

Expanding Power Trade in ASEAN

An Implementation Framework
for the ASEAN Power Grid

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Abstract

The ASEAN Power Grid (APG) is central to Southeast Asia's ambition to enhance energy security, affordability and sustainability through regional electricity connectivity. As the region's electricity demand continues to grow alongside substantial renewable energy resource potential, interconnected power systems can enable resource sharing across wider areas and enhance system reliability.

Recent developments, including the Enhanced APG Memorandum of Understanding (MoU) and the expansion of multilateral trading initiatives, have strengthened momentum to advance the APG from vision to implementation. Scaling power trade in the region to achieve the full APG vision requires enabling conditions to be strengthened across governance, regulatory, technical, and finance and commercial dimensions.

This report introduces an ASEAN Power Grid Implementation Framework to assess enabling conditions for and barriers to cross-border power trade, and to guide targeted policy and co-ordination efforts. The framework examines two layers: domestic enablers and cross-border co-operation arrangements. These layers are assessed across four dimensions: governance, regulatory, technical, and finance and commercial. The framework is applied to six ASEAN countries and two interconnection corridors to identify implementation gaps, highlight good practices, and support targeted policy and co-ordination efforts.

Drawing on stakeholder consultations, survey inputs, research and international experience, the report examines how co-operation arrangements can evolve alongside the expansion of regional power trade. It identifies practical pathways to strengthen implementation readiness, support project development and investment, and advance cross-border power trade. By providing a structured approach to assessing implementation challenges and opportunities, the framework aims to support policy makers, regulators, utilities and regional institutions in accelerating progress towards the APG vision.

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Executive summary

Regional power trade can support Southeast Asia to meet growing electricity demand securely, affordably and sustainably. Electricity demand in Southeast Asia is expected to rise by an average of [4.4% annually to 2035](#), driven by rising incomes, industrialisation and electrification. The region has abundant [renewable energy resource potential](#), but this is unevenly distributed and often located far from demand centres. Interconnected power systems can link resource-rich areas with those demand centres, thus enhancing system reliability through resource sharing across wider areas to balance supply and demand, and by sharing reserves and system services.

From vision to implementation: The ASEAN Power Grid

Political momentum and institutional support for cross-border power trade is growing. The ASEAN Power Grid (APG) is the flagship initiative under the ASEAN Plan of Action for Energy Cooperation 2026-2030 to drive regional electricity co-operation and connectivity. Recent milestones include the Enhanced APG Memorandum of Understanding (MoU), the endorsement of the terms of reference for a Submarine Power Cable Development Framework, and the launch of the APG Financing Initiative at the [43rd ASEAN Ministers of Energy Meeting](#).

ASEAN is now focused on moving the APG from vision to implementation. The region's first multilateral power trading initiative, the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP), entered Phase 2 in 2024. The Monsoon Wind Power Project, the region's first cross-border wind farm, reached commissioning in 2025. Several subsea interconnectors are now attracting commercial interest. Over [USD 27 billion of investment](#) is required between 2025 and 2040 to deliver the APG project pipeline, including for several long-distance subsea cables. Mobilising these investments and scaling up cross-border trade will require long-term revenue certainty, transparent commercial frameworks, appropriate risk allocation and strong enabling conditions.

This report introduces the ASEAN Power Grid Implementation Framework to help advance the APG vision. The framework offers a structured approach to assess domestic enabling conditions and cross-border co-operation arrangements among participating countries, focusing on governance, regulatory, technical, and finance and commercial dimensions. The framework is applied to six countries (Indonesia, Lao PDR, Malaysia, Singapore, Thailand and Viet Nam) and two “pathfinder” interconnection corridors (Indonesia-Singapore and Thailand-Malaysia) to identify practical implementation challenges and opportunities.

Implementation can advance incrementally without waiting for full regional harmonisation

Bottom-up project implementation should proceed in parallel with regional consensus-building and framework development. Moving from bilateral to sub-regional or harmonised co-operation arrangements does not necessarily require a top-down process with the creation of a regional regulatory body with binding legal authority at the outset. International experience, including from the European Union and Africa, shows that cross-border trade typically advances incrementally, starting with bilateral trading agreements and then moving towards structured co-ordination, standardised rules and stronger institutions.

Each project and trading arrangement is an opportunity to build transparent and replicable models for future corridors. Bilateral agreements have enabled power trade, but scaling will require new projects and bilateral arrangements to be designed with replicability in mind. Approaches, templates and lessons from these projects can build capacity for further co-operation and inform the development of regional frameworks. This requires moving towards documentation and disclosure of non-commercially sensitive decisions and methodologies.

Domestic enablers for cross-border power trade are progressing, but remain uneven

Governance conditions are building, and opportunities remain to strengthen cross-institutional co-ordination. Governance enablers, such as political support and public consultation frameworks, are broadly established or emerging across the countries assessed. Most countries have relevant lead institutions in place for cross-border power trade, but formal co-ordination across ministries, regulators, utilities, system operators and other relevant authorities is less developed. Countries can formally designate lead institutions to support power trade, with clearly defined roles and responsibilities across institutions.

Domestic regulations can be further tailored to support cross-border power trade and subsea cables. Several countries have developed market regulations for grid connection, permitting, renewable energy certificates (RECs) and subsea cables, while network regulations provide rules for domestic cost allocation and cost recovery. Provisions that explicitly govern cross-border interconnection and trade, cross-border REC recognition and subsea cables are partial, applied on a case-by-case basis or still under development. Countries can strengthen regulatory frameworks with dedicated provisions for cross-border power trade and, where applicable, subsea power cable activities, including permitting, cable laying, protection and repairs.

Technical foundations are relatively robust, but gaps remain. This includes grid infrastructure constraints in some countries or limited experience with certain technologies, such as subsea cables or Voltage Source Converter High-Voltage Direct Current (VSC-HVDC). Planning approaches, data collection and data-sharing practices must evolve to enable reliable interconnected systems. Strengthening technical enablers is also necessary. For example, interconnector provisions can be integrated into domestic grid codes and planning methodologies can be updated to better account for future cross-border power trade with scenario analysis and probabilistic metrics.

Financing conditions and transmission business models vary across the region. Most interconnector investment has been financed on utility balance sheets, a model that is challenging to scale where utilities face financial constraints and lending restrictions. Predictable and transparent revenue mechanisms for transmission investors, robust risk management, and close co-operation between participating countries, are required to support financing particularly where non-recourse financing models are desired. Countries can improve transparency of revenue mechanisms, and tailor them to the type of investment sought. For example, availability-based payments may improve predictability where commercial investment is sought.

Advancing co-operation arrangements for power trade

Developing cross-border interconnectors and establishing power trade requires co-operation across all stages of the project life cycle. The ability to establish co-operation arrangements depends on the maturity of domestic enablers across participating countries. Those countries may have roles as importers and/or exporters, hosts of transit flows, infrastructure owners and/or beneficiaries. Domestic enabling conditions can influence the scope, complexity and speed at which co-operation arrangements can be agreed.

Adopt a phased approach to strengthening institutional co-ordination. ASEAN can incrementally strengthen the co-ordination functions required at each stage of regional integration. Institutional arrangements can initially be applied at the sub-regional level, through initiatives such as the LTMS-PIP, before expanding and developing more formal institutional arrangements. As power trade expands, ASEAN can consider expanding the roles of existing APG institutions and establishing new institutions to support regional integration.

Pilot a cost-benefit analysis (CBA) methodology that considers regional benefits of interconnector development. A CBA with a regional or sub-regional assessment boundary may be applied to identify priority projects and ensure regional externalities are valued. These can be linked to project support mechanisms, encompassing both non-financial support (e.g. streamlined

permitting) and financial support (e.g. project preparation and investment). For example, upgrading the Thailand-Malaysia interconnector can bring benefits to Lao PDR and Singapore through facilitating multilateral power trade.

Establish transparent transmission pricing, building on experience from the LTMS-PIP, starting with a simple methodology. A first step could be to disclose the wheeling charge methodology in the LTMS-PIP, such as the formula, cost components and charging structure. [Transmission pricing](#) should support cost recovery, economic efficiency, fairness, and transparency and predictability. For example, West Africa and Central America have introduced regional, usage-based transmission pricing mechanisms, moving away from charging based on commercial transactions. As several ASEAN countries are developing domestic network charges under third-party access (TPA) schemes, opportunities exist to align domestic and cross-border transmission pricing frameworks from the outset.

Extend authorisation durations to align with investment horizons. The five-year authorisation duration for export licences from Indonesia with uncertain renewal conditions is a binding constraint to structuring non-recourse financing for projects in this corridor. Similarly, the power purchase agreements and Energy Wheeling Agreements in the LTMS-PIP are renewed on two-year terms. Long-term authorisations aligned with investment horizons can support commercial investment. For example, the Monsoon Wind Power Project for the export of power from Lao PDR to Viet Nam operates under a 28-year concession.

Establish robust risk management mechanisms. Interconnector projects must manage a series of risks throughout the project lifetime to [support long-term investments](#). The Indonesia-Singapore corridor, as the first to attract commercial interest in subsea interconnectors, offers opportunities to develop and test risk allocation and mitigation approaches. As the region gains experience in delivering interconnector projects, de-risking approaches can be standardised and scaled up, ensuring they are targeted to support risks that cannot be otherwise absorbed by commercial investors and lenders. Some risks, such as political risks, can be mitigated through government commitment, participation from multilateral development banks and via credit enhancement instruments.

Strengthen technical co-operation through a bilateral-first approach alongside regional co-ordination. ASEAN countries can continue to develop technical arrangements bilaterally in the near term, while establishing an explicit regional function to monitor developments across corridors. The APG Consultative Committee, supported by the ASEAN Centre for Energy (ACE) as a neutral technical co-ordinator and data custodian, could provide this function, subject to an agreed mandate and approval by ASEAN member states. Shared data platforms, common data standards and cybersecurity arrangements are foundations for operational co-ordination, regional planning and market operation.

Introduction

The ASEAN Power Grid (APG) is the central vision for regional power co-operation and electricity connectivity in Southeast Asia and has long been recognised as a strategic priority for the region. The APG has evolved from bilateral interconnections to sub-regional arrangements with increasing political support, yet progress remains uneven. Scaling power trade in the region to achieve the full vision of the APG requires the strengthening of enabling conditions across governance, regulatory, technical and finance and commercial dimensions.

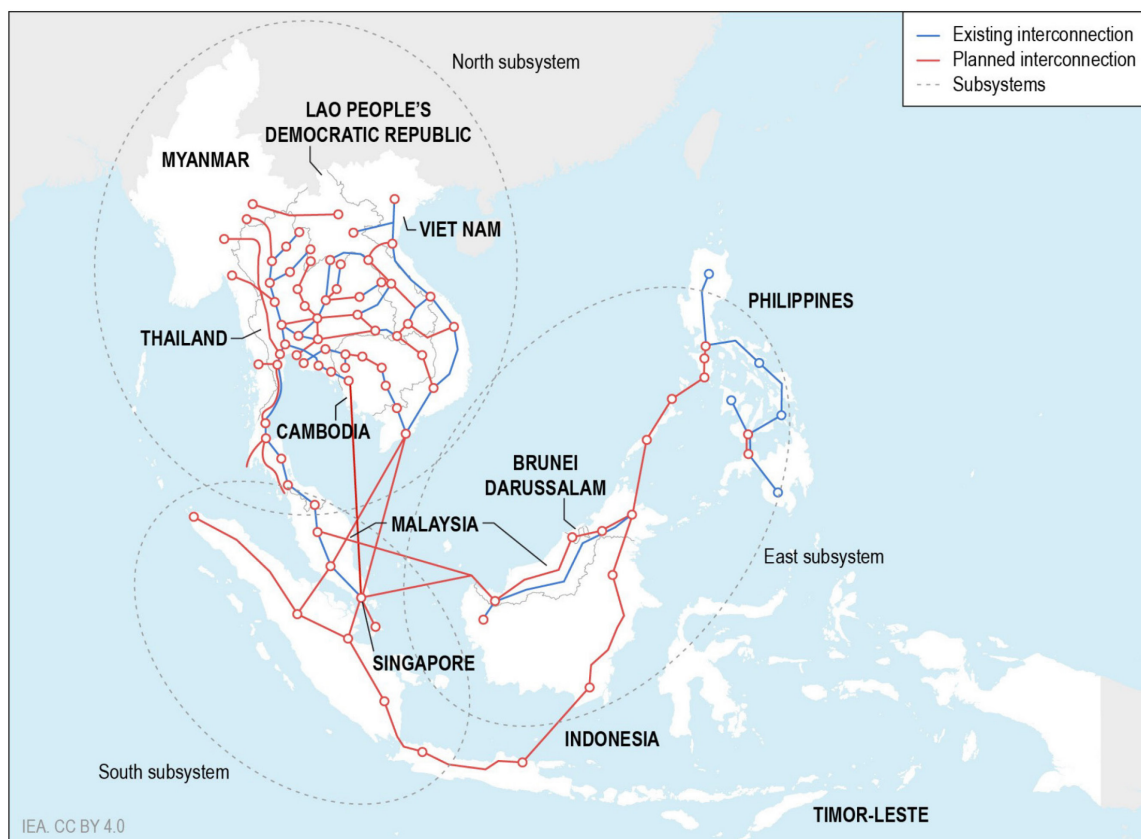
The International Energy Agency (IEA) has supported the APG initiative for many years through policy analysis and [an annual capacity building programme](#). The 2019 report, [Establishing Multilateral Power Trade in ASEAN](#), examined the minimum requirements for cross-border trade and pathways towards regional electricity market integration, while the 2026 report, [Financing the ASEAN Power Grid](#), assessed investment needs, financing challenges and business models for cross-border interconnectors. Building on this work, this report explores a central question regarding the advancement of the APG: **Are the enabling conditions required to implement and scale up cross-border power trade in place in the ASEAN region?**

To answer this question, the report introduces a practical framework for assessing implementation readiness for the APG. It examines domestic conditions and co-operation arrangements between participating countries required to support cross-border electricity trade. Developed in close collaboration with ASEAN member states and regional stakeholders, the framework complements the [ASEAN Interconnection Masterplan Study \(AIMS\) III Phase 3](#) by providing a structured approach to identify implementation gaps, benchmark progress and identify policy measures to improve implementation readiness, drawing on international experience. It is intended as a practical tool to help policy makers, regulators, utilities and regional bodies to accelerate APG progress.

The ASEAN Power Grid

As the region experiences [growing electricity demand](#) and rapid variable renewable energy deployment, the APG is an important initiative to enhance energy security, affordability and sustainability. The ASEAN region's abundant [untapped renewable energy resources](#) are unevenly distributed and often located far from major demand centres. In this context, interconnectors – electricity transmission lines that link power systems, often across borders – can connect resource-rich areas with demand centres. They can help mitigate operational challenges and ensure supply-demand balance, thereby enhancing power system reliability.

Selected major cross-border interconnection projects from AIMS III Phases 1-2 and national power sector planning



Note: The map is not intended to be an exhaustive list of all operational or planned interconnections in the region. Notably, many existing and planned generation-to-grid and domestic interconnector projects are excluded from this figure.

Source: IEA (2026), [Financing the ASEAN Power Grid](#).

The APG was first proposed in 1997 under [ASEAN Vision 2020](#), and formalised through the APG MoU signed in 2007. It is a core programme area under the [ASEAN Plan of Action for Energy Cooperation 2026-2030](#). The APG witnessed several key milestones in 2025, including the [Enhanced APG MoU](#); the endorsement of the terms of reference for a [Submarine Power Cable Development Framework](#); and the launch of the [APG Financing Initiative](#), with an initial USD 12.5 billion committed by the World Bank and the Asian Development Bank.

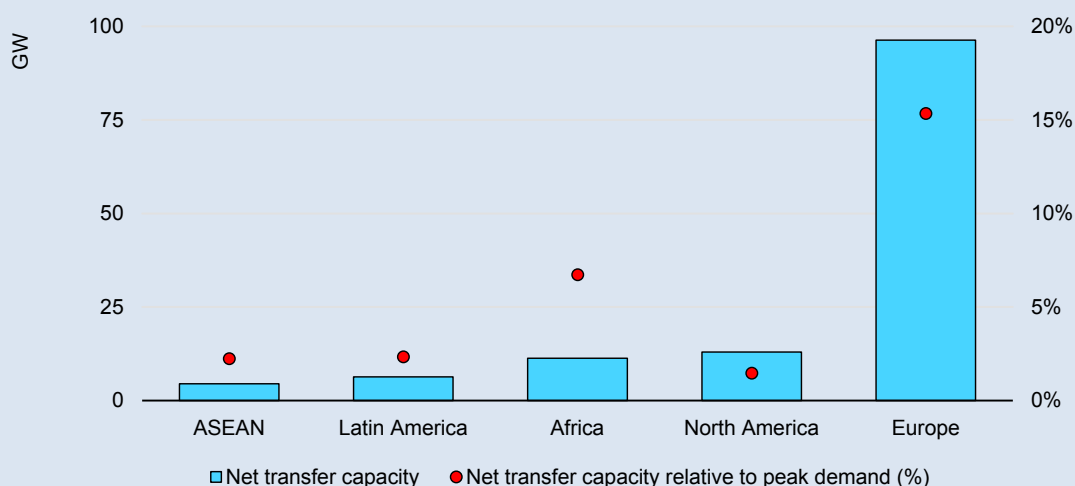
The APG's development has taken place within a co-operative framework, progressively enabling the expansion of bilateral power trade. This approach has supported the gradual expansion of interconnections, relying on country-to-country arrangements with ASEAN-wide dialogue and consensus building. Unlike

in other regions where multilateral power trading has developed, the ASEAN region does not currently have a regulatory entity¹, reflecting an emphasis on a consensus-based rather than a directive institutional model.

ASEAN power connectivity: The state of play

Despite strong momentum, regional power trade in the ASEAN region remains nascent. The region operates as a set of multiple [partially connected](#) subsystems, which are at various stages of development. Net transfer capacity in the ASEAN region is around 2-3% of peak demand in 2025, below levels in other interconnected systems in Africa, Europe and Latin America. With this limited interconnection capacity, electricity imports represent a small share of total demand in the region, at under 4%, despite steady growth in bilateral exchanges. This growth has been largely driven by the expansion of hydropower exports from Lao People's Democratic Republic (hereafter, "Lao PDR").

Net transfer capacity of cross-border power trade in selected regions, 2025



IEA. CC BY 4.0.

Note: Only grid-to-grid interconnections within each region are considered. Net transfer capacity reflects how much power can be reliably exchanged between two systems while respecting system security constraints, and is therefore often lower than the total installed nominal transfer capacity, due to security margins, operational reserve requirements and other factors.

The scale and complexity of APG interconnectors are also expected to increase with more subsea cables and grid-to-grid projects planned, expanding on the current configuration, which mainly includes land-based, generation-to-grid interconnectors. Projects that traverse multiple jurisdictions or third-party waters

¹ The ASEAN Energy Regulators Network (AERN) serves as a consultative forum for information sharing and co-operation amongst national regulatory bodies, without binding authority.

are particularly complex due to technical, security, political, governance and financing concerns. The envisioned pipeline of projects requires over [USD 27 billion](#) of investment between 2025 and 2040, a 14-fold increase from the total investment in all interconnectors in the ASEAN region since the 1970s, which have mainly supported generation-to-grid projects for one-way exports. The economic case for the development of cross-border transmission lines depends on their utilisation, and therefore the ability to trade electricity.

The APG Implementation Framework

Moving the APG from vision to implementation will require a range of enabling conditions, both domestically and across borders. These conditions determine whether interconnector projects can progress from the concept and planning phases, to financing, construction and operation.

This progress requires regional co-operation and the support of institutions. ASEAN member states are currently working together to realise the APG vision via several institutions, including the Heads of ASEAN Power Utilities/Authorities (HAPUA), ASEAN Energy Regulators Network (AERN), ASEAN Power Grid Consultative Committee (APGCC) and ACE, which serves as the APG Secretariat. The [Enhanced APG MoU](#) established APG Task Forces that oversee policy, regulatory and technical matters through which ASEAN member states are implementing the APG Workplan.

To support the implementation of the APG Workplan, this report introduces the **APG Implementation Framework**, a structured approach to assessing enabling conditions and barriers to cross-border power trade and to guide targeted policy and co-ordination efforts.

