ELECTRICITY TRADE IN A REGIONAL ELECTRICITY MARKET: ECONOMIC EFFICIENCY AND WELFARE IMPLICATIONS

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Overview

There have been huge efforts in connecting electricity markets across countries in Europe and Africa or states in the U.S. Such integrations of electricity markets are expected to improve the efficiency of electricity markets and bring larger benefits to member countries of the integrated electricity markets. The Association of Southeast Asian Nations (ASEAN) has been trying to connect member countries' power grids in the region and integrate member countries' electricity markets in the region. ASEAN Power Grid (APG) is a good example of such integration effort.

Four member countries of the ASEAN, namely, Lao PDR, Thailand, Malaysia and Singapore jointly announced in 2014 a power integration project entitled "Lao PDR, Thailand, Malaysia and Singapore (LTMS) Power Integration Project (LTMS-PIP)" to examine the feasibility of power trade across. After examining related policy, legal and commercial issues, the four countries announced to initiate cross-border power trade up to 100 MW at the 38th ASEAN Ministers on Energy Meeting in November 2020. Following this announcement, Singapore has called for "Request for proposal to appoint electricity importer to import 100MW via the existing Singapore-Peninsular Malaysia interconnector for a two-year trial" in March 2021.

Bilateral electricity trade is a first step towards integrating electricity markets. European electricity market liberalization is considered the world's most extensive cross-jurisdiction reform of the electricity sector involving integration of distinct state-level or national electricity markets (Jamasb and Pollitt, 2005). An ASEAN power grid that links the energy resource-rich and the energy resource-poor countries could potentially play an important role in reducing the overall cost to the region to meet its growing electricity demand. Based upon an optimization study, eleven potential power grid interconnection projects were selected for potential implementation through 2020 (Chang and Li, 2013).

There are a few quantitative analyses of regional power market integration in ASEAN and a few qualitative studies focused on the institutional and policy aspects of regional development in relation with energy cooperation (Yu, 2003; Economic Consulting Associates, 2010, Yu et al., 2005; Watcharejyothin and Shrestha, 2009). There have been studies on examining the welfare impacts of price equalization in energy market integration, relationship between energy market integration and efficiency of energy trade, infrastructure needs for trading electricity, possible benefits of hydropower projects in the lower Mekong River basin, and measurements of energy market integration (Kimura and Phoumin, 2014) In sum, there have been studies on power development and economic benefits in an integrated electricity market but how a bilateral or unilateral trade in an integrated regional electricity market has not been done. As a first step toward a fully integrated regional energy market, the IEA recommended a bilateral trade model (IEA, 2019). This study aims to examine how a bilateral trade works in a hypothetical integrated electricity market in the context of ASEAN.

This study takes a specific case of bilateral trade between Singapore and Malaysia under the LTMS-PIP setting. Apart from evaluating economic efficiency of the electricity markets in the two countries, it also draws welfare implications to the two countries and the ASEAN as a whole out of the cross-border power trade. This study is expected to present possible gains or losses in the economic efficiency of electricity markets in both countries along with a few policy recommendations for making individual country's electricity market more efficient. It is also expected to present how cross-border power trade would enhance the well-being of people in both countries involved in the cross-border power trade and any spillover effects to the ASEAN member countries.

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). Using a dynamic linear programming framework in power generation and cross-border electricity trade, this study aims to evaluate how

bilateral power trade between two countries in the region affects the economic efficiency of the electricity markets. The model also considers the cost of cross-border power transmission, transmission loss, carbon emissions from power generation and the carbon cost of power generation. The model is solved using General Algebraic Modelling System (GAMS).

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. This study further modifies a cross-border power trade model developed by Chang and Li (2013) to cater the bilateral power trade between Singapore and Malaysia. It employs two scenarios – unrestricted power trade in ASEAN and specific unilateral power trade between Singapore and Malaysia. The first scenario considers unlimited power trade and serves as a reference case. The second scenario considers the import of a fixed amount of electricity per year from Malaysia to Singapore.

Results

Under the reference scenario, Singapore appears to supply electricity from its own capacity and import electricity from Vietnam during the peak period and from Malaysia during the nonpeak period. During the nonpeak period, Singapore appears to import electricity from a few neighboring countries such as Cambodia a, Lao PDR, Indonesia and Thailand for some years, especially towards later period.

The discounted total cost for ASEAN appears to increase a little. This is due to the unilateral import of electricity is a deviation from the efficient and least cost solution of the simulation model of electricity trade in ASEAN under a hypothetical integrated electricity market for which no disruption or a foul play in supplying electricity. The discounted total cost for ASEAN appears to increase, but the impacts of the unilateral import of electricity on the two trading countries are different. The unilateral import of electricity from Malaysia seems not to affect the discounted total cost for Singapore but for Malaysia. This is mainly due to the fact that Malaysia has to deviate from the most efficient and least cost solution for supply and export of electricity to meet Singapore's unilateral import of electricity. The negative impact appears to deepen when the unilateral import of electricity from Malaysia applies to both the peak and nonpeak period.

Conclusions

This study considers how Singapore's unilateral import of electricity from Malaysia affects the discounted total cost of meeting electricity demand in ASEAN by adopting a simulation model of electricity trade in the ASEAN context as well as for Singapore and Malaysia. The assumption of a hypothetical integrated electricity market is a bit optimistic. The results from the simulation of the hypothetical integrated electricity mark may not represent the realistic features of electricity trade in the region. It is good to consider how to share the transmission costs and losses among the trading countries in a more realistic and equitable manner.

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