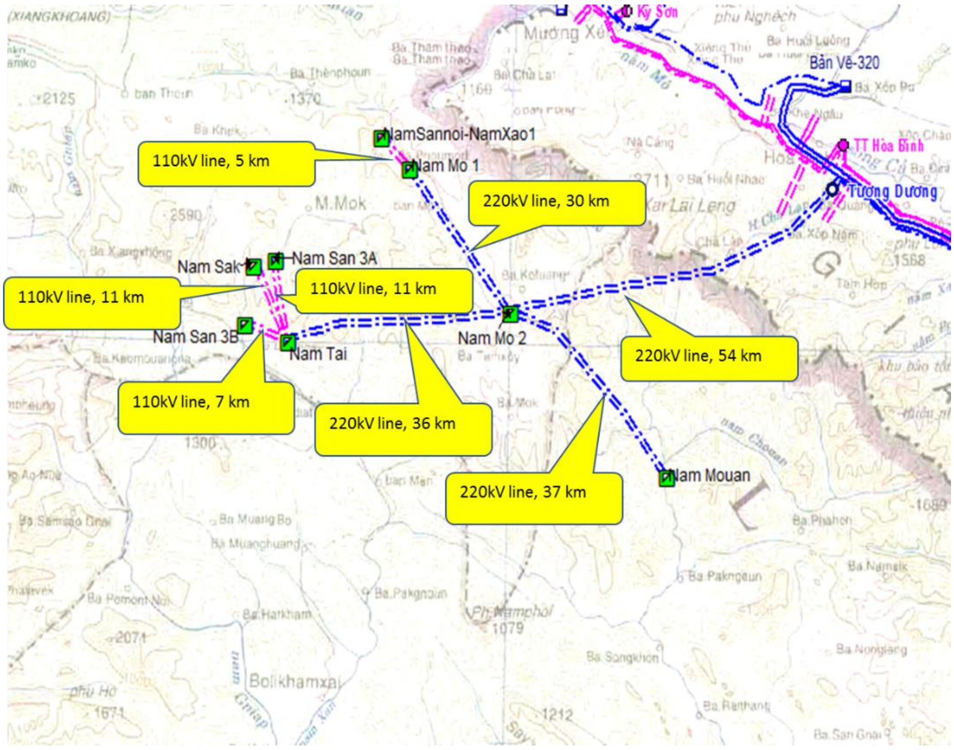
Figure 6.2-29 Nam Xam Hydropower Connection (Connection to Northern Vietnam)

2. Export from Southern Laos to Central and Southern Vietnam

The list from IE included Nam Kong1, 2 and 3, but this was excluded from the list because it was decided to export from there to Cambodia. Xekong and Lamama are also excluded because it was decided that they would export to Cambodia.

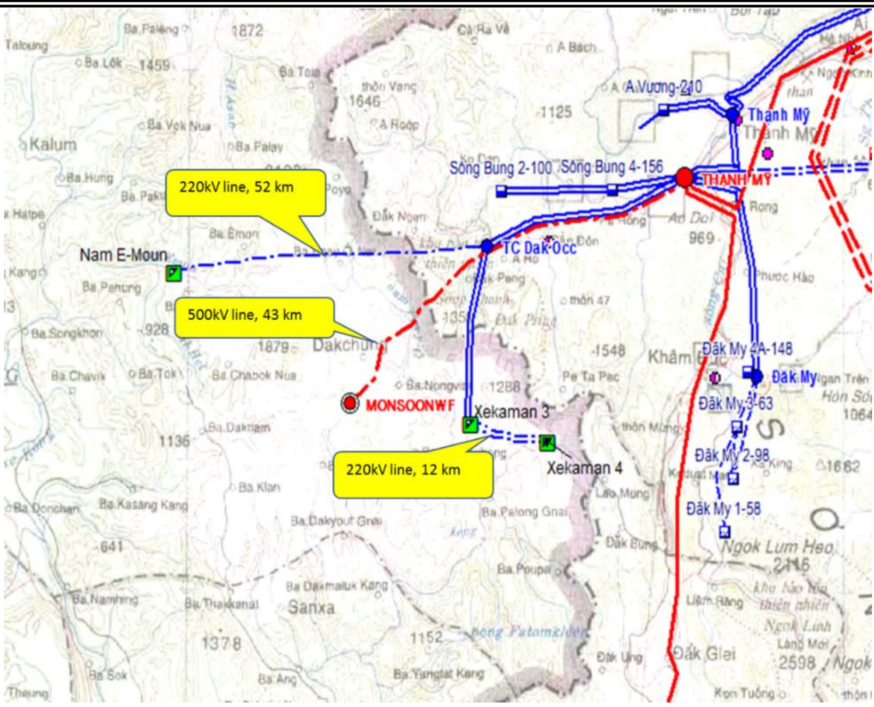
Table 6.2-13 Plans for Exports from Southern Laos to Vietnam

No	Name of projects	Capacity (MW)	Energy generation (GWh)	Type of source	Progress of project	Planning year to purchase to Vietnam
III	**Connect to the Center Central**	**869**				
	Xekaman 3	250	980	Hydro	Operating	Purchased
	Xekaman 4	70	287	Hydro	Studying for development	2020
	Cum Xavanakhet	360	1048	Hydro	Studying for development	2021-2025
	Nam Emeun	129	427	Hydro	Studying for development	2021-2025
	Houay La Ngea	60	289	Hydro	Studying for development	2021-2025
	Wind Sekong (Moonsun)	600		Wind	Studying for development	2021-2025
	Baulapha coal thermal	1800		Coal thermal	MOU	Potential
IV	**Connect to the Highland**	**735**				
	Xekaman sanxay	32	131	Hydro	Operating	Purchased
	Xekaman1	290	1050	Hydro	Operating	Purchased
	Sekong3A	129	428	Hydro	Studying for development	2021-2025
	Sekong3B	146	434	Hydro	Studying for development	2021-2025
	Nam Ang	41	183	Hydro	Studying for development	2021-2025
	Nam Ngone 1	45	273	Hydro	MOU	2021-2025
	Nam Ngone 2	35	152	Hydro	MOU	2021-2025
	Houay Ka Ouy	17		Hydro	MOU	2021-2025
	Total	**4396**				



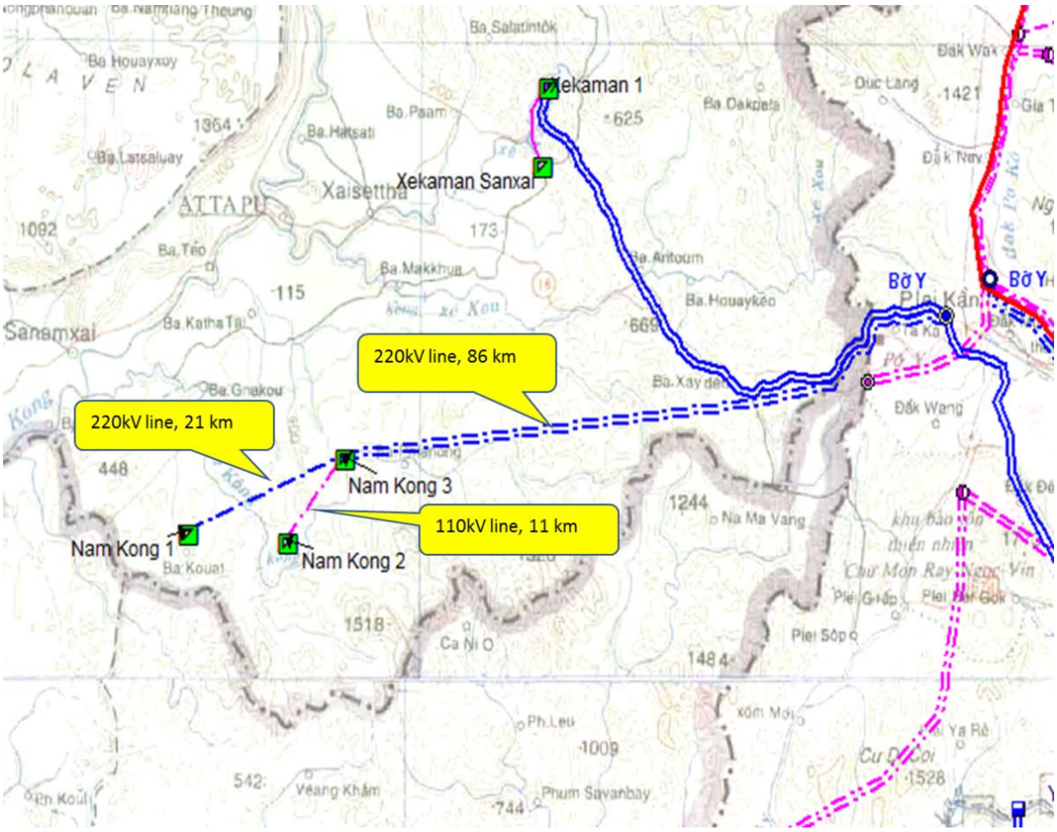
(Source: Materials obtained from IE)

