CROSS-BORDER POWER TRADE AND RENEWABLE ENERGY DEVELOPMENT IN SOUTHEAST ASIA: ECONOMIC AND ENVIRONMENTAL IMPLICATIONS

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Overview

The Association of Southeast Asian Nations (ASEAN) has been working on utilizing its energy resources scattered across the region through the integrated grid networks such as the ASEAN Power Grid (APG) and the Trans ASEAN Gas Pipelines (TAGP). The power trade in the Great Mekong Sub-region (GMS) is a successful pioneer of cross-border power trade in the region. The ASEAN member countries, especially five countries in the GMS, namely Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam have huge potential in hydropower (Chang and Li, 2013; Li and Chang, 2015; ASEAN Centre for Energy, 2022; Tran and Suhardiman, 2022). Table 1 presents the actual capacity of hydroelectricity as of 2018 and the potential capacity of hydroelectricity in the five GMS countries.

Table 1: Actual (2018) and Potential Capacity of Hydroelectricity in the GMS (unit: MW)

Capacity/Countries	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Total
Actual	1,330	5,472	3,259	3,103.4	20,170	33,334.4
Potential	26,417.27	48,949.64	108,000	12,431.65	95,568.35	291,366.91
Utilization (%)	5.03	11.18	3.02	24.96	21.11	11.44

Source: Chang and Li (2015), ASEAN Centre for Energy (2022)

As shown in table 1, the utilization rates of the hydroelectricity potential for the five GMS countries are raging from about 3% (Myanmar) to about 25% (Thailand), and 11.44% at an aggregate level. The potential capacity of hydroelectricity is huge, but the development of the potential capacity into actual one has been slow and a lack of interconnections between the supply sources of hydroelectricity and the demand sources of hydroelectricity is one of the key reasons for the slow development (Do and Burke, 2022). As of April 2020, the existing capacity of cross-border bilateral interconnections in the ASEAN is 7,720MW, the ongoing capacity is from 555MW to 625MW and the future capacity is from 18,369 to 21,769MW (ASEAN Centre for Energy, 2021).

Most cross-border interconnections within the Southeast Asia are the direct or dedicated connection between the source of exporting system to the source of importing system and no access is given to a third party. Dedicated interconnections could hinder the development of full-pledged open access interconnections of power grids in the region (Ricardo Energy and Environment, 2019). Using an ASEAN power trade model, this study aims to fill the gap in the literature to vindicate how power trade in the region will ensure the development of hydroelectricity. It also aims to draw economic and environmental justifications of cross-border bilateral and open-access interconnections that would help the region cooperate and accelerate the development of renewable energy, mainly hydroelectricity.

This study scans and collects information relating to the status of cross-border bilateral interconnections in the region. It updates the values of the variables and parameters used in the ASEAN power trade model, and afterward it modifies the model to incorporate cross-border bilateral interconnections into the framework and later to develop a full-pledged open access interconnections. Using the General Algebraic Modelling System (GAMS), it solves the model and derives solutions and policy implications.

Methods

This study adopts a dynamic linear programming framework in power generation first developed by Turvey and Anderson (1977) and later adapted by Chang and Tay (2006) and Chang and Li (2013). In the latest study of Chang and Li (2013), significant extensions of the original models were made. A new country dimension was added to allow an international framework with cross-border electricity trade. The new model also added the cost of cross-border power transmission as well as transmission loss into account. Carbon emissions from power generation as well as the carbon cost of power generation were explicitly considered.

The model sets an objective function and includes various constraints such as resource endowments, technologies, capital and operation costs, costs of interconnections and carbon emissions, among others. The objective function is stated as to minimize the cost of meeting electricity demand by taking account all resource endowments, available technologies and constraints. There are several constraints that are required to optimize the above objective function. To ensure meeting domestic demand and trading surplus electricity, this study has a few key assumptions. First, total installed capacity of power generation in the region should be greater or equal to total demand for electricity in the region. Second, the total output of electricity generation in each country is constrained by the load factor of each installed capacity of all types of electricity generation in the county. Third, the electricity supply of all countries in the region to a certain country should be greater than or equal to the demand for electricity in the country. Fourth, the total supply of electricity from one country to all countries (including the country itself) in the region must be smaller or equal to the total available supply capacity of the country at a given time.

The base case of this study is a replication of the current system-to-system interconnections in the region where no third party or open access is allowed (Ricardo Energy and Environment, 2019). Along with the base case, this study develops a few scenarios by adopting various business plans of interconnections. It also develops a few more scenarios of full-pledged cross-border interconnections with environmental consideration of imposing carbon taxes where third party or open access is allowed.

Results

This study presents the following results. First, it presents economic costs of hydroelectricity development for the GMS under the current system-to-system interconnections. Second, it presents the estimated total costs of meeting electricity demand for the GMS and country-specific net gains that could be negative for some countries under the various scenarios of business plans of interconnections. Third, it presents environmental costs of developing hydroelectricity in the GMS. Finally, it presents how the environmental consideration such as imposing carbon taxes influences the development of hydroelectricity in the GMS and the degree of mitigating the negative environmental consequences in the GMS.

The findings of this study are expected to present a few policy implications. First, this study can help the GMS countries identify business plans of interconnections in economic and environmental terms and evaluate the pros and cons of various system-to-system interconnections. Second, it also can help the GMS countries prioritize the investment order of cross-border interconnections. Third, it can help the GMS countries measure the relief or burden of carbon taxes through the development of hydroelectricity in the GMS. Finally, the findings can shed light on the level of carbon taxes and the speed of hydroelectricity integration into the power system in the GMS countries as a whole so that the GMS countries can plan and adjust the speed of developing hydroelectricity.

Conclusions

The results of this study are expected to help the region identify business plans of interconnections in economic and environmental terms and evaluate the pros and cons of various system-to-system interconnections. The study also can help the region prioritize the investment order of cross-border interconnections. In addition, it can help the region measure the relief or burden of carbon taxes through the development of hydroelectricity in the region. Finally, the findings can shed light on the level of carbon taxes and the speed of hydroelectricity integration into the power system in the region as a whole so that the region can plan and adjust the speed of developing hydroelectricity.

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