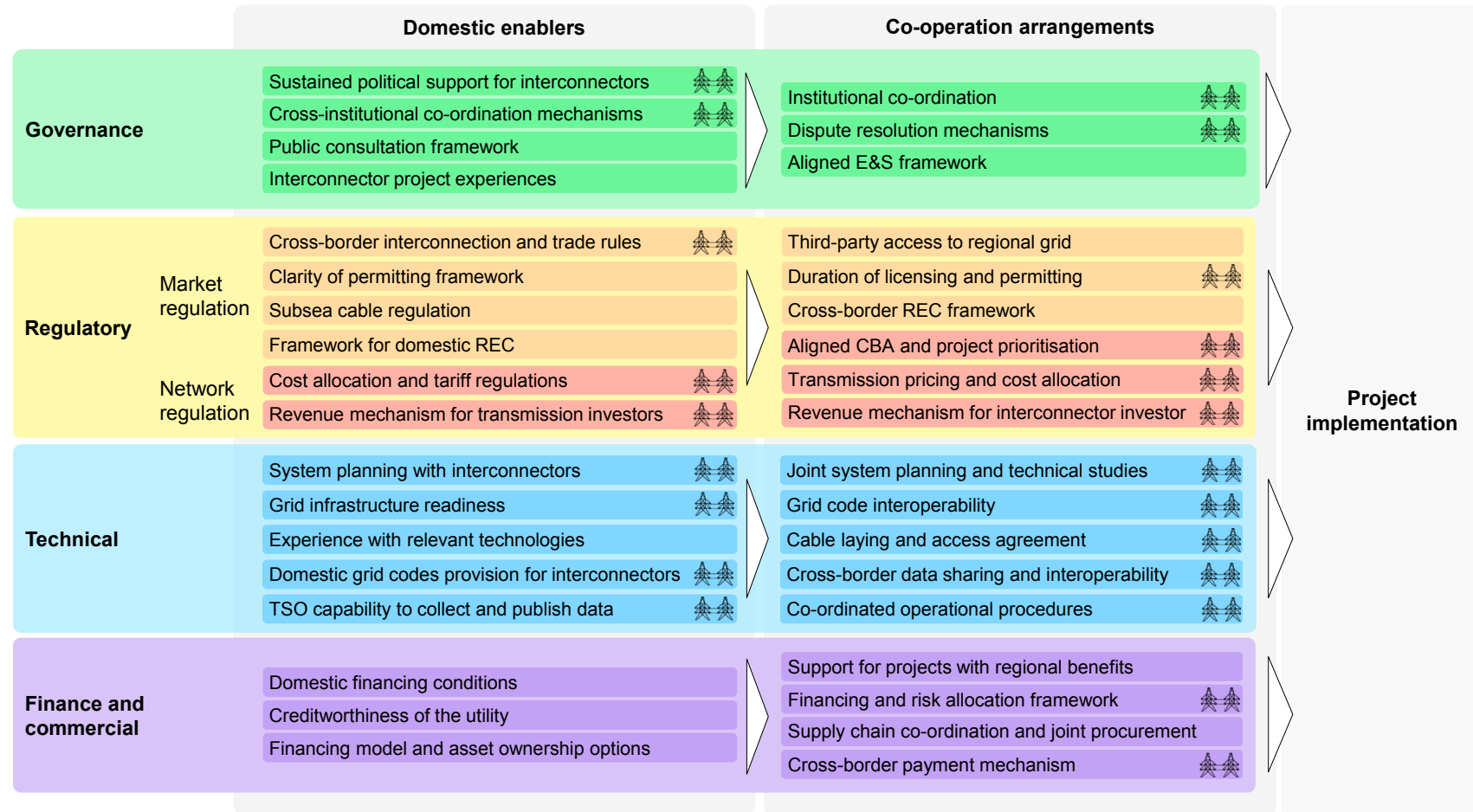
The framework evaluates implementation readiness across four dimensions: **governance, regulatory, technical, and finance and commercial**. Within each dimension, it defines the key criteria to enable cross-border power trade. It does not evaluate the detailed characteristics or bankability of individual projects.

The framework is structured into two layers:

- **Domestic enablers:** The national governance, regulatory, technical, and finance and commercial conditions for undertaking cross-border power trade. The report assesses domestic enablers in the six participating countries (Indonesia, Lao PDR, Malaysia, Singapore, Thailand and Viet Nam)². For each assessment criterion, countries are classified using the three-stage readiness scale (early, emerging or established).

² The six ASEAN member states considered for analysis of domestic enablers were selected based on the extent of existing participation in bilateral and multilateral power trades, and planned participation by 2030 as documented in power development plans and announced projects. The analysis for Malaysia focuses on Peninsular Malaysia. The selection of countries and projects should not be interpreted as a judgement on the maturity or importance of countries for the APG. Domestic enablers in Brunei Darussalam, Cambodia, Myanmar, Philippines and Timor-Leste may be considered in future analysis.

Domestic enablers and co-operation arrangements of the APG Implementation Framework



Key:  Priority preconditions for grid-to-grid trade

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Note: REC: Renewable energy certificates; TSO: Transmission System Operator; E&S: Environmental and social; CBA: Cost-benefit analysis. Identified enablers are aligned with the ASEAN Power Grid Task Force Workplan, developed with [AIMS III Phase 3](#) as a reference. The full framework and assessment criteria are provided in Annex A. Project implementation also depends on project-level factors (e.g. revenue structure, bankability), which are not depicted in the graphic.

- **Cross-border co-operation arrangements:** The governance, regulatory, technical, and financial and commercial arrangements that participating countries can adopt to develop and operate interconnectors. These co-operation arrangements may be established bilaterally, sub-regionally or regionally. The framework is applied to the Indonesia-Singapore and Thailand-Malaysia interconnector corridors to assess existing co-operation arrangements between participating countries.

By linking domestic enablers with cross-border co-operation through a consistent analytical structure, the framework provides a practical basis to identify gaps and priority actions for the development of cross-border power trade in the ASEAN region. See Annex A for further detail on the framework.

The assessment draws on stakeholder consultations, survey inputs and desk research.

Scope of the report

The report is structured as follows and ends with two annexes on the Implementation Framework.

- **Chapter 1** assesses domestic enablers for cross-border power trade and identifies common implementation gaps across the six countries reviewed.
- **Chapter 2** examines cross-border co-operation arrangements and how they translate domestic foundations into corridor-level implementation.
- **Chapter 3** reviews international experiences relevant to co-operation gaps in the ASEAN region.
- **Chapter 4** identifies pathways to advance APG implementation across domestic and regional levels.

Chapter 1. Domestic enablers for cross-border power trade

This chapter assesses in detail the domestic conditions in six ASEAN countries (Indonesia, Lao PDR, Malaysia, Singapore, Thailand and Viet Nam) by applying the APG Implementation Framework criteria outlined above.

Overview of domestic enablers criteria

As noted, the framework assesses domestic enablers for cross-border power trade across four dimensions: governance, regulatory, technical, and finance and commercial. Within each dimension, it considers the criteria that capture the domestic conditions needed to plan, finance, approve, develop and operate cross-border interconnectors. The criteria are explained in detail here.

- **Governance** criteria consider the extent to which political support is sustained, co-ordination mechanisms are in place, and delivery capacity exists. They assess whether lead governmental institutions and cross-agency co-ordination mechanisms are in place, and whether public consultation and infrastructure delivery processes can support complex projects. These criteria matter because interconnectors require decisions across ministries, regulators, utilities, system operators, environmental authorities and, for subsea cables, maritime authorities.
- **Regulatory** criteria consider the extent to which domestic regulations, procedures and market rules provide sufficient clarity for the development of interconnectors and cross-border power trade. They cover market regulations, including cross-border interconnection and trade rules, permitting framework clarity, domestic REC frameworks and, where relevant, subsea cable regulation (installation, protection and maintenance). They also cover network regulations, including transparent transmission tariff and cost allocation, and revenue models for transmission investors. Clear domestic rules reduce uncertainty over how projects can be licensed, connected and operated.
- **Technical** criteria assess the extent to which grid infrastructure and system operators are ready to support secure cross-border operation. They consider system planning, grid infrastructure readiness, grid-code provisions, experience with relevant technologies, such as HVDC, HVAC and subsea assets, and data practices from the transmission system operator (TSO). These criteria capture whether the domestic power system can reliably integrate cross-border flows.

- **Finance and commercial** criteria assess the ability to finance and deliver large-scale power interconnectors. They consider the financial capacity and creditworthiness of utilities, the availability of ownership and financing models, and the overall macro-financial context, all of which have implications on the availability, cost and tenor of financing. These criteria are closely linked to the commercial framework and revenue model for transmission sector investments, which are covered under the “regulatory” dimension.

To support the domestic assessment, each criterion is classified as early, emerging or established. The scale assesses the extent to which the arrangements relevant to enabling cross-border power trade are in place; it does not evaluate the maturity of the domestic electricity market as a whole³. Similarly, the criteria are not intended to provide a full review of each country’s power sector, nor do they intend to rank countries.

The framework offers a consistent basis for comparing progress and identifying priority areas for action for countries willing to develop cross-border power trade. Each criterion is evaluated independently, recognising that progress may differ across dimensions within the same system. This approach also helps identify practices that could be replicated across the ASEAN region.

Details of the APG Implementation Framework, including the criteria considered, are provided in Annex A.

Defining evaluation criteria

Stage	Evaluation
Early	Foundational measures are nascent or not yet in place
Emerging	Core measures are in place but remain partial or have incomplete coverage
Established	Mature and stable measures that support implementation with a high degree of certainty

Note: Early or emerging does not necessarily indicate a deficiency in a country’s existing domestic market arrangements. Where a criterion is not currently applicable under the prevailing market model, the assessment considers whether the corresponding arrangements would be needed to support cross-border power trade. Detailed definition of each criterion, thresholds and sources is provided in the annexes.

³ Early stage does not necessarily indicate a gap in the current domestic market model. It may instead indicate that an arrangement relevant to cross-border trade is not yet in place because it is not required under the existing domestic market structure (e.g. unbundled transmission tariffs in a system with a single buyer, vertically integrated utility) but would need to be developed as cross-border trading arrangements expand.

Domestic enablers set the foundation for cross-border power trade

Domestic enablers define the conditions within individual countries under which cross-border interconnection and electricity trade can be developed. Several key trends emerge from the domestic assessment across the six participating countries, though some differences emerge within the four dimensions examined. The following sections examine these topics in greater detail, and the full assessment, including sources, are provided in Annex B.

Key trends from the domestic enablers assessment

- 1. Enabling conditions for cross-border power trade remain uneven but are progressing.** Most criteria are assessed at an emerging stage, indicating that the building blocks exist in the countries assessed but they are not yet fully consolidated into trade-ready frameworks.
- 2. Governance foundations are building but cross-institutional co-ordination is less mature.** Political support is broadly established or emerging, supported by bilateral arrangements and active participation in regional or sub-regional initiatives. Most countries have designated institutional roles to lead cross-border power trade but formal co-ordination across ministries, regulators, utilities, system operators and other relevant authorities remains less consistently developed.
- 3. Technical foundations exist, but cross-border provisions need further development.** National grids and operating capability are advancing, but recurring gaps exist, including interconnector-specific grid-code provisions, planning that integrate cross-border interconnection and formalised TSO-to-TSO data sharing beyond existing pilots.
- 4. Domestic regulations provide a foundation for developing inter-connections, but provisions for cross-border trade remain limited.** Several countries have developed regulations for grid-connection, permitting frameworks, RECs and subsea cables, while network regulations provide rules for domestic cost allocation and cost recovery. However, provisions that explicitly govern cross-border interconnection and trade, cross-border REC recognition and subsea cable, are incomplete, applied on a case-by-case basis or remain under development. These could impact the future alignment of regional regulatory frameworks for future cross-border projects.
- 5. Business models need to be tailored for cross-border interconnectors.** Revenue models designed to compensate utilities for domestic grid development vary across the countries assessed (e.g. varying permissible rates of return) and are not always transparently disclosed. In addition, cross-

border projects introduce additional risks. Revenue models and commercial arrangements lack tailoring to interconnectors to provide predictable revenue streams, acceptable risk allocation, and, where desired, attract commercial involvement.

- 6. Financing conditions remain inconsistent, especially for capital-intensive subsea interconnectors.** Utility creditworthiness and macro-financial conditions vary significantly across the region, and options to finance transmission projects beyond state balance sheets remain at an early or emerging stage.

For recommendations on how to enhance domestic enablers, see Chapter 4.

Governance: Strengthening interconnector implementation capacity

Governance enablers comprise the political support, institutional arrangements and implementation capacity required to advance cross-border power trade. This includes political commitment to develop interconnectors, the clarity of lead institutional mandates, and co-ordination mechanisms across ministries, regulators, utilities and system operators. This dimension also covers public consultation frameworks and experience in delivering interconnector projects.

Having a strong domestic governance structure in place is important for entering into cross-border co-operation arrangements because these processes and institutions will provide the foundation for establishing joint governance mechanisms, resolving disputes and aligning regulatory and environmental frameworks across borders.

Domestic governance enablers to support cross-border power trade

Criterion	Indonesia	Lao PDR	Malaysia	Singapore	Thailand	Viet Nam
Governance						
Sustained political support	Emerging	Established	Established	Established	Emerging	Emerging
Domestic cross-institutional co-ordination	Emerging	Emerging	Emerging	Established	Emerging	Emerging
Public consultation frameworks	Emerging	Emerging	Emerging	Emerging	Emerging	Emerging
Interconnector project experience (land based)	Established	Established	Established	N/A	Established	Established
Interconnector project experience (subsea)	Early	N/A	Early	Early	N/A	Early

Note: Ratings reflect the latest available evidence at the time of assessment. A designation of early does not necessarily indicate a deficiency in a country's existing domestic market arrangements. Where a criterion is not currently applicable under the prevailing market model, the assessment considers whether the corresponding arrangements would be needed to support cross-border power trade. The detailed measures and sources underpinning each rating are set out in Annex B.

Sustained political support for interconnectors is generally established or emerging. This is reflected in bilateral and multilateral agreements as well as in active participation in regional and sub-regional initiatives. While leadership changes or government reshuffles can affect the level of political support, embedding interconnection and regional electricity trade in long-term national energy strategies helps bring continuity beyond an individual administration. Singapore provides the clearest established-stage example. It has a target to [import 6 GW](#) of low-carbon electricity by 2035 and has issued conditional licences and approvals for multiple long-distance import projects. Lao PDR and Malaysia also show established political support. Lao PDR, for example, is recognised as a leading regional net electricity exporter; [national strategies](#) and supporting MoUs with Thailand and Viet Nam have helped make power exports a key economic driver for the country. Malaysia, for its part, has advanced electricity sales to neighbouring countries through the [Cross-Border Electricity Sales \(CBES\)](#) framework, and participates in the LTMS-PIP. Indonesia, Thailand and Viet Nam recognise the role of cross-border trade through bilateral and multilateral engagement. To date, such engagement appears conditional and project-specific. Uncertainty remains around policy on power imports and exports, along with future expansion of cross-border interconnection, particularly grid-to-grid projects.

Co-ordination across institutions is required to convert political intent into project delivery, but gaps remain. While several countries have relevant lead institutions in place, co-ordination mechanisms across ministries, regulators, utilities and system operators are often informal, or existing bodies are not yet used for cross-border trade. Singapore provides the clearest example of a well-co-ordinated approach to the process of importing electricity, linking policy direction and regulatory and project approvals to [clearly defined roles](#) in different institutions. This work has been helped by the establishment in 2025 of [Singapore Energy Interconnections Pte Ltd \(SGEI\)](#), which develops and operates cross-border interconnector import projects by working closely with government stakeholders and industry partners. Elsewhere in the region, co-ordination among relevant government stakeholders is still emerging. In Indonesia, Lao PDR, Malaysia, Thailand and Viet Nam, various institutions are involved in cross-border power trade. Further details from each country are provided in Annex B.

Public consultation frameworks are generally present through environmental impact assessments but have a limited track record. This is particularly true for grid or cross-border projects. For example, Indonesia has formal public consultation requirements, principally through the [Environmental Impact Assessment Report](#) process. However, evidence of systematic stakeholder engagement is limited for emerging grid and cross-border electricity projects, especially beyond consultations with directly affected communities. A well-planned stakeholder engagement can help [identify local concerns](#), improve transparency and build understanding of cross-border projects among affected

communities and parties. Early engagement can also help identify potential implementation challenges and reduce the risk of delays or additional costs arising from unresolved stakeholder concerns.

All countries demonstrate experience in large-scale, land-based interconnector projects. In addition to the LTMS-PIP, most countries participate in bilateral power trade arrangements, primarily through generation-to-grid interconnectors. The Lao PDR-Thailand interconnection represents the largest amount of power traded in the region, with [Thailand importing close to 40 TWh](#) from Lao PDR through generation-to-grid arrangements in 2025, while more than 1 TWh was traded on both sides through grid-to-grid arrangements. The [Monsoon Wind project](#), operating since 2025, is a landmark generation-to-grid project in the region, featuring a 500 kV transmission line linking Lao PDR to Viet Nam. Malaysia is connected to Thailand through 300 kV HVDC and 132 kv HVAC links, and to Singapore via a 1 000 MW capacity interconnector which consists of an AC overhead line (10 km) and submarine cables (2 km). Indonesia (West Kalimantan) imports power from Malaysia (Sarawak) via a 275 kV interconnector. These existing interconnections provide a foundation of governance experience to undertake future cross-border projects.

Experience with large-scale subsea interconnector projects remains nascent. This is in part because only a few countries have initiated concrete plans. One such plan is the Singapore-Sarawak subsea interconnection corridor. Bilateral discussions have helped advance the project following a conditional approval from Singapore's Energy Market Authority (EMA) to import an estimated 1 GW of predominantly hydropower-generated electricity from Sarawak, through subsea cables spanning more than 700 kilometres. Similarly, Malaysia, Singapore and Viet Nam announced their co-operation on developing a new electricity link, which includes a feasibility study that will see Viet Nam send electricity via subsea cables to Peninsular Malaysia's northeastern coast before being transmitted overland to Singapore. Compared to land-based cables, subsea projects require additional expertise that is not systematically available in the countries assessed, including for maritime permitting, cable procurement, installation and operation, which are covered in the regulatory and technical dimensions below.

Regulatory frameworks: The importance of cross-border provisions

A clear regulatory framework shapes the degree of legal certainty for licensing, building, connecting and operating an interconnector. Key criteria span market regulation, including cross-border interconnection and trade rules; permitting framework clarity; subsea cable regulations; domestic REC frameworks; and economic regulation, including cost allocation, tariff regulations and revenue mechanisms for transmission investors.

These domestic regulations shape the extent to which cross-border regulatory arrangements can be aligned between participating countries (see Chapter 2). For example, network regulation determines how transmission assets recover costs through tariffs and network charges, and how costs are allocated across different network users and consumers, in turn setting the revenue model for investors. Where no specific regulatory framework exists for cross-border transmission assets, other arrangements need to be taken depending on the ownership of those assets; they often rely on existing domestic frameworks (e.g. only the portion owned by domestic regulated entities is governed by existing domestic frameworks, or separate arrangements apply to each new interconnector).

Domestic regulatory frameworks to support cross-border power trade

Criterion	Indonesia	Lao PDR	Malaysia	Singapore	Thailand	Viet Nam
Regulatory						
Market regulations						
Cross-border interconnection and trade rules	Emerging	Emerging	Established	Established	Emerging	Emerging
Interconnection permitting and licensing framework clarity	Emerging	Emerging	Established	Established	Emerging	Emerging
Domestic REC framework	Emerging	Early	Established	Established	Established	Emerging
Subsea cable regulation	Emerging	N/A	Early	Established	Emerging	Emerging
Network regulations						
Transparent transmission tariff and cost allocation	Early	Emerging	Established	Established	Established	Established
Revenue mechanism for transmission investor	Early	Emerging	Established	Established	Established	Established

Note: Ratings reflect the latest available evidence at the time of assessment. A designation of early does not necessarily indicate a deficiency in a country's existing domestic market arrangements. Where a criterion is not currently applicable under the prevailing market model, the assessment considers whether the corresponding arrangements would be needed to support cross-border power trade. "Not applicable" denotes criteria that do not apply to a given system (for example, subsea cable and maritime criteria for land-locked Lao PDR) or that were not scored. The detailed measures and sources underpinning each rating are spelled out in Annex B.

Domestic rules governing cross-border interconnectors and trade are essential. These help define the scope of activities, responsible authorities and obligations of participating parties. These rules are well-defined in Malaysia and Singapore, while in other countries they remain under development or are applied on a case-by-case basis. Singapore's 2022 [Guide to Electricity Imports](#) provides an established pathway for building, owning, operating and maintaining interconnectors. Malaysia developed the CBES, which [sets out conditions](#) for cross-border electricity sales of renewable and non-renewable sources to Singapore and Thailand under specific conditions. For other systems, provisions that govern cross-border interconnectors are still emerging. For example, the [Electricity Generating Authority of Thailand Act](#) includes relevant clauses but does not explicitly address interconnectors. For Indonesia, there is a regulation for

[cross-border electricity trade](#), but it is only permitted subject to domestic needs, prices and system reliability.

Clarity on interconnection permitting and licensing frameworks can accelerate delivery and support long-term investments. Responsible authorities and broad rules for interconnector infrastructure and cross-border power trade are identifiable across the region, but approval timelines are often unclear or not consistently specified. [Malaysia's Electricity Supply Act](#) and [Singapore's Electricity Act 2001](#) established clear and detailed permitting frameworks for cross-border electricity trade. [Malaysia's CBES](#) clarifies the framework application in project contexts, while the utility Tenaga Nasional Berhad (TNB) allows for a typical power purchase agreement (PPA) term of [21 years](#). Meanwhile, in systems where permitting and licensing frameworks are under development, short permit tenors can limit long-term certainty for investors. In Indonesia, for example, export permits have a [maximum duration](#) of five years, which creates renewal risks and is a barrier to structuring long-term financing.

Transparent domestic transmission tariffs can support alignment on cross-border transmission pricing. In the absence of a regional transmission pricing methodology, domestic transmission tariff methodologies can provide a shared reference point for assessing whether cross-border transmission charges are reasonable and cost-reflective. The transparency and structure of transmission charges differ across the region. Indonesia has no explicit transmission tariffs, instead transmission costs [are bundled](#) in retail tariffs. Lao PDR, where a national high-voltage transmission concession became operational in 2024, requires the state utility Électricité du Laos (EDL) to pay [transmission charges](#) to the concessionaire, Électricité du Laos Transmission Company, though the approach for determining these charges is not publicly disclosed. In Malaysia, Singapore and Viet Nam, transmission and network costs are determined through regulatory processes based on cost recovery, though the degree to which the methodology is disclosed varies. The implementation of third-party access schemes in Malaysia, Viet Nam and Thailand provides an opportunity to align domestic and cross-border transmission pricing approaches from the outset.