Figure 6.2-30 Connection of Nam Mo Hydropower (Connection to Northern Vietnam)



(Source: Materials obtained from IE)

Figure 6.2-31 Connection between Nam Emoun Hydropower and Monsoon Wind Power (Connection to Central Vietnam)



(Source: Materials obtained from IE)

Figure 6.2-32 Nam Kong Hydropower Connection (Connection to Vietnam Highlands Area)

6.3. Myanmar

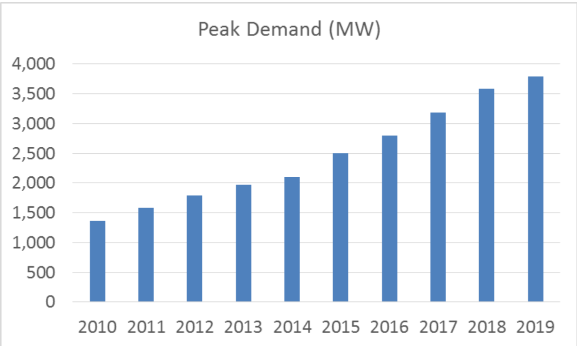
6.3.1. Power Sector in Myanmar

The power sector in Myanmar is governed by the Ministry of Electricity and Energy (MOEE). The power generation and transmission business is undertaken by MOEE departments, the Electric Power Generation Enterprise (EPGE) and the Department of Power Transmission and System Control (DPTSC). Distribution business is implemented by Yangon Electricity Supply Corporation (YESC), Mandalay Electricity Supply Corporation (MESC), and Electric Supply Enterprise, which are also MOEE divisions. The long-term plans for the power sector are formulated by MOEE's Department of Electric Power Planning (DEPP).

Another power-related organization at the Ministry of Power and Energy is the Department of Hydropower Implementation (DHPI), which is responsible for hydropower construction.

6.3.2. Power Demand Records

Myanmar's power demand records are shown in the following figure. Maximum power demand increased by the ratio between around 10% and 20%. The maximum power demand in 2019 was 3,798 MW, an increase of about 50% compared to 2015. Increasing at this rate, Myanmar's peak power demand in 2020 is expected to exceed 4,000 MW.



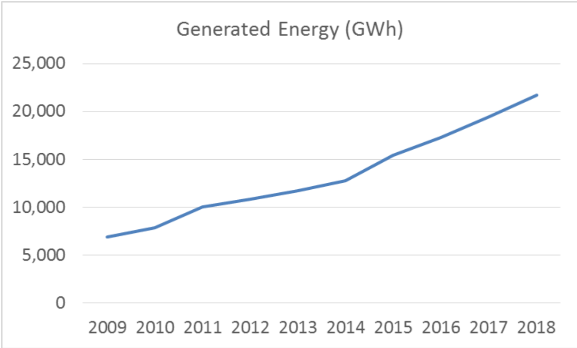
(Source: RPTCC 26, Country Report)

Figure 6.3-1 Maximum Power Demand Records in Myanmar

Table 6.3-1 Maximum Power Demand Records in Myanmar

Year	Peak Demand (MW)	Growth Ratio
2010	1,371	21.4%
2011	1,588	15.8%
2012	1,790	12.7%
2013	1,969	10.0%
2014	2,102	6.8%
2015	2,497	18.8%
2016	2,802	12.2%
2017	3,189	13.8%
2018	3,586	12.4%
2019	3,798	5.9%

(Source: RPTCC 26, Country Report)



(Source: RPTCC 26, Country Report)

Figure 6.3-2 Power Energy Demand Records in Myanmar

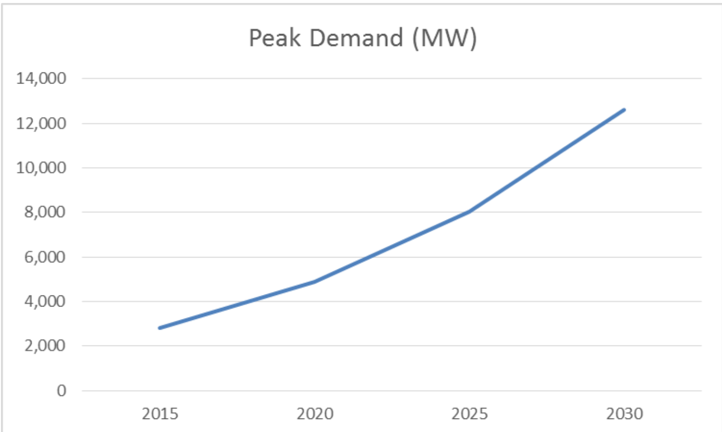
Table 6.3-2 Power Energy Demand Records in Myanmar

Year	Generated Energy (GWh)	Growth Ratio
2009	6,830	
2010	7,811	14.4%
2011	10,036	28.5%
2012	10,837	8.0%
2013	11,682	7.8%
2014	12,727	8.9%
2015	15,392	20.9%
2016	17,285	12.3%
2017	19,416	12.3%
2018	21,717	11.9%

(Source: RPTCC 26, Country Report)

6.3.3. Power Demand Forecast

In the Project for Capacity Development of Power Sector Development Planning (December 2017), a maximum power demand forecast is assumed for each scenario from a macro analysis based on the GDP growth rate. The base case maximum power demand forecast is shown in the following figure. It was expected to be 4,876 MW in 2020 and 12,611 MW in 2030.



(Source: Project for Capacity Development of Power Sector Development Planning (December, 2017))

Figure 6.3-3 Maximum Power Demand Forecast

Table 6.3-3 Maximum Power Demand Forecast

FY	Peak Power Demand (MW)
2015	2,800
2020	4,876
2025	8,051
2030	12,611

(Source: Project for Capacity Development of Power Sector Development Planning (December, 2017))

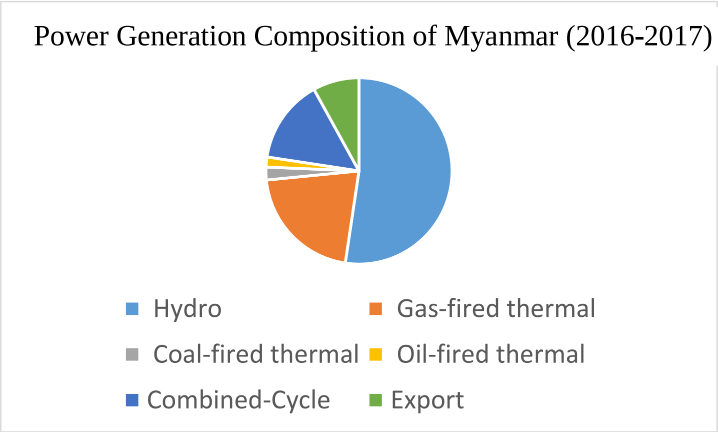
6.3.4. Power Generation Plan

Table 6.3-3 shows the generation composition for Myanmar for 2015-2016 and 2016-2017. Power exports are carried out for China. The increase ratio of power generation capacity is 5.2% for the year. The total amount of power generation capacity is 4,957 MW, excluding power exports. There seems to be margin for peak demand. However, because hydropower amounts for more than half of the total capacity and many hydropower stations are located in the north of the country, power shortages due to the dry season and power transmission line constraints are a concern.

Table 6.3-4 Power Generation Composition

Sources	2015-2016	2016-2017
Hydro	2782	2822
Gas-fired thermal	1140.2	1136.2
Coal-fired thermal	120	120
Oil-fired thermal	95	94
Combined-Cycle	554.8	784.8
Export	433	433
Total	**5125**	**5390**
		5.2%

Source: RPTCC 23 Country Report



Source: RPTCC 23 Country Report

Figure 6.3-4 Power Generation Composition

The existing power stations in Myanmar are shown in Table 16.3-3.

