Developing Sustainable Connectivity in Energy

LESSONS FROM TRADE OF ELECTRICITY IN ASEAN

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Energy connectivity is a platform which is being explored at subregional levels in different parts of the world. Both Asia and Europe have successful models of energy connectivity and energy market integration. Cooperation in energy connectivity for sharing good practices among member countries can be fruitfully explored under the Asia–Europe Meeting (ASEM).

This paper examines what are the potential benefits from increased energy market integration in the Association of Southeast Asian Nations (ASEAN) region, why progress has been slow so far, and how the obstacles to greater regional energy and electricity integration in the Asia-Pacific can be overcome.

A fully functioning regional grid bears many benefits to countries involved. The interconnected grids can take the advantage of the varying timing of peak and non-peak hours in different countries and thus save a large portion of the investment in expensive peak power generation capacities.

Fundamental to the goal of a totally integrated power system in the ASEAN region is the development of physical infrastructure and the harmonisation of technical standards, operational procedures, and regulatory frameworks. An appropriate business model to ensure adequate economic benefit for each country involved in the multilateral electricity trading is also a key challenge for the future multilateral trade of electricity.

A comparative understanding of the Nordic experience in energy connectivity shows the way forward to explore the energy cooperation programme under ASEM.

Introduction

Driven by economic and industrial development, population growth, and higher living standards, electricity demand in the Asia-Pacific is projected to more than double between 2010 and 2035 (ADB, 2013), a growth rate that is higher than that of any other region in the world. A critical component of the region's economic development lies in its capacity to secure reliable, affordable, and sustainable energy supplies.

The Asian Development Bank (ADB) estimates that to supply projected demand for electricity, the 10 countries of ASEAN, together with China and India, will need a cumulative investment of about $11.7 trillion in the energy sector between now and 2035 (ADB, 2013). Where that money will come from and how it will be invested remains to be seen, but it will need to include infrastructure for upstream energy extraction and production, midstream energy transformation, and transportation to downstream energy distribution.

ASEAN, China and India, the International Energy Agency (IEA), and the World Bank have all stressed the importance of integrated electricity markets and transmission networks to support the region's development. Similarly, efforts to enable the integration of natural gas markets within the region have hastened in recent years, particularly since the Fukushima nuclear disaster in Japan.

In the first instance, plans to secure energy supplies in the region require evaluation of the geographic scope of integration that is desirable and feasible within the three Asia-Pacific regional blocs: Northeast Asia, Southeast Asia, and Oceania – with both modest and ambitious integration plans proposed. For example, the ASEAN Plan of Action for Energy Cooperation 2010–2015 has a number of objectives which include the establishment of an ASEAN Power Grid (APG), increased penetration of renewable energy, and the further development of an ASEAN gas network. The APG is a flagship programme consisting of 16 interconnection projects; it is expected to expand from a bilateral to a subregional basis, and ultimately aims to achieve a totally integrated system. Smaller regional integration potential exists between the yet-to-be-developed CLMV (Cambodia–Lao PDR–Myanmar–Viet Nam) countries and the BIMP (Brunei Darussalam, Indonesia, Malaysia, and Philippines) countries.

Despite the promising objectives of the ASEAN APG plan, and the potential of the CLMV and BIMP grids, implementation to date has been problematic largely owing to concerns about the political and economic stability of the region; associated concerns around sovereign risk; and the absence of a transparent, coordinated legal and institutional structure that can be agreed to by all countries. Indeed, fundamental to the goal of a totally integrated system in the ASEAN region is the development of physical infrastructure and the harmonisation of technical standards, operational procedures, and regulatory frameworks. However, the nature of the overarching institutions and the existing intra-regional energy dynamics make electricity market integration significantly more complex for the Asia-Pacific region than was the case in Europe or North America.

Much excellent research has been done on the economic and technical viability of electricity integration in ASEAN (Chang and Li, 2013; Chang and Li, 2015; Kutani, 2013), as well as on the financial viability of power infrastructure investment (see Li and Chang, 2015).

For example, Li and Chang (2015) point to three main barriers to grid interconnection in the ASEAN+2 (China and India) region:

1. Investment in transmission lines is very capital intensive, usually costing from millions to billions of (US) dollars, thus, necessitating both public and private sector investments.
2. Cross-border electricity trade is complicated by political, social, and environmental considerations; therefore, such projects are considered high risk.
3. The profitability of each transmission line is dependent on the evolution of the pattern of cross-border electricity trade in the region, which in turn is dynamic and difficult to predict.

