Study Committee C5

ELECTRICITY MARKETS AND REGULATION

Paper ID - 10993

Benefits of Cross-border Electricity Trading in Thailand Renewable Energy Integration

Worrapong WONGLIMAMORNLERT

Electricity Generating Authority of Thailand (EGAT)

Motivation

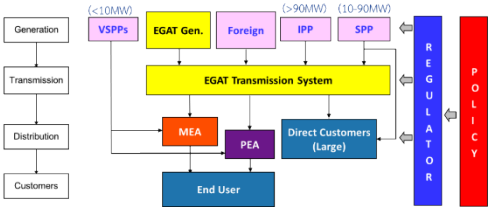
- Recent penetration of renewable energy generations (REGs) and other disruptive technologies in Thailand power system is causing a paradigm shift from fossil-fuel based power generation to hybrid fuel power generation, as well as an increase in the intermittent power generated from REGs and change power system behavior.
- To effectively address the difficulties, national-scale efforts to strengthen power system resilience through sustainable domestic power system resources and accessible power system resources via international grid connectivity must be accelerated
- Further steps toward greater electricity sector interconnection and electricity trade among Southeast Asian countries can help to mitigate challenges mentioned above
- Furthermore, increased electricity sector interconnection and trade resulted in more efficient resource utilization and increased Gross Domestic Product (GDP), employment, and other socioeconomic benefits among neighboring countries

Objective

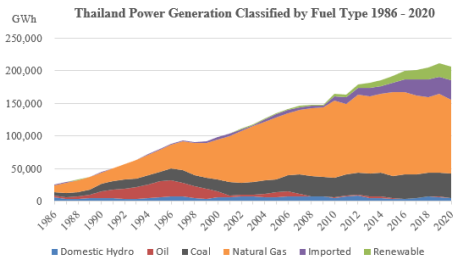
- Study the current model of electricity market in Thailand including the cross-border power trading
- Assess the benefit and potential of the new feature of existing cross-border electricity trading using the statistical operational data of increasing REGs, collected power system load profile, and the dispatching data
- Determine the potential, type, level, and cost of concept of adequate ancillary services that should be provided by cross-border electricity trading in order to maintain power system security in a changing power system paradigm.

Overview of Thailand electricity market landscape

- Thailand's electricity market is structured under an "Enhanced single buyer model"
- The state-owned Electricity Generating Authority of Thailand (EGAT) owns approximately 40% of Thailand's total generation capacity as well as being a transmission system owner, power system operator and a single buyer
- EGAT purchases bulk electricity from private power producers, such as Independent Power Producers (IPPs), Small Power Producers (SPPs) and neighboring countries
- The wholesale electricity is sold to Thailand's two distribution utilities, the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA), as well as a small number of direct industrial customers and utilities in neighboring countries



- Natural gas has dominated the fuel source for electricity generation in Thailand over the past 30 years, accounting for around 70% of total generation in the early 2000s.
- In recent years, the generation mix has become more diverse, with gas-fired generation falling to 60 percent in 2019 and renewable and international grid connection generation increasing significantly
- The share of electricity generated by renewable energy has steadily increased, rising from 12% of total generation in 2017 to nearly 20% in 2019, primarily from hydropower (both domestic and imported), with solar and wind generation accounting for around 4% of total generation.



Renewable energy generations in Thailand: growth and concerns to power system

- Due to technological advancements and rapid cost reductions, Thailand is experiencing accelerated uptake of variable renewable energy (VRE), particularly solar PV, raising concerns about the impact of such technologies on the power sector in both the short and long term.