Table 6.3-5 Existing Power Stations in Myanmar

No.	Power Station Name	Capacity (MW)	No.	Power Station Name	Capacity (MW)
Installation power of hydropower plants					**3,225**
State-owned power station					
1	Baluchaung (1)	28	13	Keng Taung	54
2	Baluchaung (2)	168	14	Yeywa	790
3	Kinda	56	15	Shwegyin	75
4	Sedawgyi	25	16	Kun	60
5	Zawgyi(1)	18	17	Kyeeon Kyeewa	74
6	Zawgyi(2)	12	18	Nancho	40
7	Zaungtu	20	19	Hpyauuhkyaungg	40
8	Thapanzeik	30	20	Upper Paunglaung	140
9	Mone	75	21	Myogyi	30
10	Paunglaung	280	22	Myittha	40
11	Yenwe	25	23	Rarj gyaoh	4
12	Kabaung	30			
JV/ BOT Power Station			**IPP/ BOT Power Station**		
24	Shweli (1)	600	27	Thauk-ye-khat (2)	120
25	Dapein (1)	240	28	Baluchaung (3)	52
26	Chpwinge	99			
Installation power of gas-fired power plants					**2,283**
State			STG		
1	Kyawannhkyaungg	54.3	1	Hlawga	54.3
2	Mann	36.9	2	Ywama nedo	9.4
3	Shwedaung	55.35	3	Ahlone	54.3
4	Myanaaung	34.7	4	Tharkheta	35
5	Sahtone	50.95	Rental		
6	Hlawga	99.9	1	Kyawwathpyauu(V Power)	90
7	Ywama	36.9	2	Myinnhkyaan(V Power)	133
	Ywama (NEDO)	24	3	Myinnhkyaan(V Power)	90
	Ywama (240)	240	4	Kyawwatsai(Powergen)	145.49
8	Ahlone	99.9			
9	Tharkheta	57	IPP		
10	Selawar	50	1	Ahlone (Toyo Thai)	94
Private			2	Hlawga (MCP)	50
1	Toyo Thai	27	3	Ywama (UPP)	50
2	Myanmar Lighting	78	4	Tharkheta(Max Power)	50
3	UREC	36	5	Myanmar Lighting	152
4	Sembcorp	82	6	Sembcorp	143
			7	UREC	70
Charging power of coal-fired power plant					**120**
1	Te kyit	120			
Installation Power of Solar Power Plant					**40**
1	Mainnbhuu	40			

(Source: Information from DPTSC)

Shweli (1) hydropower station and Depain (1) hydropower station are export-oriented power stations that export their power to China.

- Shweli (1) hydropower station is a JV/BOT project that started operation in 2009. The generation capacity is 600 MW, 300 MW for domestic power supply and 300 MW for power export.
- Depain (1) hydropower station is a JV/BOT project that started operation in 2011. The generation capacity is 240 MW, 7 MW for domestic power supply and 233 MW for power export.

Table 6.3-4 shows the records of power exports.

Table 6.3-6 Records of Power Exports from Export-oriented Power Plants in Myanmar

No	Name of export	Voltage (kV)	2015		2016		Export to
			GWh	MW	GWh	MW	
1	Shweli (1)	220	517.089	200	377.354	200	China
2	Dapain (1)	500	888.442	233	934.062	233	China

Source: RPTCC 23 Country Report

The MOU between MEM in Laos and MOEE in Myanmar regarding electricity cooperation is expected to be agreed soon.

An MOU on electricity was concluded between MEM in Laos and MOEE in Myanmar in January 2018. The amounts for export and import are not described. Based on this MOU, a joint working group has been established in Laos and Myanmar to consider exporting electricity from Laos.

According to information from Laos, a future capacity of 300-500 MW is anticipated, but as of 2019, it seems that there has been almost no agreemen on the 100 MW of exports from Bokeo Province.

The following table shows the power plants under construction in Myanmar. A total of 1,355.4 MW of hydropower plants is under construction, mainly in northern Myanmar. After completion of the on-going 500 kV projects, power transmission to Yangon city via the 500 kV transmission line is expected. Thahton gas-fired power station is located east of Yangon and north of the Mawlamyine district. Minbu Solar is located about 120 km west of Naypyidaw, Magway, and Phase I (40 MW) has already been completed.

Table 6.3-7 Power Plants Under Construction in Myanmar

No.	Project	MW
Hydro		
1	Shweli (3)	671
2	Upper Yeywa	280
3	Middle Paunglaung	152
4	Upper Kyaingtaung	51
5	Upper Beluchaung	30.4
6	Thahtay	111
7	Deedoke	60
Gas		
8	Thahton	118.9
Renewable Energy		
9	Minbu	170

Note: Minbu Solar Project (40 MW, Phase 1) has already been accomplished.

(Source: Information from DPTSC)

The following emergency power sources were recruited in 2019. At the 230 kV substation in Yangon, it will be installed at Ahlone, Thanlyin and Tharketa. All are based on Take or Pay contracts that purchase the entire amount of generated power.

Table 6.3-8 Emergency Power Supply Recruited in 2019

Kyun Chaung	20 MW	(Gas) Inland gas field (Magway Area)	5 years	
Ahlone	120 MW	(Gas) Tanada Gas Field	5 years	
Kyauk Phyu	150 MW	(LNG) (Steel Mill IPP)	5 Years	
Thanlyin	350 MW	(LNG, land-based gas, barge, or other)	5 years	Connected to Thilawa
Tharketa	400 MW	(LNG)	5 years	

In the future, the development of power plants will continue with the development of hydropower plants with low power generation costs, aiming to configure hydropower and thermal power at an appropriate ratio, but development has not progressed as expected. For this reason, as mentioned above, emergency power sources were recruited in 2019.

Although there is no clear power development plan in Myanmar, the following is a list of hydropower plants for export.

Table 6.3-9 Export Hydropower on Project List

	Plant Name	Status	Installed
2009	Shweli(1)	Existing	600
2011	Dapein(1)	Existing	240
2013	Chipwinge	Existing	99
Subtotal			*939*
2021	Shweli(2)	MOA	520
2022	Dapein (2)	MOU	140
2023	Upper ThanLwin (Kunlong)	MOA	1,400.00
2024	Mantong	MOA	225
2026	Gawlan	JVA	120
2026	Hkan Kawn	MOA	140
2026	Lawngdin	MOA	600
2026	Naopha	MOA	1,200.00
2026	Tongxingiao	JVA	340
2029	He Kou	MOU	138
2029	Keng Tong	MOU	170
2029	Keng Yang	MOU	70
2029	Nam Kha	MOU	210
2029	So Lue	MOU	240

(Source: Project for Capacity Development of Power Sector Development Planning (December, 2017))

However, the progress of development is uncertain in each case.

6.3.5. Power Generation Costs

According to the power generation costs in 2018, gas-fired power plants are costing more than about 140 kyat (10 cents) per kWh, which is very high.

6.3.6. Power Imports and Exports

Myanmar is currently exporting electricity from its northern hydropower plants to China.

As domestic hydropower development is uncertain and there are few suitable sites for large-scale thermal power development with high economic efficiency, it is expected that imports from China and economic and stable power imports via Thailand will be highly effective. In particular, since the import point from Thailand is relatively close to Yangon, it is easy to develop transmission lines, and economic efficiency is considered to be high when combined with cheap power from Laos.

According to an interview in Myanmar in January 2020, the following are being considered for imports from neighboring countries.

- Transmission from China at 500 kV is being considered. The receiving substation is the Payagyi substation in northern Yangon, which is currently under construction.
- Direct power transmission from Thailand is being considered.
- A plan to transmit power directly from Laos to Myanmar is under discussion with Laos.
- Imports from the three countries total 1,500 - 2,000 MW.

