A Study of System to System: Lao PDR and Thailand

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ABSTRACT

This paper deals with a system to system power interconnection model from case study Lao PDR and Thailand. ASEAN Interconnection Mater Plan-II (AIMS-II) and Thailand PDP2015 are reviewed in details. The result is recommended for EDL to be used as a guideline for implementation of the System-to-System power interconnection in the future. The paper is presented only views and ideas implementation process only. The power system study for the power system interconnection such as load flows, stabilities, contingencies, etc. those are out of the scope of the paper. System-to-system power import/export requires good cooperation among the countries involved. Bilateral and multi-lateral agreements between parties who will be taking part in the power trade must be established. As for Lao PDR, the steps that should be done in the system-to-system implementation is presented.

Keywords: *System-to-System, Power interconnection, ASEAN Power Grid.*

1. INTRODUCTION

In preparation to comply with the national policy on "Battery of Asia", cross-border interconnection between Laos and her neighboring countries has to be well planned. Cooperation among the countries to be connected for power trade is utmost important. Fortunately, ASEAN member countries have been interested in the ASEAN power grid since the beginning of establishing ASEAN. Electricity network on power cooperation has also been set up by Heads of ASEAN Power Utilities/Authorities (HAPUA) to explore the opportunity of realization of ASEAN Power Grid (AGP). HAPUA has conducted a study on ASEAN Interconnection Mater Plan (AIMS) which was revised to become AIMS-II at present. EDL is also an active member of HAPUA and may use the floor of HAPUA to facilitate the power trade with her neighbors. The participation of EDL in HAPUA will be useful for in the undertaking of the System-to-System Power Exchange [1].

The study on System-to-System power interconnection will be carried out jointly between RATCH and EDL. A working group has been appointed to carry out the study. It has been agreed that the study be conducted in this manner:

(1) Review the result of ASEAN Interconnection Master Plan Study II (AIMS II) which a focus on the interconnections among the six countries of interest, namely, Thailand, Myanmar, Laos, Vietnam, Cambodia and Southern China. This study primarily focused on the analysis of technical aspects as follows; (i) Existing Power Grid in Laos such as Power Purchase (PP) and Energy Exchange (EE) (ii) Long term forecast of each system (iii) Interconnection master plan (iv) Demand and supply in future.

(2) Review Power Development Plan (PDP) [2] of the six countries. The study will cover demand and supply forecast, transmission line expansion, cross border

interconnections, etc.

(3) Review Power market in Laos and Power interconnection in future. The study will cover Existing/Plan of power purchases with neighboring countries, Concept of Enhanced Single Buyer (ESB), Type of Interconnection (HVAC/HVDC) and other related subjects.

(4) Explore the attitude of neighboring countries towards system-to-system interconnections regarding power purchases from Laos. Inviting relevant representatives from these countries to attend some working group meetings may be considered as an advantage.

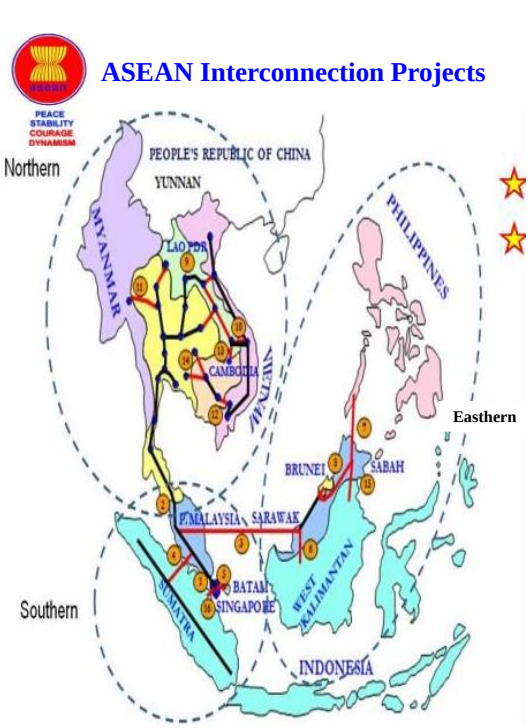
(5) Examine the structure of implementation process including ideas on energy trade, power pool, long term PPA and competitive pricing, etc.