Clear and predictable revenue mechanisms for transmission investors are vital for providing confidence to investors. This applies to both state-owned utilities and private sector investors. Such mechanisms help investors to recover costs and achieve a required return on investment across decades of operations. Since transmission networks are natural monopolies, revenue models and allowable returns are typically highly regulated. In vertically integrated markets such as Indonesia, transmission revenues are bundled with generation, and cost recovery occurs at the corporate level. Where transmission is ring-fenced (e.g. through account unbundling), permissible revenues are typically determined based on cost recovery (CAPEX and OPEX) plus an allowable rate of return –

varying from [3% in Viet Nam](#) to [more than 9% in Singapore](#). The divergence in rates of return has implications on the ability to attract private sector investors. For cross-border interconnectors, the revenue mechanism must be agreed between participating countries, explicitly defined and provide sufficient long-term certainty to attract financing.

Domestic REC frameworks enable credible cross-border trade of green attributes. Such frameworks provide clear guidance on governance arrangements, common REC instruments and registries in use. They also track best practices. Although they are not a core readiness requirement to establish cross-border power trade, they constitute an enabling mechanism that attracts a lot of attention in the region, hence its inclusion in the assessment. These foundations are most developed in [Malaysia](#), [Singapore](#) and [Thailand](#), which have governance arrangements for national REC markets, including recognised standards and registries. [Indonesia](#) operates an emerging market through the PLN REC scheme but lacks an independent national governance body, while [Lao PDR](#) and [Viet Nam](#) run voluntary International Renewable Energy Certificate (I-REC) markets with no national issuer or governance body.

Specific regulation for subsea cables is important for countries planning to develop such interconnectors. This is particularly relevant because the [APG pipeline is dominated](#) by subsea transmission projects. The development of subsea cables involves different regulatory aspects compared to provisions for land-based projects, hence being considered as a separate criterion in our assessment. Transparent domestic regulatory regimes for marine surveys, cable laying, inspection and maintenance of subsea cables, supported by a clearly mandated lead authority, provide a foundation for facilitating subsea cable activities, particularly in complex maritime boundaries. Development and maturity of domestic subsea cable regulation vary across the ASEAN region. Singapore, for example, has well-established regulations with specific guidance on regulatory process, timelines and relevant government agencies. Along with Thailand and Viet Nam, it also has regimes with explicit clauses for the electricity sector and operates within the broader [international legal framework](#) established by the United Nations Convention on the Law of the Sea (UNCLOS)⁴. Indonesia and Malaysia, by contrast, rely on general maritime or telecommunications laws that are not tailored specifically to power cables.

⁴ UNCLOS recognises the rights of states to lay and maintain submarine cables in the exclusive economic zone and on the continental shelf, while recognising certain rights and jurisdiction of coastal states, including over cable routes and cables entering their territory or territorial sea.

Technical foundations: Closing the gaps in planning and grid technologies

Technical dimensions consider whether the physical system, system operators and supporting institutions are equipped to manage cross-border flows securely. It covers several areas, including co-ordinated system planning; the capacity, reliability and controllability of the transmission backbone; grid codes and protection requirement applicable to interconnectors; experience with relevant technologies (e.g. HVDC and subsea assets); and the collection and exchange of planning and real-time data. Across the region, important technical foundations exist, but maturity varies considerably and should not be inferred from installed voltage levels or prior project experience alone.

Robust technical foundations are key for developing interconnectors, especially for grid-to-grid projects, as they determine the ability of participating countries to develop compatible technical standards and to co-ordinate system operations.

Domestic technical conditions to support cross-border power trade

Criterion	Indonesia	Lao PDR	Malaysia	Singapore	Thailand	Viet Nam
Technical						
System planning with interconnectors	Emerging	Emerging	Emerging	Established	Emerging	Established
Grid infrastructure readiness to support cross-border power flows	Emerging	Early	Established	Established	Established	Emerging
Domestic grid codes provisions for interconnectors	Emerging	Early	Established	Established	Established	Emerging
Domestic experience with relevant grid technologies	Emerging	Emerging	Established	Emerging	Emerging	Emerging
TSO data collection relevant to cross-border infrastructure	Emerging	Emerging	Established	Established	Established	Emerging

Note: Ratings reflect the latest available evidence at the time of assessment. A designation of early does not necessarily indicate a deficiency in a country's existing domestic market arrangements. Where a criterion is not currently applicable under the prevailing market model, the assessment considers whether the corresponding arrangements would be needed to support cross-border power trade. The detailed measures and sources underpinning each rating are spelled out in Annex B.

System planning is generally updated regularly across all the countries reviewed. Current planning processes increasingly references interconnection, although they still focus mainly on ensuring that domestic demand is met with domestic supply. In Singapore and Viet Nam, system planning practices are well established. Such plans explicitly consider interconnectors and neighbouring systems and are updated at least every two years. They also have a planning horizon of at least 10 years and include scenario-based quantitative studies. In other systems, multi-scenario studies are less common, and interconnectors are not systematically considered in planning practices. In Malaysia, for example,

interconnector capacity is not considered firm in the Power Development Plan until a PPA governing the interconnector has been signed⁵.

Grid infrastructure readiness provides a foundation for interconnection with other systems. Such readiness is determined by the size, reliability and controllability of national transmission networks. Malaysia, Singapore and Thailand have strong grid infrastructure with meshed high-voltage backbones, very high availability and wide-area monitoring. Constraints persist in the other systems. Indonesia's power system, for example, is split across island grids with internal bottlenecks; Viet Nam's North-South corridor is frequently congested, and Lao PDR's four regional grids are only moderately interconnected, placing it at an early stage on infrastructure readiness. Solutions are being implemented to address transmission bottlenecks, such as [battery storage](#) in Thailand and [dynamic line rating](#) in Malaysia.

Domestic grid codes in Malaysia, Singapore and Thailand are well established and include provisions for interconnectors. Indonesia aligns technical requirements on a case-by-case basis, as it did for the West Kalimantan-Sarawak interconnection. Lao PDR does not have a published grid code and follows Thai grid-code requirements for synchronised links, representing an early stage of bilateral alignment. Viet Nam's grid [is synchronised with](#) Cambodia's but uses back-to-back HVDC converters with the People's Republic of China (hereafter, "China"). Most projects importing power from Lao PDR follow Vietnamese grid codes, as they are independent power producer (IPP) projects supplying electricity exclusively to Viet Nam. Further details on domestic grid codes are provided in the [AIMS III Phase 3 report](#) on minimum technical standards.

Experience with relevant grid technologies is uneven in the six countries assessed. Expertise is concentrated in a small number of countries. Malaysia and Thailand have operational experience with Line-Commutated Converter (LCC) HVDC, while Malaysia also has experience with the 230 kV AC submarine cables to Singapore. LCC-HVDC generally requires a relatively strong AC grid, while VSC-HVDC can operate with weaker AC systems, making it particularly relevant for integrating isolated or weakly interconnected grids and for subsea interconnectors. Regional experience with the VSC-HVDC and long subsea HVDC cables, which dominate in the future pipeline, therefore remains very limited, which is a distinct technical readiness gap from existing AC and LCC experience.

TSO data collection processes exist in all countries but there is a lack of standards and agreed methodologies. TSO data collection and sharing

⁵ Based on consultation meetings.

between system operators assesses the existence of systematic processes for collecting data relevant to interconnector planning and operation. It also considers their public availability and update frequency, along with the availability of channels to transmit these data to external counterparts. In terms of data collection, while processes exist in all countries, the main challenge is a [lack of standards and agreed methodologies](#). For example, there is no basis for consistent reporting on power exchange data. As for data sharing, the four LTMS-PIP participants share day-ahead, intra-day and next-business-day schedules through a common platform and are progressing towards real-time monitoring. They are therefore considered established in the framework. Outside such corridors, formal bilateral data sharing remains underdeveloped. Indonesia has no operational mechanism for transmitting grid data externally, and Viet Nam, despite having a functioning data exchange with China for the Guangxi link, has not yet formalised cross-border data-sharing protocols.

Finance and commercial conditions: A varied landscape

Today, state-owned utilities sponsor most grid investments in Southeast Asia, including almost all grid-to-grid interconnector investment. Mobilising private and non-recourse financing is challenging because many projects lack predictable, project-level revenue streams. These constraints are compounded in some markets by restrictions on private participation in transmission, shallow domestic capital markets, limited availability of long-tenor debt, lender-concentration limits and currency mismatches. This dimension assesses the balance sheet capacity of utilities, the ability to apply third-party financing models, and the domestic financing context, all of which have implications for the ability to mobilise investment for cross-border interconnectors.

Risk and bankability in the context of cross-border interconnectors

Cross-border interconnectors are long-lasting projects with high upfront capital requirements and substantial risks across the life cycle that can impact the ability to attract financing, including:

- **Political and regulatory:** Risk of changes in policy and regulation that affects authorisations or commercial performance. Sustained political support and regulatory stability is required across multiple decades.
- **Technical and physical:** Risk of cable damage due to weather, natural disasters, installation faults and third-party damage (e.g. anchor dragging).

- **Permitting and access:** Risk that authorisations are delayed, denied, revoked or not renewed. Permitting can be complex, requiring intensive engagement with multiple jurisdictions, national and sub-national authorities, and community representatives.
- **Off-taker:** Failure of off-taker to meet payment obligations. This is closely linked to long-term financial health of utilities where they are the off-taker.
- **Currency:** Exchange rate fluctuations where projects are financed in hard currency (such as US dollars), while revenues are earned in local currency.

The impacts of these risks are compounded by tight supply chains for cable equipment and repair vessels. Notably, delays in cable repair following breakages can lead to substantial business interruption costs.

Key risks across project development for subsea interconnectors

Key risks	Development		Operations	
	Preparation	Construction	Concession period	Remaining operations
	7-15 years		25-30 years	15+ years
Political and regulatory	●	●	●	●
Technical and physical	●	●	●	●
Permitting and access	●	●	●	●
Off-taker	●	●	●	●
Currency	●	●	●	●

● High risk ● Medium risk ● Low risk

Note: Risks are indicative. Risk ratings and timelines differ by project.

Source: IEA (2026), [Financing the ASEAN Power Grid](#).

To attract commercial financing, projects must achieve predictable revenues at a sufficient level to service debts and achieve adequate returns. Projects must also be capable of appropriately managing, allocating and mitigating project risks. This in turn determines the ability of the project to attract private sector capital and the financing models which may be applied.

Domestic macro-financing conditions impact the availability, pricing and tenor of financing options. These conditions include currency stability, availability of hedging products and the depth of local capital markets, the latter of

which varies among the six countries assessed. While domestic financial institutions play an important role in funding energy infrastructure, they may be constrained by single borrower limits, for example for lending to state utilities in Indonesia and Viet Nam. Lending can also be constrained through tenor mismatches between the short-term nature of deposits and long-term lending required for large infrastructure investments. Currency risks remain an issue in several countries. While Malaysia, Singapore and Thailand have remained relatively stable against the US dollar, other markets have seen strong currency depreciation and volatility over the past decade, and long-term currency hedging products remain unavailable or illiquid in most markets.

The creditworthiness of a utility determines whether it can take on additional lending to meet financing requirements for new infrastructure.

Creditworthiness also determines whether they are perceived to be creditworthy off-takers. This differs sharply across the region. Singapore's SP PowerAssets (SPPA), Malaysia's TNB and the Electricity Generating Authority of Thailand (EGAT) have [strong credit ratings](#), relatively low leverage ratios and higher operating cash flow ratios, supported by cost-reflective tariffs. Indonesia's state electricity company PLN and Viet Nam's National Power Transmission Corporation (EVNNPT) face tighter constraints, with higher leverage ratios and higher exposure to fuel price volatility due to regulated tariff rates. EDL in Lao PDR has not published annual reports on its website since 2019, however the [ASEAN+3 Macroeconomic Research Office \(AMRO\)](#) highlights high debt burdens and financial pressures, including those due in part to currency depreciation. Engagement with lenders, credit enhancement mechanisms and sovereign or multilateral support are important for utilities in strengthening creditworthiness.

Third-party ownership models may be considered as an alternative to utility-led financing. These models may include, for example, independent transmission projects (ITPs) and may be relevant where there are constraints to mobilising financing on utility balance sheets. Establishing third-party ownership requires strong cashflow visibility, which is lacking under current commercial models. Special purpose vehicle (SPV) models have been applied successfully in multiple [generation-to-grid projects](#) originating from Lao PDR, where the cross-border transmission line is financed and developed alongside a power generation asset. This approach is constrained in most ASEAN countries where there is a requirement for state ownership of transmission assets. However, models such as Indonesia's [Joint Ventures and Investment Trusts](#) may be explored for large and complex projects (e.g. those involving subsea cables) while maintaining state oversight.

Domestic finance and commercial conditions to support cross-border power trade

Criterion	Indonesia	Lao PDR	Malaysia	Singapore	Thailand	Viet Nam
Finance and commercial						
Domestic financing conditions	Emerging	Early	Established	Established	Established	Emerging
Creditworthiness of the utility	Emerging	Early	Established	Established	Established	Emerging
Financing model and asset ownership options	Early	Emerging	Emerging	Emerging	Early	Early

Note: Ratings reflect the latest available evidence at the time of assessment. A designation of early does not necessarily indicate a deficiency in a country's existing domestic market arrangements. Where a criterion is not currently applicable under the prevailing market model, the assessment considers whether the corresponding arrangements would be needed to support cross-border power trade. The detailed measures, thresholds and sources underpinning each rating are spelled out in Annex B.

Chapter 2. Co-operation arrangements for cross-border trade

Domestic enabling conditions described in Chapter 1 cannot deliver interconnector projects or cross-border electricity trade on their own. Participating countries also need to agree on how projects are planned, financed, regulated, governed and operated across borders. Co-operation arrangements define how these capabilities are co-ordinated among national systems.

This chapter sets out a framework for assessing the maturity of co-operation arrangements that support interconnector development and power trade. This is illustrated through two “pathfinder” interconnection corridors: 1) Indonesia to Singapore (subsea), and 2) Malaysia to Thailand (land based) as part of the LTMS-PIP corridor. Outside the scope of this report, this framework may be applied in a similar manner to assess the maturity of co-operation arrangements across other corridors in the ASEAN region, recognising that the long-term development of the APG will require broader pan-ASEAN arrangements.

Overview of co-operation arrangement criteria

Developing cross-border interconnectors and establishing power trade requires co-operation across all stages of the project life cycle, from planning to operations.

This co-operation establishes the market frameworks, rules and institutions within which individual projects and trades are developed. Project milestones, such as establishing a revenue model, securing permits and financing, require market-level frameworks. Where these are absent or incomplete, each project must negotiate and develop its market context independently, increasing the risks and costs of project implementation.

Four dimensions of co-operation arrangements are considered below. A full description of co-operation arrangements can be found in Annex A.

- **Governance co-operation** provides the institutional and legal basis for cross-border power trade. This includes institutional co-ordination, dispute resolution mechanisms and aligned environment and social (E&S) frameworks. Institutional co-ordination includes expanding the roles of existing institutions

and, where necessary, establishing dedicated regional entities, intergovernmental agreements and working groups. Strong governance underpins co-operation arrangements in all other dimensions.

- **Regulatory co-operation** provides clarity on the rules that allow cross-border trade to proceed with long-term certainty. This includes market regulations, governing licensing duration, TPA to regional grids and cross-border recognition of RECs. It also includes network regulations, governing approaches to cross-border cost allocation, transmission tariffs and revenue models for interconnector investors. This provides market participants and investors with the long-term visibility over revenues and authorisations. Such visibility may help participants to commit capital and resources to participate in power trade.
- **Technical co-operation** supports secure system planning and operation across the interconnected power systems and ensures interconnectors are planned and operated reliably across different national grid systems. This includes grid code interoperability; operational practices in dispatch and scheduling; joint system planning and technical studies; data sharing and cable laying; and access agreements. Many of these criteria must be agreed early in project development to establish the technical feasibility of power trade, before commercial and regulatory frameworks can be established.
- **Finance and commercial co-operation**, including joint financing and risk allocation frameworks, co-ordination on supply chain and procurement issues, and cross-border payment mechanisms, can improve visibility and risk management for parties involved in interconnector implementation. Addressing these issues at the framework level may support project-level structuring, thus reducing the negotiation burden and timelines of individual projects.

The ability to establish co-operation arrangements depends on the maturity of domestic enablers across participating countries, which play different roles, for example as importers or exporters, hosts of transit flows, infrastructure owners, and/or beneficiaries. Domestic enabling conditions can influence the scope, complexity and the speed at which co-operation arrangements can be agreed.

The link between domestic enablers and co-operation arrangements is evident within each dimension of the implementation framework (governance, regulatory, technical, and finance and commercial). For example, within the technical dimension, robust domestic system-planning practices, grid code provisions and TSO data systems all support cross-border co-operation on joint planning and studies, grid code interoperability and cross-border data exchange.

How co-operation arrangement criteria link to domestic enablers

Criteria	Linked domestic enablers
Governance	
Institutional co-ordination	• Sustained political support for interconnectors • Cross-institutional co-ordination mechanisms
Dispute resolution mechanisms	• N/A
Aligned E&S framework	• Public consultation framework
Regulatory	
Third-party access to regional transmission network	• N/A
Duration of licensing and permitting	• Clarity of permitting framework
Cross-border REC framework	• Framework for domestic RECs
Aligned cost-benefit analysis and project prioritisation	• N/A
Transmission pricing and cost allocation	• Cross-border interconnection and trade rules • Cost allocation and tariff regulations
Revenue mechanism for interconnector investors	• Revenue mechanism for transmission investors
Technical	
Joint system planning and technical studies	• System planning with interconnectors
Grid code interoperability	• Grid infrastructure readiness • Domestic grid codes provision for interconnectors
Cable laying and access agreement	• Subsea cable regulation (e.g. for installation, protection, operations and maintenance)
Cross-border data sharing and interoperability	• TSO capacity to collect and publish data
Co-ordinated operational procedures	• Grid infrastructure readiness • Grid code provision for interconnectors • System planning with interconnectors • TSO capacity to collect and publish data
Finance and commercial	
Support for projects with regional benefits	• N/A
Financing and risk allocation framework	• Domestic financing conditions • Financing model and asset ownership options
Supply chain co-ordination and joint procurement	• N/A
Cross-border payment mechanism	• N/A

Bilateral agreements have enabled early power trade, but do not scale

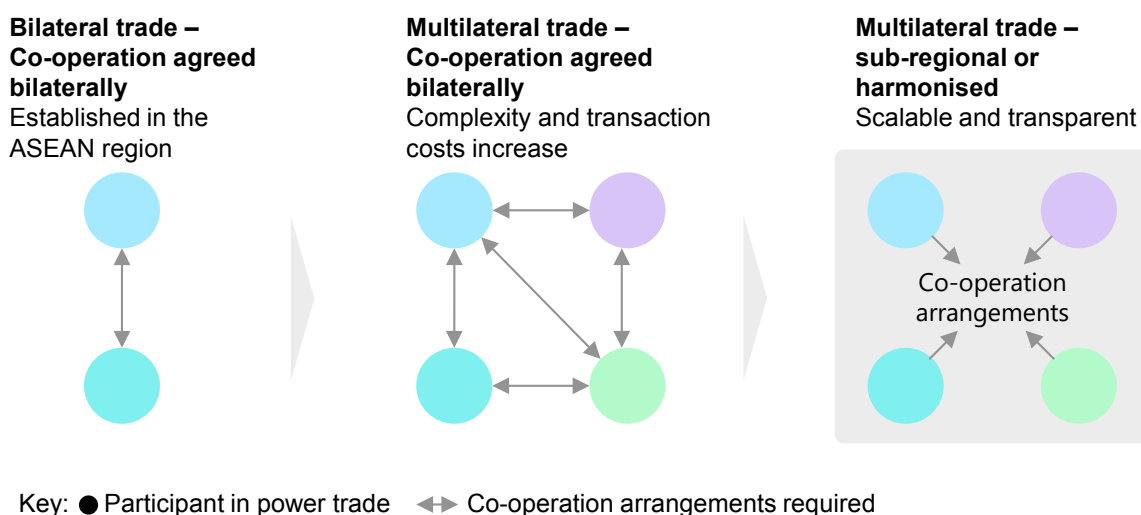
The process for establishing co-operation arrangements and the transparency of such arrangements has important implications for replicability and the ability to scale power trade in the region both to expand trading in existing interconnector corridors (i.e. between different jurisdictions) and in new corridors.

To date, co-operation arrangements in the ASEAN region have been negotiated bilaterally on a project-by-project basis. This approach builds on a strong tradition of consensus-building among ASEAN members, with regional bodies such as HAPUA, APGCC, and AERN acting in a consultative capacity. For example, the LTMS-PIP established multilateral trading on a pilot basis through bilateral power purchase, wheeling and interconnection agreements. Similarly, bilateral co-operation in the Singapore-Indonesia corridor has [attracted substantial commercial interest](#).

Yet, bilateral arrangements may also be limiting, namely because they are difficult to scale in the ASEAN context. Project-specific agreements, such as wheeling charges agreed for bilateral trades, can support early exchange, but do not provide a general framework for [harmonised bilateral and multidirectional trade](#) among countries and may constrain multilateral trade. Each new trading arrangement requires separate agreements on commercial frameworks, transmission and/or wheeling charges, technical arrangements and dispute resolution. As the number of trading arrangements expands to new countries, corridors and new participants, the complexity of maintaining such arrangements grows too.

These challenges are compounded by limited transparency. For example, the formulas used for determining wheeling charges in the LTMS corridor are not fully disclosed. This limits the opportunity of future new trades to build on what has already been established and can create uncertainty over how future transactions would be handled using the same approach.

How co-operation arrangements develop as power trade scales



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Moving from bilateral to sub-regional or harmonised co-operation arrangements does not necessarily require a top-down process with the creation of a regional regulatory body with binding legal authority at the outset. In parallel with regional

consensus-building and framework development, it requires bottom-up incremental progress, with each new bilateral arrangement designed with replicability in mind. [International experience](#), including from [Central America](#), the [European Union](#), [Southern Africa](#) and [West Africa](#) shows that cross-border trade typically advances incrementally, starting with bilateral trade, then moving towards more structured co-ordination, standardised rules and stronger institutions.