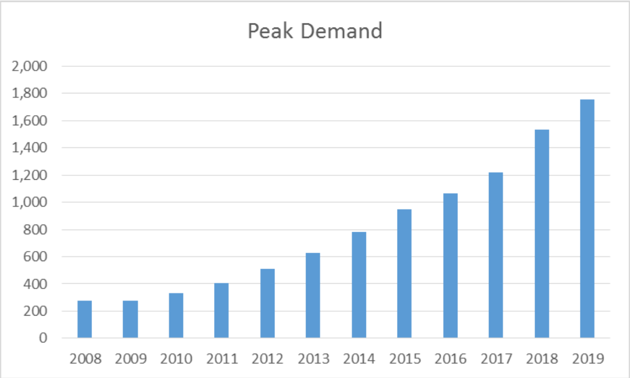
6.4. Cambodia

6.4.1. Current Situation

In the Cambodian power sector, the government consists of MME (Ministry of Mining and Energy) for policy, EAC (Cambodia Electricity Authority) for regulation, electric utilities for EDC (Cambodia Electric Power Corporation), IPP, local electric utilities, etc. The EAC is responsible for establishing electricity tariffs and granting business licenses.

The information below is based on materials obtained from EDC and presentation materials by EDC at the RPTCC-26 meeting.

The following table shows data on the peak power demand in Cambodia.



(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-1 Maximum Power Demand Records

Peak power demand has increased at a very high rate, decreasing from 2008 to 2009, but increasing by more than 20% from 2010 to 2015.

The growth rate was 12-14% in 2016 and 2017, but it was extremely high at 26% from 2017 to 2018. The maximum power demand in 2019 is 1,755 MW.

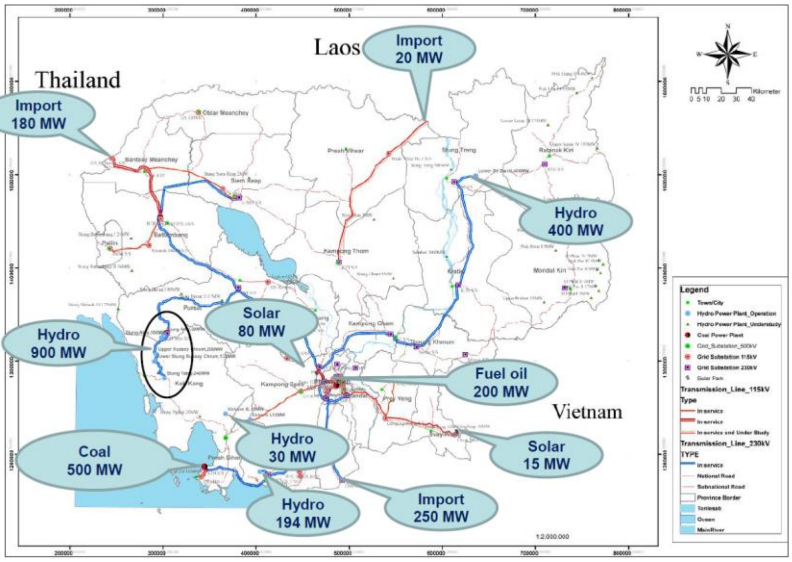
The estimated capacity of existing power generation facilities is shown in Table 6.4-1. Hydropower accounts for about 50% of the existing power generation facilities. Coal and imports account for about 20% each.

Table 6.4-1 Existing Power Generation Facilities

	MW	Share	
Fuel Oil	200	8%	Approximate
Hydro	1,330	52%	Approximate
Coal	505	20%	Approximate
Solar Farm	85	3%	
Imports via High Voltage	450	18%	Approximate
Total	2,570		Approximate

(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

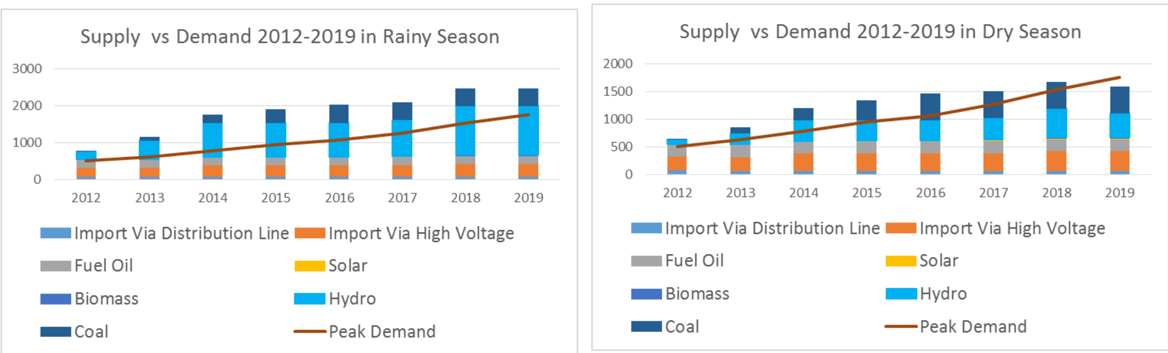
An outline of the current power generation facilities and transmission lines in Cambodia is shown in the following figure.



(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-2 Current Power Generation Facilities and Transmission Lines

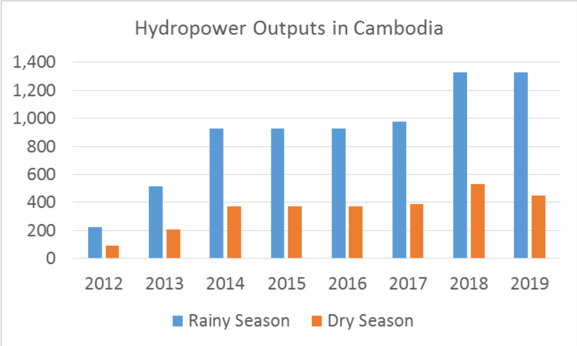
At present, the share of hydropower in Cambodia is over 50%. However, in the dry season, the output of hydropower decreases, and there is a concern that there will be a shortage of supply capacity at the time of maximum demand during the dry season. The figure below is a graph comparing maximum demand and supply capacity in the rainy season and dry season. At the time of peak demand during the dry season in 2019, power supply was insufficient.



(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-3 Supply and Demand Balance in the Rainy and Dry Seasons in Cambodia

The output of hydropower plants in the dry season has reduced to about 30-40% of the rainy season.



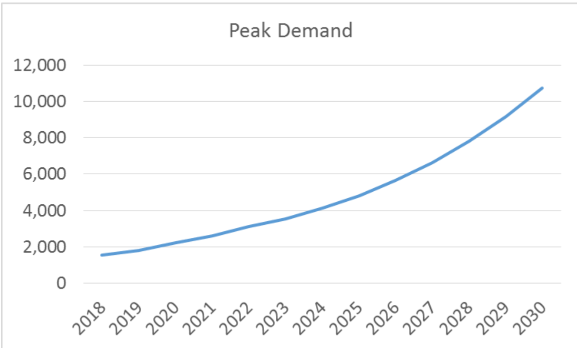
(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-4 Seasonal changes in the output of hydropower plants in Cambodia

For this reason, in Cambodia, although there is a hydropower development plan, there are many plans for thermal power and imported power sources, and solving the shortage of supply in the dry season is an issue.

6.4.2. Power Demand Forecast

The figure below shows EDC's forecast for maximum demand by 2030.



(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-5 Maximum Power Demand Forecast

Table 6.4-2 Maximum Power Demand Forecast

Year	2018	2019	2020	2021	2022	2023	2024
Peak Demand Rainy	1,537	1,818	2,215	2,627	3,097	3,538	4,122
Growth Ratio		18.3%	21.8%	18.6%	17.9%	14.2%	16.5%
Year	2025	2026	2027	2028	2029	2030	
Peak Demand Rainy	4,828	5,664	6,647	7,802	9,157	10,749	
Growth Ratio	17.1%	17.3%	17.4%	17.4%	17.4%	17.4%	

(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Power demand is assumed based on high growth rates. It was 1,818 MW in 2019 and will be 5,664 MW in 2026, about three times' that of 2019. In 2030, it is expected to increase by about 6 times to 10,749 MW.

6.4.3. Cambodia's Current Interconnections with Neighboring Countries

This section shows the current status of Cambodia's international interconnections with neighboring countries. Power is imported from Thailand, Vietnam and Laos via distribution lines. It is urging each country to further increase imports from distribution lines. The country has been supplied from Vietnam by a 230 kV transmission line since 2009.