The result is recommended for EDL to be used as a guideline for implementation of the System-to-System power interconnection in the future. The paper is presented only views and ideas implementation process only. The power system study for the power system interconnection such as load flows, stabilities, contingencies, etc. those are out of the scope of this paper.

2. REVIEW OF AIMS-II RESULTS

In preparation to comply with the national policy on "Battery of Asia", cross-border interconnection between Due to the fact that all electric utilities and authorities in ASEAN are members of the Heads of ASEAN Power Utilities/ Authorities (HAPUA) which is a non-profit organization with an aim to unite and consolidate the power systems of the members to become an ASEAN Power Grid (APG). To realize this endeavor, the member utilities and authorities joined hands to create a joint technical project which was referred to as an ASEAN Interconnection Master Plan Study (AIMS). The project covered a long-term planning of the combined ASEAN power systems considered as a single system. An optimization study was carried out under the assumptions to interconnect the neighboring countries with cross-border tie lines and also to exploit the regional energy resources such as hydro, natural gas, coal and lignite, etc. to benefit the regional electricity sector. The first AIMS was completed in 2003 and was revised to AIMS-II in 2012.

The latest result of the AIMS project is known as AIMS-II which is the revision of the first AIMS outcome. AIMS-II result has been endorsed by executives of each HAPUA member country and can be used as a directive framework for power development in each ASEAN member to finally realize the APG. Projects which have been identified in AIMS-II consist of 16 cross-border interconnection routes as shown in Fig. 1 and Table 1 below.



	Earliest COD
1) P.Malaysia – Singapore (New)	**2018**
2) Thailand – P.Malaysia	
• Sadao – Bukit Keteri	Existing
• Khlong Hgae – Gurun	Existing
• Su Ngai Kolok – Rantau Panjang	2015
• Khlong Ngae – Gurun (2nd Phase, 300 MW)	2016
3) Sarawak – P.Malaysia	**2015-2021**
4) P.Malaysia – Sumatra	**2017**
5) Batam – Singapore	**2015-2017**
6) Sarawak – West Kalimantan	**2015**
7) Philippines – Sabah	**2020**
8) Sarawak – Sabah – Brunei	
• Sarawak – Sabah	2020
• Sabah – Brunei	Not Selected
• Sarawak – Brunei	2012, 2016
9) Thailand – Lao PDR	
• Roi Et 2 – Nam Theun 2	Existing
• Sakon Nakhon 2 – Thakhek – Then Hinboun (Exp.)	Existing
• Mae Moh 3 – Nan – Hong Sa	2015
• Udon Thani 3 – Nabong (converted to 500 kV)	2018
• Ubon Ratchathani 3 – Pakse – Xe Pian Xe Namnoy	2018
• Khon Kean 4 – Loei –Xayaburi	2019
• Thailand – Lao PDR (New)	2015 – 202
10) Lao PDR – Vietnam	**2011-2016**
11) Thailand – Myanmar	**2016 – 2025**
12) Vietnam – Cambodia (New)	**2017**
13) Lao PDR – Cambodia	**2016**
14) Thailand – Cambodia (New)	**2015 – 2020**
15) East Sabah – East Kalimantan	**2020**
16) Singapore – Sumatra	**2020**

Fig. 1 *Interconnection Projects Identified in AIMS-II*

Table 1 *Result of AIMS-II Showing Potentials of Regional Interconnection within ASEAN.*

