

Technical Potentials and Challenges to Regional Power Grid Interconnections

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SYNOPSIS

Establishing interconnections among power grids in the ASEAN region is a pivotal strategy for bolstering the area's energy security and facilitating a transition to renewable energy by optimising resource sharing. However, attaining regional power grid interconnections may encounter specific technical constraints and establishing a cohesive electricity market necessitates the harmonisation of technical norms and operational procedures on a regional scale. Technical challenges may be overcome through various measures of standardisation and harmonisation across countries. It is anticipated that regional agencies will have a crucial role in facilitating dialogue across various levels to tackle challenges. They will also be instrumental in collecting essential knowledge and data, forming the groundwork for these discussions.

KEY POINTS

- The success of LTMS-PIP represents a milestone, demonstrating the technical and institutional feasibility of long-distance power transmission across countries.
- Surrounding technical obstacles and ensuring successful integration efforts necessitate the involvement of regional institutions for coordination and supportive services.
- Achieving interconnections in regional power grids faces technical challenges, such as disparate voltages and frequencies, outdated infrastructures, and differing opinions among stakeholders regarding the formulation of wheeling charges.
- Countries engaged in regional power trade may possess diverse and occasionally conflicting norms, criteria, and procedures related to the transmission and distribution of electricity.

INTRODUCTION

The power industry of the Association of Southeast Asian Nations (ASEAN) is transforming due to the pressure from regional energy security and climate change mitigation goals. The penetration of variable renewable energy (VRE) will be deepened by phasing out fossil fuels. Establishing interconnections among power grids in the region is a pivotal strategy for enhancing the area's energy security and facilitating the transition to renewable energy by optimising resource sharing. Nevertheless, attaining regional power grid interconnections may encounter specific technical hurdles, impacting rules, processes and assets that facilitate cross-border trades, such as disparate voltages and frequencies, outdated

infrastructure, market structures, grid codes and differing wheeling charge methodology. Furthermore, countries in the region may exhibit differences in these technical requirements at various stages of development.

ANALYSIS

ASEAN Energy Sector Overview

Over the last two decades, Southeast Asia has undergone rapid development, emerging as a substantial contributor to global economic growth. This leads to substantial growth of energy consumption. According to the 7th *ASEAN Energy Outlook* developed in 2019 by the ASEAN Centre for Energy, energy consumption from end-use sectors in ASEAN increased 1.6 times compared to the 2005 level.

The adverse impacts of the COVID-19 pandemic did contribute to a decline in energy consumption in 2020. The economic recovery and the long-run socio-economic prospects for ASEAN, however, are perceived to drive the energy demand in this region.

Efforts to enhance energy efficiency over the past decades have somewhat mitigated the overall growth in demand. [While the average annual GDP growth from 2005 through 2020 stood at 4.6%, the average yearly growth of TFEC was lower at 2.7% during the same period.](#) ASEAN member states (AMS) have implemented various energy-saving measures, such as increasing the utilisation of efficient cooking and lighting technologies and raising minimum energy performance standards for cooling appliances.

Meanwhile, most ASEAN countries lack a high capacity for clean technology innovation and exhibit low levels of core research and development. ASEAN's own talent output falls short of meeting the current large-scale development of new energy, resulting in a substantial technology and talent shortage. Additionally, many ASEAN countries have weak power infrastructure and face a significant financing gap, posing challenges to the development and widespread utilisation of new energy.

Recent Development of Power Integration in ASEAN

The push for renewable energy in ASEAN goes beyond bilateral power agreements, moving towards multilateral power trading schemes, although progress is sometimes hindered. The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP), proposed in 2014, was recently launched in June 2022. The initial phase of the project successfully traded up to 300 megawatts (MW) from Lao PDR to Malaysia. In 2020, an Energy Purchase and Wheeling Agreement was signed to expand the trade to Singapore and determine the wheeling charge paid to transit countries, namely Thailand and Malaysia.

The LTMS-PIP involves unidirectional, long-term power transmission between predetermined pairs of buyers and sellers, with the electricity passing through multiple countries. The success of LTMS-PIP represents

a milestone, demonstrating the technical and institutional feasibility of long-distance power transmission across countries.

In September 2023, Singapore's Energy Market Authority issued conditional approvals to five projects for the importation of a combined 2 gigawatts (GW) of low-carbon electricity from Indonesia into Singapore. These conditional approvals build upon one granted to Keppel Energy in March 2023, allowing for the import of 1 GW of low-carbon electricity from Cambodia. These efforts represent a significant advancement in Singapore's goal to import up to 4 GW of low-carbon electricity by 2035.

Regional Power Integration: Technical Potentials

As the LTMS-PIP serves as a trailblazing project, likewise, the ASEAN Power Grid (APG) has the potential to optimise the region's renewable energy sources, enhancing energy security and stability. It offers the opportunity to optimise investments in these connections and accelerate progress in decarbonisation. In particular, each ASEAN nation possesses unique energy resources. For example, in Indonesia, Vietnam, and the Philippines, wind power is predominantly accessible, and the feasibility of solar PV greatly dependent on the specific geographical locations. By sharing renewables between the resource-rich and resource-poor countries through a regional grid, a more balanced fuel mix can be achieved. This fosters stability and security of energy supply by mitigating the risks and potential cost impacts of individual fuel shocks. In addition, cross-border power networks can play a crucial role in overcoming geographical obstacles for electricity transmission in ASEAN. Many instances arise where remote locations in one nation are closer and more accessible to established power networks in another, addressing geographical challenges effectively.