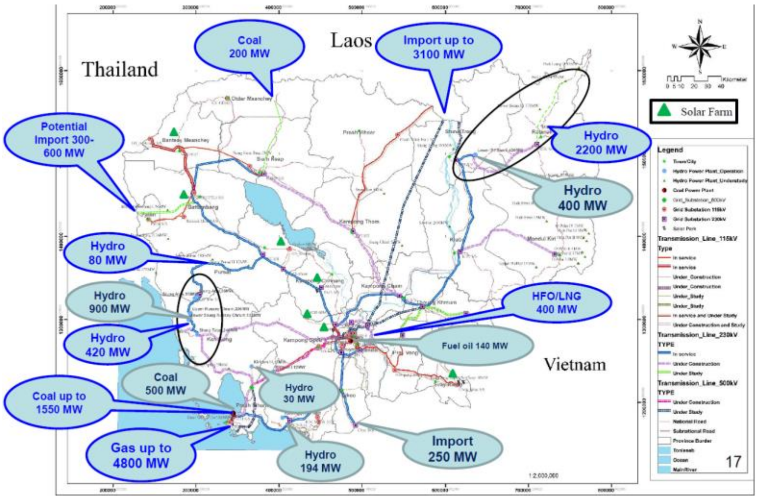
Table 6.4-3 Current status of Interconnections

Country	Thailand	Vietnam	Laos
Current Status	22 kV: 7 sites 115 kV, 2007	22 kV, 35 kV: 19 sites 230 kV, 2009	22 kV: 2 sites 115 kV
Request	22 kV, 35 kV: 7 sites	22 kV, 35 kV: 3 sites	Several sites
Under Construction			500 kV (1st stage 230 kV), 2020-2021 (under construction)

(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

6.4.4. Plans

Plans for power plants and transmission lines up to 2030 are shown in the figure below.



(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

Figure 6.4-6 Plans for Power Plants and Transmission Lines up to 2030

Table 6.4-4 Power Generation Plans

CEL II coal	135	end of 2019
EDC's HFO/LNG	400	2020
Import from Hydro in Lao Don Sahong and Attapeu	700	2020-2023
Coal at Oddor Meanchey	200	2021-2022
Solar Park	340	2020-2022
New Coal Power Pant	1400	2022-2025
Renewable, Solar Park, Wind, Biomass	580	2022-2030
Domestic Hydropower Plant	2600	2023-2030
New NG/CCGT Power Plant	4800	2027-2030
Imort from Laos Coal Mine at Sekong	2,400	2024-2027
Potential Import from Thailand via 230 kV Line	300-600	2022-2027

(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

6.4.5. Power Import Plans

The existing 115 kV transmission line from Ban Hat to Preah Vihear in Cambodia is currently operated. Export at 115 kV started at 20 MW in 2018. It will be 70 MW in October 2019 and 120 MW in October 2020 (March 16, 2019 EDL / EDC MOD). This source is not from Dongsahong Hydropower (260 MW), under construction near the border, but from an existing power source connected to a 115 kV system such as Xeset 1-3. This will be implemented.

The following are anticipated as imports from Laos.

- Donsahong Hydropower and Hydropower in Attapeu Province
- Coal-fired thermal power in the Xekong area

The Agreement on Energy Cooperation between the RGC and Lao PDR was signed by Ministers from Laos and Cambodia on September 12, 2019.

The following PPAs were signed on the same day.

PPA 500 MW EDC and EDL, September 12, 2019

PPA 600 MW EDC and TSBP Sekong Power and Mineral Company Limited, September 12, 2019

PPA 1,800 MW EDC and Xekong Thermal Power Plant Company Limited, September 12, 2019

Of the 4 units, 3 units of Dongsahong Hydropower are for export, and 195 MW is exported from Dongsahong to Cambodia via the Ban Hat substation. A PPA has been concluded at EDL-EDC.

(According to information from MEM in August 2019, all four units will be for export to Cambodia.)

In addition, power supply of 300 MW in Laos' Attapeu Province has been studied at EDL/EDC from April this year. It appears that the developer and EDC agreed on exports from Xekong thermal power (1,800 MW) in May 2019.

- Nam Kong 1, 2, and 3, which were to be connected to the EDL domestic supply grid, will be converted for export to Cambodia. The transmission route is Nam Kong 1, 2, 3-Ban Na-Ban Hat-Cambodia.
- 300-600 MW is expected to be imported from Thailand in the future.

6.4.6. Demand/Supply Balance

The following table shows the future supply and demand balance. Imports from neighboring countries in 2030 are expected to amount to 4,315 MW. Although the details are not clear, it is probable that this forecast anticipates the above-mentioned imports from Laos and imports from Thailand.

Table 6.4-5 Overview of Power Supply and Peak Demand in Cambodia from 2019 to 2030

Dry Season

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel Oil	218	218	649	649	629	629	581	536	536	536	536	536	536
Imports Via Distribution Lines	68	68	68	68	68	68	68	68	68	68	68	68	68
Solar	10	75	235	555	615	615	615	615	715	815	1,015	1,415	1,615
Imports via High Voltage	340	340	895	895	1,165	1,165	1,715	2,315	3,115	3,715	4,015	4,315	4,315
Hydro	531	399	531	531	531	563	563	563	691	691	839	1,034	1,613
Coal	485	477	640	740	1,190	1,540	1,890	2,240	2,240	2,240	2,240	2,240	2,240
Gas	0	0	0	0	0	0	0	0	0	600	1,200	1,800	3,600
Biomass	14	14	30	30	130	130	130	130	130	130	130	130	130
Wind	0	0	0	0	0	0	80	80	80	80	80	80	80
Peak Demand (Dry)	1,537	1,818	2,215	2,627	3,097	3,538	4,122	4,828	5,664	6,647	7,802	9,157	10,749

Rainy Season

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel Oil	250	249	649	649	629	629	581	536	536	536	536	536	536
Imports Via Distribution Lines	68	68	68	68	68	68	68	68	68	68	68	68	68
Solar	10	75	235	555	615	615	615	615	715	815	1,015	1,415	1,615
Imports via High Voltage	340	500	895	895	1,165	1,165	1,715	2,315	3,115	3,715	4,015	4,315	4,315
Hydro	531	531	531	531	531	563	563	563	691	691	839	1,034	1,613
Coal	485	640	640	740	1,190	1,540	1,890	2,240	2,240	2,240	2,240	2,240	2,240
Gas	0	0	0	0	0	0	0	0	0	600	1,200	1,800	3,600
Biomass	30	30	30	30	130	130	130	130	130	130	130	130	130
Wind	0	0	0	0	0	0	80	80	80	80	80	80	80
Peak Demand (Rainy)	1,537	1,818	2,215	2,627	3,097	3,538	4,122	4,828	5,664	6,647	7,802	9,157	10,749

(Source: Data from EDC presentation material in ADB RPTCC-26, November 2019)

6.5. Current Electric Power Situation in Southern China

China Southern Power Grid Company (CSG) is an electric power utility managing power transmission and distribution covering four provinces and one autonomous region in China (Guangdong, Guizhou, Yunnan, Guangxi Zhuang Autonomous Region and Hainan). It takes on the role of power trading with GMS countries. Table 6.4-1 and Figure 6.4-1 show the sales energy and power generation capacity in 2016.

There are the following interconnections.

- Myanmar 500 kV single circuit + 220 kV double circuits
- Laos 115 kV single circuit
- Vietnam 220 kV triple circuits + 110 kV four circuits

A 500 kV DC connection has been constructed between CSG and State Grid Corporation of China.

Table 6.5-1 Sales Energy and Power Generation Capacity of CSG in 2016

2016	Net System Energy Demand
Guangdong	351,600 GWh
Guangxi Zhuang	97,600 GWh
Yunnan	109,700 GWh
Guizhou	89,000 GWh
Hainan	22,100 GWh

2016	Power Generation Capacity
Thermal	149 GW
Hydro	113 GW
Wind	14.68 GW
Nuclear	12.85 GW
Solar & Other	4.18 GW
Total	295 GW

(Source: CSG CSR Report, etc.)