For ASEAN countries, new bilateral or multilateral arrangements can help create more transparent and consistent approaches for future corridors and thus build capacity and confidence for further co-operation. This requires moving towards documentation and disclosure of non-commercially sensitive decisions and methodologies. This may include sharing relevant information such as CBA approaches, transmission and/or wheeling charge formulas and data-sharing protocols. Eventually, this can support increased consistency and harmonisation across the region.

“Pathfinder” corridors provide an opportunity for broader co-operation

Pathfinder corridors refer to connections between jurisdictions and provide near-term opportunities to develop and test co-operation arrangements. They do not need to be identical templates for future projects but can help participating countries address issues that recur across APG corridors. These issues may include institutional co-ordination; cross-border licensing; wheeling charges; revenue certainty; risk allocation; technical interoperability; data exchange; and subsea cable access.

This section assesses co-operation arrangements in two corridors, Indonesia-Singapore and Malaysia-Thailand, to identify near-term priorities and opportunities that can be replicated for future projects in the region. The lessons gleaned from establishing co-operation arrangements in these corridors should be systematically captured and shared across the region.

Indonesia-Singapore: The first subsea corridor to attract commercial interest

The level of commercial interest in the Indonesia-Singapore corridor is a significant achievement. This corridor has attracted more active private sector engagement than any other proposed ASEAN interconnector route, with multiple participants – including Indonesian, Singaporean, regional and international firms – supporting subsea interconnector projects to export renewable energy to Singapore. Following the [guidance for electricity imports](#) developed by Singapore’s EMA in 2022, [seven projects totalling 3.4 GW](#) have received either

Conditional Licences or Conditional Approvals for power import from Indonesia (Riau Islands) to Singapore. This reflects confidence in the commercial potential of this corridor – high-quality solar resource in Indonesia, strength of corporate demand for renewable energy in Singapore, and high-level political support in both countries. The governments signed bilateral MoUs in [2023](#) and [2025](#), a commitment [reaffirmed by the leaders](#) of both countries in 2026. That support was further underpinned by two additional MoUs signed between Danantara – newly assigned as Indonesia’s lead implementing agency for power trade – and Keppel Electric and Sembcorp Utilities in Singapore. These signals have attracted private capital into early-stage project preparation, creating urgency and incentives to drive regulatory development and co-operation.

As of September 2026, multiple elements of these projects were under development or negotiation, including ownership models and pricing as well as discussions around the extent of government involvement. Given the commercial sensitivities, the IEA does not comment on individual projects or issues related to pricing and ownership structures. Instead, it seeks to identify the co-operation arrangements and practices that, once established, may be modelled to create other APG corridors.

Advancing interconnection in this corridor may provide a model for similar co-operation arrangements elsewhere in the region. As there are no existing interconnections between Singapore and Indonesia, a range of co-operation arrangements will need to be developed in parallel with commercial negotiations to develop interconnectors and establish power trade. While the precise co-operation arrangements required will depend on the desired technical configuration and ownership structure of projects in this corridor⁶, they may include transmission pricing, cross-border data sharing and technical co-operation, financing and risk allocation, and cross-border REC frameworks. To sustain private sector participation, investors – which contribute high risk development capital – must be able to see a clear pathway to financial close and stable operations. The corridor presents several opportunities to define sustainable and replicable co-operation arrangements, including on issues such as revenue models, long-term authorisations and financing arrangements.

⁶ Announced projects between Indonesia and Singapore have, to date, been envisaged as generation-to-grid projects. It is possible that in future projects landing on the island of Batam may connect to existing high-voltage power grids, in which case additional co-operation arrangements (e.g. grid code interoperability) may need to be established. Similarly, it is not known whether the subsea cables will be owned by the generation companies, or by a third party.

Indonesia-Singapore corridor: Priorities and replicability for other corridors in the ASEAN region

Dimension	Key co-operation arrangements to strengthen in this corridor	Replicability for other corridors in ASEAN region
Governance	• Dispute resolution mechanisms: Depending on the project structure and participants, which may include government-government engagement, project-level commercial agreements, formal state-to-state mechanisms	• Design and participation of state-backed vehicles (e.g. SGEI) in interconnector development
Regulatory	• Duration of licensing and permitting: Alignment on authorisation durations and renewal conditions – particularly the five-year export licences from Indonesia • Transmission pricing and cost allocation: cross-border transmission charges where there is third-party cable ownership • Cross-border REC framework: Recognition required	• Alignment on required licensing duration and renewal conditions to support commercial investment • Methodology for transmission pricing can be replicated, if documented and disclosed • Cross-border REC design
Technical	• Co-ordinated operational procedures: To be established ahead of commissioning • Cable laying and access agreement: Including for maintenance and repair	• Operational procedures may be replicated to other bilateral corridors • Subsea cable design, permitting procurement, construction, operation and maintenance
Finance and commercial	• Financing and risk allocation framework: Strong commercial participation, with details to be finalised (e.g. ownership structure, risk allocation) as projects proceed • Cross-border payment mechanism: These would be applied to cross-border payments	• Lessons from the application of third-party ownership structures • Risk allocation framework for subsea cable development may be documented and applied elsewhere in the ASEAN region • Model for state support, e.g. through direct ownership or de-risking

Third-party ownership structures would require development of transmission pricing mechanisms. While financing and ownership structures have not been finalised, some projects may involve third-party cable ownership. In this case, explicit transmission pricing would be required to compensate the cable owner for its investment and operational costs. Establishing this transparently (e.g. through disclosing the formulas) and applying it consistently to all projects in the same corridor can set a precedent to improve revenue certainty for future projects between Indonesia and Singapore. It can also set an example for future subsea projects in the ASEAN region that follow a similar model.

Long-term authorisations and revenue certainty are key for investors. One of the [key challenges](#) for potential investors in the Indonesia-Singapore corridor is the five-year authorisation duration and renewal cycle for export licences from Indonesia. Five years is a much shorter window than the typical payback period and debt tenor for subsea interconnectors, which may range from 15-20 years or more. This creates renewal risks for lenders and is a binding constraint to structuring non-recourse financing for projects in this corridor. Longer authorisation periods with clear renewal mechanisms can preserve government oversight, while providing greater revenue certainty for investors. Clarity on other regulatory requirements, such as the treatment of cross-border infrastructure in Indonesia's local content requirements, can further strengthen clarity for investors.

Cross-border REC frameworks are a key enabler for corporate off-takers. A significant driver of Singapore's renewable energy demand is from corporate buyers seeking to meet their renewable energy and climate targets. This demand requires a cross-border REC framework that enables renewable energy attributes associated with imported electricity to be recognised. For corporate buyers, the framework should support credible use of these attributes under relevant corporate greenhouse gas accounting and renewable energy target-setting frameworks, including appropriate provisions on attribute ownership, retirement and double counting. Both Indonesia and Singapore have domestic foundations, with voluntary domestic REC markets using compatible international standards. Singapore has engaged the International Tracking Standard (I-TRACK) Foundation to develop a [cross-border REC framework](#) that can be applied in the ASEAN region, while ACE has established an [ASEAN REC Taskforce](#).

Robust risk management and risk allocation are needed to support bankability. Private sector investment and bankability, particularly where project finance models are applied, require an allocation of risk that is acceptable for each party involved. They can be managed and allocated through [intergovernmental agreements, regulatory frameworks, contracts and insurance](#) in a way that ensures an acceptable balance of risk between generators, transmission owners and consumers, while providing sufficient revenue certainty throughout the investment horizon. For example, availability-based mechanisms can be considered for interconnector investors (where third-party cable ownership is desired) to manage demand risk from change in consumption and/or generation profiles. Interface risks, where generation and transmission assets are developed by separate entities, can be managed through [integrated project structures and aligned project timelines](#). This corridor offers the opportunity to develop and test risk management, allocation and mitigation approaches that address [political, regulatory, technical, permitting and access risks](#) that are important considerations for subsea projects in the ASEAN region. Experience in this corridor may be applied in other subsea corridors that face a similar risk profile.

Technical co-operation arrangements are still being defined. Nevertheless, the Indonesia-Singapore corridor can generate valuable experience for other subsea interconnectors in the ASEAN region, notably on design, permitting, procurement, construction and operation. Several design decisions still to be taken will shape the extent and nature of the technical arrangements required. This includes grid code interoperability, data-sharing arrangements and operational procedures for scheduling, dispatch, outages, emergency response and restoration ahead of commissioning. For instance, in the Batam-Singapore interconnector projects (with overland access to the existing Batam HV grid), the decision on whether generation assets exporting to Singapore are fully integrated into the Batam grid or connected through an interlocked arrangement to supply local communities will affect the need for system impact assessments and operational co-ordination frameworks. Indonesia can also draw on experience from the Kalimantan-Sarawak interconnector for structuring bilateral technical agreements and co-ordination practices for these projects.

Malaysia-Thailand: Potential benefits beyond host countries

Peninsular Malaysia and Thailand operate two grid-to-grid interconnectors, a 300 MW HVDC link commissioned in 2002, and an 80 MW HVAC link operating since 1980. These links were initially developed to support system stability in both grids, particularly during contingency events. Over the past decade, this HVDC corridor has taken on wider regional significance beyond bilateral power exchange, becoming a central part of ASEAN's first multilateral power trade arrangement, enabling power export from Lao PDR to Malaysia during 2018-2021 as part of the Lao PDR-Thailand-Malaysia Power Integration Project (LTM-PIP) and part of the LTMS-PIP since 2022. Discussions are ongoing to upgrade the [interconnection between](#) Malaysia and Thailand.

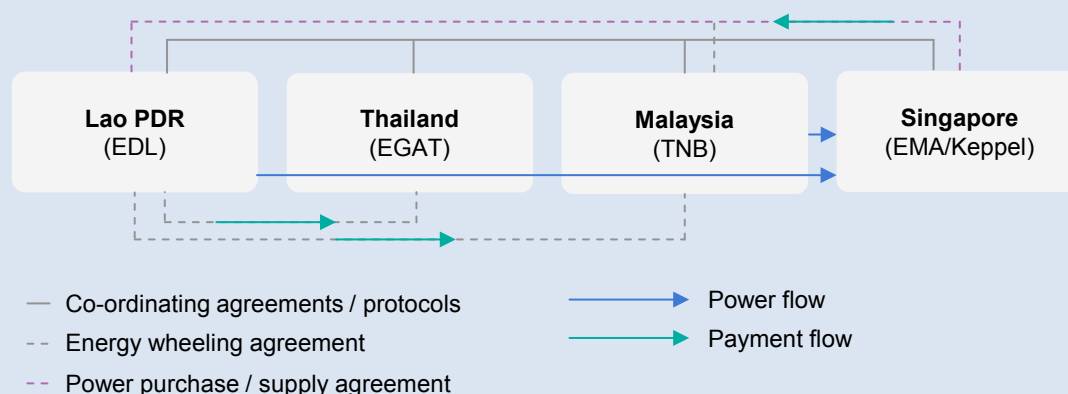
The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP)

The LTMS-PIP, the first multilateral power project in the ASEAN region, was introduced in 2022 on an initial two-year trial to [import 100 MW](#) of electricity from Lao PDR to Singapore, with wheeling through grids in Thailand and Malaysia. The total power trade capacity was expanded to 200 MW during [Phase 2](#), which includes imports from both Lao PDR and Malaysia. The project utilises existing interconnection infrastructure between the participating countries and did not require construction of new interconnections.

Commercial arrangements in the LTMS-PIP are implemented through a [series of bilateral contracts](#), including:

- Power purchase agreement between EDL and Keppel for the supply of up to 100 MW of electricity from Lao PDR to Singapore ([renewed in 2024](#) for a two-year period).
- Energy wheeling agreement between EDL and EGAT for wheeling through the Thailand grid ([renewed in 2026](#) for a two-year period).
- Energy wheeling agreement between EDL and TNB for wheeling through the Peninsular Malaysia grid ([renewed in 2026](#) for a two-year period).
- Power supply agreement between TNB and Keppel for the supply of up to 100 MW of electricity from Malaysia to Singapore ([signed in 2024](#)).

LTMS-PIP commercial arrangements



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Source: ASEAN Centre for Energy (2024), [The Study on the Roadmap for Multilateral Power Trade in ASEAN](#); and Bernama (2026), [TNB Signs Energy Wheeling Agreement Phase 2 Under LTMS 2.0](#).

The established multilateral governance architecture of the LTMS-PIP can be replicated for future projects. Power exchange between Thailand and Malaysia is supported at both the government and utility levels. LTMS countries hold ministerial meetings annually alongside the ASEAN Ministers on Energy Meetings, issuing [six joint statements since 2020](#), each time reaffirming political commitment to power trade through the LTMS-PIP and the APG. These are operationalised through regular LTMS-PIP Working Group meetings represented by senior government officials, along with four task forces, including technical, legal and regulatory, commercial and tax and tariff, each of which is chaired by one of the LTMS countries. This structure provided a [flexible mechanism](#) for countries to join the project even if they were not initially involved – for example, Singapore joined after the LTM-PIP was already operationalised. This structure

may be applied to other multilateral corridors, for example the Brunei Darussalam, Indonesia, Malaysia and the Philippines Power Integration Project (BIMP-PIP) or expanded to accommodate additional countries wishing to participate within the LTMS structure.

Improving transparency on wheeling charge calculations, alongside domestic efforts to develop grid charges for TPA. The wheeling charge formulas applied in LTMS-PIP are not disclosed but they are understood to be based on [cost recovery mechanisms](#), covering transmission, loss, balancing and administrative charges. Thailand's wheeling charge has been publicly reported at [3.1584 US cents per kWh](#) (prior to the renewal of the Energy Wheeling Agreement in 2026). Malaysia's wheeling revenues were reported at [MYR 137 326 Malaysian Ringgit \(MYR\)⁷ on a total of 0.58 GWh](#) wheeled through Malaysia's grid system between January and February 2026⁸, while [AIMS III Phase 3](#) estimates Malaysia's wheeling charge at between US 2-4 cents per kWh. This issue is closely linked with national approaches to setting transmission charges for domestic users, particularly as both Thailand and Malaysia are rolling out domestic TPA schemes for which the structure and level of system access charges are a central design requirement. Perceived fairness relative to domestic network users is an important consideration when designing cross-border transmission charges.

The scope of CBA can be expanded to capture regional and sub-regional externalities. Any future expansion of power trade in the region and/or sub-region utilising this corridor, for example through expanded LTMS capacity or [inclusion of additional countries](#) such as Viet Nam, is limited to the existing 380 MW transfer capacity between Thailand and Malaysia. Expansion of this transfer capacity has the potential to provide benefits to other countries in the (sub-)region through facilitating power trade. In contrast, CBA is typically conducted at the national level. While other countries have opportunities to provide feedback through bilateral dialogues and regional forums (e.g. at ASEAN-level meetings and/or at LTMS meetings and within working groups), there is currently no regional approach to quantifying or comparing benefits and costs between countries. It is important that positive externalities to non-hosting countries are evaluated during project appraisals so that projects bringing regional benefits are considered and may serve as a starting point for discussions on cost allocation.

⁷ Exchange rate: 1 Malaysian Ringgit (MYR) = EUR 0.2151 = USD 0.2456 (as of 30 June 2026).

⁸ Care should be taken when interpreting or comparing these values as the methodology, inclusions and adjustments used to calculate these figures are not specified. If a direct ratio is used, this implies an effective rate of MYR 23.7 sen per kWh on the 0.58 GWh of wheeled electricity over the two months.

Malaysia-Thailand corridor: Priority co-operation arrangements and replicability

Dimension	Key co-operation arrangements to strengthen in this corridor	Replicability for other corridors in ASEAN region
Governance	Long-running bilateral co-operation and LTMS governance is well established. Non-binding arrangements (e.g. ministerial statements) may evolve into formal multilateral frameworks	Multi-layered institutional co-operation structure for LTMS (ministerial meetings, ASEAN endorsement, utility-level working groups) can be replicated for other sub-regional trading arrangements, or expanded to accommodate additional countries
Regulatory	CBA and project prioritisation: CBA approach that considers regional externalities, e.g. for expanded trade through LTMS. Transmission pricing and cost allocation and Duration of licensing and permitting: Increased transparency on wheeling formulas and pricing, with long-term authorisations beyond two-year pilot period, can support new infrastructure development	- Cross-border CBA approach may be trialed for this corridor, with scope to consider regional externalities (e.g. benefits from continued and/or expanded LTMS trade) - Wheeling charges approach and formulas as part of LTMS may be disclosed and used to inform the development of transmission pricing in other corridors
Technical	Technical co-operation between Thailand and Malaysia is well established. In future, this can be strengthened across all LTMS countries	Operational procedures, technical arrangements, and data exchange arrangements can provide a template for other corridors (e.g. structure of Thailand-Malaysia HVDC system interconnection agreement)
Finance and commercial	Financing and risk allocation approaches: Not yet established for development of new generation and transmission assets. LTMS was delivered using existing infrastructure	- TSO-TSO payment mechanism for wheeling charges may be replicated - Risk allocation approach, included in wheeling and PPA agreements, may inform development of future multilateral arrangements

Longer-term commercial frameworks can support new infrastructure development. The two-year commercial arrangements have succeeded in establishing pilot power trade using existing infrastructure. However, it may not provide the long-term certainty and sufficient revenue visibility for investments in new interconnector or generation capacity that seek to participate in LTMS corridor, which usually require more than 15 years of revenue certainty to support financing. Longer-term trading arrangements would better align with infrastructure payback periods and debt tenors, providing investors and off-takers greater confidence to commit capital to interconnector projects.

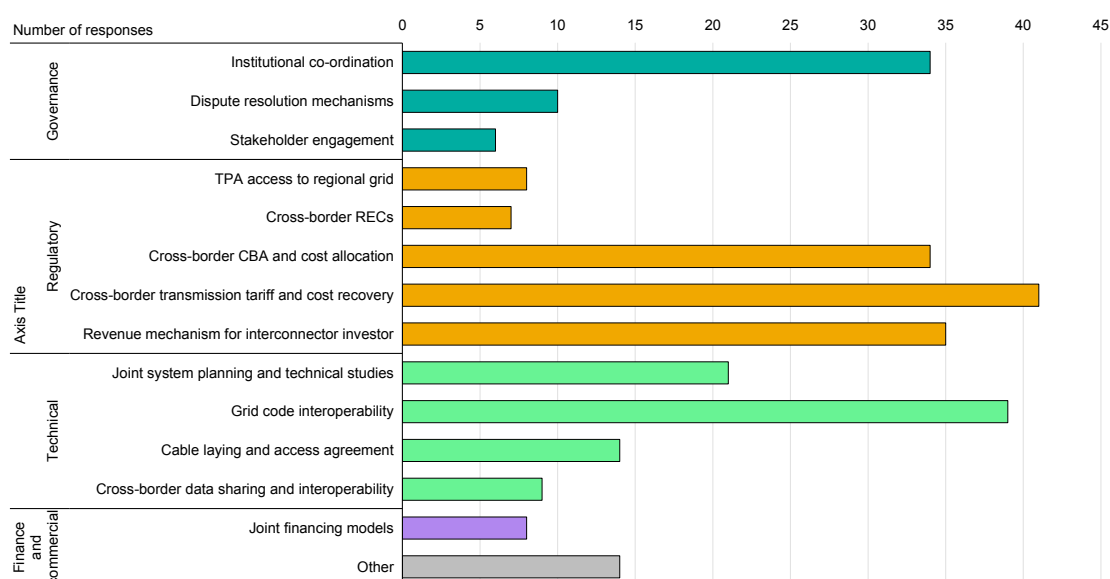
Chapter 3. International experiences and implications for ASEAN countries

This chapter examines international experiences in advancing co-operation arrangements that support cross-border power trade and their implications for ASEAN, building on the examples outlined in Chapter 2.

A survey and stakeholder consultations conducted as part of [the 2026 Singapore-IEA Regional Training](#) involving ASEAN ministries, regulators, utilities and international partners identified priority co-operation arrangements for supporting cross-border power trade in the region. These arrangements included institutional co-ordination; cross-border CBA and cost allocation; clear and stable revenue models; aligned transmission and/or wheeling charges; grid code interoperability; and joint system planning and technical studies.

This chapter explores three priority topics based on international experiences: institutional co-ordination, CBA and cost allocation, and technical co-operation (which includes grid code interoperability, co-ordinated system planning and data sharing).

Survey question: “What are the key co-operation arrangements that must be improved to establish power trade?”



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Note: Survey of around 150 policy makers, regulators, utilities, international partners and technical experts during the 10th Singapore-IEA Regional Training held in May 2026.

Institutional co-ordination

Cross-border power trade requires effective co-ordination between governments, regulators, utilities and system operators across participating jurisdictions in order to align priorities and establish decision-making processes and governance arrangements. Governments play a critical role in providing the political and legal foundation for interconnection projects; political will and leadership can support the early stages of the process. Regulators support the development of regulatory frameworks, technical requirements and commercial arrangements that enable cross-border power trade. Utilities and system operators translate these commitments into practical arrangements for implementation.