International Energy Agency's *Southeast Asia Energy Outlook 2019* underscores that optimised transmission flows typically lead to a decrease in annual operational costs, attributed to a reduction in the curtailment rate of VRE. Economic benefits are noted to escalate with increased penetration of renewable energy. These savings contribute to a decrease in the average electricity price

generated by renewables, fostering more competitiveness against traditional fossil fuels. Consequently, governments are incentivised to invest in additional renewable energy infrastructure, gradually phasing out fossil fuel generators.

In accordance with the ASEAN Interconnection Master Plan Study III, the APG aims to increase the capacity of interconnection to 27–30 GW in the next two decades, surpassing the 2020 capacity of under 8 GW by more than threefold. This expansion has the potential to:

- (1) Boost prospects for electricity exchange within ASEAN and broaden power supplies.
- (2) Lower energy costs by linking demand hubs with regions abundant in resources.
- (3) Diminish ASEAN's overall dependence on thermal power derived from fossil fuels.

Regional Power Integration: Technical Challenges

The scope of transnational electricity trading extends beyond cross-border electricity interconnections and transmission lines to include domestic grids. They become vital as the trade progresses, utilising domestic power grids to transmit electricity. In this sense, the obstacle lies in the necessity for AMS to invest in upgrading transmission grids to accommodate the substantial integration of VRE. Given the region's ageing grid infrastructure, there is a need for grid enhancements to manage challenges associated with transferring power efficiently to areas of high demand.

[Establishing a cohesive electricity market necessitates the harmonisation of technical norms and operational procedures on a regional scale.](#) This task is intricate due to the differences within ASEAN and its power networks, encompassing varied, and occasionally conflicting standards, specifications, and procedures for the transmission and distribution of electricity. Countries in the region may differ in power markets at different stages of development, ownership rules and grid codes, differences in frequencies, voltages, information technology systems, and even policies for safeguarding consumer interests. Some countries in ASEAN may lack connected national power grid networks. For instance, Brunei and Cambodia lack nationally interconnected power grid

networks, and Indonesia and Malaysia have fragmented power grids as well. The deployment of a costly submersible high-voltage line among countries may also be a technical challenge.

Resistance from incumbent utilities may further complicate matters. State-owned utilities, for example, in Indonesia, are unlikely to willingly relinquish their current market dominance for a more competitive market structure. Certain high-cost electricity generators, including those operated by state-owned utilities, could face challenges in competitiveness if wholesale prices were to converge through a robust market integration. Electricity utilities, often inclined toward maintaining the status quo due to risk aversion and a desire to protect their incumbent positions, may employ strong lobbying power. They can use various technical reasons to impede progress toward regional integration, highlighting the need for significant [reforms in key countries to prepare state-owned electricity utilities for active cross-border competition and wholesale trade.](#)

Market integration entails information sharing, a practice that may not be enthusiastically embraced by all countries, partly due to concerns about data sensitivity related to national security. For example, the experience with LTMS-PIP illustrates that determining wheeling charges for planned interconnections can present a complicated challenge. A variety of stakeholders expressed differing views on the wheeling charges: some believed they were excessive, while others considered them insufficient. In general, the consensus among most stakeholders was that the wheeling charges within the four countries lacked a precise formula and were established with a focus on fostering collaboration to expedite project initiation. This necessitates the establishment of consensus among stakeholders with a difference in initial perspectives on cooperation.

Overcoming Barriers to Regional Power Integration

From a technical standpoint, initiating a fundamental structure for power trading and setting up a domestic power market within individual countries serve as the initial phase for power grid interconnection. As of now,

ASEAN lacks a unified regional grid code, with each country independently formulating its own rules and procedures. The synchronisation of grid codes is crucial for optimisation and mitigating risks linked to regional interconnections, such as the potential for cascading grid failures. Achieving harmonisation demands enhanced institutional capabilities among participating utilities that may include proficiency in a common language. This may necessitate staff training and document translation, with the level of challenge escalating as the market model becomes more integrated.

Following the completion of power trading between neighbouring countries, it becomes essential to establish trading arrangements. Without the minimum trading arrangements in place, engaging in more intricate power trading becomes unfeasible. Both the countries involved in trading and the regional levels must reach agreements to facilitate the organisation of power trading.

Specifically, measures to facilitate regional power trading and market integration may differ over the short, medium, and long term. If an action can be undertaken promptly, it falls into the category of short-term measures. Conversely, measures requiring foundational groundwork are categorised as either mid-term or long-term. For example, in the short term (<5 years), conflicts in standards and operations across countries may be identified. The potential of cross-border interconnections may be assessed accordingly, and capacity building for agencies related to regional energy connectivity may be identified as well. In the medium run (5-10 years), compatible standards and grid codes may be established, and stakeholder capacity building may be initiated by also including private resources. In the long run (>10 years), standards and grid codes across countries may be harmonised. However, it is important to note that the classification based on the time horizon is not always precise. Additionally, the operation of the network requires a regional entity to oversee interconnections and implement mechanisms for dispute settlement to improve the safeguarding of investments.

CONCLUSION

Establishing interconnections among power grids in the region is a vital strategy for enhancing the area's energy security and facilitating a transition to renewables by optimising resource sharing efficiently. Overcoming technical barriers and implementing effective integration initiatives require regional agencies to coordinate and support services, supplementing the efforts at the national level by the respective country's agencies. Regional agencies are expected to play a crucial role in fostering dialogues at different levels to address obstacles, gathering foundational knowledge and data that form the basis for such dialogues.

WHAT TO LOOK OUT FOR

- Expedited development of power grid infrastructure to enhance regional connections
- Enhanced and harmonised technical frameworks in anticipation of substantial electricity transmission
- Initiatives and measures for the establishment of a short-term power trading market to facilitate the trading of intermittent renewable energy

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