Market Design for Multilateral Trade of Electricity in ASEAN: A Survey of the Key Components and Feasibility*

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Abstract
The member states of ASEAN have together identified a need to develop the ASEAN Power Grid and enable the multilateral cross-border trade of electricity in a coordinated manner within ASEAN. This has been set out in the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–25. Moving forward from the current situation, this paper reviews the key components and feasibility of establishing an interconnected and competitive multilateral electricity market within the ASEAN countries. An indicative roadmap is developed based on an in-depth survey of experts to profile an appropriate market design for the multilateral trade of electricity in the ASEAN.

1. Introduction

The ASEAN Power Grid (APG) is a flagship program that was initiated in 1997 by the ASEAN Heads of States/Governments under ASEAN Vision 2020 to ensure regional

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Figure 1. Indicative map of APG interconnection projects

Source: *Authors based on APAEC 2016–25 (original map: courtesy of mapcruzin.com).*

energy security while promoting the efficient utilization and sharing of resources. The APG program (Figure 1) involves all the ASEAN countries and concerns the interconnection of all their power grids. It consists of 16 interconnected projects to develop the cross-border transmission lines within ASEAN and is an integral and key part of the ASEAN Economic Community Blueprint 2025 (ASEAN Secretariat 2015) and ASEAN Plan of Action for Energy Cooperation 2016–25 (ASEAN Centre for Energy 2015).

The economics, financial feasibility, prioritization of power grid interconnection projects, and basic technical and physical harmonization of power grid operation and regulation required have been studied by academia as well as international organizations. Table 1 summarizes the important findings from the past studies on the APG.

The trading of electricity in ASEAN is currently limited to the bilateral mode, however. To develop the APG and achieve its full potential for economic and social benefits,

Table 1. Assessments of the benefits of the APG in the literature

Authors/ organization	Scope of study	Methodology	Main findings
Asia Pacific Energy Research Centre (APERC) (2004)	ASEAN	ASEAN Interconnection Master Plan Study (2003)[a]	11 proposed transmission links are identified as cost-effective options. Among these, 7 selected projects generated total net savings of US$ 662 million in 2000.
Asian Development Bank (ADB) (2009)	Greater Mekong Subregion (Cambodia, China, Laos, Myanmar, Thailand, and Vietnam)	MESSAGE (Model of Energy Supply Systems Alternatives and their General Environmental Impacts)	Over the next two decades, 19 percent of the total electricity costs or nearly US$ 200 billion could be saved for the subregion. To reap such benefits, the subregion needs to invest US$ 585 billion in power and transmission infrastructure. Coal-based power generation could be lowered by 40 percent, while decentralized solar photovoltaic power could double its capacity in the subregion.
Economic Research Institute for ASEAN and East Asia (ERIA) (2014)	ASEAN, China, and India	Optimal power generation planning model	Interconnection projects with positive net economic benefit, which indicates the economic feasibility of the project, are identified. These prioritized projects include the Viet Nam–Lao–Thailand–Malaysia–Singapore route, the Cambodia–Thailand route, and the Malaysia–Indonesia route. The savings in the total system cost could be as high as US$ 9.1 billion by 2035 for all the 12 countries.
Economic Research Institute for ASEAN and East Asia (ERIA) (2015)	ASEAN	Power infrastructure simulation model (project financial analysis)	The Thailand–Lao route has the highest return to investment, followed by the Lao–Thailand–Malaysia–Singapore route and lastly by the Vietnam–Lao–Thailand route.
UN ESCAP (2018)	ASEAN, China, and India	Regional interconnection comprehensive benefit model	By 2050, in the most aggressive scenario of renewable energy integration, 62 percent of the electricity supply in the ASEAN will come from renewables. This is enabled by fully developed power grid interconnection in the ASEAN. The average cost per kWh will also be reduced by US$ 0.02/kWh.
Chang and Li (2013)	ASEAN	Linear dynamic programming model	The total system cost of the electricity supply between 2010 and 2030 will be reduced by 3 percent compared with the scenario without any power trade. In absolute terms, the savings will amount to US$ 20.9 billion.
Chang and Li (2015)	ASEAN	Linear dynamic programming model	With an interconnected power grid in the ASEAN, feed-in tariff policies appear to be more effective in reducing carbon emissions and promoting the development of renewable energy.
Li and Chang (2015)	ASEAN, China, and India	Dynamic linear programming model, with a financial sub-model for transmission infrastructure	In the case of optimal capacity of cross-border transmission interconnection, 0.67 percent of the total system cost of the electricity supply for the 12 countries covered in the study could be saved.