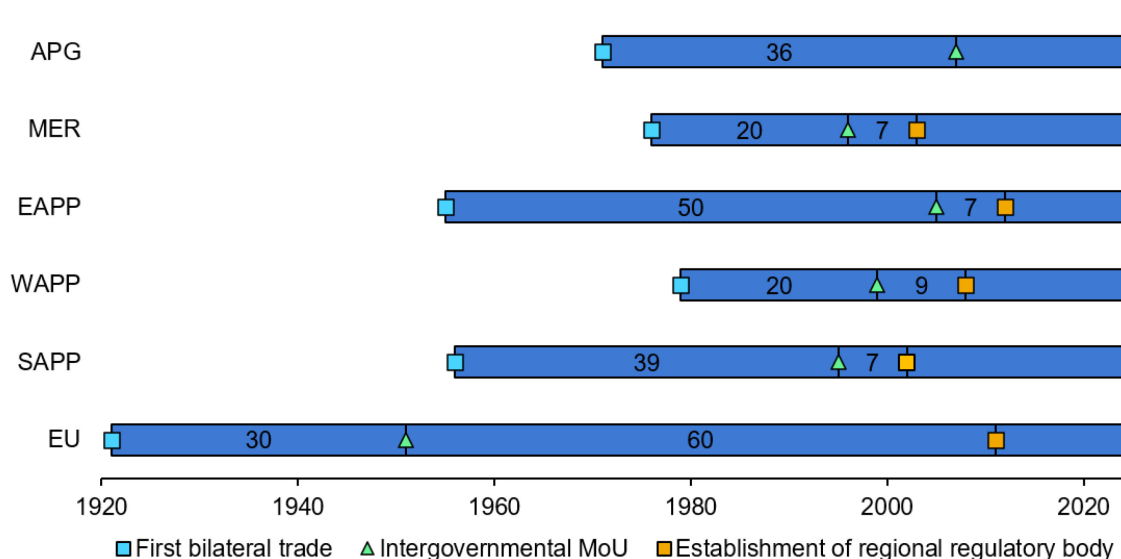
Institutional co-ordination can take different forms, ranging from formal intergovernmental agreements, MoUs and joint statements, to working groups and task forces, which can all spur greater regional co-operation by establishing common objectives and provide a mandate for implementation activities.

These arrangements do not need to be fully established before market integration begins. International experiences suggest that the process typically evolves incrementally over decades, often beginning with bilateral trading arrangements before expanding to multilateral trades through MoUs, kicking off a regional market initiative. The institutional co-ordination can evolve to include the establishment of dedicated regional bodies responsible for system planning, operation, market co-ordination, regulation and dispute resolution.

In the ASEAN region, sub-regional agreements for specific interconnection projects have built on the APG MoU that includes LTMS-PIP, which is now in Phase 2, and the BIMP-PIP. The LTMS-PIP [is supported through](#) ministerial meetings and joint statements, senior official meetings, the working group and specialised task forces. These support mechanisms cover technical viability, legal and regulatory framework, commercial arrangement and tax and tariff structure.

Intergovernmental agreements in other regions – for example the Southern African Power Pool (SAPP), the West African Power Pool (WAPP) and the Central America Regional Electricity Market (MER) – play a foundational role by offering a clear signal of political support. That support in turn leads to the creation of regional bodies, the definition of rights and obligations, and provides a basis for technical, regulatory and commercial co-ordination.

Institutional co-ordination milestones for regional power system integration initiatives



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Note: APG: ASEAN Power Grid. MER: Mercado Eléctrico Regional. EAPP: Eastern Africa Power Pool. WAPP: West African Power Pool. SAPP: Southern African Power Pool. EU: EU Internal Electricity Market. For SAPP, the regulatory body is an association without the authority to establish or enforce regulations.

Source: IEA (2023), [Institutional Architecture for Regional Power System Integration](#).

The West African Power Pool: Institution-led co-ordination

The WAPP, a specialised agency to facilitate power trade across 14 West African countries, is a good example of a regional, institution-led approach to regional integration. The Economic Community of West African States (ECOWAS) took the lead in creating WAPP in 1999; it became officially operationalised in 2006 and is supported by political decisions taken at the ECOWAS level.

The framework was strengthened in 2008 through the creation of a central regulatory entity, the ECOWAS Regional Electricity Regulatory Authority (ERERA), which has the authority to issue legally binding decisions to regulate cross-border electricity connections and trade by developing regional market rules, transmission tariffs and dispute resolution mechanisms. These arrangements reduced regulatory uncertainty for utilities and investors and supported the implementation of regional transmission projects and market design initiatives.

The WAPP has taken a sequenced approach to cross-border power trade, prioritising physical interconnected grids while moving towards an operational regional market. At the time of writing, official trading had not begun. In 2025, the WAPP conducted a test run connecting all member countries within a single network for four consecutive hours, demonstrating successful grid synchronisation in what was considered a milestone for the project. The next phase, scheduled for

2026, will aim to convert the grid synchronisation test into permanent synchronisation and move to a unified system. This approach has made the WAPP one of the most successful power pools in Africa for cross-border infrastructure. Market implementation is also progressing. ERERA concluded a review of the regional grid code in 2024, paving the way for a regional electricity market. The WAPP stands out from other regional projects in other parts of the world that launched competitive markets earlier but were constrained by insufficient transmission infrastructure.

The WAPP highlights the importance of institutional co-ordination to help move beyond bilateral transactions towards a more integrated regional market with cross-border grid infrastructure in place.

The Southern African Power Pool: Utility-led co-ordination among diverse domestic markets

The SAPP co-ordinates the planning and operation of the electric power system among member utilities in Southern Africa. The SAPP illustrates how regional interconnection can emerge from institutional co-ordination led by national utilities with political support. The SAPP was established in 1995 with an Intergovernmental MoU (IGMoU) signed by 12 governments within the Southern African Development Community (SADC), which provided the political commitment for regional integration. The IGMoU was complemented by the Inter-Utility MoU (IUMoU) in the same year, which allowed national power utilities to establish management structure, areas of work and cost-and-benefit-sharing framework among participating utilities. The framework was strengthened through a revised IGMoU signed in 2006.

The SAPP's governance framework is structured as a hierarchy, and its co-ordination is determined by multiple agreements. The IGMoU and IUMoU were supported by an Agreement Between Operating Members (ABOM), which established the basic operating principles, functional structure and member obligations at a high level. The Operating Guidelines provide details of the ABOM, outlining rules and standards to guide operations of the interconnected grid. Co-ordination is supported through the SAPP Coordination Centre, which is responsible for areas such as monitoring market and system operations, performing operations and planning studies. The SAPP is a self-regulated market, since the Regional Energy Regulators Association (RERA) has no authority to establish or enforce regulations.

These co-operation arrangements have facilitated cross-border power trade by providing common procedures for scheduling, dispatching, accessing transmission, exchanging information and co-ordinating operations. Rather than relying on a regional regulator or a fully integrated market from the outset, the

SAPP initially expanded through bilateral transactions and utility-led co-ordination, with more structured market arrangements introduced over time.

The SAPP experience demonstrates how institutional co-ordination can facilitate cross-border trade even where domestic market structures are different, and without binding regulations or supranational institutions. Utility-led co-ordination, political support and clear governance arrangements provided the foundation for the gradual expansion of regional trade, while allowing participating countries to retain responsibility for their domestic electricity sectors. The SAPP example may be particularly relevant for ASEAN countries, as it evolved from utility-led co-ordination without requiring changes to domestic markets.

The Central America Regional Electricity Market: A formalised approach

The MER illustrates how a formal intergovernmental agreement can provide the foundation for regional electricity integration. MER was established through [the Framework Treaty](#), signed by Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama in 1996 to formally create a regional competitive power market. The treaty transformed a series of bilateral trading and co-operation initiatives into a co-ordinated regional integration process, which represents a more formalised approach to regional electricity integration.

A defining feature of the MER is having [dedicated regional institutions](#) responsible for regulation, market operation and governance. The Regional Electricity Interconnection Commission (CRIE) regulates the regional market and co-ordinates national regulators, the Regional Operator (EOR) co-ordinates market operations, and the Council of Directors of the MER (CDMER) provides policy oversight and co-ordination among governments. The grid owner Empresa Propietaria de la Red (EPR) is responsible for the design, financing, construction and maintenance of the SIEPAC interconnection line.

The MER demonstrates how regional institutions can facilitate cross-border trade by co-ordinating policy, regulatory, operational and infrastructure functions within a common framework. These arrangements allow countries with different market structures to participate in regional power trade through a common institutional framework. For ASEAN, the key lesson is that regional integration can be supported through institutions with clearly defined and complementary responsibilities, underpinned by an intergovernmental framework that provides political direction and continuity.

Institutional co-ordination arrangements: International experiences

	ASEAN	Western Africa Power Pool (WAPP)	Southern African Power Pool (SAPP)	Central America Regional Electricity Market (MER)
Overall approach	Co-ordination based	Regional institution-led co-ordination	Utility-led co-ordination	Regional institution-led co-ordination
Intergovernmental foundation	APG MoU signed in 2007 and strengthened by Enhanced APG MoU in 2025.	Established in 2006 under the ECOWAS framework through decisions of ECOWAS Heads of State and Governments.	Established through IGMoU in 1995 by SADC member and revised IGMoU in 2006.	Central American Electricity Market Framework Treaty signed by six governments in 1996.
Governance and policy co-ordination	- AMEM and SOME provide policy direction. - APGCC provides policy guidance on the implementation of regional integration. - ACE serves as APG Secretariat to support co-ordination and implementation.	- ECOWAS Heads of State and Energy Ministers provide political direction through the ECOWAS framework. - WAPP Secretariat acts as the implementing regional institution.	- Establish IUMoU, Agreement Between Operating Members - Energy Ministers annual meeting to provide policy direction and political leadership.	The CDMER provides policy oversight and co-ordination among participating governments.
Regulatory co-ordination	- No dedicated ASEAN regional regulator. - AERN acts as a platform to share best practices and networking.	ERERA develops and enforces regulations including regional market rules, transmission tariffs and dispute resolution mechanisms.	- No dedicated regional regulator. - Regulatory co-ordination occurs through RERA.	CRIE regulates the regional market, co-ordinates national regulators, develops market rules and sets transmission tariffs.
System and market operation co-ordination	- No regional market operator. - HAPUA supports technical co-ordination. - National utilities/TSOs operate their own systems and co-ordinate cross-border trade. - Regional working groups.	- WAPP Coordination Centre oversees regional system co-ordination, reliability standards and market development. - Full operational responsibilities remain with national utilities/TSOs.	- SAPP Coordination Centre as the market operator, facilitating trading in the Day Ahead Market. - National utilities/TSOs own and operate a segment of the transmission network. - A committee structure in areas of operating, markets, planning and environment.	EOR operates the regional market and co-ordinates system operations.

Note: ACE: ASEAN Centre for Energy; AERN: ASEAN Energy Regulatory Network; AMEM: ASEAN Ministers on Energy Meeting; CDMER: Consejo Director del Mercado Eléctrico Regional (the Council of Directors of the MER); CRIE: Comisión Regional de Interconexión Eléctrica (The Regional Electricity Interconnection Commission); ECOWAS: The Economic Community of West African States; EOR: Ente Operador Regional (Regional Operating Entity); ERERA: ECOWAS Regional Electricity Regulatory Authority; HAPUA: Heads of ASEAN Power Utilities/Authorities; MER: Mercado Eléctrico Regional (Regional Electricity Market); SOME: ASEAN Senior Officials Meeting on Energy; RERA: Regional Electricity Regulators Association; TSOs: Transmission System Operators.

Institutional co-ordination: Implications for ASEAN

The international experiences outlined above offer important opportunities and lessons for ASEAN countries and the APG, explored in detail below.

- **Sustained political support is essential to advance regional integration.** Intergovernmental agreements provide the foundation for cross-border power trade by establishing common goals and providing continuity across political and policy cycles. The 2025 Enhanced APG MoU provides ASEAN with a strong foundation. The priority is to maintain political commitment and translate regional objectives into concrete implementation actions.
- **Institutional arrangements evolve as regional power trade expands.** Regional integration is a gradual process. Bilateral and project-specific arrangements can support early cross-border projects, but they become less effective with more interconnectors. More structured co-ordination through regional institutions can help improve consistency across projects, thereby reducing uncertainty for investors and expediting implementation.
- **Clear institutional roles and responsibilities are key.** International experience highlights the importance of clearly defining responsibilities between governments, regulators, system operators and regional institutions. Clear mandates reduce duplication, improve accountability and facilitate implementation. As cross-border trade expands, ASEAN may benefit from expanding the roles of the existing APG institutions and establishing new ones to support regional integration.
- **Regional institutions need clear roles and political support.** Regional institutions can play a key role in co-ordinating planning, regulation and market operation, but their effectiveness depends on the level of authority and the support of participating governments. ASEAN's existing institutions can support deeper regional integration, provided they are given clear mandates and sufficient resources to perform their co-ordination functions effectively.
- **Adopt a phased approach to strengthening institutional co-ordination.** ASEAN's institutional, policy and market context differs from other regions. Rather than replicating any single model, ASEAN should focus on strengthening the co-ordination functions required at each stage of regional integration, using “pathfinder” projects and sub-regional initiatives to build experience and progressively develop more formal institutional arrangements where needed.

CBA, cost allocation and transmission pricing

Cost-benefit analysis, cost allocation and transmission pricing may help to address several questions: Do cross-border interconnectors provide sufficient net benefits to justify its costs? How are these benefits and costs distributed across participating countries? And who ultimately bears these costs?

CBA provides the analytical foundation to justify projects, ensuring net economic benefits (usually calculated on a net present value basis) relative to total project costs. By looking at how benefits and costs are distributed across countries, CBA can provide a common starting point for discussions on cost allocation. The geographic scope of the CBA is an important parameter to define. Regional benefits (beyond those in asset-hosting countries) may be identified through extending the assessment boundary to non-hosting beneficiaries.

Cost allocation may be one of the most contested decisions for participating countries, requiring political agreement on cost shares. Transmission pricing and tariff design then determines how each country's allocated cost shares are recovered, both through cross-border payments and domestic tariffs. Key objectives that guide [transmission pricing and cost allocation](#) include cost recovery, economic efficiency, fairness and transparency.

ASEAN does not currently have a regional approach to CBA, cost allocation or transmission pricing for cross-border trade. This gives rise to several challenges. First, establishing CBA at a national level results in a lack of a common starting point and evidence base for discussing the benefits of projects. Second, there are no mechanisms to capture externalities where benefits accrue to other countries not directly hosting the interconnector infrastructure. Third, cost allocation is typically established on a case-by-case basis, limiting transparency and replicability, with transmission cost recovery often bundled with power sales.

Determining transmission pricing and cost allocation

Interlinked elements may be considered in developing regional cost allocation approaches, building on the framework outlined in [ESMAP Guidelines on Transmission Pricing and Cost Allocation for Regional Power Trade](#), summarised below.

Define the scope of eligible assets. Interconnector infrastructure includes cross-border transmission lines, substations (for AC) and converter stations (for DC) on either side of the border, along with other grid elements. A broader range of enabling infrastructure, including domestic grid reinforcements, may be required as well.

Domestic transmission infrastructure essential for enabling cross-border flows can also be considered.

Define the cost base and revenue requirement to be recovered. These may include CAPEX, OPEX, an adjustment for losses and a permitted rate of return for the TSO or investor. This rate of return may be standardised for cross-border assets within the market (as is the case in the WAPP, for example).

Allocate costs among participating countries. A cross-border payment is required to transfer value from the parties who benefit from and/or use grid infrastructure to the parties who invested in it. Costs may be allocated based on each country or agent's utilisation of each transmission element as a proxy for benefits. For example, in the WAPP, the average participation method is applied to establish each TSO's contribution to shared transmission system usage. Allocation of upfront investment costs must also be considered. Often, territorial allocation is used, where each party pays for the portion of the infrastructure within their territorial borders. Similarly, several subsea cables in the European Union have applied an agreed 50-50 cost split. Costs may also be allocated based on the distribution of benefits across beneficiary countries. This requires CBA to be conducted for the project across each country that receives costs and/or benefits. For example, the European Union [establishes cost allocation](#) based on the “economic, social and environmental costs and benefits of the projects”.

Determine cost recovery mechanism. Following cost allocation, each country bears a share of costs in proportion to the agreed allocation. Domestic tariff and cost recovery mechanisms are used to recover these costs from domestic consumers.

Transmission cost allocation: International experiences

Design of transmission cost allocation for cross-border trade in the European Union, the MER and the WAPP

Step	ASEAN (bilateral projects)	ASEAN (LTMS-PIP)	European Union	Central America regional market (MER)	Western African Power Pool (WAPP)
Define scope of eligible assets and cost base	Not defined. Bilaterally agreed on a project-by-project basis.	Not disclosed.	Regulated. Assets designated as projects of common interest or projects of mutual interest by working groups including representatives from EU Commission and EU member states, as outlined in Regulation EU/2022/869 .	Regional transmission network, Red de Transporte Regional, designated by the EOR. Includes both interconnectors owned by the regional system operator, and portions of national transmission lines.	Designation of regional assets (WAPP-ITS) by ERERA. Includes both cross-border infrastructure and national transmission lines important for cross-border trade.
Define cost base and revenue requirement	Not defined. Bilaterally agreed on a project-by-project basis.	Not disclosed , though based on cost recovery .	Regulated. Calculated by project promoter/TSO based on ENTSO-E Guidelines , and submitted for approval to national regulatory authorities and ACER.	Regulated. Authorised revenues calculated as set out in regional market regulations . Includes CAPEX, OPEX, an availability adjustment, taxes and a regional return on equity annually determined by CRIE .	Regulated (by resolution No. 20/ERERA/26). Includes CAPEX, OPEX, losses and a regional weighted average cost of capital determined by ERERA.
Cost allocation among participating countries	Not defined. Transmission cost recovery bundled as part of power sales. Investment costs allocated through territorial approach for overhead lines; not defined for subsea cables.	Wheeling charge determined independently by each country . Malaysia applies postage stamp approach, while Thailand applies a mix of contract path and postage stamp. LTMS-PIP uses existing infrastructure.	Usage-based through inter-TSO payments to countries hosting transit flows as established in Regulation (EU) 2019/943 . Investment costs allocated by benefits. Based on distribution of benefits , with common CBA methodology.	Usage-based through a combination of dominant flow and average participation method. Investment costs for regional SIEPAC line shared equally by six participating TSOs through equity participation, with additional (minority) equity from external investors.	By usage , with inter-TSO payment calculated through average participation method. Investment costs typically shared through territorial approach.
Cost recovery	Cost recovery established nationally				

Note: ACER: EU Agency for the Cooperation of Energy Regulators; CRIE: Comisión Regional de Interconexión Eléctrica (The Regional Electricity Interconnection Commission); LTMS-PIP: Lao PDR-Thailand-Malaysia-Singapore Power Integration Project; TSO: Transmission system operator; EOR: Ente Operador Regional (Regional Operating Entity); ERERA: ECOWAS Regional Electricity Regulatory Authority.

The European Union cross-border cost allocation framework

The European Union has established a comprehensive framework for cost allocation of cross-border infrastructure projects identified as projects of common interest (PCI) or projects of mutual interest (PMI). These arrangements are underpinned by an [EU regulation](#) on trans-European energy infrastructure, as well as [official guidelines](#) from the EU Agency for the Cooperation of Energy Regulators (ACER). The framework includes a [harmonised CBA methodology](#), common regulatory mechanisms for cross-border cost allocation (CBCA), and support for projects that generate regional benefits beyond the countries in which they are situated.

The scope of eligible assets is defined through a “Union list” of PCI and PMI projects identifying interconnectors with a significant cross-border impact. A CBA is conducted for PCIs/PMIs, after which a CBCA request may be submitted to the national regulators or to ACER. National regulators have [six months](#) to reach an agreement, after which ACER becomes the competent authority. This creates a clear ceiling on approval timelines and impetus for regulators to resolve cross-border issues collaboratively. PCIs/PMIs can benefit both from streamlined permitting and from financial assistance through project preparation and CAPEX grants implemented through the Connecting Europe Facility.

Despite a sophisticated CBCA framework, most investment costs are still split based on territorial principles (by national borders on land, or 50-50 for subsea). There have, however, been instances where investment costs are split based on benefits. The Celtic interconnector between Ireland and France, for example, had a [65-35 split of costs](#) based on distribution of benefits.

Cost-benefit analysis for grid development projects in the European Union

The European Network of Transmission System Operators for Electricity (ENTSO-E), the association of European TSOs, publishes CBA guidelines for grid development projects. First [introduced in 2015](#) (and revised three times since), the guidelines are applied as the analytical foundation for the cross-border cost allocation process for PCIs and PMIs, using a combined multi-criteria and CBA methodology. The CBA monetises and assesses the maximisation of socio-economic welfare, and multi-criteria analysis assessing different objectives that cannot be monetised. The CBA is conducted against a reference network based on the EU 10-year grid development plan, isolating the project impact on the network across a set of sensitivity scenarios covering fuel prices, carbon prices, demand and generation flexibility, and storage availability.

Benefits are assessed based on a socio-economic welfare calculation that accounts for producer surplus (the difference between electricity price and generation cost), consumer surplus (the difference between willingness to pay and electricity price), and transmission surplus (congestion rent). Other benefits assessed include renewables integration value; emissions reduction; supply security and demand adequacy (based on loss of load expectation); system flexibility benefit; system stability (including frequency stability); black start services and voltage/reactive power services; and reduction of reserve requirements for redispatch. Benefits are calculated net of revenues, which may be received through congestion revenues or inter-TSO payment mechanisms.

The WAPP regional transmission cost allocation framework

Within the WAPP, a [regional transmission cost allocation](#) (RTCA) framework was approved in 2026. ERERA is responsible for determining regional interconnection transmission system (WAPP-ITS) assets and setting their revenue requirements, including calculation of the regulated asset base and setting a regional weighted average cost of capital (WACC).

The average participation method is used to model and assign responsibility for cross-border flows to generators and consumers. This is aggregated at the country level to determine the compensation obligation of each TSO. An “Inter-Grid Operator Compensation Mechanism” is used to settle payments on an ex-ante (one year ahead) basis, with national regulators adjusting domestic tariffs accordingly. The WAPP System and Market Operator, established in 2023, assumes the operational role for collecting and distributing inter-TSO payments.