Study Committee C5

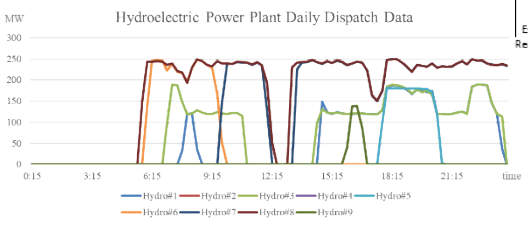
ELECTRICITY MARKETS AND REGULATION

Paper ID - 10993

Benefits of Cross-border Electricity Trading in Thailand Renewable Energy Integration

continued

- Resilient Power System (RPS) is crucial for ensuring security of supply in changing power systems and for a successful clean energy transition; it is the ability of the system to handle the variability and uncertainty of the system.
- Flexibility is critical at all timescales, from several years to seasons, days, hours, minutes, and seconds.
- The balancing process is carried out by the National Control Center (NCC) using a transmission-scale conventional power plant, and the cost of imbalance power has not yet been charged to the causers.
- Based on EGAT practices, the gas-fired combined cycle power plants and hydroelectric power plants are used to provide the primary spinning reserve for regulating frequency and load balancing in power system.
- The main drawback of using combined cycle power plants as a spinning reserve is the variable generation cost, such as fuel cost, which is usually on the higher end.
- Hydroelectric power plants, on the other hand, have negligible or lower-end variable generation costs but are subject to water supply limitations and irrigation constraints, particularly domestic hydroelectric power plants that prioritize irrigation over power generation.
- From technical aspect for power system flexibility provider, the international grid connected hydroelectric power plants (categorized as Foreign Independent Power Producer :FIPP) are highly preferred due to EGAT's fully dispatching rights based on machine and reservoir water availability.
- EGAT typically uses hydroelectric power plants as peaking plants during peak periods in its daily dispatch pattern.



Existing cross-border electricity trading: benefit and effect on system security

- This study focuses on the Foreign IPP pattern due to highest trading volume.

Type of Cross-border Trade	Trading Products	Trade Volume in 2019 (GWh)
Grid-to-Grid (Laos PDR and Malaysia)	Mainly energy trading but can provide ancillary services in emergency situations	1,413.37
Foreign Independent Power Producer (FIPP)	Consisted of energy, capacity, and ancillary services	24,112.11
LTM-PIP	Wheeling service provided by Thailand's electricity transmission network	13.51

- To assess the benefits and effects of cross-border electricity trading in terms of system security, the statistical power system load profile and dispatching data from existing cross-border electricity trading were used to compare the current case and a scenario without cross-border electricity trading.
- The current case is made up of actual operating data and total generation costs in 2019, which are reflected in the electricity tariff.

Type of Power Plant	Range of Ramp Rate (MW/min)	Daily Start-Stop Capability	% Capacity / Total Generation in EGAT System
Thermal Power Plants (Oil, Gas, Coal)	5 – 12 MW/min	None - Start-up time 2 – 12 days - Minimum Up time 7 days - Minimum Down time 3 days	29.6%
Combined Cycle Power Plant	9 - 35 MW/min	Minimal - Start-up time 3 – 77 hours - Minimum Up time 1 day - Minimum Down time 1 day	58.2%
Gas Turbine Power Plant	25 min/min	Moderate – Highly - Start-up time 20 – 30 minutes - Minimum Up time 1 day - No Minimum Down time	0.4%
Hydroelectric Power Plant	30 - 90 MW/min	Highly - Start-up time 5 minutes - Minimum Up time 30 Minutes - Minimum Down time 30 minutes	14.1%
Non-dispatchable Renewable Energy Generation	-	-	3.7%

- The without scenario assumes that no cross-border electricity trading occurred in 2019.
- The study's key indicators are adequate power flexibility to handle daily operations and the affected total generation cost.

Observed Indicator	Present Case	Without Scenario	Differences
Peak demand of 2019 (MW)	30,853		
EGAT system reserve capacity (MW)	12,060	8,182	-3,878
Reserve margin (%)	39.08%	26.52%	-12.56%
Range of ramp rate (MW/min)	9 – 90 MW/min	9 - 15 MW/min	Less flexible
Daily cycle operation capability	72.3% Capacity of Total Generation in EGAT System has daily cycle operation capability	58.2% Capacity of Total Generation in EGAT System has daily cycle operation capability	-14.1%
Estimated generation cost (US cents/kWh)	5.9959	6.9226	15.46%

Remark: exchange rate = 30 Thai Baht for 1 US dollar

- According to the findings, the without scenario resulted in lower system security due to reduced reserve capacity, lower system flexibility, lower average ramp rate, and more constraints on daily cycle operation.
- The estimated energy generation cost is increased considerably due to the absence of cross-border electricity trade which resulted in the increase in the overall cost of energy produced or purchased from combined cycle power plants that are more expensive than the hydroelectric power plant, and the need for combined cycle power plant to operate at a less efficient minimum stable level during off-peak more frequently than in the present case.