Source: *Authors summarized based on literature.*

Note*: a. A study conducted by the Heads of ASEAN Power Utilities/Authorities (HAPUA) in 2003, the report of which is not publicly available.*

multilateral trading of electricity is needed. The recent Lao PDR–Thailand–Malaysia energy integration initiative by these countries, demonstrating the cross-border trading of electricity among them through negotiated terms and agreements, clearly indicates the strong willingness of the ASEAN countries to develop multilateral trading of electricity.

Therefore, at this junction, the key issues to be discussed include the liberalization of national electricity markets, the harmonization of the operation, and the regulation of the transmission system, especially the cross-border power grid interconnection, the electricity market framework/model for the region, coordination in network planning and capacity development, the development of common algorithms for capacity allocation, and the sharing of infrastructure on the basis of fair compensation (Rakhmah and Li 2016; IEA 2019).

This paper thus aims to review comprehensively the key components and feasibility of establishing an interconnected and competitive multilateral electricity market within ASEAN countries. A survey method is adopted to collect opinions from utility experts as well as energy policymakers from the ASEAN member states regarding the acceptability and feasibility of an ASEAN electricity market framework/design. Section 2 provides a literature review on the issue, especially referring to existing market models from other parts of the world, such as the European Union regional electricity market. Section 3 presents the methodology of the survey on the opinions of power sector experts in the ASEAN. Section 4 discusses the results and key findings of the survey. Section 5 concludes and draws policy implications.

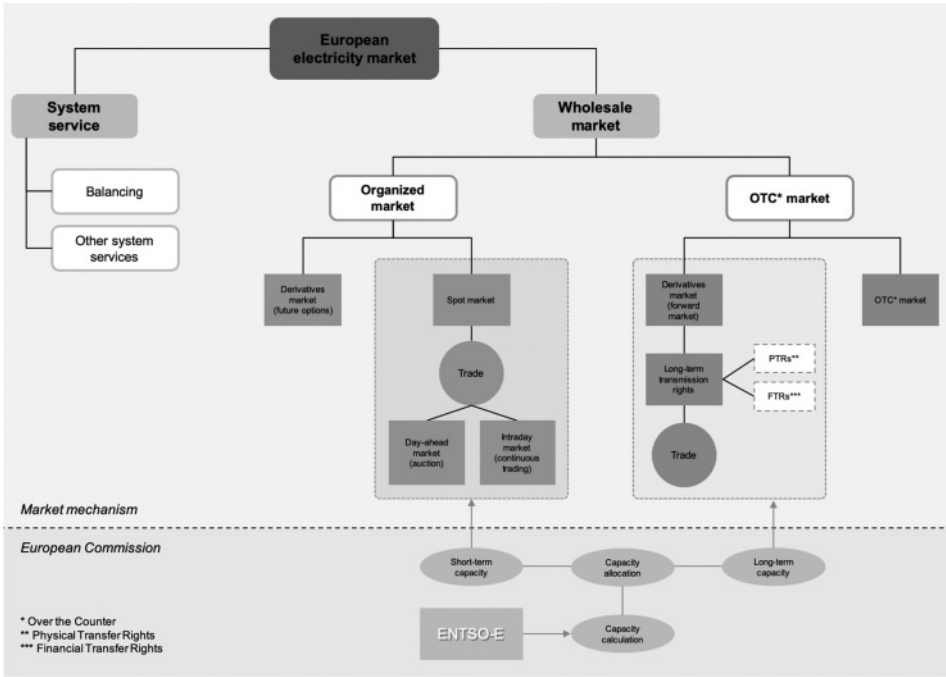
2. Theoretical framework of an integrated electricity market: Lessons from the European market

The EU represents one of the most advanced regions in interconnection in terms of the electricity markets' integration across borders. Section 2.1 summarizes the lessons on the overall market design. Section 2.2 highlights the key components of such a market design as functioning integration of the electricity markets in ASEAN.