The RTCA framework does not provide guidance on how investment costs are split between participating countries for new infrastructure, which typically uses territorial allocation or is negotiated. CBA is conducted by ERERA through a consistently applied methodology. The allocation methodology provides a certain level of certainty for investors, since cost recovery is de-coupled from utilisation. However, as the value of the WAPP-ITS, and therefore the cost recovery amount, is updated every five years, uncertainty is introduced through possible adjustments of revenues.

Prior to this, a MW-km load flow-based tariff methodology was [established in 2015](#). However, this has proved challenging to scale and was [never implemented in practice](#). The methodology introduced a charge on cross-border commercial transactions, thus disincentivising power trade, and required a separate tariff

calculation for each trade, which introduced additional complexity. Further, there was a lack of implementation capacity prior to the introduction of the WAPP System and Market Operator in 2023.

The MER transmission cost allocation framework

The backbone of the regional network, the Red de Transporte Regional, is the 1 800-kilometre, 230 kV Central American Electrical Interconnection System (SIEPAC) transmission line. The transmission line is owned by EPR while some segments are owned by national TSOs. CRIE determines the revenue requirement, including components of OPEX, losses and a [regional WACC](#) updated annually. Investment costs for the SIEPAC line are shared between the TSOs of the six participating countries and three external investors (Enel, ISA Colombia, CFE Mexico), each holding an 11.11% share.

The regional cost allocation method was [defined by CRIE in 2009](#), prior to the development of the SIEPAC line, but was not implemented until 2018. This applies a usage-based approach, allocating contributions firstly between national and regional transactions, then to market participants. Transmission network investors earn a regulated revenue, with cost recovery achieved through congestion charges, sale of transmission capacity rights and a charge for usage of the regional transmission network, including a usage-based toll charge and a supplementary charge as a top-up to meet the authorised revenue requirement.

CBA, cost allocation and transmission pricing: Implications for ASEAN

- **Developing a transparent regional CBA approach can provide a trusted and shared evidence base to compare costs and benefits.** CBA may also allow countries to discuss cost shares without needing a formal cost allocation framework upfront. Benefits should capture not only financial gains but also economic benefits (e.g. contributions to electricity security) and emissions reduction. Trialling a CBA approach on one interconnector corridor, such as the Thailand-Malaysia one, is a practical first step to assessing the benefit for hosting and non-hosting countries. Such arrangements can be incrementally improved and expanded as the region gains experience.
- **Develop mechanisms to support projects with net benefits and positive externalities.** This can take the form of financial support (e.g. project preparation grants and loans) or non-financial support (e.g. streamlined permitting). Providers of financial support such as multilateral development banks (MDBs) and development finance institutions (DFIs) can make CBA a condition of support and build knowledge and transparency of CBA approaches in the region.

- **Begin with a simple transmission pricing methodology.** ASEAN countries can initially prioritise the most common transmission pricing method (e.g. postage stamp) before increasing sophistication. Usage-based methods, such as the average participation method applied in the WAPP and SIEPAC, may be considered. Experience from SIEPAC demonstrates that this approach may be applied to existing bilateral assets, even as further infrastructure build-out continues.
- **Transmission pricing should evolve as power trade scales.** Even as wheeling charges piloted in LTMS-PIP have enabled multilateral trading, scaling power trade requires further refinement of transmission pricing. Experience from the WAPP demonstrates that charges applied to commercial transactions, as in its 2015 RTCA methodology, can disincentivise the trades that regional interconnection seek to enable. Similarly, the European Union seeks to apply a [single transmission charge](#) for power imports and exports and eliminate “tariff pancaking”.
- **Strengthen domestic enablers for cross-border transmission pricing.** Not all ASEAN countries have transparent and regularly updated transmission tariffs, meaning they lack a starting point for aligning cross-border transmission pricing. Several countries, including Malaysia, Thailand and Viet Nam, are implementing domestic TPA schemes for corporate consumers. Transmission pricing and network charges for cross-border and domestic users can be designed in parallel.
- **Institutional capacity is needed to implement cost allocation.** The RTCA methodology introduced in the WAPP in 2015 was never implemented, partly because of limited institutional capacity. The WAPP System and Market Operator, responsible for collecting and distributing inter-TSO payments, was not established until 2023. Development of a settlement mechanism and/or body for collecting and distributing payments is required.
- **Prioritise transparent cost recovery mechanisms for investors over the allocation of upfront investment costs in the short-term.** Even with a sophisticated cost allocation methodology, in practice the share of upfront investment costs is determined by negotiation. In the European Union’s CBCA approach, most projects split investment costs based on territorial or 50-50 principles, with funding through the Connecting Europe Facility supporting projects with positive externalities. The near-term priority for ASEAN countries should be to build robust and transparent mechanisms to ensure that investors supporting transmission assets used for cross-border power trade can recover their costs regardless of the allocation of upfront investment costs.

Technical co-operation

Technical co-operation between TSOs has been identified by stakeholders as one of the priorities for advancing the APG. It can help address a number of issues, including differences in national grid codes; lack of joint planning that can lead to suboptimal system expansion; limited data exchange and operational co-ordination; and insufficient real-time visibility across systems.

In the ASEAN region, technical co-operation remains largely bilateral and project-specific under system interconnection agreement negotiated on a case-by-case basis, which define technical standards and operational protocols. Where operational links exist, such as between Kalimantan and Sarawak or Lao PDR and Thailand, grid code and technical standards alignment are ad hoc, comparing each country's code and selecting applicable elements per project. Multilateral efforts through the HAPUA body and the AIMS process have produced limited adopted outputs, and stakeholders consistently view bilateral agreements as more workable than supranational harmonisation.

System planning is similarly fragmented. Each member state has developed its own expansion plans while considering neighbouring systems as external inputs rather than co-optimised parts of a wider system. On data sharing, the LTMS-PIP is the most established operational arrangement in the region, covering day-ahead and intra-day schedule exchange and emergency co-ordination among four TSOs. However, it remains corridor-specific and does not yet include real-time power flow visibility or a common grid model.

International experience suggests that technical co-operation typically evolves incrementally, beginning with bilateral operational arrangements and then progressing towards more structured regional co-ordination. The following sections examine international approaches to grid code interoperability, co-ordinated planning and information sharing, and implications for ASEAN countries.

Grid code interoperability

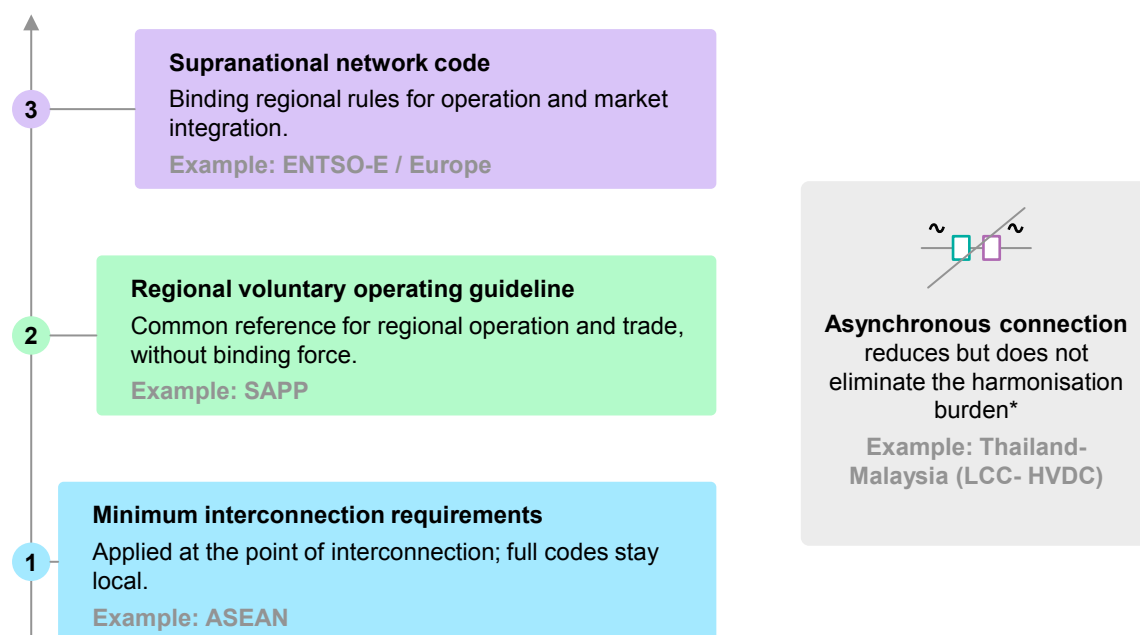
Differences in national grid codes and technical standards can increase the complexity of developing cross-border interconnections. However, full grid code harmonisation is not required in the early stages of regional integration. The more immediate priority for ASEAN countries is ensuring that interconnected systems can operate reliably and securely through agreed technical arrangements.

Replacing national codes with a single regional code is not politically or institutionally feasible in the near term, though it remains the endorsed long-term objective, as indicated in the [AIMS III Phase 3](#). The practical question is therefore

what minimum level of bilateral alignment is required for reliable cross-border operation, and how this can evolve over time.

International experience suggests a level of maturity depending on the stages of regional integration is required, starting with project-specific technical arrangements, before moving towards voluntary regional guidelines and more formal harmonisation. But a formal code is not a precondition for multilateral trade. Europe and Southern Africa traded across borders for a long period before adopting formal [network codes between 2015 and 2017](#) for Europe, or voluntary regional operating guidelines for Southern Africa. The transition to a binding code is nevertheless beneficial in the longer term, as the traded volume increases and variable renewable generation raises operational complexity. They also provide clearer enforcement mechanisms and ensure systematic updating of technical requirements.

Different maturity levels of grid codes harmonisation



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* Additional functionalities offered by newer VSC-HVDC technologies can provide controllable power flows and voltage support, facilitating connections to weaker AC systems.

For ASEAN countries, bilateral interoperability arrangements remain the most practical approach in the near term. Future interconnections can build on project-specific agreements covering areas such as protection co-ordination, frequency and voltage requirements, fault ride-through, operational communications and emergency procedures. Over time, experience from these arrangements can support the development of more consistent regional technical guidelines.

While grid code harmonisation is evolving, asynchronous HVDC interconnection, which electrically isolates the connected systems and reduces security interdependency, can ease technical harmonisation requirements. HVDC has been adopted for some existing and planned interconnections, including Viet Nam-China and Viet Nam-Lao PDR. It is also the only viable option for links between systems operating at different nominal frequencies, such as the proposed Indonesia (Kalimantan)-Philippines interconnection (50 Hz and 60 Hz). HVDC may come at a higher capital cost, depending on the length and configuration, and does not eliminate the need for technical co-operation, such as interconnection standards, operational procedures and converter performance requirements.

Co-ordinated system planning

Co-ordinated planning among countries by aligning national energy plans with regional development goals can help identify opportunities for regional benefits while reducing the risk of inefficient investments in generation, grids and storage. Currently there is no mechanism in the ASEAN region for TSOs to jointly conduct system-wide planning.

There are two layers for co-ordinated system planning. One focuses on regional resource and resilience planning, and the other on joint network planning between TSOs.

The first layer is regional resource and resilience planning, which guides the long-term planning and investment decisions on generation and transmission networks, including locations and technology type to meet the objectives in terms of system reliability and cost minimisation. It uses scenario-based modelling that considers generation adequacy, transmission expansion and resilience in a single framework. Regional planning can optimise renewable resources by enabling countries to share reserves and reduce redundancy. The [SAPP Pool Plan](#) is an example of a co-ordinated generation and transmission expansion plan, covering all 12 member systems. [Australia's Integrated System Plan](#) offers a more advanced example of an integrated resource and transmission plan, taking into account elements such as demand-side resources, storage, system security services, renewable energy zones and reliability requirements. Both the SAPP and Australia's plan are intended to be updated every two years, although the latest official SAPP Pool Plan was published in 2017 and the new [Generation and Transmission Master Plan Update](#) is expected to be published by the end of 2026.

The second layer is joint network planning between TSOs, covering items such as interconnector sizing, power flow and contingency analysis. In Europe, co-ordinated network planning is done through ENTSO-E's [10-Year Network Development Plan \(TYNDP\)](#) and the [common grid model](#). Reaching their current state required roughly a decade of incremental alignment across more than 40 TSOs. While the TYNDP provides a well-developed regional planning framework, there are still areas for improvement, including [greater transparency](#)

in scenario assumptions and infrastructure planning inputs, as well as consistency with the European Resource Adequacy Assessment. These lessons highlight the importance of transparent and consistent planning approaches.

In the ASEAN region, the most relevant regional planning exercise is the AIMS, although it focuses primarily on interconnections and power trade. The recent [Integrated Resource and Resilience Planning \(IRRP\)](#) study, developed under the AIMS III Phase 3, proposed a three-phase implementation plan to support the transition towards IRRP by incorporating demand-side resources, probabilistic assessment and scenario-based planning and resilience considerations. The IRRP study suggests that independent and regionally co-ordinated planning could be achieved by 2040, after focusing on strengthening national planning (by 2030) and enhancing regional co-ordination through shared assumptions and improved data exchange (by 2035).

Two aspects of co-ordinated system planning and select international examples

Scope	International examples	Status and trajectory in the ASEAN region
1. Regional indicative resource and resilience planning		
Scenario-based modelling that combines generation adequacy, transmission expansion and resilience Horizon: 20-30 years	- Southern Africa: SAPP Pool Plan - Australia: Integrated System Plan - Central America: EOR regional generation and transmission plan	- AIMS is the principal regional planning exercise, focusing on interconnections - ACE proposes a phased extension to demand-side resources, probabilistic adequacy and scenario-based resilience
2. Joint network planning between TSOs		
Co-ordinated network studies covering interconnector sizing, power flow and contingency analysis Horizon: rolling multi-year cycle	- Europe: ENTSO-E Ten-Year Network Development Plan and common grid model - United States: MISO Transmission Expansion Plan	- No regional mechanism exists today - ACE proposes a gradual progression towards an independent and regionally co-ordinated process by 2040

Data sharing

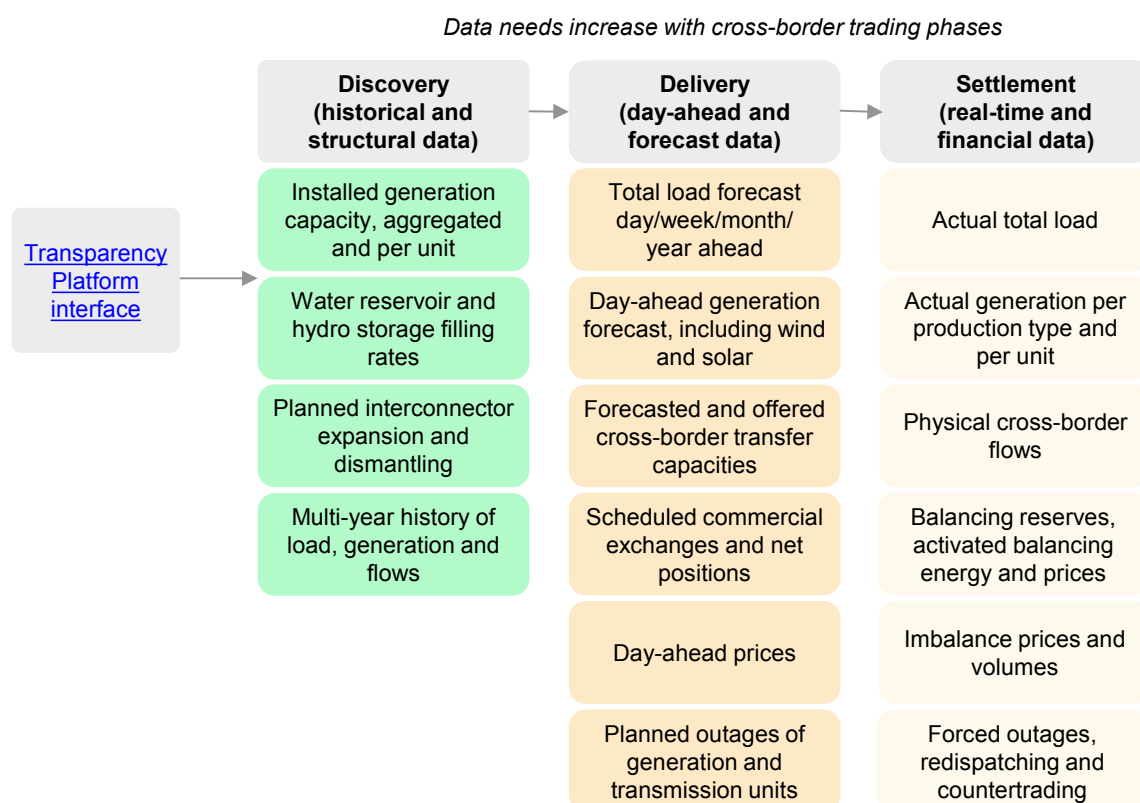
Data sharing and the digital systems supporting it are a foundation for cross-border power trade and typically evolve in terms of the volume and nature of data exchanged. This ranges from (i) planning data, including historical operational data, scenarios and network models, (ii) day-ahead and intra-day data for scheduling co-ordination, and (iii) real-time operational data for system balancing and settlement. In the ASEAN region, only the second level is partially in place in the LTMS corridor, with efforts toward greater real-time exchange under way. Ensuring the quality and

consistency of data is essential, which requires common data standards, validation procedures, benchmarking practices and stakeholder review.

International experience offers instructive options on how technical arrangements for cross-border data sharing can be carried out and institutionalised in practice. In Southern Africa, the SAPP operates a Coordination Centre that serves as a neutral regional hub for operational and market data. Operating members submit data to the centre, which acts as the official custodian of transaction information and disseminates system and market data to participants. The centre also supports real-time operational co-ordination and electricity market operations across the interconnected system.

In contrast, Europe does not rely on a single regional co-ordination centre acting as the sole operational data hub. Instead, data exchange is governed through a combination of legally mandated transparency requirements, common network codes and operational co-operation among TSOs through ENTSO-E. Under the [EU Transparency Regulation](#), TSOs and other market participants are required to submit operational and market data to ENTSO-E's Transparency Platform, which serves as a common repository for data relevant to cross-border power trade.

Overview of data available on the EU Transparency platform



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Note: The concepts of Discovery, Delivery and Settlement power trading phases are proposed by ACE and are not commonly used in the European context, but they help clarify which data ASEAN countries need in each phase in comparison with the data made available on the ENTSO-E platform.

Sources: ENTSO-E (2026), [Transparency Platform](#); ACE (2026), [ASEAN Interconnection Masterplan Study III Phase 3: ASEAN-wide Integrated Resource and Resilience Planning](#).

Beyond the choice between a central hub and a distributed model, international experience points to two further requirements: common data standards and agreed governance.

Standards allow data to be used without bilateral reconciliation each time a new counterparty or dataset is added. European TSOs exchange network models under the International Electrotechnical Commission's [Common Information Model standards](#), which allow individual national models to be merged into the common grid model used for co-ordinated planning and security analysis. Real-time operational data is exchanged through standardised telecontrol protocols, also applied [between operators](#) in the United States.

Governance arrangements are agreed alongside the datasets themselves. They define data ownership, confidentiality, quality obligations and cybersecurity requirements. Such arrangements typically broaden as markets mature. For example, European TSOs first published market data [voluntarily from 2011](#) before submission became mandatory under the [2013 Transparency Regulation](#). The [ENTSO-E Transparency Platform](#) was launched in January 2015 to collect generation, load, transmission and balancing data centrally. Dedicated [cybersecurity requirements](#) for cross-border flows followed in 2024.

For the ASEAN region, the [ASEAN data sharing framework and guidelines](#) proposes a step-by-step approach for data exchange starting from historical grid-level data and progressing towards more detailed and planning-oriented data, including monthly and substation-level data. The framework proposes further development of [the ASEAN Energy Database System](#) as the central platform for regional data exchange, including to support standards and automation.

Technical co-operation: Implications for ASEAN

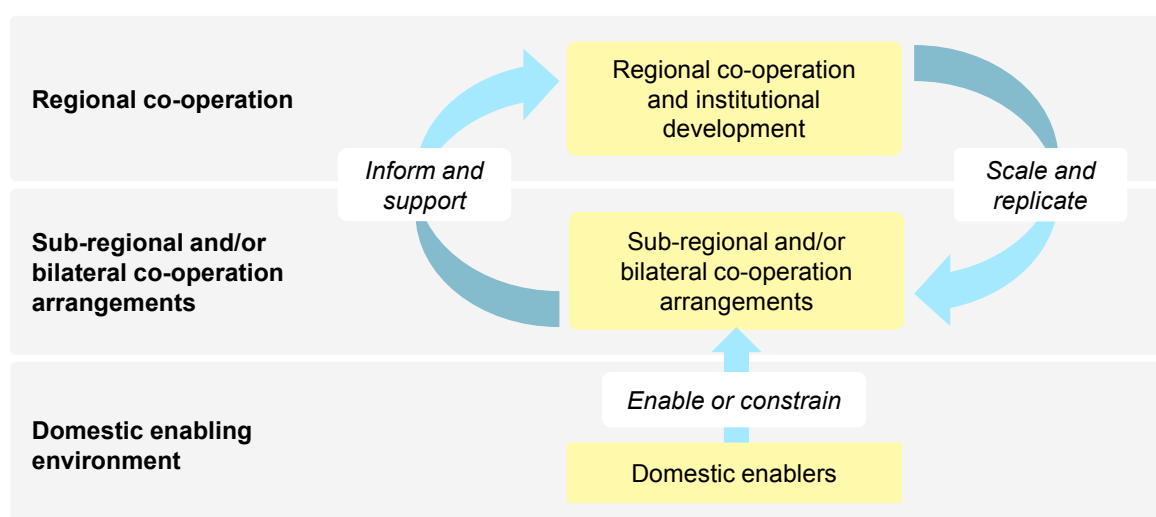
- **A bilateral-first approach to technical co-operation remains the most practical pathway for ASEAN in the near term.** This is consistent with stakeholder preferences and the sequencing logic set out in AIMS III Phase 3. The main risk is divergence across sub-regions, where bilateral solutions evolve in different directions and later become difficult to reconcile.
- **Establishing an explicit regional co-ordination function can reduce this risk.** As proposed in AIMS III studies, the APGCC could serve as the co-ordinating body to track technical developments across corridors and identify divergence early. ACE, which currently serves as the [APG Secretariat](#), could support this function as a technical co-ordinator and data custodian, aiding both planning and operational functions. This co-ordination function is subject to an agreed mandate, governance arrangements, cybersecurity safeguard and approval by ASEAN member states.

