RENEWABLE ENERGY, SYSTEM FLEXIBILITY AND DECARBONIZATION IN AN INTEGRATED REGIONAL ELECTRICITY MARKET

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Overview

Energy is one of the essential components of sustaining decent living. The number of population without access to electricity in Southeast Asia is over 200 million (International Energy Agency, 2014). Achieving sustainable energy is one of the key components of sustainable development as presented in the Sustainable Development Goals (United Nations, n.d.). The Association of South East Asian Nations (ASEAN) has been working on utilizing its energy resources scattered across the region through the integrated grid networks. The ASEAN Power Grid (APG) and the Trans ASEAN Gas Pipelines (TAGP) are the backbone of the integration efforts. The power trade in the Great Mekong Sub-region (GMS) is a good example of successful power trade in the region.

Energy market integration has been suggested as a way of achieving sustainable energy and development (e.g., Wu et al, 2012; Kimura et al, 2013; Chang and Li, 2013; Li and Chang, 2015). There are extensive discussions on linking the AGP and the TAGP to the Belt and Road Initiative (BRI). The BRI can help the regional power interconnection by bringing investment, technical support and regulatory assistance to the region if a clear mechanism for the ASEAN is established (ASEAN Centre for Energy, 2018).

The ASEAN has huge potential in renewable energy such as hydropower, solar, wind energy and biofuel (Chang and Li, 2015). Due to the intermittent availability of renewable energy, however, integrating renewable energy into a power grid has been slow. Grid operations are a matter of balance between supply and demand. The supply and demand can be flexible if supply components such as conventional generators, renewable generators and storage, and demand components such as building end uses, electric vehicles and storage are appropriately considered. Wind and solar could add variability to the supply side. Accessing such flexibility is a key to renewable energy integration and there are various options to increase flexibility such as sub-hourly scheduling and dispatch, demand response, load shedding, ramping and storage.

The development of renewable energy has accelerated the transformation of the global energy sphere. The capacity of installed renewable energy has more than doubled from 2007 to 2017, hydropower remains the largest contributor and wind and solar energy is growing very fast. Since 2012, renewable energy constitutes more than 50% of total capacity added, and around 31% and 25% of the global total installed capacity and production, respectively (Chen, 2018).

Updating and modifying the ASEAN power trade model (Chang and Li, 2013; Li and Chang, 2015), this study aims to examine how system flexibility affects renewable energy intergrtion and eventually decarbonization in ASEAN. First, it examines how the integration of renewable energy incorporating system flexibility into the regional power trade affects the structure and phase of the transformation of power system in the ASEAN. Second, it evaluates the total cost of meeting the energy demand of the ASEAN as a whole. Third, it explores whether and how system flexibility with carbon taxes affects the speed of transforming power system in the region. Fourth, it verifies whether and how system flexibility and carbon taxes shapes the process of decarbonization in the region and at what costs.

Methods

The updated and modified ASEAN power trade model includes various flecxibility option for supply of and demand for electricity. For these purposes, first, this study scans and collects information relating to the status of renewable energy integration and the options of system flexibility from various sources such as Clean Energy Ministerial Secretariat, 21st Century Power Partnership, International Renewable Energy Agency (IRENA), ASEAN Centre for Energy, and China Electricity Council, among others. Second, it updates the values of the variables and parameters employed in the ASEAN power trade model, and afterward it modifies the model to incorporate system flexibility into the framework. Third, using the General Algebraic Modelling System (GAMS), it solves the model and derives solutions and policy implications.

The model sets an objective function and includes various constraints such as resource endowments, technologies, capital and operation costs, and carbon emissions and corresponding taxes, among others. The objective function is stated as to minimize the cost of meeting energy demand by taking account all resource endowments, available technologies such as reneable generators and storage and electric vehicles and storgar and constraints such as capital and operation costs,carbon emissions and corresponding taxes and cross-border transmission losses and costs.

Along with the base case in which there is no system flexibility, this study builds a few scenarios relating to the system flexibility such as sub-hourly scheduling and dispatch, demand response, load shedding, rampaging and storage, and environmental considerations such as imposing carbon taxes. This study compares the case with no system flexibility with ones with various forms of system flexibility stated above.

Results

This study shows how incorporating renewable energy integration with system flexibility in an existing power trade model will affect the transformation of power system and economic growth, and presents the evaluation of the cost of meeting ever-increasing energy demand in the ASEAN. It also presents how the environmental consideration such as imposing carbon taxes will influence the transformation of power system, decarbonization and economic growth, and how the incorporation of renewable energy integration with system flexibility will mitigate negative environmental consequences of conventional generators.

Other specific results are to be presented are ths status of demand and all supplies of countries in ASEAN, additional capacity required, amount of electricity exports and imports among ASEAN countries, total canbon emissions, unit carbon cost, total cost of existing capacity of power generation and total investment cost on new transmission lines. With these results, this study explicitly presents the possible effects of renewable energy integration and system flexibility on energy consumption, per capita GDP, energy access and glonal environmental pollution.

Conclusions

The study confirms that system flexibility would reduce and eventually solve the intermittency problem in integrating renewable energy into the grid system of electricity supply and demand. It also clearly presents how renewable energy integration could have impacts on energy access and the environment. The findings of this study draw a few policy implications. First, the findings can help the ASEAN prioritize the options of system flexibility to adopt for minimizing the economic and environmental costs for the region. Second, they can weigh the burden of carbon taxes so that they can help allocate the burden sharing among the member countries. Third, the findings can shed light on the level of carbon taxes and the speed of renewable energy integration into the power system in the ASEAN region as a whole so that the ASEAN can plan and adjust the speed of adopting system flexibility.

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