ASEAN POWER GRID COOPERATION: CROSS-BORDER ELECTRICITY TRADE AND ITS INFLUENCE ON CARBON EMISSIONS

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Overview

ASEAN Power Grid cooperation was initiated in 1997 to establish cross-border electricity interconnections between 10 ASEAN member countries, namely: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The ASEAN Power Grid (APG) consists of 16 cross-border transmission projects that are divided into the Northern, Southern and Eastern development corridors, allowing for electricity transfer of up to 28 gigawatts between South-east Asia countries. An overview of transmission interconnection of the three APG corridors is presented in Figure 1.

Figure 1: ASEAN Power Grid Interconnection

The Laos-Thailand-Malaysia interconnection was the first multilateral project signed in 2017 to transfer 100 MW of electricity from hydro power in Laos to Malaysia via transmission lines in Thailand. Although this project has been marked as a milestone for APG cooperative, the progress of APG infrastructure development is rather slow. The schedule of cross-border transmission projects in APG has been revised a few times since its inception in 1997.

There have been a few studies on APG such as Ahmed et al (2017) that investigate investment chocies of cross-border transmission technologies and Chang and Li (2013) that analyse an optimal development plan for power generation capacities. Further analysis is required to understand electricity trade opportunies and their implication for carbon emissions in APG.

Methods

A multi-region power system model is applied to analyse the implication of ASEAN power grid interconnection proposed by Head of ASEAN Power Utilities/Authorities (HAPUA) on cross-border electricity trade and carbon emissions in South-east Asia. The model is based on linear programming techniques whose objective function is to minimise total system cost of electricity generation and transmission for the whole of South-east Asia. System cost is composed of annualised capital investment cost, operation and maintenance cost, fuel cost and carbon emission cost. The objective function can be expressed in the following equation. A detailed description of a multi-region power system model can be found in Otsuki et al. (2016).

$$\min. TC = \sum_{n} (CI_n + CO_n + CF_n + CC_n)$$

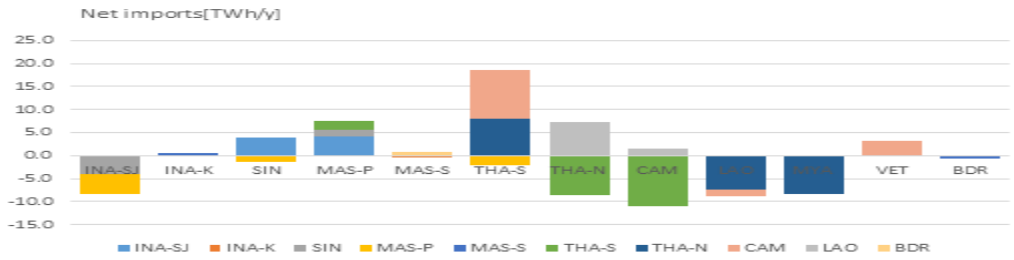
Where:

TC: total annual cost [US$/yr]; CIn: annualized initial cost of generation, storage and transmission facilities in node n [US$/yr]; COn: annual O&M cost of generation, storage and transmission facilities in node n [US$/yr]; CFn: annual fuel cost in node n [US$/yr]; and CCn: annual carbon cost for fuel combustion [US$/yr].

Results

1. Electricity trade in TWh of electricity

The HAPUA interconnection plan enables cross-border electricity trade involving all members of ASEAN countries. On the Northern and Southern corridors of interconnection, Thailand has the largest share of imports from other ASEAN countries. It imports 26 TWh/year from Cambodia (41% of the total imports), Lao PDR (28%) and Myanmar (31%). Malaysia (Peninsula) receives 7.4 TWh/year of electricity from Indonesia (55% of the total imports), Thailand (26%), and Singapore (19%). Indonesia (the Sumatera's interconnection) sends an equal amount of 4.1 TWh/year to Malaysia (Peninsula) and Singapore, respectively. Vietnam imports 3.3 TWh/year from Cambodia.



Legend: INA-SJ (Indonesia-Sumatera-Java), INA-K (Indonesia-West Kalimantan), SIN (Singapore), Mas-P (Malaysia-Peninsula), Mas-S (Malaysia-Sarawak), THA-S (Thailand-North), THA-N (Thailand-North), LAO (Laos), MYA (Myanmar), VET (Viet Nam), BDR (Brunei)

On the Eastern corridor of the APG interconnection, electricity trade is relatively small compared with the trade in the Northern and Southern corridors. Total electricity trade in the Eastern corridor only represents 7% of the total electricity trade of APG. The Eastern corridor creates electricity export opportunities from Malaysia (Sarawak) to Indonesia (West Kalimantan) at 1.1 TWh/year and from Malaysia (Sarawak) to Brunei Darussalam at 1.24 TWh/year. The absolute trade value of cross-border electricity exchanges under the APG is US$ 7.12 billion in 2030. Electricity export-import in the Northern and Southern corridors of interconnection accounts for 6.83 billion while Malaysia (Sarawak) acquires US$ 290 million from exporting electricity to Brunei and Indonesia (Kalimantan) in the Eastern corridor of APG.

2. Electricity generation and carbon emissions

South-east Asian countries that have reserve margin of power generation above 10% (e.g. Indonesia, Malaysia and Singapore) can improve the capacity factor of the existing power plants for electricity exports. However, a noticeable increase in carbon emissions occurs in the countries that increase electricity generation from their existing fossil fuels power plants (e.g. coal and natural gas) for electricity exports. Cambodia, Laos and Myanmar have low carbon emissions because of large hydro power generations.

Generation	INA-SJ	INA-K	SIN	MAS-P	MAS-S	THA-S	THA-N	CAM	LAO	MYA	VET	BDR
Emissions	219.2	71.6	23.4	82.6	55.8	12.3	106.6	11.3	0.01	0.01	87.8	1.9
CO_2 intensity	0.75	0.73	0.34	0.57	0.58	0.32	0.48	0.58	0	0	0.38	0.36

Conclusions

The APG interconnection enables ASEAN countries that have large hydropower resources (e.g. Cambodia, Lao PDR and Myanmar) and abundant fossil fuel resources (e.g. Indonesia) to increase electricity generation from existing power plants and export it to mainly Thailand, Malaysia, Singapore and Vietnam. The Northern and Southern corridors of APG have the most active cross-border electricity trade between eight ASEAN countries while the Eastern corridor of APG only accounts for 7% of the total APG electricity trade. Carbon emissions from power generation in South-east Asia increases because of the increased electricity generation from the existing fossil fuels

power plants (e.g. coal and natural gas) for cross-border electricity exports, mainly in Indonesia, Malaysia and Thailand.

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