STATUS OF ASEAN INTERCONNECTION PROJECT (AUGUST 2013 DATA)				(MW)
SYSTEM REGION	**EXISTING**	**ON-GOING**	**FUTURE**	**TOTAL**
NORTHERN REGION	2,659	6,062	16,374	25,095
9. Thailand – Lao PDR	2,111	3,352	2,465	7,928
10.Lao PDR –Vietnam	248	2,410		2,658
11.Thailand –Myanmar			11,709	11,709
12.Vietnam –Cambodia	200			200
13.Lao PDR –Cambodia		300		300
14.Thailand - Cambodia	100		2,200	2,300
SOUTHERN SYSTEM	450	600	1,800	2,850
1.P.Malaysia – Singapore	450		600	1,050
4.P.Malaysia - Sumatra		600		600
5.Batam - Singapore			600	600
16.Singapore - Sumatra			600	600
EATERN SYSTEM		400	800	1,200
6.Sarawak – W..Kalimantan		200		200
7.Phillippines - Sabah			500	500
8.Sarawak – Sabah – Brunei		200	100	300
15.E.Sabah – E.Kalimantan			200	200
NORTHERN – SOUTHERN SYSTEM	380	100	300	780
2.Thailand – P.Malaysia	380	100	300	780
SOUTHERN – EASTERN SYSTEM			3,200	3,200
3. Sarasak – P.Malaysia			3,200	3,200
GRAND TOTAL	**3,489**	**7,162**	**22,474**	**33,125**

Table 1 has indicated interconnection between Lao PDR and Thailand, Lao PDR and Cambodia as well as Lao PDR and Vietnam. Although the result in Table 1 is not up-to-date, it can be construed that potentials of interconnection between Lao PDR and her neighboring countries exist. It will be worthwhile for the further study to be carried out to determine the likely potentials based on more recent information.

3. REVIEW OF THAILAND PDP

Thailand PDP2015 [2] can be summarized as follows: In 2036, the total capacity will be 70,335 MW comprising existing capacity of 37,612 MW (as of December 2014), new capacity of 57,459 MW, and retired capacity during 2015 – 2036 of 24,736 MW as shown below:

Generating capacity during 2015 – 2036

- Existing capacity as of December 2014	37,612 MW
- New capacity during 2015-2036	57,459 MW
- Retired capacity during 2015-2036	-24,736 MW
- Total capacity in 2036	70,335 MW

New capacity added during 2015 – 2036 of 57,459 MW can be classified as follows:

Renewable power plant	21,648 MW
- *Domestic*	*12,105 MW*
- *Power purchase from neighboring countries*	*9,543 MW*
Pump-storage hydro power plant	2,101 MW
Cogeneration power plant	4,119 MW
Combined cycle power plant	17,478 MW
Thermal power plant	12,113 MW
- *Coal/Lignite power plant*	*7,390 MW*
- *Nuclear power plant*	*2,000 MW*
- *Gas turbine power plant*	*1,250 MW*
- *Power purchase from neighboring countries*	*1,473 MW*
Total	**57,459 MW**

To ensure power system reliability of subsystem areas in terms of generation, transmission, and distribution, 2 areas which have high possibilities of power shortages were considered thoroughly. Ensuring power system reliability in Southern of Thailand Power demand in southern of Thailand will grow 3 percent annually; therefore, 3 power plants will be added during 2019 – 2024 as the followings:

- *In 2019, Krabi Coal-fired Power Plant 800 MW*
- *In 2021, Thepa Coal-fired Power Plant unit 1 1,000 MW*
- *In 2024, Thepa Coal-fired Power Plant unit 2 1,000 MW*

Ensuring power system reliability in Metropolitan area and central of Thailand Electricity consumption of metropolitan area - the country's largest economy area - acquired the largest portion accounting for 30 percent of the total electricity consumption. However, relying on power from other areas, and lacking its own capacity, the area has been confronted with the challenge of the continuously growing power demand. Therefore, power plants are needed to be developed to maintain power system reliability in the area during 2019 – 2025 as the following:

- *In 2019, replacement of South Bangkok Thermal Power Plant unit 1-5 1,300 MW*
- *In 2019, replacement of Bang Pakong Thermal Power Plant unit 1-2 1,300 MW*
- *In 2022, replacement of South Bangkok Combined Cycle Power Plant unit 1-2 1,300 MW*
- *In 2023, replacement of Wang Noi Combined Cycle Power Plant unit 1-2 1,300 MW*
- *In 2025, replacement of Wang Noi Combined Cycle Power Plant unit 3 1,300 MW.*

Thailand PDP2015 reveals that hydro power is a big component in the present PDP of Thailand. The import will be mainly from Lao PDR.