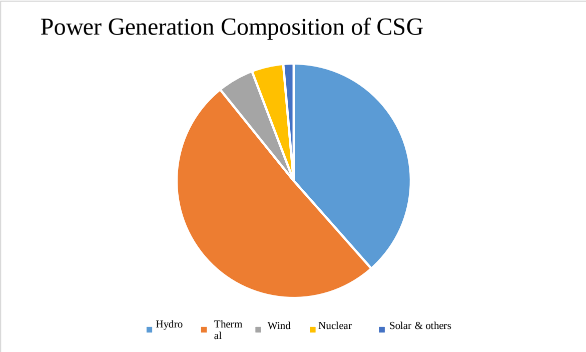


Figure 6.5-1 Power Generation Composition of CSG

6.6. Situations in Thailand, Vietnam, Cambodia and Myanmar

The table below summarizes the status and positioning of power in neighboring countries in Laos under the GMS. Myanmar and Cambodia have an urgent need for power sources due to rapid increases in power demand, and new power sources will continue to be needed in the future. In Thailand, demand is saturating, growth is low at 3%, and the supply from new power sources is not very high.

Table 6.6-1 Situation in and positioning of neighboring countries in GMS

Item	Thailand	Vietnam	Myanmar	Cambodia	Laos
Scale of Current Peak Power Demand	40 GW	30 GW	4 GW	2 GW	1 GW
Current Power Generation	Thermal main	Hydro 40% Thermal 50%	North –Hydro South - Thermal	Hydro 50%	Hydro
Position in Regional Interconnection Scheme	Power Consumption Area	Power Consumption Area	South – Power Consumption Area North – Power Sources Area	Power Consumption Area	Power Sources Area
Power Demand Growth	Low, 3%	Increased	Emergency generators required due to rapid demand growth	Emergency generators required due to rapid demand growth	Surplus Power in wet season
Status of power system	500 kV Grid	500 kV Grid	500 kV Grid Under construction	230 kV	230 kV
Future Development	Domestic 500 kV Transmission Lines	Domestic 500 kV Transmission Lines Responding to rapidly increasing PV generation (reinforcement of regional grid)	Domestic 500 kV Domestic System Reinforcement	Domestic System Reinforcement	North 500 kV Domestic System Reinforcement
System Operation	Perform frequency adjustment	Perform frequency adjustment	Frequency fluctuates greatly and adjustment is insufficient	No frequency adjustment (synchronous with Vietnam)	No frequency adjustment (synchronous with tie)
Grid Code	Existing in Compliance	Existing in Compliance	Does not exist	Does not exist	Exists in EDL Not in Compliance
Solar Power Installation Situations	Increase in solar power in communities	10 GW solar installed recent 1-2years	Plan of 0.2 GW	Small amount	

Therefore, as a method of utilizing the surplus power in Laos to be transmitted to Thailand, the amount of thermal power in Thailand will be reduced, or the power will be transmitted from Thailand to Myanmar and Cambodia.

In Cambodia, due to the lack of power during the dry season, the power supply configuration will be changed from hydropower to thermal power. Coal power from Laos is expected.

Myanmar is currently seeking emergency power sources such as gas turbines and LNG due to the surge in demand. There are several plans for large-scale thermal power, but due to the cost of port development and fuel costs, thermal power in Myanmar is considered to be high in power generation costs, and there are plans to transmit economical hydroelectric power from the north in the future.

Chapter 7. Study on Laos' Power Network System by China

7.1. Study on Laos' Power Network System by China

In the Belt and Road Forum for International Cooperation that was held in Beijing in May 2017, it was agreed between the two heads of states that the Belt and Road should bring mutual beneficial cooperation.

In March 2017, the National Energy Administration of China and Laos' MEM agreed a cooperation study on Laos' power network system plan in order to make Laos the battery of the region. According to this agreement, the study on the plan is being carried out by EPPEI (Electric Power Planning & Engineering Institute) and CSG under the National Energy Administration.

In the report by EPPEI in September 2017, a plan was studied involving power exports from Laos to Thailand and Vietnam, combining power imports from China to Laos and the surplus generation power of Laos.

The following description shows an outline of the results of the study in September 2017. However, it should be re-examined because the power demand in Laos was not assumed based on the latest demand forecast, which is less than half of the old one, and power export methodologies to Vietnam determined up to 2025 are not mentioned there.

1. Outline of the report by China EPPEI (Sep. 2017)

The following is an excerpt from the report in 2017, which is different from the current plans of Laos. In particular, there are differences in the power demand forecast and the forecast for Laos' power sources to neighboring countries. In addition, Vietnam is described based on the export volume described in the MOU, but there are cases where the implementation of power exports has not been agreed upon in the process of contract negotiations between the power producer and EVN.

a) The following are assumed.

- Peak power demand of Laos is set as 5,892 MW in 2030.
- The power sources of Laos are divided into export power and domestic usage. The power exports to Vietnam and Thailand from China through Laos are counted separately to Laos' domestic usage.
- The balance of power outputs is examined for dry seasons and the energy balance is examined for a year.
- For Thailand, power exports of 9,000 MW up to 2030 are assumed to be achieved through Pakbeng 820 MW in 2025, small hydropower of 9 MW, Phoungoy 686 MW and some small hydropower of 119 MW, aside from the contracted export-oriented IPPs. The interconnections between China, Thailand and Laos are assumed to be used with a ratio of power trades that is 6 to 4 for power imports from China to Thailand and from Laos to Thailand.
- Power exports to Thailand are assumed to be started from 2025 -2026. The total amount of these power exports is around 400 MW. Shortages are assumed to be imported from China.
- For Vietnam, power exports of 1,000 MW up to 2020 are assumed to be achieved via power exports through Xekaman 1 and 3 transmission lines. Power exports of 3,000 MW up to 2025 and 5,000 MW up to 2030 are assumed to be achieved through existing power plants covering 483 MW, those under construction covering 32 MW and planned units covering 4,485 MW.
- For Vietnam, power exports of 4,000 MW from 2023 are to be achieved via nominated power plants in Laos of around 400 MW. The remaining power is planned to be imported

from China. 300 MW for Myanmar and 300 MW for Cambodia are assumed. (As will be described later, the target values for export to Vietnam, Myanmar and Cambodia can be achieved via the power supply in Laos.)

- Power exports of 1,500 MW are assumed from the north of Laos to the north of Vietnam and 3,500 MW is assumed from the south of Laos to the south of Vietnam.

b) The following results have been obtained.

- Dry season in 2020
  - Laos has surplus power even in the dry season. Power of around 1,000 MW is exported from the north of Laos to China and power of 600 MW is sent from Central 1 to the south of Laos.

- Dry season in 2025
  - Power in Laos is insufficient in the dry season. Power is imported from China to the north of Laos, amounting to 2,700 MW. Power is exported to the south of Vietnam directly from the north of Laos through a DC interconnection, amounting to 2,500 MW. Power of around 1,500 MW is exported from the north of Laos to the north of Vietnam. Power transmission of around 1,000 MW is carried out from the north of Laos to its Central 1 and around 1,300 MW, from the south of Laos to its Central 2.

- If Laos doesn't import power from China, additional installation of hydropower stations - Luangprabang 1,200 MW in the north and Ban Koum 1,872 MW in the south, or Coal Fired (Boulapha) 1,800 MW in Central 2 and Coal Fired (Laman) 700 MW - are required up to 2030.

c) The following are recommended.

- Synchronous interconnections between Laos and China, and 500 kV AC transmission lines from north to south in Laos, should be applied.

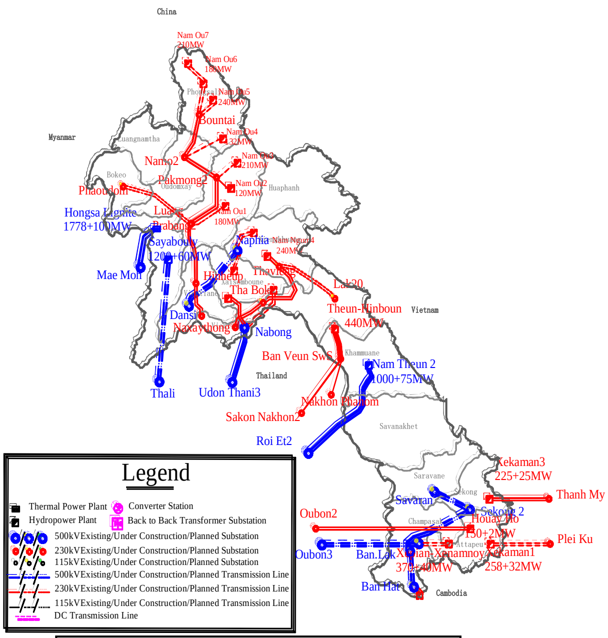
- Interconnections between Laos and Thailand, and the interconnections between Laos and Vietnam, should be asynchronous ones.