- **Digital capability and data governance should be treated as a foundational infrastructure.** Early development of shared data platforms, common data standards and cybersecurity arrangements creates the basis for both operational co-ordination and regional planning and, in time, market operation. Locating data management and planning tools within a single neutral institution such as ACE supports consistency across these functions.
- **Technical co-operation requires dedicated resourcing and a clear institutional mandate.** Experience from other regions shows that sustained cross-border integration depends both on continuous technical work and stable co-ordination structures, along with predictable financing for joint studies, data systems and operational tools.

Chapter 4. Pathways to accelerate APG implementation

Scaling power trade in the ASEAN region requires actions to improve both domestic enablers and co-operation arrangements. At the domestic level, countries can address the conditions that enable or constrain potential co-operation arrangements. Establishing co-operation arrangements at the bilateral or sub-regional level – particularly for “pathfinder” corridors – provides an opportunity to develop and test transparent and replicable models by providing practical experience to support regional alignment and standards. Doing so may encourage scale and replication of such arrangements across the region.

The relationship between actions at the domestic, regional and sub-regional levels



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This chapter identifies priority actions for countries to improve domestic readiness for cross-border power trade, and the co-operation arrangements that need to be agreed between participating countries. The recommendations build on those proposed in the [AIMS III Phase 3](#).

Domestic actions: Strengthening foundations for cross-border power trade

Enabling conditions for cross-border power trade have progressed across the ASEAN region but remain uneven. Implementation priorities cannot follow a uniform checklist in every country; policies should be tailored to countries' implementation readiness. The recommendations below set out staged domestic priorities for policy makers, regulators and utilities to improve enabling conditions.

- Moving enabling conditions from an **early to emerging** stage requires establishing the foundational mandates, rules and technical capabilities to participate in cross-border power trade.
- Moving enabling conditions from an **emerging to established** stage requires developing predictable, transparent and consistently applied rules, regulations and frameworks. This supports larger-scale implementation and stronger interoperability and alignment with regional frameworks.

These recommendations focus on the criteria where key gaps were identified in Chapter 1 and are not intended as an exhaustive set of actions.⁹

Recommendations to improve domestic enablers

Sustained political support: To advance from an early to emerging stage, countries can formally recognise the role of cross-border power trade and interconnection in national energy, economic and sustainability agendas. This may be reflected by embedding interconnection and electricity trade into long-term national energy strategies. Political support is reflected through active participation in bilateral, sub-regional and ASEAN initiatives, including, for example, governmental endorsement of priority projects and co-operation initiatives.

To advance from an emerging to established stage, countries can translate political support into implementation by aligning domestic policies and actions with regional commitments with clear targets. Sustained political momentum beyond individual projects or political cycles is required, along with mechanisms to co-ordinate follow-up actions across government agencies.

Cross-institutional co-ordination: To move from an early to emerging stage, countries should establish formal co-ordination mechanisms involving relevant ministries, regulators, utilities and system operators to support planning, permitting, implementation and operation of cross-border power trade initiatives.

⁹ Though the assessment focuses on six ASEAN member states, the recommendations may also serve as a helpful reference for the development of domestic enablers in the other five ASEAN member states.

Existing inter-agency structures can be used or expanded to facilitate information sharing, joint decision-making and co-ordination on cross-border issues.

To move from an emerging to established stage, countries can designate lead institutions with clear responsibilities in advancing cross-border power trade, supported by well-defined accountability arrangements and co-ordination across government agencies and private sector stakeholders. Roles and responsibilities across government agencies, regulators, utilities and other stakeholders should be distinct and clearly defined. Singapore provides an example of structured co-ordination that links policy direction, regulation and project implementation, supported by clearly defined institutional responsibilities.

Subsea cable regulation: To advance from an early to emerging stage, countries considering subsea cables can clarify the rights and obligations of parties conducting subsea cable activities, including marine surveys, installation, maintenance, repair and cable protection. For example, the [Cross-Border Electricity Trade Framework](#) between Australia and Singapore provides guidance on cross-border subsea power cable activities of each country, including for surveys, installation and maintenance, vessel activities, and cable protection. Efforts to minimise timelines and uncertainty for cable repairs, such as pre-agreed vessel repair arrangements and authorisations, should be considered, given the high cost of potential business interruption in the event of cable damage.

To move from an emerging to established stage, countries can develop dedicated regulations governing subsea power cable activities, including cable laying, transit rights, protection and repairs. Such regulations should provide clarity under domestic law to complement multilateral governance, such as that provided by UNCLOS. Permitting requirements for subsea cables may also be clarified and streamlined. Issues that go beyond domestic permitting requirements, such as transit rights through third-country maritime zones, state consent, and co-ordinated access for cable laying and emergency repairs, may need to be addressed through cross-border co-operation arrangements.

Cost allocation and tariff regulations: To move from an early to emerging stage, countries may create a distinct cost recovery approach for transmission that is separate from energy sales. This allows the allocation of costs across users of the transmission network, which, for example, may contain a greater fixed cost component than energy sales. Designing these charges transparently, including disclosure of calculation approaches and formulas, provides the foundation for alignment for cross-border charges and can support investment planning.

To move from an emerging to established stage, countries can tailor cost recovery and revenue mechanisms to the type of investment sought. For example, infrastructure where commercial investment is sought may require higher permissible rates of return than those requiring investment from state-owned

utilities, while availability-based payments may improve predictability for investors. Several countries are in the process of developing and/or implementing domestic [TPA schemes](#) (e.g. Malaysia, Thailand and Viet Nam). Throughout their development, fairness and consistency of transmission tariffs and network charges between domestic users and cross-border users may be considered. Countries that establish transparent and credible cost allocation methodologies provide a strong starting point for cross-border tariff negotiations.

System planning: To move from an early to emerging stage, countries can strengthen national planning processes by integrating cross-border interconnectors into power sector development plans by considering neighbouring systems' supply-demand dynamics, and by introducing a minimum 10-year planning horizon supported by scenario analysis and probabilistic metrics. Depending on institutional arrangements, these activities may be undertaken by a dedicated planning agency or a combination of entities with planning responsibilities.

To move from an emerging to established stage, countries can align domestic planning with regionally agreed methodologies. These methodologies keep improving at each AIMS iteration and should eventually lean towards an [IRRP framework](#).

Grid infrastructure readiness: To move from an early to emerging stage, countries can prioritise addressing domestic transmission constraints that may limit cross-border exchanges. They may also establish monitoring mechanisms to assess transfer capability at proposed interconnection points.

To move from an emerging to established stage, it is necessary to develop more integrated high-voltage transmission networks. This should be supported by wide-area monitoring, improved controllability and dynamic system security assessment. Doing so will allow larger cross-border transfers and the integration of higher shares of variable renewable energy.

Financing model and asset ownership options: To move from an early to emerging stage, countries can conduct structured reviews for how key risks can be allocated and mitigated for priority interconnector projects and identify potential financing models. This requires engagement with lenders, guarantee and insurance providers and DFIs. Clear revenue visibility, risk management and risk allocation are prerequisites for commercial lending and non-recourse financing.

To move from an emerging to established stage, countries can pursue non-recourse financing options for specific interconnector assets – particularly for large subsea cables – to reduce balance sheet financing requirements, where revenue certainty and risk allocation is established. [Joint venture and investment trust structures](#) may also be considered to reduce balance sheet requirements while maintaining state oversight.

Selected recommendations to strengthen domestic enablers

	Priority Criteria	Early to emerging	Emerging to established
Governance	Sustained political support	Establish bilateral intergovernmental agreements for interconnector development and incorporating cross-border power trade into national energy strategies	Expand multilateral intergovernmental agreements with sustained political support
	Cross-institutional co-ordination mechanisms	Establish clear inter-agency co-ordination mechanisms for interconnector planning, permitting and delivery	Formalise cross-institutional co-ordination through standing committees, regular reporting and clear decision-making procedures
Regulatory	Subsea cable regulation	Develop provisions to address rights to conduct subsea cable activities (e.g., laying, transit, repair), including measures to minimise delays in cable repair	Develop dedicated regulations for subsea power cables aligned with international standards and supported by clearly mandated authorities
	Cost allocation and tariff regulations	Increase transparency of transmission tariff rates and calculation approach, distinct from energy sale tariffs	Tailor cost recovery mechanisms and rate of returns to the type of investment sought (e.g., SOE vs. private investor) and align with partners
Technical	System planning with interconnectors	Update planning practices with a 10 year-horizon, supported by probabilistic metrics, with inclusion of planned cross-border interconnectors	Participate in regional planning exercises and progressively align planning assumptions with ASEAN IRRP
	Grid infrastructure readiness	Address bottlenecks that may limit cross-border exchanges and monitor transfer capability near interconnection points	Consolidate wide-area monitoring and controllability on the transmission backbone, with dynamic system security assessment
Finance and commercial	Financing model and asset ownership options	Engage with lenders, insurers and DFIs to identify risk allocation and mitigation approaches and financing options	Pursue non-recourse financing options for specific interconnector assets where revenue certainty and risk management can be established

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Note: IRRP: Integrated Resource and Resilience Planning; SOE: State-owned enterprise; DFI: Development finance institution. Recommendations are not exhaustive and focus on key criteria where gaps are identified in Chapter 1.

Co-operation arrangements: From bilateral initiatives to regional frameworks

Co-operation arrangements can be advanced both through top-down and bottom-up processes. In the near term, bilateral and sub-regional initiatives offer an opportunity to introduce and test transparent and replicable co-operation arrangements. This can contribute to longer-term development of regional frameworks, supporting existing processes to build alignment among ASEAN member states. The recommendations are not intended to be exhaustive; they cover those considered to be the most critical.

Recommendations to improve co-operation arrangements

Institutional co-ordination: In the near term, institutional co-ordination can be strengthened through bilateral and sub-regional arrangements, building on existing initiatives, such as the LTMS-PIP. Priority actions include defining roles, responsibilities and co-ordination processes among governments, regulators, utilities and system operators through agreements and structures such as intergovernmental agreements, MoUs, joint statements and working groups. Existing regional institutions, including ACE, AERN, APGCC and HAPUA, can play a greater role in supporting co-ordination activities, facilitating information sharing and resolving cross-border issues.

In the longer term, as cross-border trade expands with increased multilateral power trading, ASEAN can progressively strengthen co-ordination across planning, regulatory and operational functions. Existing regional institutions may require enhanced mandates, roles and capacities. International experience suggests that establishing a dedicated regional body can be beneficial to carry out regulatory functions. In this context, the [AMS Regulatory Board](#) has been proposed under AIMS III Phase 3 to support regulatory co-ordination and oversee regional power trade, planning and system operations.

Regional CBA and project prioritisation: In the near term, ASEAN countries can pilot a CBA methodology that considers regional benefits of interconnector development beyond countries in which the asset is located. For example, upgrading the Malaysia-Thailand interconnector can bring benefits to Lao PDR and Singapore by facilitating LTMS trade. Similarly, developing or upgrading interconnectors between Brunei Darussalam, Indonesia, Malaysia and the Philippines can support multilateral trade through the BIMP-PIP corridor. A CBA with a regional or sub-regional assessment boundary may be applied, initially to the most advanced projects, to identify priority projects for targeted support. This could encompass both non-financial support (e.g. streamlined permitting) and financial support (e.g. project preparation and investment funding).

Selected recommendations to strengthen co-operation arrangements

	Governance	Regulatory			Technical		Finance and commercial
	Strong institutional co-ordination	Authorisation (e.g. licensing and permitting) durations	CBA and project prioritisation	Regional transmission pricing methodology	Grid codes	Data sharing	Financing and risk allocation model
Longer-term actions	Strengthen institutional arrangements to support regulatory co-ordination, planning and operation functions	Align authorisation processes, durations and renewal conditions for cross-border projects at the regional level	Develop mechanisms to support projects providing regional benefits (see financing recommendation)	Develop and implement harmonised regional transmission tariff and cost recovery frameworks	Develop regional guidelines for both HVAC and HVDC, before formalisation into a binding regional code	Implement a regional data-sharing framework	Systematically apply national and/or regional mechanisms to support project financing and de-risking
Near-term actions	Establish corridor-specific institutional arrangements and clearly defined roles among participating countries <i>(e.g. building on LTMS-PIP experience)</i>	Align authorisation durations with investment horizons <i>(e.g. alignment of export license duration in Indonesia-Singapore corridor)</i>	Pilot a regional CBA approach that considers regional externalities to identify priority projects with regional benefits <i>(e.g. test CBA approach for Malaysia-Thailand corridor considering benefits for LTMS-PIP trade)</i>	Develop transparent transmission pricing charge methodology for pathfinder corridors <i>(e.g. building on LTMS-PIP, testing in Indonesia-Singapore corridor if third-party cable ownership)</i>	Develop sub-regional voluntary guidelines for grid codes, and align early on HVDC-specific requirements <i>(e.g. building on Malaysia-Thailand HVDC experience)</i>	Agree on shared data platforms, common data standards and cybersecurity arrangements <i>(e.g. building on Lao PDR-Thailand operational experience)</i>	Develop and test risk allocation for pathfinder corridors; link to existing financing mechanisms (e.g. APGF) and public support (e.g. SGEI) <i>(e.g. test for projects in Indonesia-Singapore corridor)</i>
Related domestic enablers	- Political support for interconnectors - Cross-institutional co-ordination mechanisms	- Clarity of permitting framework - Cross-institutional co-ordination - Public consultation framework	- Transparent transmission tariff regulations - System planning with interconnectors and regional interdependencies	- Domestic grid infrastructure readiness - Domestic grid code provision for interconnectors	- Cross-border interconnection and trade rules - Transparent transmission tariff regulations	TSO capacity to collect and publish data	- Domestic financing conditions - Financing model optionality

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Note: APGF: APG Financing Initiative; CBA: Cost-benefit analysis; HVDC: High-voltage direct current; LTMS-PIP: Lao PDR-Thailand-Malaysia-Singapore Power Integration Project; SGEI: Singapore Energy Interconnections; TSO: Transmission system operator.

In the longer term, a harmonised CBA methodology could be developed with a regional and/or sub-regional assessment boundary and systematically applied to proposed projects. This can be coupled with formal mechanisms to support projects that bring net regional benefits and could utilise existing structures, such as the [ASEAN Power Grid Financing Initiative](#) and the [Partnership for ASEAN Connectivity on Energy](#), with commitments from MDBs and other regional and international financiers.

Licensing and permitting duration: Investors and lenders require certainty on licensing and renewal conditions across investment horizons. For example, a revoked export licence can turn a profitable project into a stranded asset. Further, licensing and permitting differ across ASEAN countries, both in terms of process and content. Obtaining these across two or more jurisdictions can be a time-consuming and complex undertaking. In the near term, countries seeking commercial investment in interconnectors should seek to align the duration of licences and permits – including export and import licences – with at least the expected payback period of interconnector projects, which may exceed 20 years. For example, the [Monsoon Wind Power Project](#) operates under a 28-year concession agreement with Lao PDR and a 25-year PPA with Vietnam Electricity.

In the longer term, to reduce the time and complexity (and therefore cost) of permitting and licensing, ASEAN member states could seek to develop more harmonised and consistent processes and requirements. These may include mechanisms to accelerate approvals for projects considered of strategic bilateral regional value. In the European Union, for example, interconnectors designated as PCIs and PMIs are [entitled to accelerated permitting procedures](#).

Develop regional transmission pricing and cost recovery mechanisms: In the near term, ASEAN countries can pilot transparent transmission pricing approaches in pathfinder corridors. A first step could be to disclose the wheeling charge methodology in the LTMS-PIP, such as the formula, cost components and charging structures applied. The Indonesia-Singapore and Malaysia (Sarawak)-Singapore corridors, which are among the first subsea corridors to secure commercial involvement, provide opportunities to develop and test transmission pricing regimes. To prepare for a scale-up of power trade, transmission pricing should consider [international principles](#) to support cost recovery, economic efficiency, fairness, and transparency and predictability. This includes efforts to avoid so-called “[tariff pancaking](#),” where multiple fees accumulate across borders and discourage power trade. In addition, standardised bilateral contracts (e.g. a voluntary PPA template) may be developed to improve consistency of treatment for participants in power trade.

In the longer term, ASEAN countries can build on experiences and approaches in pathfinder projects to develop harmonised transmission tariffs and cost recovery frameworks that can be applied elsewhere in the region.

Grid codes interoperability: Differences may exist in national grid codes between two interconnected systems, with TSOs agreeing on compatible technical requirements at the interconnection point. But such discrepancies may create barriers for scaling regional interconnections, as they add operational complexity and increase costs. Still, full harmonisation is not a precondition for trade: Europe traded across borders for years before adopting formal network codes between 2015 and 2017. In the near term, ASEAN countries in a shared corridor can start by developing a voluntary sub-regional guideline specifying interoperability requirements for new interconnectors, covering protection co-ordination, frequency and voltage requirements, fault ride-through, operational communications and emergency procedures.

In the longer term, ASEAN member states could move toward a regional guideline, covering both HVAC and HVDC interconnectors before agreeing on a binding regional grid code in line with the [AIMS roadmap](#) for multilateral power trade.

Cross-border data exchange and interoperability: What system operators can see across a border will impact how much interconnector capacity can be used securely. The LTMS-PIP is the region's most established data-sharing arrangement, supporting day-ahead and intra-day schedule exchange and emergency co-ordination among four TSOs. However, it remains corridor-specific, without real-time visibility of cross-border power flows or a common grid model. In the near term, participating countries can agree on minimum datasets for planning and operations, with common data standards and communication protocols. Governance arrangements covering data ownership, confidentiality and cybersecurity should be developed alongside these technical standards.

In the longer term, implementing a regional data framework building on the [ASEAN Energy Database System](#) will progressively support broader data sharing, from planning information to near real-time operational data and, eventually, market and settlement data.

Financing and risk allocation model: Interconnector projects must manage a [series of risks](#) throughout project development and operations. Technical, physical, permitting and access risks are heightened for subsea cables, while off-taker, price and demand risks vary depending on the commercial arrangements and project structure. These risks must be appropriately allocated and mitigated prior to financing, particularly where non-recourse financing structures are applied and commercial financing is desired. Today, given the novelty of subsea interconnectors in the region, there is limited experience and standardisation for how these risks are allocated and managed in practice. Risk allocation frameworks

and guidance for cross-border transmission projects can be developed for the ASEAN context. For example, the Singapore Sustainable Finance Association provides potential bankable [risk allocation matrices](#) for the Indonesia-Singapore and Malaysia (Sarawak)-Singapore corridors. These frameworks can inform where risks may be addressed through project structuring, and where public financing and de-risking support is required.

A range of actors can support risk management. DFIs and [export credit agencies](#) can anchor lending and confidence, coupled with a broad range of credit enhancement instruments, such as credit guarantees and political risk insurance. The insurance industry can provide commercial routes for risk transfer tailored for ASEAN interconnectors, while specialised funds can provide long-term currency hedging in the absence of liquid hedging markets. National participation in projects can play an important role, as seen with the appointment of SGEI to develop and operate cross-border electricity interconnections to enable power imports into Singapore. Similarly, the Government of Indonesia designated [Danantara Indonesia](#) to “spearhead” cross-border electricity trade between Singapore and Indonesia.

As the region gains experience in delivering interconnector projects, de-risking approaches can be standardised and scaled, ensuring that they are targeted to support risks that cannot be otherwise absorbed by commercial investors and lenders. This may include voluntary risk allocation templates that can be applied to projects with a mix of public and private participation. Market development initiatives can be pursued to attract a wider range of participants to the sector to provide a broader range of products and liquidity.

Annexes

Annex A: The APG Implementation Framework

Summary of the APG Implementation Framework

Dimension	Criteria	Description and measures
Country-level enablers		
Governance	Sustained political support for interconnectors	Existence and stability of bilateral or multilateral intergovernmental agreements, including evidence of sustained political support or decisions affecting interconnector development.
	Cross-institutional co-ordination mechanisms	Existence of formal co-ordination mechanisms and structure among ministries, the regulator and the transmission system operator; designation of a lead institution responsible for interconnector development.
	Public consultation frameworks	Existence of formal impact assessment and public consultation requirements for large grid projects; transparent public consultation records, including record of litigation or public opposition.
	Interconnector project experiences (land-based and subsea cable)	Delivery of overland cross-border infrastructure projects within the past 10 years and announced plans for cross-border subsea cable projects.
Regulatory	Cross-border interconnection and trade rules	Existence of published laws or regulations governing cross-border interconnectors, including their scope, responsible authorities, and the rights and obligations of participating parties (including, where relevant, frameworks from the telecommunications or maritime sector).
	Interconnector permitting and licensing framework clarity	Transparency and predictability of a legal and administrative framework for approving interconnector infrastructure and cross-border power trade, including the responsible authorities, required licences and approvals, approval conditions and duration, indicative timelines, and evidence of implementation in practice.
	Subsea cable regulation	Clarity of the national regulatory regime for the installation, protection, supervision and maintenance of subsea cables consistent with UNCLOS, under a clearly mandated lead authority with transparent permitting, and without cabotage or vessel restriction.