In many respects, the first challenge (cost) can be overcome if greater understanding and certainty is achieved in relation to the second (non-economic factors) and third (regional trade patterns) challenges. The emphasis of this project is therefore on understanding the non-economic factors and the regional trade patterns within the region.

To that end, and building on the work that has already been done in relation to integrated electricity systems in ASEAN, this article examines **what** the potential benefits from increased energy market integration are in the ASEAN region, **why** progress has been slow so far, and **how** the obstacles to greater regional energy and electricity integration in the Asia-Pacific can be overcome. Based on the lessons learnt, a sustainable energy connectivity between Asia and Europe can be explored under the aegis of the Asia–Europe Meeting (ASEM).

Results from Current Energy Connectivity Studies

Intensive research on power grid interconnection and electricity market integration in ASEAN has been done. The literature generally has taken a three-step approach in research in this regard, as the following figure indicates.

Figure 1: Methodology Flow Chart for Studies on ASEAN Power Grid Interconnection and Electricity Market Integration

Source: ERIA.

For example, the 'Study on Effective Investment of Power Infrastructure in East Asia through Power Grid Interconnection' (Kutani, 2013) reported the results of the quantitative assessment of the costs and benefits of selected cross-border power grid interconnection projects in ASEAN countries (Table 1). Accordingly, cases B, E, and G are identified as economically feasible and should thus be prioritised.

Table 1: Possible Interconnection Lines and their Priority

Line	Possible cumulative net cost–benefit range (Million USD)	Estimated cost of transmission line (Million USD)	
A: THA–KHM	4,560–5,470	162–1,009	second priority
B: THA–LAO	19,282–20,604	728–1,957	first priority
C: THA–MYA	(4,607)–(2,766)	2,244–3,956	need careful assessment
D: MYA–THA–MYS–SGP	(1,118)–3,064	2,384–6,272	need careful assessment
E: VNM–LAO–THA	21,604–23,715	922–2,885	first priority
F: MYS–IDN	3,968–4,087	1,790–1,901	second priority
G: LAO–THA–MYS–SGP	23,217–26,557	868–4,273	first priority

IDN = Indonesia, KHM = Cambodia, LAO = Lao People's Democratic Republic, MYA = Myanmar, MYS = Malaysia, SGP = Singapore, THA = Thailand, VNM = Viet Nam.

Note: Numbers in brackets are negative.

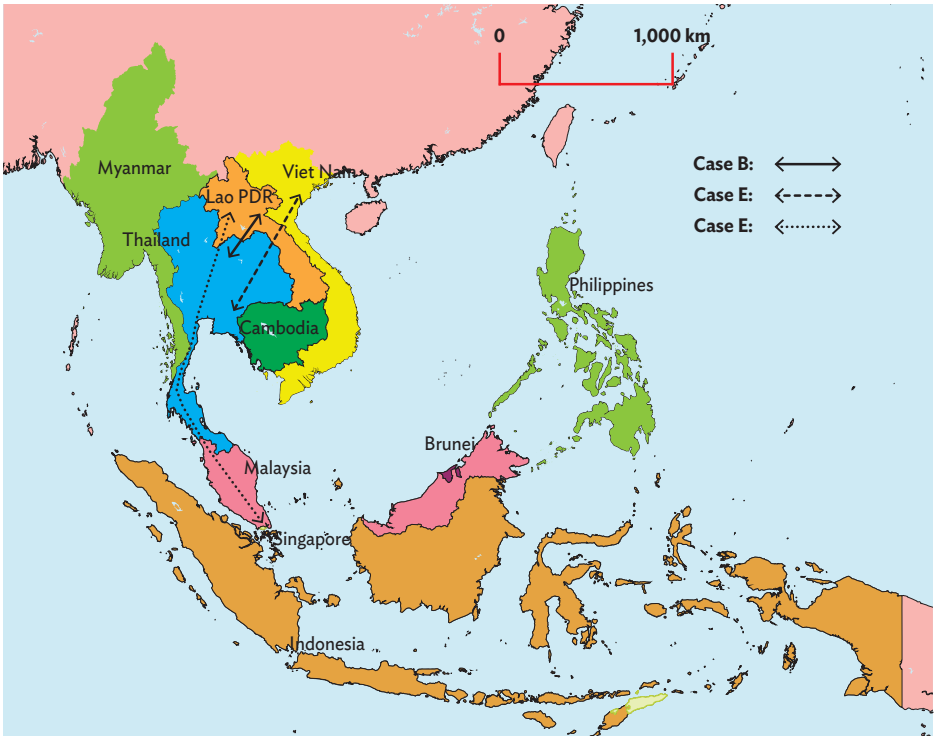
Source: ERIA.