Study Committee C5

ELECTRICITY MARKETS AND REGULATION

Paper ID - 10993

Benefits of Cross-border Electricity Trading in Thailand Renewable Energy Integration

continued

- Thailand is expected to benefit from increased power imports from Lao PDR and other neighboring countries in terms of lower energy generation costs, reduced greenhouse gas emissions leading to improved environmental quality, and increased distributed energy sources (DER).
- For Lao PDR, the hydropower contributes significantly to the overall economy through taxes, royalties, and dividends from state-owned utility; Electricite du Laos (EDL) and Independent Power Producers (IPPs).
- Furthermore, Lao PDR benefits from significant international private investment in power and related sectors, which creates more job opportunities.

Proposed outline concept of additional ancillary services from the cross-border electricity trading

- The imported energy charge will not be imposed on power plants that operate in condensing mode in accordance with EGAT's regulations.
- When operating in condensing mode, the compensation price for service is dependent on variable operation and maintenance costs.
- Pump mode operation, being an energy storage system, can divided into 2 options;
- 1. The water pumped up to be stored in the upper reservoir is equivalent to the electrical energy deposited by EGAT
  - The account for balancing of the amount of water and the EGAT deposited electrical energy from the pump mode operation is required.
  - EGAT pays the pumping service fees to the power plant.
  - EGAT withdraws the energy for free.
  - If the water level exceeds the maximum level of the upper reservoir, the power plant is not allowed to operate in this manner.
- 2. The water that is pumped up to be stored in the upper reservoir is owned by the power plant itself.
  - There is no need to make a balance of the amount of water or energy deposited by EGAT during pump mode operation (assume that equals to normal inflow water)
  - EGAT is not required to pay pump service costs but if the power plant uses the electricity from the EGAT system to pump water, the power plant is required to pay the electricity charge.
  - Tariff rate of electricity during this pumping period must be lower than the tariff rate at which EGAT purchases electricity from the power plant
  - The power plant shall study the feasibility of pumping water up to store it and then use it for energy production to EGAT under the original contract.
  - If the water level exceeds the maximum level of the upper reservoir, the power plant is not allowed to operate in this manner
- According to the results of the study, there was a technical constraint of FIPP in condensing mode operation and running in pump mode due to technical reasons
- FIPPs with reservoir are not specifically designed to operate in condensing mode and pump mode which requires the upper and lower reservoirs to be operate.
- For run-of-the-river type FIPPs power plants, in addition to technical limitations, there will still be restrictions under the concession agreement
- In addition, the data collected from individual FIPPs revealed that, in the financial aspect, the proposed outline of services are not feasible

No.	Project	Technical Feasibility		Financial Feasibility
		Condensing Mode	Pump mode	
1	FIPP No. 1	Yes	Yes	No
2	FIPP No. 2	No	No	No
3	FIPP No. 3	-	No	No
4	FIPP No. 4	-	No	No
5	FIPP No. 5	-	No	No
6	FIPP No. 6	No	No	No
7	FIPP No. 7	No	No	No

- The ability of hydroelectric power plants of FIPPs to operate in condensing mode or operate in a pump mode must be identified during the feasibility study of the project allowing the FIPP to study the required capabilities in the technical and financial aspects.

Conclusion

- The current cross-border electricity trading with international grid connections not only provides the required energy, but also improves system flexibility by providing ancillary services, thereby making Thailand's power system resilient
- To ensure successful transition toward clean energy in the future, the energy resource procurement guidelines and methods should include more artificial intelligence techniques aimed at improving power system flexibility.
- International power trade has the potential to be a significant source of electricity and ancillary services.
- During the project development stage, the capability to deliver additional ancillary services or more flexible operations from cross-border electricity trading should be addressed.