Carbon Neutrality in the Power Sector of the ASEAN: Perspectives from An Integrated Power Trade Model

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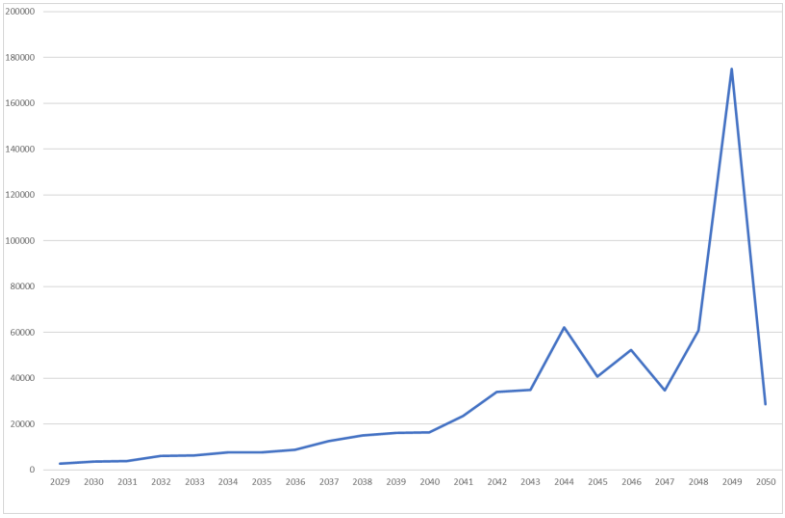
Overview

Carbon neutrality in the power sector implies transition to non or little carbon-emitting electricity generation technologies such as hydropower, wind energy, solar energy, geothermal energy, biofuels and even natural gas with or without carbon capture and storage. As carbon dioxide, once emitted, is expected to stay in the atmosphere about 150 or 200 years until it completely dissipates into a natural sink such as ocean (Nordhaus, 1994; Yin and Chang, 2020), achieving net-zero emissions by 2050 implies that the level of carbon dioxide emissions must peak by 2030 at the latest (Fankhauser et al, 2022).

Various pathways for ASEAN member nations to achieve net-zero transition are presented in a study utilizing the Low Emissions Analysis Platform (LEAP). The study shows projections of greenhouse gas emissions and the costs of meeting the Paris climate goal. It suggests ASEAN member nations to full and swift utilization of renewable energy potential (Handayani et al, 2022). However, the study does not consider how cross-border power trade in the ASEAN power sector affects the ASEAN member countries' pathways to achieve net-zero transition. When cross-border power trade in the ASEAN power sector is incorporated and allowed in an integrated power trade model, cross-border power trade suggests viability of net-zero transition by 2050 in the ASEAN power sector with various levels of added capacity (Chang, 2024). Figure 1 presents the level of aggregated added capacity under the assumption that up to 50% of domestic electricity demand can be imported from neighboring countries.

Figure 1. Aggregated Added Capacity in the ASEAN Power Sector (Unit: MW)



Source: Author's own calculation

As shown in Figure 1 above, net-zero transition by 2050 appears to require significant amounts of added capacity in the power sector of the ASEAN under the various assumptions of the level of imported electricity from neighbouring countries. It is not surprising to see that the financial requirements of realizing the added capacity to achieve carbon neutrality could not be negligible. Noticing ASEAN member countries' declarations of pledges to achieve net-zero transition by 2050, various electricity generation technologies and renewable energy potential in the region, this study aims to viability of net-zero transition and estimate financial requirements of carbon neutrality in the ASEAN power sector under the assumptions of various allowed levels of cross-border power trade and explore possible policy options to meet the financial requirements.

Methods

As noted above, achieving net-zero emissions by 2050 means the emissions must peak by 2030. Using a cross-border power trade model developed by Chang and Li (2013) and modified by Chang (2024), this study takes the amount of carbon emissions that should peak by 2030 from the business-as-usual case of an integrated cross-border power trade model (Chang, 2024).