2.1 The design of an integrated electricity market

2.1.1 The overall market structure The increasing concern for energy supply security has pushed the EU member states to formulate a common energy policy that allows energy to flow freely across borders. The Lisbon Treaty and the adoption of the Third Energy Package made a clear commitment to the completion of the Internal Energy Market by 2014, allowing free flow of gas and electricity across borders. In 2006, the EU created seven regional electricity markets, marking an interim step toward the target of a single European electricity market in which energy would be traded freely across borders. The seven

Figure 2. Structure of the electricity market in Europe



Source: *Authors.*

Note: *OTC = over the counter, PTRs = physical transfer rights, FTRs = financial transfer rights, ENTSO-E = European Network of Transmission System Operators for Electricity.*

regional markets are the France–UK–Ireland, Central-East, Central-West, Central-South, South West, Baltic, and Northern markets (IIEA 2014).

In general, the current electricity market in Europe is divided into two main components: the wholesale market and system service (Figure 2). The wholesale market allows electricity generators, retailers, large consumers, and other financial intermediaries to buy and sell electricity either through an organized market or through the over-the-counter type of markets.

Electricity in the organized spot market is mainly traded in an intraday market and single day-ahead market through implicit auctions. The transmission capacity and electricity are traded together in the implicit auction, which is also known as market coupling. In the intraday market, participants trade closer to real time and trading mostly takes place during the operation day.

Such trading requires the calculation of the available cross-border capacity in a coordinated manner at the regional level to ensure reliable capacity calculation and the availability of the optimal capacity to the market. Transmission System Operators (TSOs) establish a common grid model that covers the estimation of electricity generation per hour, load, and network status to achieve this integrated calculation. This mechanism allows power to flow from low-price to high-price areas. The market coupling operator uses a common algorithm, the so-called European Hybrid Electricity Market Algorithm (EUPHEMIA), to match bids and offers optimally. The results from this calculation are made open to all the power exchanges in a non-discriminatory manner.

At the same time, electricity can be traded in derivative markets (forward markets), in which suppliers can buy and use long-term and forward contracts in advance to cover their consumption portfolio. The derivative markets could also include explicit auctioning to allocate long-term transmission rights to market participants as financial transmission rights (FTRs) and physical transmission rights (PTRs). These derivative markets aim to reduce the risk associated with an electricity price hike and to secure the electricity supply (ENTSO-E 2013).

2.1.2 Preparation for the integration of electricity markets The integration of the European electricity markets started with a top–down process of liberalization and coordination. The European Commission adopted a set of directives and regulations known as the Third Energy Package on 3 March 2011. The package targeted reform in five main areas: (1) ownership unbundling, which stipulates the separation of energy suppliers from network operators; (2) strengthening the independence of regulators to generate a competitive internal energy market and to ensure that regulations are fairly implemented and enforced; (3) the establishment of the Agency for the Cooperation of Energy Regulators (ACER), which plays a central role in encouraging electricity market integration and enhancing competition through the development of the EU-wide network and market rules; (4) the cross-border cooperation between the TSO and the creation of the European Network of Transmission System Operators for Electricity (ENTSO-E); and (5) increased transparency in retail markets to benefit consumers (European Commission 2016).

Looking at the situation of liberalization and deregulation of electricity markets across ASEAN, Singapore was the first country to launch a competitive, liberalized, and deregulated electricity market. The Philippines and Vietnam followed the trend by establishing a competitive wholesale electricity market. Indonesia, Malaysia, and Thailand have achieved partial liberalization, specifically including the unbundling of transmission and generation, corporatization of utilities, independent power producers, an independent regulator, and third-party access, but have yet to introduce wholesale competition into their electricity market (Sen et al. 2017).

ASEAN has established the Heads of ASEAN Power Utilities/Authorities to coordinate the utility companies in the ASEAN as well as the ASEAN Power Grid Consultative Committee to coordinate the electricity market regulators and policymakers in the ASEAN. These bodies function more as a secretariat, however, than as formal institutes to carry out regular coordination activities such as harmonization, infrastructure planning, monitoring and exchange of operation information, and so on. The region thus has yet to establish formal institutions, like ACER and ENTSO-E in Europe.

The multilateral trade of electricity in the ASEAN will most likely be developed as a loose over-the-counter market first. Eventually, however, it will have to evolve into organized markets to cater to the needs of active regular trading of various products and services, as described in the next two subsections.