4. POWER MARKET IN LAO PDR

Energy Sector Institutional Framework of Lao PDR is shown in Fig. 2, current structure of Lao PDR power sector is shown in Fig. 3, respectively [3].

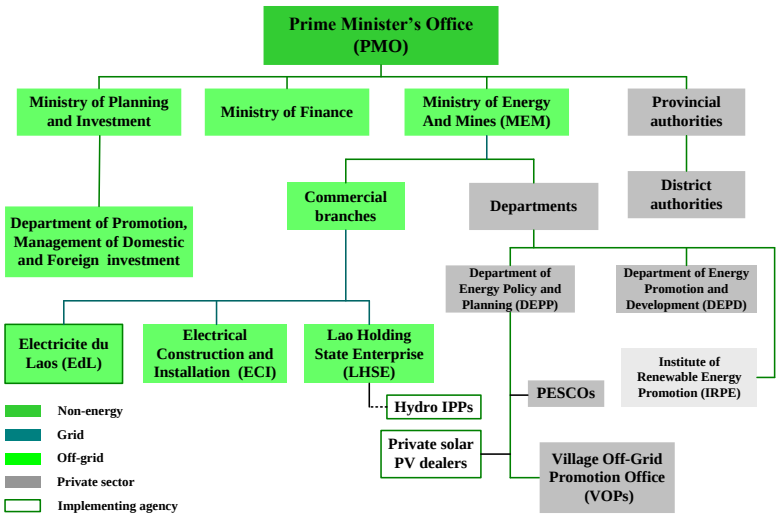


Fig. 2 *Energy Sector Institutional Framework of Lao PDR*

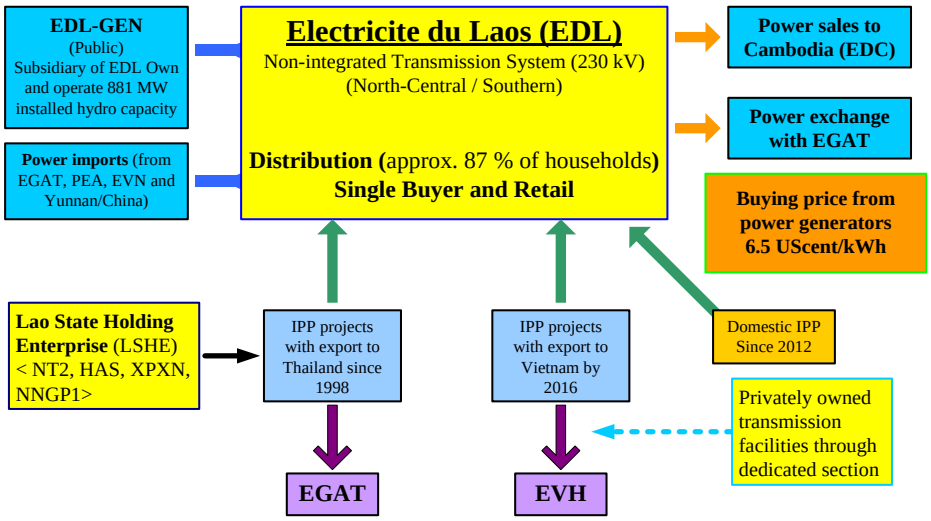


Fig. 3 *Current Structure of Lao PDR Power Sector*

4.1 MOU WITH THAILAND

Bilateral agreements in the form of memoranda of understanding (MOUs) between governments on the power cooperation are normally exercised between countries where power import/export is taking place. The government of Lao PDR should make an effort to have such MOU signed with the governments of the neighboring countries. It will be used as a reference when further actions on power exchange between countries which may be taken place in the future.