The objective of the integrated cross-border power trade model is to minimize the total system costs of electricity generation from 2018 to 2050 subject to capital expenditure, operation expenditure, carbon emissions and costs, and cross-border transmission costs and losses, and various constraint conditions to make the cross-border power trade happen. Interconnection plans of power grids in the ASEAN are reflected in the examination of the possibilities of achieving net-zero transition in the ASEAN power sector. Relevant data are collected from various sources such as the ASEAN Energy Centre, International Energy Agency and the statistical office of ASEAN member countries.

This study considers four scenarios – Business-As-Usual (BAU), No cross-border power trade with emissions capped at the level of 2030 (NZT NT 2030), Cross-border power trade up to 50% of domestic electricity demand for each member country with emissions capped at the level of 2030 (NZT T50 2030), and Cross-border power trade up to 80% of domestic electricity demand for each member country with emissions capped at the level of 2030 (NZT T80 2030). The models are solved using General Algebraic Modelling System (GAMS).

Results

This study presents viability of net-zero transition by 2050 and financial requirements of aggregated added capacity to achieve carbon neutrality in the ASEAN power sector by 2050. The simuation results of six aspects are presented – carbon emissions, total capacity, total capacity by fuel, added capacity by fuel, total system costs and capital costs for added capacity. One of the key results is that "the lower level of cross-border power trade, the greater amount of aggregated added capacity". Carbon emissions are proected to peak around 2030 when up to 80% of domestic electricity demand is met by imports from neighboring countries. The scenario of up to 80% of cross-border power trade appears to require the largest total capacity mainly due to net increases in solar PV but present the lowest total system costs while total costs of added capacity are slightly higher than the scenario of up to 50% of cross-border power trade. Majority of the added capacity appear to be met by solar PV followed by hydro.

Conclusions

Net-Zero transition by 2050 in the ASEAN Power sector would require the level of carbon emissions to peak around 2030. The ASEAN power sector is endowed with huge potential of renewable resources such as hydropower, wind and solar, and considered to have applicable power technologies to achieve net-zero transition by 2050. Net-zero transition by 2050 in the ASEAN power sector is viable under the various assumptions of high level of cross-border power trade such as 50% or 80% of domestic electricity demand is met by electricity imported from neighboring countries. However, financial requirements of realizing added capacity to achieve carbon neutrality appear to be considerable. Policy implications drawn from the key findings are as follows. First, it would be beneficial to complete the planned cross-border interconnection in the ASEAN power grid. Second, it would be also good to accerlerate the integration of solar PV and hydropower into the power system of the ASEAN. Third, it would be imperative to develop transparent, fair and efficient frameworks of cross-border power trade in the ASEAN power sector. Fourth, it would be necessary to establish ASEAN-wide funds to support the installation of the added capacity through the integration of electricity markets.

References

Chang, Youngho (2024). Power trade and hydroelectricity development in the Greater Mekong Sub-region: Perspectives on economic and environmental implications, in *Economic Analysis of Large Deployment of Solar PV and Battery Storage in ASEAN* edited by Rabindra Nepal and Han Phoumin, pp. 55 – 77.

Chang, Youngho and Yanfei Li (2013). Power generation and cross-border grid planning for the integrated ASEAN electricity market: A dynamic linear programming model. *Energy Strategy Reviews*, 2: 153 – 160.

Fankhauser, S. and 14 authors (2022). The meaning of net zero and how to get it right. *Nature Climate Change*. Vol 12 (January 2022), 15 – 21.

Handayani, Kamia, Pinto Anugrah, Fadjar Goembira, Indira Overland, Beni Suryadi and Akbar Swandaru (2022). "Moving beyond the NDCs: ASEAN Pathways to a Net-zero Emissions Power Sector in 2050", *Applied Energy*, Vol. 311: 118580.

Nordhaus, William. D. (2014). *A question of balance: Weighing the options on global warming policies*: Yale University Press.

Yin, Di. and Youngho Chang (2020). Energy R&D investments and emisions abatement policy. *Energy Journal*, Vol. 41. No. 6, 133 – 156.