2.2 Key components of and steps toward an integrated electricity market in ASEAN

To establish a multilateral electricity trading framework in the ASEAN with the basic functions, we identified the following basic building blocks to be developed.

2.2.1 Open access Open access to transmission and distribution grids by market participants from all member states is a fundamental step toward the integration of electricity markets. Opening access to the grid is a long-term process rather than a discrete event. The initial step toward open access is to enforce legal rights for suppliers to access the grid and to sell their electricity and capacity and for buyers to have an agreement with suppliers, whether it is a direct agreement or one reached through an authorized market operator. The institutional requirement at minimum includes transparency in regulations and procedures on market and grid operations, unbiased TSOs, and financial objectives (World Bank 2013).

2.2.2 Capacity estimation, allocation, and compensation In a liberalized electricity market, the available cross-border capacity should be calculated in a coordinated manner; in the European electricity market, the calculation is conducted by TSOs. The network code on capacity allocation and congestion management regulates the available capacity trade. The forward capacity allocation network code, on the other hand, regulates long-term capacity trade, whereby TSOs establish a common grid model according to the individual grid model from each TSO. This model incorporates the generation estimates, hourly load, and network status.

Electricity trade also involves cross-border electricity flows and normally leads to electricity losses. Therefore, compensation is necessary for the infrastructure costs for hosting cross-border electricity flows and the costs for electricity losses incurred by particular transmission systems that host cross-border flows. The European electricity market has

established the Inter-TSO Compensation mechanism to compensate for electricity losses and grid congestion (EC 2010).

There are two components to the calculation of compensation. The first component is the transmission losses based on a with-and-without-transit model. Losses are calculated for each TSO's transmission grid in a load flow situation with and without transits. TSOs are compensated for the costs incurred as a result of hosting cross-border electricity flows on their networks. In addition to this, the national transmission system operator from which cross-border flows originate and the systems where those flows end provide the compensation. Compensation is made on a regular basis with regard to a given time period in the past (EC 2010).

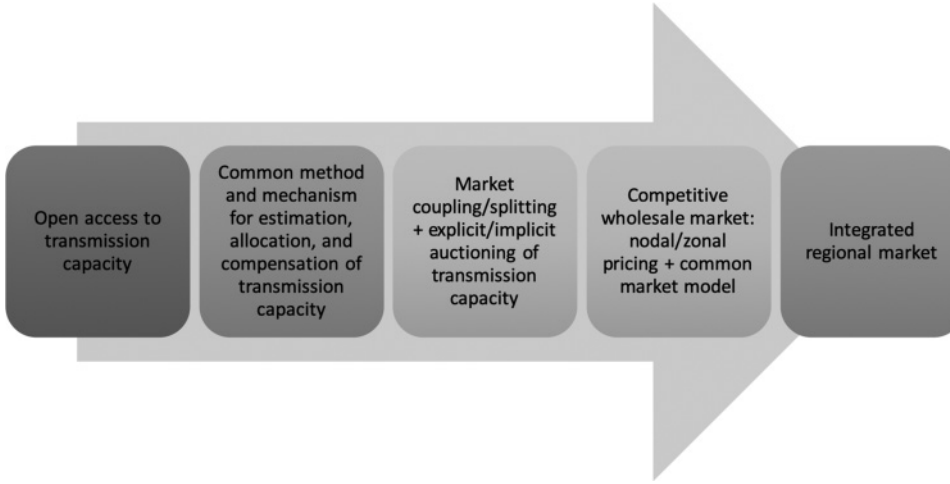
The second component is an infrastructure cost to compensate for hosting cross-border flows. The level of payment for this infrastructure is based on the infrastructure cost asset value used to host cross-border flows and the amount of cross-border flows between participating TSOs. The cost calculation for hosting cross-border flows is established on the basis of forward-looking long-run average incremental costs that also incorporate investment in new infrastructure, account losses, and an appropriate proportion of the existing infrastructure cost (Androcec et al. 2011). The benefits incurred as a result of hosting cross-border flows are also taken into consideration to reduce the compensation payment.