Another study (Kutani and Li, 2014) was continued to focus on the prioritised cases (Figure 2): the interconnection between Thailand and Lao PDR; between Viet Nam, Lao PDR, and Thailand; and between Lao PDR, Thailand, Malaysia, and Singapore.

This study went into close-to-real-project cost estimation based on realistic project design and route planning, rather than the general cost estimation for constructing and operating cross-border transmission lines applied in the earlier study. It covers as much engineering and economic details as possible to reflect the accurate costs of constructing and operating cross-border transmission lines. Figure 3 illustrates the methodology through a flow chart.

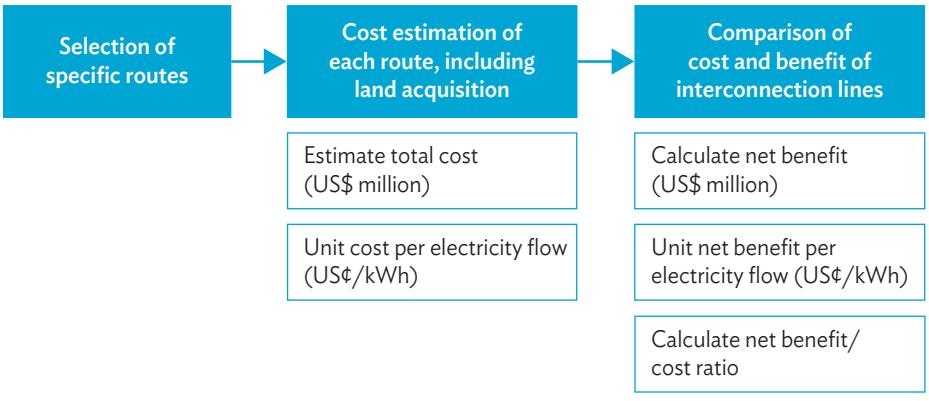
At the same time, this study applies a regional model for electricity trading among the countries connected by the cross-border transmission lines, based on a merit-based dispatching algorithm to minimise the cost of electricity for all countries. The model thus simulates potential trading for the period 2025–2035, as the three selected routes of new interconnections are assumed to be completed by 2025.

Figure 2: The Three Prioritised Routes of Power Grid Interconnection



Source: ERIA.

Figure 3: Methodology for Cost Estimation



Source: ERIA.

The net benefits, resulting from avoided peak generation capacities and saved expensive fossil fuels for peak power generation, are summarised in Table 2 and compared to the costs of investing and operating interconnection projects.

Table 2: Return on Investment, 2025–2035

Case	Net Benefit (US$, million)	Construction Cost (US$, million)	Benefit/Cost (–)
B THA–LAO	19,881	1,506	13.2
E VNM–LAO–THA	22,610	2,097	10.8
G LAO–THA–MYS–SGP	25,490	2,000	12.7

Source: ERIA.

The following trade flows are projected in 2025–2035 with the newly established interconnections (Table 3).

Table 3: Trade Flow from 2025 to 2035, by Route (unit: TWh)

Route	Trade Flow, 2025–2035
VNM–LAO	105
LAO–THA	567
THA–MYS	52
MYS–SGP	91

Source: ERIA.

The following observations are made based on these quantitative simulation results on the economic feasibility of these interconnection projects:

1. In terms of size of the net benefit, Case G provides the largest net benefit.
2. In terms of return on investment, Case B is the most beneficial.

These results thus indicate that although the three interconnection projects are capital intensive, the attainable benefits seem to be large enough to justify the investment well. These projects thus firmly stand as feasible and should be prioritised for implementation as early as possible.

Key Findings

A fully functioning regional grid bears many benefits to countries involved. Through such interconnection, the development of the cheaper renewable energy resource which exists with abundance in the region could be further developed, especially hydropower in the Greater Mekong Subregion. In addition, the interconnected grids can take advantage of the varying timing of peak and non-peak hours in different countries and thus save a large portion of the investment in expensive peak power generation capacities. The Economic Research Institute for ASEAN and East Asia (Kutani, 2013) estimated some US$11 billion net savings in the cost of electricity generation for all ASEAN countries plus two Southwest China provinces and Northeast India in 20 years, despite the high initial costs of investment in interconnecting transmission lines. The other independent estimation by Chang and Li (2013) presents a net savings of US$20.9 billion for ASEAN alone in 20 years.