- When the interconnection between the north of Laos and the north of Vietnam is operated in 2023, B to B converter stations are installed at the interconnection between Laos and Vietnam (ref. the following figure: Case with interconnection between north of Laos to north of Vietnam)

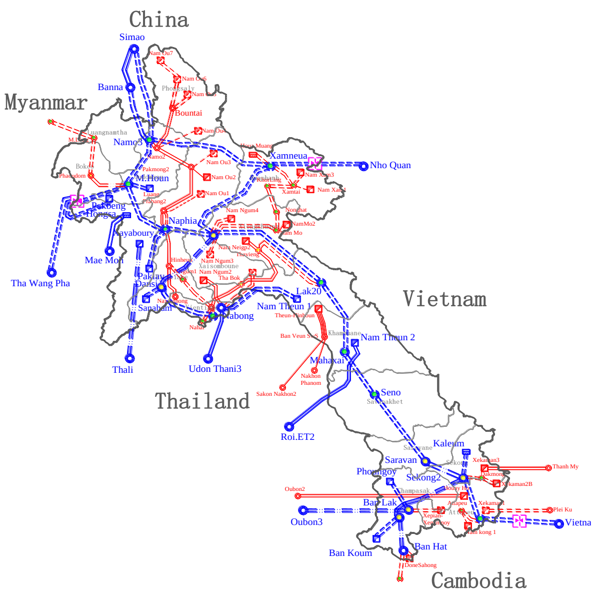
- If the construction of the interconnection between the north of Laos and the north of Vietnam is delayed or uncertain, DC interconnection between the north of Laos and the south of Vietnam should be constructed. (Ref. the following figure: Case with interconnection between north of Laos and south of Vietnam via DC interconnection without interconnection between north of Laos and north of Vietnam.)

- The plans for and construction of export oriented power plants in Laos should be adequately arranged according to the construction schedule for interconnection.

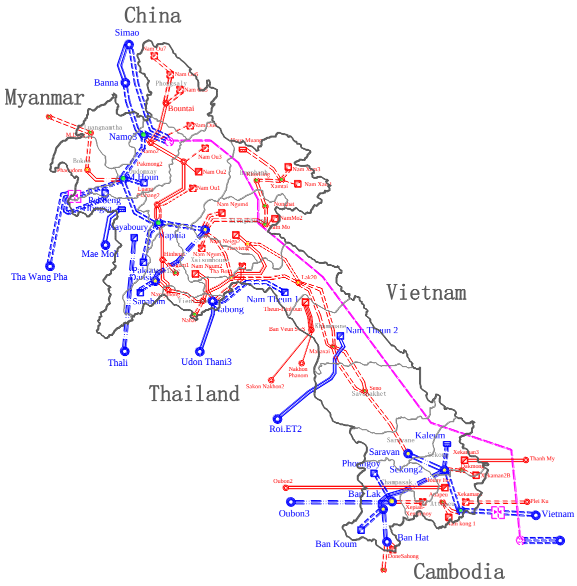
- Figure 6.4-2 shows the recommended plans for bulk power transmission lines in Laos.



Exisiting & Under Construction



Case with interconnection between north of Laos to north of Vietnam



Case with interconnection between north of Laos and south of Vietnam via DC interconnection without interconnection between north of Laos and north of Vietnam

Figure 7.1-1 Recommended Plan for Bulk Power Transmission Lines in the report by China EPPEI

(Source: Documents by China EPPEI, September 2017)

DC interconnection between the north of Laos and central south part of Vietnam (as indicated by a pink line in Figure 6.4-2) has been proposed by Phongsaptari (a company in Laos) and EDL. The companies signed an MOU with a company, Hanoi-Vientiane, but there is no signed MOU with EVN. The MOU contains power exports of 3,000 MW to Vietnam in 2020-2025 and 6,000

MW in 2025-2030. Both of the vice prime ministers acknowledged the MOU, and MEM and EDL in Laos intend to approve it. This DC line aims to realize power exports from China to Vietnam through routes in China – DC converter station in the north of Laos – DC line – central Vietnam. Power exports from Laos to Vietnam can also be realized by connecting some power stations such as Nomo to this DC line at the converter station.

7.2. Study on EDL-T

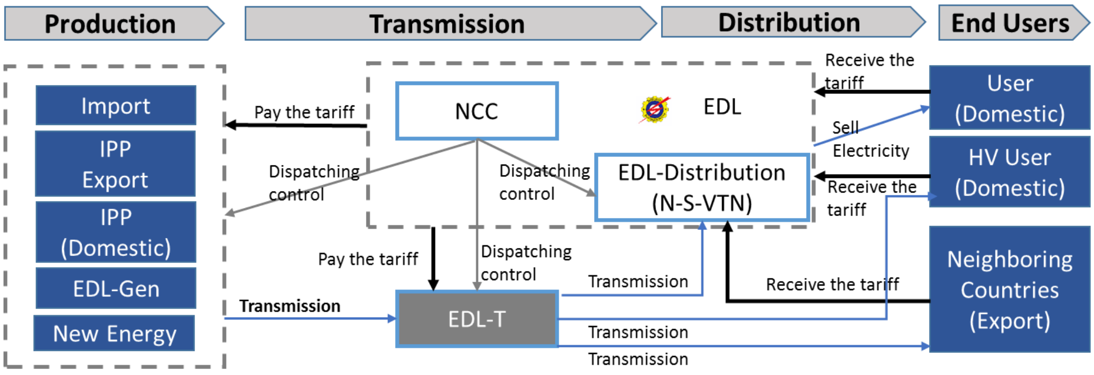
CSG and EDL have carried out a feasibility study on the establishment of EDL-T - a company in Laos to manage the bulk power transmission lines. Two cases are described. One would make it a 100% subsidiary company of EDL. The other sees ownership of the company shared by EDL and CSG. There are also two options regarding management areas. One is to construct, operate and own only the bulk power transmission lines. The other is to construct, operate and own all the transmission lines in Laos.

The high voltage power transmission system in Laos will greatly affect the power system of the neighboring countries in future through power trades for countries such as Thailand and Vietnam, as well as China. If other capital enters the enterprise managing the high voltage power transmission system in Laos, it may ensure that fair transmission operation in the future GMS is not compromised by the capital participation of China alone. For this reason, the participation etc. of Thailand and Vietnam should also be considered.

1. FS in November 2018

In November 2018, an EDL-T FS report (co-authored by EDL, CSG and accenture) was submitted to the Lao government. In this report, system planning, EDL-T business model, EDL-T establishment form, etc. are examined. The power system plan in this report is based on the final report on the Lao system planning study by China EPPEI in the next section.

- EDL-T is responsible for both the transmission of electricity to domestic power demand and the export of electricity to neighboring countries. The former will be recovered by wheeling charge, and the latter will be recovered by the difference between the revenue from the sale of electricity from exports and the payment to the generator.
- Domestic supply fee revenues can be recovered by adjusting domestic electricity rates. However, for exports to neighboring countries, it is unclear whether export prices can be negotiated at a price that can recover the cost of the transmission lines constructed for export. After contracting for an export price commensurate with the cost of the transmission line, construction of the transmission line necessary for export should be started.
- In the scheme proposed in the FS report, the construction entity of the transmission line is EDL-T, and EDL-T recovers its costs by payment from EDL. EDL is the main provider of domestic power transmission and export to neighboring countries. The problem here is that the EDL-T itself is responsible for planning transmission line construction for the EDL-T. In other words, apart from EDL, which is the business management organization, there is EDL-T as an organization that plays a central role in the planning and construction of equipment. As a result of proceeding with the construction of transmission lines independently of the business management plan, there is a risk that the costs of the transmission business and construction may not be recovered.



	Domestic Business	International Business
Tariff Payment	End users → EDL	Neighboring countries → EDL
	EDL → EDL-T & Gen.	EDL → EDL-T & Gen.
Tariff Setting	Domestic	EDL-T negotiates with foreign countries
Planning	EDL-T makes a project list of EDL-T's Project	
Construction	EDL-T makes investment for 500kV, 230 kV	

Source: EDL-T FS report (co-authored by EDL, CSG, accenture) and JICA Study Team based on it

Figure 7.2-1 EDL-T's business form in FS of EDL-T

One of the following is suggested as an improvement plan.