2.2.3 Market coupling, market splitting, and auctions Market coupling is one way to achieve market integration. It takes place in a network that consists of several areas or countries, among which market transactions will be settled through a common algorithm that takes grid constraints into account. If there are differences in the market area prices, then the operators will calculate the tradable transmission capacity in their market areas to even up the price in the coupled markets. A system price is thus created through this mechanism (Toljan et al. 2011).

However, in circumstances in which the necessary trading capacity exceeds the interconnector capacity, bottlenecks occur and the market is necessarily decoupled. Subsequently, the prices between previously coupled areas will differ and these areas will no longer use the system price. It implies that, without sufficient interconnection between different markets, a single price system cannot operate. Thus, bottlenecks will create different prices in each of the bidding areas even if they are in the decoupled market. This is known as the market splitting procedure (Van den Bergh et al. 2016).

2.2.4 Nodal or zonal pricing Nodal pricing is a method to determine market clearing prices, which are calculated in a number of locations on the transmission grid, known as

Figure 3. From grid interconnection to market integration—Key components and steps



nodes. Nodes refer to each point on the transmission system at which generators inject energy or loads withdraw energy. Because nodal prices reflect the marginal costs of electricity provision at different locations, these prices give incentives for the trading of electricity (Oren et al. 1995).

Nodal prices may be different at the individual node in the network where a single transmission line is contested (Stoft 1997; Hogan 1998). Hence, network nodes are segregated into price zones that share similar prices. This approach is known as zonal pricing, which is also called market splitting (De Vries and Hakvoort 2002).

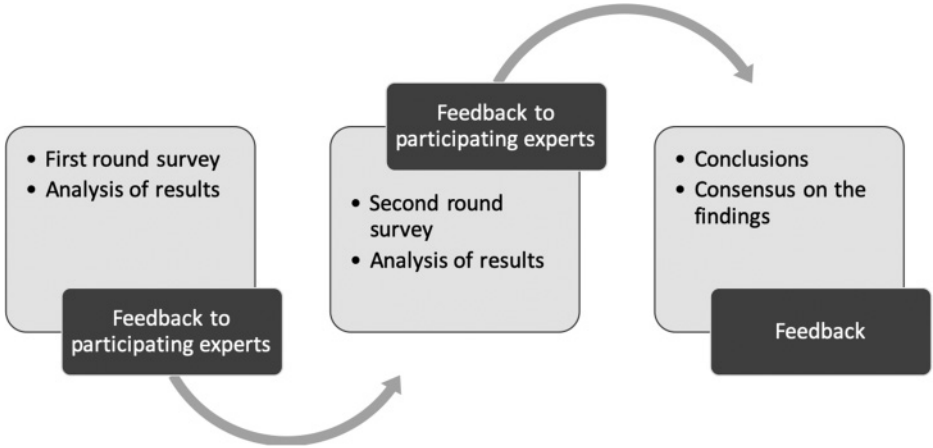
3. Survey methodology

Based on the literature review, we summarize the guiding principles of the market design for multilateral trading of electricity in the ASEAN as follows:

1. Maximize the economic potential of the APG;
2. Ensure the safety and reliability of the ASEAN member states' power grid;
3. Incentivize transmission infrastructure investment; and
4. Enable open access and a common transmission capacity mechanism.

Accordingly, we identify the theoretical components and steps toward the building of an integrated regional electricity market in the ASEAN as shown in Figure 3.

Figure 4. Delphi method



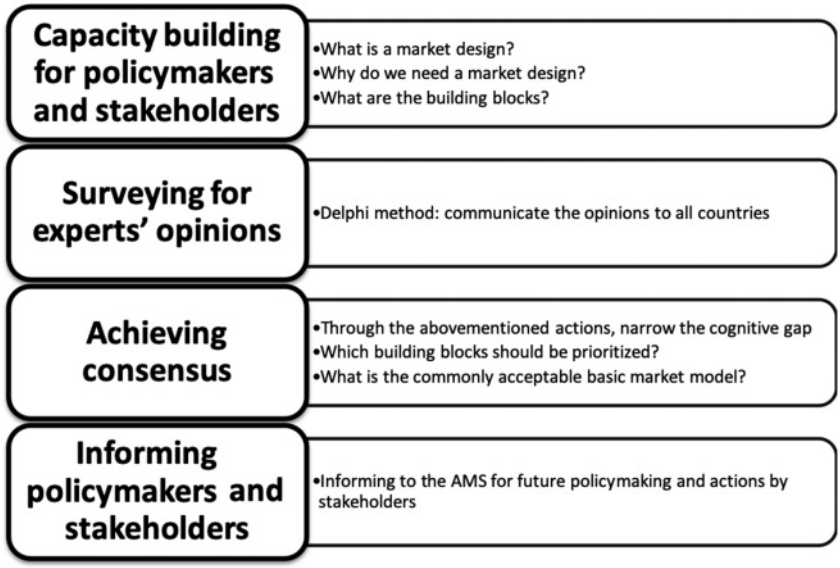
However, we fully understand that the feasibility of such an ideal market model is subject to the reality of ASEAN member states, especially concerning their own electricity market structure, legislation, regulations, standards, and even politics. Therefore, we conducted the first round of the survey on the following five blocks of issues:

1. Part I: General opinions on multilateral electricity trade;
2. Part II: The feasibility of establishing ASEAN multilateral electricity trade based on the APG;
3. Part III: Institutions for third-party use of transmission capacity in ASEAN multilateral electricity trade (estimation, allocation, and compensation);
4. Part IV: Market design for multilateral electricity trade in the ASEAN; and
5. Part V: Setting up institutions for coordination and cooperation in multilateral electricity trade.

The first round of the survey produced indicative results of the components and the kind of overall institutional framework that are preferred. However, a common market model derived from such preferences and thus customized for the ASEAN is still to be recognized as acceptable to most member states. Therefore, a second round of the survey was conducted to assess the acceptance of a two-stage market development model for ASEAN.

This survey method is also known as the Delphi method (Figure 4). The Delphi method is a forecasting method based on the results of questionnaires sent to a panel of experts. Several rounds of questionnaires are distributed, and the anonymous responses are aggregated and shared with the group after each round.

Figure 5. Purposes of the survey



Note: *AMS = ASEAN member state.*

The adoption of the Delphi method is thus not only an analytical process to provide solutions to the research questions but also a capacity-building and consensus-reaching process for the experts of ASEAN countries in their power sector. It is believed that such a practice could also to some extent facilitate the relevant parties future actions toward the formation of a multilateral and regional electricity market (Figure 5).

The questionnaire for the first-round survey as well as the second-round survey contains questions that scale the responses to five levels, from very negative, negative, and neutral to positive and very positive.

4. Results and key findings

4.1 The first-round survey

The first-round survey received a total of seventeen responses from experts from nine ASEAN countries. The opinions collected from the survey can be summarized in three categories:

First, issues that have been confirmed or agreed by most experts, which include the following:

- The majority of respondents lack knowledge about competitive multilateral electricity trade in an integrated market, such as the EU and U.S. regional markets;
- ASEAN cannot follow any existing market models and needs its own market design due to its own characteristics;
- ASEAN needs common guidelines for the technical and physical interconnection of power grids;
- ASEAN countries can share data about cross-border transmission capacities;
- The net transfer capacity should be used in estimating the available cross-border transmission capacity;
- ASEAN needs a common model to estimate the loop flow in the cross-border interconnections and compensate for it accordingly;
- Any of the methods, namely, market splitting, market coupling, and nodal pricing, could be used to manage congestion in cross-border transmission interconnectors;
- ASEAN countries agree to set up several institutions to support and coordinate issues related to an ASEAN common electricity market, including a planner group, regulator group, and TSO group, as well as an ASEAN-wide infrastructure development plan; and
- ASEAN countries agree to establish a special financing fund for an ASEAN common electricity market.

Second, there is a weak preference for or motivation to develop the following issues in the ASEAN electricity market:

- A common market model for electricity pricing;
- A common guideline/coordinated method for the allocation of cross-border transmission capacity and compensation for open access;
- A common methodology for the configuration of trading/bidding areas/nodes;
- ASEAN countries can share data about domestic electricity generation, transmission, distribution, and load;
- Implicit auctioning of cross-border transmission capacity for the trading of electricity in the ASEAN context;
- PTR and FTR can be useful for market participants to manage better the risks related to transmission; and
- An ancillary services market is necessary as an integral part of the future ASEAN integrated electricity market.