Furthermore, the interconnection of grids in the region enhances the overall capacity of countries to adopt renewable sources of power generation, such as solar photovoltaic and wind turbines. Chang and Li (2015) show that, with power grid interconnection among ASEAN countries, by implementing feed-in-tariff (FiT) policy for renewable energy, renewable energy adoption could be increased by some 70 percent compared to the baseline scenario with no interconnection and no FiT, while the total cost of electricity generation increases by only 8 percent. With less aggressive FiT policy, an increase in the total cost by 1 percent can increase the renewable energy adoption by some 30 percent.

However, the high upfront cost of new transmission lines for cross-border interconnection and the uncertainty of future demand for imports and exports of electricity through these transmission lines complicate the financial decisions to invest. The financial feasibility of each proposed cross-border transmission lines needs to be carefully studied. The study by Economic Research Institute for ASEAN and East Asia (Kutani and Li, 2014) identified that the power grid interconnection among Lao PDR, Malaysia, Singapore, Thailand, and Viet Nam are financially feasible and should be prioritised. This finding coincides with the initiative by the governments of Lao PDR, Thailand, Malaysia, and Singapore to develop interconnection and demonstrate a multilateral framework for cross-border trade of power.

However, further institutional issues are still standing as barriers to the realisation of fully interconnected power grid in the region. According to Li (2015), these mainly concern (i) regional coordination of infrastructure development plans and rules for data and information communication, (ii) wheeling charge (transmission tariff) for multilateral cross-border power trade with proper unbundling and coordinated review criteria in each participating country, and (iii) harmonisation of technical standards, including operation and connection standards.

Implications for a Road Map of Energy Connectivity between Asia and Europe

To move to the next stage of trading, namely, grid-to-grid multilateral electricity trading between Asia and Europe, the foremost requirement is contiguous land area because electricity trade can be done over land. The second major issue is harmonisation of technical standards and regulations in the countries involved. ASEM may well explore the feasibility of this trading among countries with a keen focus on the need for harmonisation of standards in this regard.

Among them, institutional barriers are the key issues, as they usually concern the domestic electricity market structure of member countries, vested interests of industry groups as well as consumer groups, and domestic legislative procedures and politics.

In addition, the search for an appropriate business model to ensure adequate economic benefit for each country involved in the multilateral electricity trading is also a key challenge.

Further study on ASEM power grid interconnection should focus on the economic feasibility of identified project(s). It will also include the key barriers and challenges to multilateral interconnection, mainly covering the following issues:

- Regional coordination of infrastructure development plans and rules for data and information communication
- Wheeling charge (transmission tariff) for multilateral cross-border power trade with proper unbundling and coordinated review criteria in each participating country
- Harmonisation of technical standards including operation and connection standards.

Moreover, following existing regional electricity trading models such as those in Europe (the Nordic system and the continental regional systems) should be further studied as references in addressing the key issues in market design and business model development, such as the (i) harmonisation of transmission capacity estimation; (ii) proper division between market coupling and market splitting; (iii) allocation of cross-border transmission capacity and revenue from congestion charge; and (iv) coordination of infrastructure investment, especially the transmission capacity, through integrated power development plan of participating countries. All these are key elements of a well-functioning multilateral electricity trading market, as evident in documentation on the interconnected and integrated European electricity markets.

Before arriving here at a competitive Europe-wide electricity market, as in the Nordic countries' case, the development of a regional cross-border electricity market took a long way—more than half a century—to evolve from bilateral power exchange agreement,

to bilateral trade of electricity, and to regional multilateral trade of electricity. Eventually, it evolved into a Europe-wide competitive electricity market such as in the last two decades, driven by very strong political will in the European Union so that the European Commission imposed the integration of the energy market among all member countries. In other parts of the world, where most likely only voluntary procedure for power grid interconnection and electricity market integration could be adopted, progress may naturally be slower. Nevertheless, the measurable significant benefits of interconnection and integration in the European case show the necessity of pursuing these targets in other regions, especially in Asia, as much and as fast as possible. Besides all other technical, economic, and institutional challenges of 'energy security', a higher level of trust among Asian countries may turn out to be the key to determine 'how much' and 'how fast' they can go.

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