- The EDL-T power transmission line plan is not formulated by EDL-T, but by EDL, the business management entity. EDL-T will construct necessary transmission lines according to the plans and instructions formulated by EDL.

Or,

- ED EDL-T, which plans and constructs transmission lines, also conducts its own export business and recovers the cost of the equipment it has constructed.

2. FS in December 2019

At the end of 2019, CSG compiled an EDL-T FS report. It analyzes the current state of EDL and examines the need for EDL-T in the range up to 2035. The following three issues are set as issues.

- Based on the demand forecast in Laos and the export volume of MOU for power export with neighboring countries, shortage of power in dry season and surplus of power in rainy season are expected. Therefore, power interchange with neighboring countries, especially China, is urgently needed.
- Loss of power system in Laos is large, power supply trouble frequently occurs, and system reliability is low. For this reason, the operation and management of a highly reliable system will be performed by strengthening the system with backbone transmission lines.
- Uncontrolled grid planning results in high investment costs and unnecessary and timely EPC projects.

To improve the above, the establishment of EDL-T is proposed.

- Power costs can be reduced by balancing power surplus and shortage during the rainy season and dry season through power interchange with CSG.
- CSG demands only a low return of 6% from EDL-T's business, and if EDL-T purchases CSG's inexpensive power, it can reduce the cost of electricity in Laos and increase its competitiveness.

- The value of EDL assets is significantly lower than its book value, and CSG can reduce the deficit by distributing Chinese electricity to the Lao grid and earning money from its consignment charges.
- It is considered that the project should be started after the PPA confirms the intention of the neighboring country to which it sells to purchase power, or should start only in the range necessary for the confirmed distribution of power.

7.2.1. Study on Power Network System in Laos by China (March 2018)

The Final Report on Laos' Power System Plan as prepared by EPPEI of China was submitted in March 2018. In comparing the study conditions regarding the amount of planned power generation and power exports between this report and the JICA MP, the following features are observed.

- Both studies estimate the amount of power exports based on MOUs and exports of surplus power to Myanmar, Cambodia and Vietnam.
- In EPPEI's report, the power generation plan is selected so as to secure the amount of power exports based on MOUs and exports of surplus power to Myanmar, Cambodia and Vietnam. In JICA's scenario, the power generation plan is selected according to the progress of projects' development and by prioritizing reservoir types, etc. The required amount of power exports is then selected as a result of this.
- Power exports to Thailand are 10,163 MW in the report by EPPEI and 8,348 MW in the JICA MP (lower in the JICA MP than in the report by EPPEI). Power exports to Vietnam are 7,927 MW in the report by EPPEI and 9,897 MW in the JICA MP (higher in the JICA MP than in the report by EPPEI).
- Power exports to Thailand from China though Laos are predicted to be 600 MW in the report by EPPEI. In this report, power exports from China to Laos are predicted to be 214 MW.
- In the report by EPPEI, power outputs of 3,000 MW from power generation in Laos are exported via DC transmission line. In the JICA MP, DC transmission lines are not expected to be used for power evacuation from Laos.
- The maximum power output from the Laos grid is estimated to be 60% of its power generation capacity in the report by EPPEI and 50% in JICA MP.
- The amount of power generation from Laos is larger in the JICA MP.

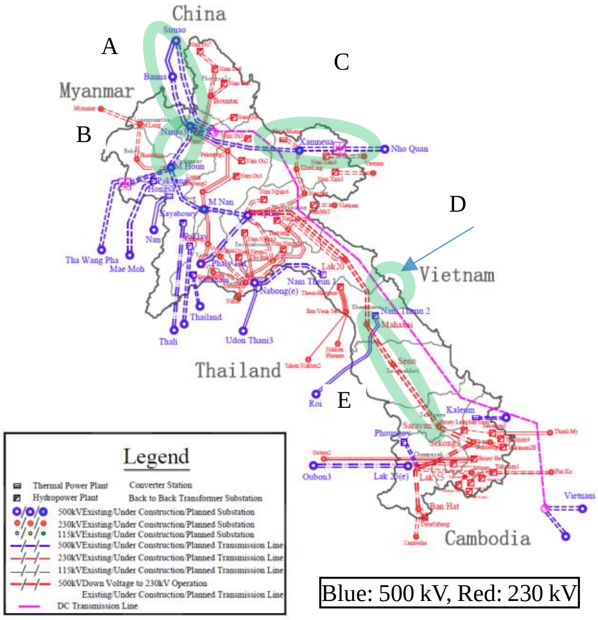
The maximum power demand for Laos in 2030 is expected to be 5,892 MW in the July 2017 report. However, this has been reduced to 2,921 MW (almost halved). In line with this, the amount of imports required from China to Laos drastically decreases, being around 200-300 MW in the dry season of 2030.

Construction of a 500 kV Backbone transmission line from North to South was proposed, but this is not proposed in the March 2018 report because the amount of power transmission required from the North of Laos to the South was reduced by reconsidering the power demand forecast in Laos and power exports to Vietnam from the south of Laos.

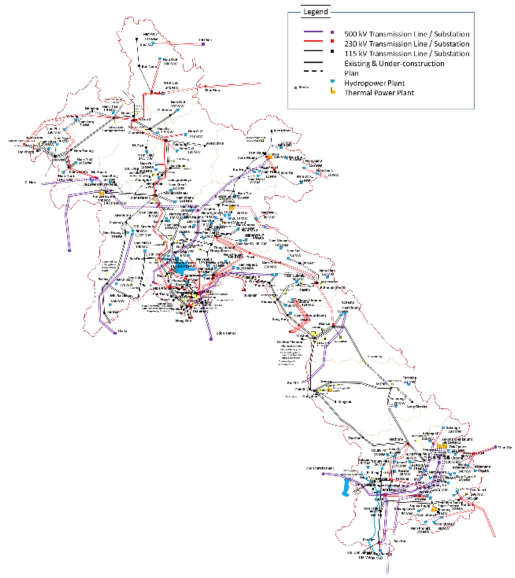
However, due to the necessity of supplying the domestic power demand in central Laos, construction of 230 kV transmission lines from northern to central Laos, and from southern to central Laos, is proposed.

Table 7.2-1 Comparison of Power Generation and Power Demand Forecasts for 2030 between the Report by China (March) and JICA MP (May)

	Report by China (March)				JICA MP (May)			
	Power Generation		Domestic Power Demand/Power Exports for 2030		Power Generation		Domestic Power Demand/Power Exports for 2030	
Grid	From China	214	Domestic Power Demand	2,921	From China	0	Domestic Power Demand	2,691
	Power Generation in Laos	8,910	Power Exports	2,523	Power Generation in Laos	13,457	Power Exports	4,070
	Sub Total	9,124	Sub Total	5,444	Sub Total	13,457	Sub Total	6,761
By dedicated Transmission Lines	Power Generation in Laos	16,170	Power Exports	16,170	Power Generation in Laos	15,175	Power Exports	15,175
Total		25,294		21,614		28,632		21,936
	Total Power Exports			18,693	Total Power Exports			19,245
	Power Wheeling for Power Exports From China to Thailand through Laos			600	Power Wheeling for Power Exports From China to Thailand through Laos			0



Planning and Construction Plan for Laos Power Grid in 2030



	Main Project	Rpoet by China (2018-2019)	JICA MP
A	500 kV China - Norh of Laos iterconnection	With	Without
B	500 kV Nam mo - M. Houn	With	Without
C	500 kV Nam Mo - Nho Quan (Vietnam)	With	Without
	North-south 500 kV Bacck-bone transmission line	Without	Without
D	North of Laos - Central Vietnam DC line (Private)	With	Without
E	230 kV Mahaxai - Saravan transmission line	With	Without

Figure 7.2-2 Main differcence between the plan of China EPPI and JICA MP

The following breakdown of power export estimations includes exports from export-dedicated IPPs.

Power Export Estimations (2030)

Country	China Report (March)	JICA MP (May)
Thailand	10,163	8,348
Vietnam	7,927	9,897
Myanmar	302	500
Cambodia	301	500
Total	18,693	19,245