Third, there are several issues that the majority of experts perceived to be less important and infeasible in ASEAN:

- An explicit auction of available cross-border transmission capacity;
- The development of PTR or FTR to incentivize investment in the cross-border transmission infrastructure;

- A common guideline for the grid operation procedure, performance standards, and grid codes; and
- Liberalization or unbundling in the domestic market of the ASEAN member countries.

4.2 The second-round survey

Based on the information collected and comprehended during the first round of the survey, we can identify components that are commonly agreed to be the building blocks for the beginning stage of market development in the ASEAN. Less-preferred components serve as the building blocks for an advanced stage of market development in the ASEAN. The second-round survey on the feasibility of an electricity market grand design generated eleven responses from eight ASEAN countries. To avoid overweighting the opinion of a country with more responses than others, we take the average of the responses from the same country. Therefore, in the following Table 2, the outcome of the survey is presented as the scoring of the opinions of eight countries.

The results of the second round of the survey reaffirmed the previous finding that certain components are readily acceptable among most ASEAN countries and are in principle sufficient to support a regional electricity market for multilateral trading. Nevertheless, moving toward a more organized and competitive market in the region (i.e., components 7–10 in Table 2) requires deeper structural reforms of the domestic electricity markets, legislation, and regulations—for which the preferences of most ASEAN countries become neutral.

According to the results of the two rounds of survey, we present the following roadmap summary as a feasible one (Figure 6), with key building blocks for the regional electricity market design in ASEAN. To implement such a roadmap for market development, we recommend that the following stakeholder groups are formed to take coordinated actions (Figure 7).

First, the policymaker group aims to achieve consensus and agreements at the policymaker level to foster more harmonized multilateral electricity trade. This group especially targets the improvement of the way in which the internal electricity market functions as well as addressing structural issues.

Second, the regulator group is responsible for monitoring the functioning of the cross-border electricity market. It will need to provide a framework for market integration, which will serve as a base for formulating a set of common guidelines that govern both the power systems and the power markets.

Third, the TSO group is responsible for coordinating and maintaining effective and transparent access to the transmission networks across participating countries. It also provides a

Table 2. Results of the second-round survey

	No.	Question	Very negative	Negative	Neutral	Positive	Very positive
About the survey process and methodology	1	Has the survey process so far helped you in enhancing your knowledge about market design/models for a competitive multilateral electricity market?	0%	13%	38%	50%	0%
	2	Common guideline for technical/physical interconnection of ASEAN member states' power grid	0%	0%	13%	38%	50%
	3	Common guideline for sharing data and information that are necessary for coordinated operation and planning	0%	0%	13%	75%	13%
Basic market building blocks: Feasibility in the near future	4	Common guideline for coordinated estimation and allocation of available cross-border transmission capacity	0%	0%	13%	38%	50%
	5	Common guideline for a compensation mechanism for third-party access to the transmission capacity or grid in general	0%	0%	38%	63%	0%
	6	Setting up institutions such as a policymakers' group, regulator group, planning group, and TSO group in the ASEAN	0%	0%	0%	100%	0%
	7	Deregulation, unbundling, and domestic electricity market reform	0%	38%	50%	13%	0%
Advanced market building blocks and market design: Feasibility in the medium to long term	8	Harmonization of the grid operation procedure, performance standards, and grid codes	0%	0%	13%	63%	25%
	9	A common regional market model to determine the (implicit) allocation of cross-border transmission capacity, congestion charge, and nodal/zonal electricity pricing as well as the configuration of trading/pricing zones	0%	0%	63%	38%	0%
	10	Developing advanced auxiliary and derivative markets, such as a balancing service market and markets for long-term transmission capacity allocation rights	0%	13%	75%	13%	0%

common platform that governs the way in which electricity is produced, traded, transmitted, and distributed.

Finally, the ASEAN-wide planning group develops a coordinated approach to region-wide infrastructure planning and aims to develop and promote a financing mechanism for the APG.