The first MOU (MOU1993), the framework was to develop the potential power projects in Lao PDR for approximately 1,500 Megawatts by the year 2000. There are two projects successfully developed which are Theun Hinboun with capacity of 220 Megawatts operated in 1998 and Houay Ho project with capacity of 126 Megawatts operated in 1999. On 18 December 1996, the Thai-Laos MOU was revised to support the development of more power projects in Lao PDR up to 3,000 Megawatts (including the existing capacity of the first MOU of 1,500 Megawatts) by the year 2006. Two additional projects were successfully developed namely, Nam Thuen 2 and Nam

Ngum 2 in 2010 and 2011 with capacity of 948 Megawatts and 597 Megawatts respectively. The extended MOU has brought about successful projects of 1,891 Megawatts. The second extension of MOU (MOU2006) was executed on 19 June 2006 to develop the power projects with expected capacity of 5,000 Megawatts (including the existing capacity of the first MOU of 3,000 Megawatts) by the year 2015. Under MOU 2006 (second extension), there is no project successfully developed. Only one year after the execution of MOU2006, the third extension of MOU was signed on 22 December 2007 for the capacity totalling 7,000 Megawatts. This MOU has increased a capacity of 2,000 Megawatts without expiration. Six projects have been successfully developed: Theun-Hinbound Expansion Project, Hongsa Project, Xe-pian Xe-namnoy project, Xayaburi project and Nam Ngiep 1 project. The accumulated capacity of the committed projects are 5,947 Megawatts which nearly exceeds the limit specified in the MOU2007 (7,000 MW) and it leads to the negotiation of the fourth extension. The latest MOU puts the potential capacity to 9,000 Megawatts until the year 2030 and has introduced the platform for the grid-to-grid power trade.

The last set of projects with a total capacity of 1,843MW was to come from hydropower plants, which are scheduled to be completed and start commercial operations in 2019. They are the 354MW Xe Pien Xe Namnoy hydropower project, Xayabury Dam (1,220MW) and the Nam Ngiep project (269MW).

Laos has agreed to sell 100 megawatts (MW) of electricity to Malaysia via Thailand power grid in a trade deal which was already signed by the concerned parties. The energy purchase and wheeling agreement (EPWA), the first multilateral energy exchange or trade in ASEAN, was signed during the ASEAN Ministers on Energy Meeting (AMEM) in the Philippines. Under the two-year agreement, Laos will export power to Malaysia beginning on January 1. Once the agreement ends its term, the involved parties will negotiate again (on future energy trading). The EPWA governs the obligations of the parties in the selling, wheeling and purchase of energy from EDL via EGAT (the wheeler) to TNB for the two-year period based on the agreed terms and conditions. The EPWA was inked after energy authorities from Laos, Malaysia and Thailand signed a memorandum of understanding in September 2016 in Myanmar during the AMEM, which indicated that Malaysia intended to purchase power from Laos. Laos has strongly supported the initiative as it seeks to export more electricity. The country boasts high potential to produce and export more power to its neighbors and other ASEAN members via the regional power grid.

Among the countries surrounding Lao PDR, Thailand may remain the most potential power importer from Lao PDR. This is due to the fact that the power consumption in Thailand is still increasing. Thailand will need to import energy from aboard whether it be coal, LNG or electricity. Diversification of power sources is a factor to be considered by Thailand for fuel supply security. If the price of electricity from Laos is competitive and there are no other technical limitations, Thailand can be considered as no. one power exporter of Laos. The second customer to be considered will be Vietnam due to similar situations as explained earlier for Thailand. The reason why Vietnam is ranked after Thailand is that Vietnam is promoting foreign investments in power sector in a more advanced manner than Thailand and Vietnam may not need much import of electricity. Other potential importers of electricity may be Cambodia and Myanmar.

Possibilities may exist for power exports to countries which do not share border with Laos but there are some restrictions to be solved and large amount of power may not be possible to dispatch to countries not sharing border with Lao PDR due to transmission system limitation.

4.2 IMPLEMENTATION OF POWER EXPORT FROM LAO PDR

In addition to upgrading the transmission system so that it becomes strong and consolidated which will make it possible for power flow throughout the country without limitation, the structure of the power market itself will need to undergo modification to cater for the system-to-system power import/export.

Since Thailand will remain the major country to which Lao PDR will export electricity, the electricity structure of Thailand which allows system-to-system power trade with single buyer market shall be used as a model for Lao PDR as shown in Fig. 4.