Figure 6. A feasible roadmap for the regional electricity market design in ASEAN

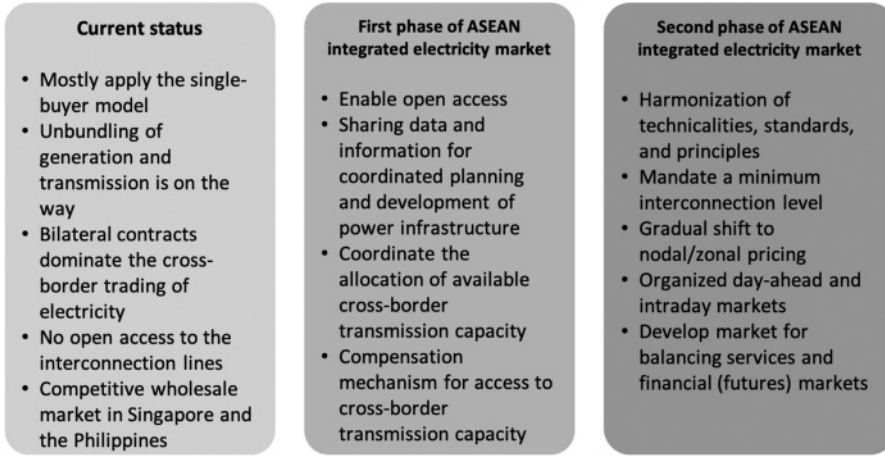
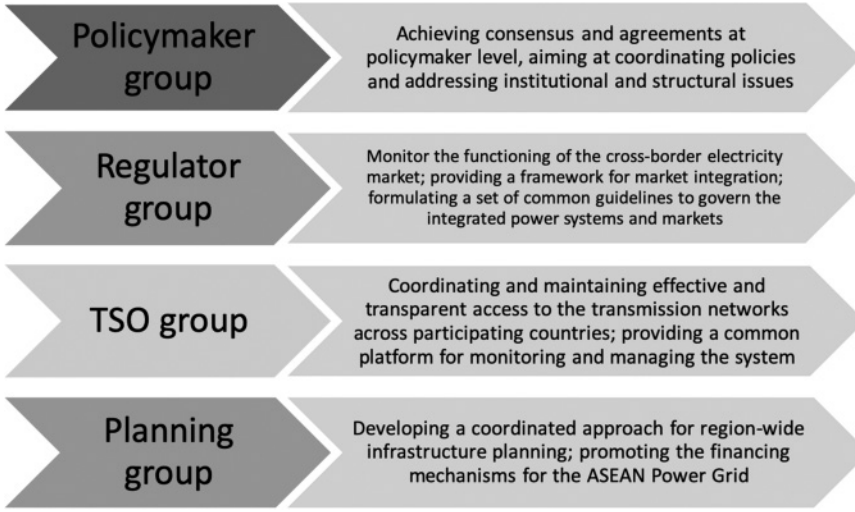


Figure 7. Stakeholder groups for the implementation of the proposed roadmap



Note: *TSO = Transmission System Operator.*

We hope that this illustration clearly explains how a regionally integrated electricity market works and what the necessary building blocks are. The ideal market model will depend on the preferences of the ASEAN member countries, however—particularly taking

into consideration the existing legislation, regulation, and market structure in each member state.

5. Conclusions and the way forward

In conclusion, a two-phase market development strategy is recommended for ASEAN to move forward into an integrated electricity market. Such a strategy would be based first on the experiences and lessons learned from the EU integrated electricity market. The proposed framework/model is subsequently tested through a structured survey on the feasibility as well as the priority sequence of developing the necessary building blocks.

In phase 1, to facilitate sporadic multilateral trade of electricity, the following are considered as the necessary building blocks:

- Enabling open access;
- Sharing data and information for coordinated planning and development of the power infrastructure;
- Coordination for the allocation of available cross-border transmission capacity; and
- A compensation mechanism for open access to the grid.

Then, for phase 2, the following should be developed to establish a fully integrated regional electricity market:

- Harmonization of technicalities, standards, and principles;
- Mandate a minimum interconnection level;
- A gradual shift to nodal/zonal pricing;
- Organized day-ahead and intraday markets; and
- Develop balancing service and financial (futures) markets.

Our findings coincide with and reaffirm the main policy advice given by the study on the feasibility of multilateral power trade conducted by the International Energy Agency for ASEAN (IEA 2019), which offered ASEAN the options of developing a "secondary" market model first before moving to a "primary" market model. Our study also further explored the feasibility of the building blocks in each phase of market development. The survey showed a certain extent of consensus among ASEAN countries on these issues and thus the validity of the proposed two-phase framework/model.

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