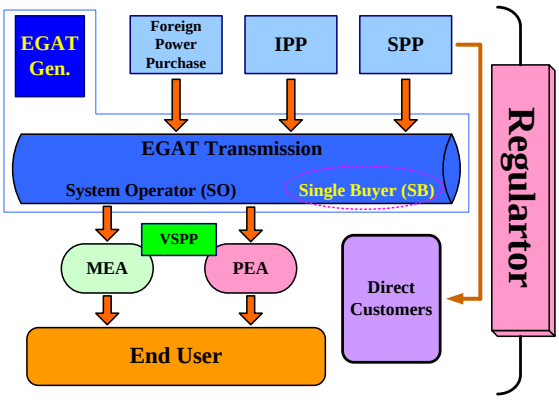


Fig. 4 *System-to-System Power trade model between Lao PDR and EGAT Thailand.*

Under the single buyer model of Thailand, the account of EGAT business units is unbundled into generation and transmission. EGAT retains the present generation while new capacity will be procured through competitive bidding which will be overseen by the regulator. EGAT also retains transmission system and is responsible for transmission system operation and maintenance. Transmission of power is under the Grid Code and transmission license.

Third party access to transmission right is not valid at present. The system operation is ring-fenced within EGAT transmission business. The system operator performs dispatch planning, dispatch, real time balancing and network operation planning.

EGAT is a single buyer of power who is responsible for contracting adequate capacity and accountable for long term system adequacy planning. The single buyer operation will need to be transparent.

MEA and PEA continue to operate distribution networks with regulated tariffs. MEA and PEA are regulated via Grid Code and distribution licenses. Third party access will be yet considered.

The regulator enforces Grid Code and generation, transmission as well as distribution licenses. The regulator coordinates long term system adequacy planning and manages new Power Purchase Agreement (PPA) awarding process.

5. CONCLUSION AND RECOMMENDATION

System-to-system power import/ export requires good cooperation among the countries involved. Bilateral and multi-lateral agreements between parties who will be taking part in the power trade must be established. As for Lao PDR, the steps that should be done in the system-to-system implementation may be as follows:

5.1 Establish MOUs with neighboring countries as the initial step in the system-to-system power exchange.

5.2 At present, Lao PDR may be able to begin system-to-system power export or import to/ from neighboring countries through bilateral or multi-lateral agreements. A good example is the export of 100 MW from Laos power system to Maylasia through Thailand power grid. In this case, an agreement between Laos, Thailand and Malaysia will have to be settled. Laos may export power to other countries using the same model. Another project which may fit into this category is the Don Sahong Project. If the power from the project can be exported to Thailand or Vietnam, it can also be carried out in this manner.

5.3 For new projects to be constructed in Laos by the private investor, there should be an agreement between the investor and EDL that all the power from the project will be sold to EDL where as EDL will sell the power to the neighboring countries. In this case, the transmission system from the project may be linked directly to the customers in other countries without using the network of EDL. However, the contract will have to be such that the power is sold to EDL and EDL will sell the power to the customers. Under this circumstance, Laos may need to transform the electricity market within the country to be a single buyer model with EDL as the buyer of the power within the country. Laws and regulations will need to be issued to allow EDL to carry on the business as a single buyer of electricity in the country. EDL may follow the model which is now used by Thailand and may modify the model to fit the situations in Lao PDR.

5.4 In the meantime, Laos will have to upgrade and consolidate the transmission system to prepare for the more flexibility in the future. If the transmission system of Laos become strong and reliable, power can be transmitted from power plants located anywhere within Laos territory. Then it will be appropriate for Laos to implement full system-to-system power exchange with her neighboring countries.

5.5 Since Laos would like to become the battery of Asia, it is recommended that Laos be active in the ASEAN activities such as Heads of ASEAN Power Utilities/ Authorities (HAPUA) in a leading role since the main objective of

HAPUA is to make the ASEAN Power Grid (AGP) to happen. The AGP is a full system-to-system power network which will allow ASEAN power utilities to perform power trade across the borders among the member countries with is totally in line with the policy of Lao PDR.

5.6 In the process of transmission system development, Laos needs to spend a large amount of investment. In doing so, careful planning will need to be conducted. The planning work will include both technical and financial aspects. This is to ensure that the transmission system will be most appropriate and will not be a burden to the country's financial performance.

6. ACKNOWLEDGEMENTS

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