Dimension	Criteria	Description and measures
Country level enablers (continued)		
Regulatory (continued)	Domestic RECs framework	Existence of an active domestic REC market based on credible standards; presence of credible REC issuer(s); clarity on REC market governance.
	Transparent transmission tariffs and cost allocation	Clear and transparent tariff and charging mechanisms for network users, including generators and consumer groups.
	Revenue mechanism for transmission investors	Clear and predictable revenue mechanisms for investors in transmission, including revenue stability mechanisms (e.g. availability payments, cap and floor).
Technical	System planning with interconnectors	Regularly updated TSO plans, including robust quantitative system studies; inclusion of interconnectors that export/import power in national energy or power plans; consideration of interconnectors and neighbouring countries' supply/demand dynamics in planning methodologies.
	Grid infrastructure readiness to support cross-border power flows	Extent and voltage level of national transmission backbone; frequency of transmission-related system stress events; documented grid constraints; availability of stability enhancing equipment; level of grid controllability.
	Domestic experience with relevant grid technologies	Comparable assets in operation or construction in the country of relevant technologies (e.g. HVDC, High-capacity AC, subsea or offshore assets).
	Domestic grid codes provisions for interconnectors	Extent to which domestic grid codes incorporate interconnector connection requirements and cross-border operation scenarios.
	TSO data collection relevant to cross-border infrastructure	Existence of internal TSO processes for systematic data collection relevant to interconnector planning and operation (e.g. load flows, generation mix, grid topology, stability margins); regularity and quality of publicly available power system data; availability of data management systems to exchange data with external counterparts.
Finance and commercial	Domestic financing conditions	Considers the depth of domestic capital markets (e.g. long-tenor local currency loans, maturity of local bond markets) and currency stability (e.g. depreciation, volatility, availability of hedging products, convertibility).
	Creditworthiness of the utility	Ability of utility to take on debt and act as a creditworthy off-taker. Considers credit rating, balance sheet leverage, presence of cost-reflective tariffs and reliance on government support.
	Financing model and asset ownership options	Established mechanisms to manage key risks of transmission investments, ability to apply different financing models for transmission investments (e.g. SOE-led, concession, joint venture), and restrictions on private sector and/or foreign ownership of transmission.

Dimension	Criteria	Description and measures
Cross-border co-operation arrangements		
Governance	Institutional co-ordination on interconnection	Existence of bilateral or multilateral agreements or MoUs beyond the APG MoU, including participation in relevant working groups, committees or task forces on cross-border interconnections.
	Dispute resolution mechanisms	Transparent mechanisms to settle deviations in trade volumes and payment failures or delays, including settlement arrangements embedded in market frameworks and cross-border trading agreements.
	Aligned environmental and social framework	Aligned environmental and social framework with requirements for permitting and licensing for both overhead and submarine interconnectors.
Regulatory	Third-party access to the regional transmission network	Regulatory framework (e.g. transmission licence, connection and usage agreement) enabling TPA to the regional transmission network owned and operated by national TSOs for the purpose of cross-border electricity trade. These may include vertically integrated utilities or private IPPs with long-term agreements.
	Duration of cross-border licensing and permitting arrangements	Alignment and predictability of cross-border licensing arrangements, including length and renewal of export permits and wheeling agreements, in providing long-term investment certainty for interconnector development and operation.
	Cross-border REC framework	Involvement in cross-border transfer of RECs associated with grid-to-grid and/or generation-to-grid power trade; compatibility of countries' domestic RECs regulation and framework, including interoperable REC instruments and registries, attribute ownership and transfer, issuance and retirement, prevention of double counting, residual mix treatment, relevant geographic or physical deliverability requirements and time-matching intervals.
	Aligned cost-benefit analysis and project prioritisation	For CBA, aligned approach for assessing economic costs and benefits of interconnector projects and their distribution across countries. This can provide a starting point for discussions on project prioritisation and cost allocation.
	Transmission pricing and cost allocation	Agreed approach to cost allocation and transmission pricing, aligned with objectives of cost recovery, economic efficiency, fairness and transparency.
	Revenue model for interconnector investor	Alignment on the revenue structure and revenue determination for interconnector between participating countries, with mechanisms for revenue stability.

Dimension	Criteria	Description and measures
Cross-border co-operation arrangements (continued)		
Technical	Joint system planning and technical studies	Existence and depth of joint technical studies on interconnection feasibility and grid impacts; integration of the interconnector within national planning as a modelled scenario; alignment on key planning assumptions (e.g. demand forecasts); establishment of bilateral TSO-level technical working groups or task forces.
	Grid code interoperability and joint technical arrangements	Adoption of bilateral or sub-regional technical arrangements for grid code interoperability (e.g. connection, protection, frequency and voltage standards), including active TSO participation in harmonisation efforts and documented minimum interconnection requirements.
	Cable laying and access agreement	Agreements and rules for surveys, installation and maintenance, vessel activities and cable protection across all marine and land territories involved, including for maintenance and repair.
	Cross-border data exchange and interoperability	Existence and standardisation of data exchange arrangements between member states or TSOs (e.g. agreed data formats, communication protocols and interfaces) with identified responsible organisations, operationalisation of data-sharing processes (including frequency, scope and validation), and evidence of functional data exchange under existing bilateral arrangements or pilot projects.
	Operational procedures for cross-border scheduling, dispatch and real-time co-ordination	Joint operational procedures for cross-border scheduling and established communication and escalation protocols between control centres; regular conduct of joint operational drills or simulations.
Finance and commercial	Support for projects with regional benefits	Availability of mechanisms to support projects providing benefits to countries outside of those hosting the infrastructure.
	Financing and risk allocation framework	Alignment on risk management and risk allocation approaches for large-scale projects, such as through a risk allocation framework, and ability to apply cross-border financing arrangements.
	Supply chain co-ordination and joint procurement	Alignment on performance standards, contracting structures and procurement processes to improve visibility of demand for manufacturers and improve bargaining power of purchasing utilities and/or developers.
	Cross-border payment mechanism	Agreed payment mechanisms to collect tariffs and distribute payments across borders.

Annex B: Assessment of domestic enablers in participating countries

Indonesia: Assessment of domestic enablers for interconnector development

Criterion	Indonesia	Assessment
Governance		
Sustained political support for interconnectors	Emerging	Active engagement with Singapore and Malaysia on potential interconnectors and subsea exports. However, co-operation remains largely at MoU or exploratory stage, with regulatory and policy uncertainties (e.g. export conditions, domestic supply prioritisation) affecting implementation certainty.
Cross-institutional co-ordination mechanisms	Emerging	PLN, under the oversight and with close co-ordination with the Ministry of Energy and Mineral Resources (MEMR), oversees cross-border electricity co-operation.
Public consultation frameworks	Emerging	Large grid projects must undergo an AMDAL (Environmental Impact Assessment), governed by Law No. 32 of 2009 as amended by the Job Creation Law, with procedures detailed in Government Regulation No. 22 of 2021 (PP 22/2021). Public consultation with directly affected communities is mandatory during the scoping and assessment phases. PLN conducted a series of public consultations for HVAC lines in Java and Sumatera.
Interconnector project experiences (land based)	Established	PLN imports electricity from Sarawak (Malaysia) to supply West Kalimantan via a 275 kV interconnection, including two phases: Import Phase (Sarawak-Kalbar) and Exim Phase (two-way export-import).
Interconnector project experiences (subsea cable)	Early	Indonesia-Singapore co-operation of electricity trade includes the exploration of a subsea interconnector.
Regulatory		
Cross-border interconnection and trade rules	Emerging	Under GR 42/2012 , cross-border electricity is allowed under the following conditions: (1) Domestic electricity needs have been met; (2) The selling price of electricity is not subsidised; and (3) Cross-border electricity sales must not interfere with the quality and reliability of domestic supply. Under GR 40/2025 , Article 28, point (c) PLN has centralised export-import authority.
Permitting framework clarity	Emerging	Law No. 30 of 2009 on electricity, amended by Law No. 6 of 2023 , centralises licensing authority and simplifies permitting for nationally strategic infrastructure. The MEMR issue approvals, permits or licences for power business activities. PLN is the sole owner and operator of transmission networks. Overlaps between land offices, local governments and PLN for transmission lines cross multiple districts with differing spatial plans and land acquisition practices (land acquisition is governed under Law No. 2 of 2012 and its amendments).
Subsea cable regulation	Emerging	No dedicated regulation in electricity sector on subsea cables. Other relevant regulations include Act of Republic of Indonesia on the Indonesia Exclusive Economic Zone, Art 4(3) ; Ministerial Decree (Kepmen KP) No. 14 of 2021, issued by the Ministry of Marine Affairs and Fisheries (KKP), concerning submarine pipelines and cable systems; Act No. 6 of 8 August 1996 regarding Indonesian Waters, Art 9, Art 22 ; Government Regulation No. 52 of 2000 Regarding Telecommunications Operation . No specified regulatory duration.
Domestic RECs framework	Emerging	Active domestic REC market through PLN REC scheme, aligned with IREC. PLN issuer for grid-based RECs, I-REC issuance by the international issuer, Green Certificate Company (GCC). No independent national REC governance body.
Transparent transmission tariffs and cost allocation	Early	No explicit or published transmission tariff methodology.
Revenue mechanism for transmission investor	Early	Transmission is bundled with generation, with cost recovery at PLN corporate level.

Criterion	Indonesia	Assessment
Technical		
System planning with interconnectors	Emerging	Presidential decree mandates all cross-border interconnection must be included in long-term electricity planning through PLN's RUPTL, a 10-year electricity supply business plan. However, interconnector projects are intended to serve domestic needs first before cross-border power exchange. Cross-border international interconnection features at feasibility-study stage (USTDA grant for Sumatra-Malaysia and Kalimantan-Sabah studies, March 2024). MoU with Singapore on cross-border electricity trade signed June 2025.
Grid infrastructure readiness	Emerging	Extensive high-voltage transmission assets, including a 500 kV Java-Bali backbone and 275 kV/500 kV backbone in Sumatra. Power system spans across separate island systems, with internal bottlenecks and reliability constraints in several corridors. Planning documents and project assessments point to the need for major network expansion, digitalisation and stronger inter-island links. SCADA/EMS is being deployed across distribution under the World Bank I-ENET programme (2024-2029), but large portions of the system remain manually operated. FACTS and digital substations planned under RUPTL 2025-2034 but not yet widely deployed. Peak demand: ~47 GW nationally (2024).
Domestic grid codes provisions for interconnectors	Emerging	Law No. 30 of 2009 on electricity, amended by Law No. 6 of 2023 explicitly allows cross-border electricity interconnection, subject to government approval and national interest considerations. GR 42/2012 , amended by GR No. 23/2014 , supplemented by GR 25/2021 , regulates electricity supply business activities, including construction and operation of transmission lines; and national and transnational interconnection approvals under MEMR authority. PLN Grid Codes apply uniformly to all connections to the PLN transmission network, including large lines, yet designed for domestic system not explicitly for cross-border. The harmonisation with Sarawak Energy was conducted on a case-by-case basis; both countries compared their codes and selected the best provisions, applying the result only to that specific interconnector. This harmonisation process only existed with Malaysia, not yet with Singapore, but offers a precedent of bilateral technical harmonisation.
Domestic experience with relevant grid technologies	Emerging	Indonesia has substantial experience with high-capacity AC transmission (Kalimantan-Sarawak interconnection has been operational since 2016) and is now planning major HVDC projects, including the Sumatra-Java interconnection, but comparable HVDC interconnector assets are not yet in operation. Publicly available material points to project planning and concept-stage subsea HVDC experience rather than operational experience.
TSO data collection relevant to cross-border infrastructure	Emerging	PLN has established data collection and planning processes sufficient for domestic RUPTL preparation and is deploying SCADA/EMS in core regions. No existing mechanism for transmitting real-time or historical grid data to external partners, and significant portions of the network are manually operated.
Finance and commercial		
Domestic financing conditions	Emerging	Currency: 10-year annual depreciation against USD of 2.0%. Up to five years currency hedging available with thin liquidity. Depth of domestic capital markets: Domestic lending often uncompetitive with USD lending. Short tenor loans (<5 years) in energy sector, though DFIs moving towards longer tenor project finance. Average interest rate for PLN is 5.4-6.1%.
Creditworthiness of the utility	Emerging	PLN is rated BBB investment grade with 3.2x net debt/earnings before interest, taxes, depreciation and amortisation (EBITDA). Highly dependent on support from Ministry of Finance, with 30% of revenues in 2023 coming from compensation payments and subsidy due to non-cost reflective retail tariffs set below cost, and mandate to supply electricity to rural areas. Government support perceived as reliable.
Financing model and asset ownership options	Early	PLN currently relies on SOE balance sheet financing across its business areas. Third-party ownership models are being explored, but there is not yet a clear legal basis for them. Some domestic transmission lines are also being considered for privately owned project finance structures, although this has not been publicly disclosed.

Lao PDR: Assessment of domestic enablers for interconnector development

Criterion	Lao PDR	Assessment
Governance		
Sustained political support for interconnectors	Established	Extensive network of formal bilateral agreements with Cambodia, China, Thailand and Viet Nam. Proven track record as a regional power exporter, including participation in LTMS-PIP. No major reversals; strong and consistent political backing for cross-border interconnections.
Cross-institutional co-ordination mechanisms	Emerging	The Ministry of Industry and Commerce acts as the lead institution, working closely with EDL. No substantive evidence of formalised multi-agency governance structures.
Public consultation frameworks	Emerging	Environment impact assessment (EIA) is mandatory for large transmission and export-oriented projects under the Environmental Protection Law (2012) and EIA Decree (2019/2022), including mitigation measures for affected communities. Governance is centralised, with limited evidence of litigation or formal challenge mechanisms in practice.
Interconnector project experiences (land based)	Established	Operational cross-border interconnections include the Lao PDR-China 500 kV link (COD 2025), Lao PDR-Viet Nam (572 MW, COD 2018-2022), and GMS links with Thailand (230 kV) and Cambodia (115 kV). Participation in LTMS-PIP demonstrates growing multilateral trade integration.
Interconnector project experiences (subsea cable)	N/A	Not applicable.
Regulatory		
Cross-border interconnection and trade rules	Emerging	The Electricity Law (2017) provides a high-level framework for cross-border co-operation, technical standardisation and system integrity. The Ministry of Industry and Commerce (MOIC) and EDL/EDL-T hold primary institutional and operational responsibilities, with no detailed or dedicated cross-border trade regime specified.
Permitting framework clarity	Emerging	Permitting follows a centralised, government-led process (plan inclusion, MOIC approval and bilateral agreement negotiation), without statutory timelines. Approvals are case specific. The two-grid structure streamlines export projects, with established cross-border developments delivered broadly in line with government planning and intergovernmental agreements.
Domestic RECs framework	Early	An active voluntary REC market operates under the I-REC Standard. However, there is no government-designated national issuer, registry, or central governance body; issuance and tracking are conducted via international platforms (e.g. GCC).
Subsea cable regulation	N/A	Not applicable.
Transparent transmission tariffs and cost allocation	Emerging	Tariff rates and methodology not disclosed, with tariff reform ongoing under 2025-2029 tariff roadmap.
Revenue mechanism for transmission investor	Emerging	Transmission usage fees to be paid by EDL to EDL-T.
Technical		
System planning with interconnectors	Emerging	National planning frameworks (National Power Development Strategy 2021-2030, and Power Development Plan 2026-2035) prioritise cross-border interconnection as a central policy objective, with EDL-T mandated for implementation. However, planning remains export contract driven, with limited multi-scenario analysis and no regularised long-term (>10-year) planning cycle.
Grid infrastructure readiness	Early	The transmission system comprises four regional 115-230 kV grids with moderate interconnection. Cross-border infrastructure includes several IPP-led generation-to-grid transmission lines to China, Thailand and Viet Nam, including 500 kV links, developed under concession-based SPVs that will transfer to the Lao PDR government at the end of their concession periods. However, fragmented domestic integration, reliance on concession-based export lines and limited advanced grid technologies constrain system-wide optimisation and resilience.

Criterion	Lao PDR	Assessment
Technical (continued)		
Domestic grid codes provisions for interconnectors	Early	Synchronous links with Thailand apply Thai grid code requirements, while interconnections with Cambodia and Viet Nam remain asynchronous. No formal national grid codes are currently published, although domestic grid and interconnection codes, supported by the Japan International Cooperation Agency, are under development and near finalisation.
Domestic experience with relevant grid technologies	Emerging	Lao PDR has operational cross-border AC interconnections at 115 kV, 230 kV and selected 500 kV levels with Cambodia, China, Thailand and Viet Nam, indicating practical experience in high-voltage AC cross-border integration. However, infrastructure development and technical operations are largely led by counterpart utilities (e.g. CSG, EGAT, EVN), reflecting limited domestic engineering and system integration capacity within EDL. There is no deployment of HVDC, subsea cables or advanced long-distance transmission technologies.
TSO data collection relevant to cross-border infrastructure	Emerging	EDL participates in structured operational data exchange under LTMS-PIP (day-ahead to next-day scheduling). Beyond this corridor, data systems remain limited, as is the public availability of validated national system data.
Finance and commercial		
Domestic financing conditions	Early	Currency stability: Heavy 10-year annual depreciation against USD of 10.3%. Currency hedging markets are nascent, established in 2022 , and highly regulated. Depth of domestic capital markets: domestic banks provide mostly short- to medium-term, relatively high-cost financing; long-tenor (>10-year) local currency lending is not yet established. Lending is constrained by macro instability, high inflation and financial sector vulnerabilities . The need to deepen local currency bond markets to improve maturity and financing conditions is highlighted by ADB , AMRO .
Creditworthiness of the utility	Early	Financial reports not published since 2019. However, secondary sources highlight persistent operational losses with high debt burden from over-building of hydropower, liabilities from take-or-pay PPAs and currency depreciation. Non-cost reflective tariffs transitioning to cost reflectivity.
Financing model and asset ownership options	Emerging	Historically, transmission financing is a state monopoly under EDL, transitioned in 2024 to a whole-of-grid concession to EDL-T (90% owned by China Southern Grid and 10% by EDL). SPV models with private sector ownership have been commonly applied for cross-border generation-to-grid lines under long-term concession agreements.

Malaysia: Assessment of domestic enablers for interconnector development

Criterion	Malaysia	Assessment
Governance		
Sustained political support for interconnectors	Established	Formal and operational interconnections with Thailand and Singapore, participation in LTMS-PIP, Viet Nam-Malaysia-Singapore offshore wind project. Supported by stable bilateral agreements and consistent policy support, with no major reversals observed. Continued engagement in regional initiatives indicates durable commitment. Energy Exchange Malaysia (ENEGEM) Auction first introduced in 2024 as a dedicated platform for cross-border green electricity trade.
Cross-institutional co-ordination mechanisms	Emerging	The Ministry of Energy Transition and Water Transformation of Malaysia (PETRA) and state-owned utility TNB act as the lead institutions in LTMS. Sarawak Energy Berhad (SEB) is the lead institution in Sarawak-West Kalimantan. Limited public evidence of co-ordination with other institutions.
Public consultation frameworks	Emerging	Under the Environmental Quality Act 1974 (Section 34A) and EIA Order 2015 , transmission infrastructure must undergo EIA approval . Public participation is required, typically via public display and stakeholder consultation, although guidance on depth and access is limited and varies by state. No public information of former litigation cases.
Interconnector project experiences (land based)	Established	LTMS Phase 1 (2022: 100 MW import from Lao PDR to Thailand and Malaysia into Singapore) and Phase 2 (2024-2026: 200 MW); Sarawak-West Kalimantan 275kV HVAC ; Viet Nam-Malaysia-Singapore offshore wind project .
Interconnector project experiences (subsea cable)	Early	Singapore and Malaysia announced co-operation on electricity trade, with plans to import renewable electricity from Sarawak via subsea cables spanning over 700 kilometres.
Regulatory		
Cross-border interconnection and trade rules	Established	Established relevant regulatory frameworks: Electricity Supply Act 1990 , amended in 2025 (New Part IVA – Importation and Exportation of Electricity; Section 22D - Electricity importing or exporting licensing; Section 4, subsections 4(la) and 4(lb) – Energy Commission license and regulate electricity import and export). Guide for CBES (2024) - Licensing requirement for interconnections with Singapore and Thailand.
Permitting framework clarity	Established	Electricity Supply Act empowers the Energy Commission to license, regulate and enforce cross-border electricity trade, with ministerial approval. Licence term up to 21 years. CBES defines roles (Energy Commission, ENEGEM, Single Buyer, the Grid System Operator, TNB) and requirements, without fixed statutory timelines. Operational/near-term projects (e.g. ENEGEM CBES-RE pilot exports; LTMS-PIP wheeling) were approved and executed within planned windows.
Domestic RECs framework	Established	Malaysia operates a voluntary REC market: TNBX issues and manages mRECs via mGATS; SEDA acts as verifier and links to international registries (e.g. Tradable Instrument for Global Renewables (TIGR) / APX). PETRA sets policy and market design, while the Energy Commission oversees electricity and green attributes.
Subsea cable regulation	Early	No specific regulations for electricity subsea cables, but there are applicable general regulations: Exclusive Economic Zone Act 1984: Sect 22, 23; Merchant Shipping Ordinance 1952; Continental Shelf Act 1966 Law of the Sea; 6. (1) The Yang di-Pertuan Agong (j); Penal Code, 431A. Mischief by injury to telegraph cable, wire, etc.
Transparent transmission tariffs and cost allocation	Established	Published tariffs and methodology by ST Malaysia under incentive-based regulation .
Revenue mechanism for transmission investor	Established	ST Malaysia sets the allowed revenue for regulated business entities such as TNB's transmission unit, using target profit margin of 7.3% for TNB from 2025 to 2027.
Technical		

Criterion	Malaysia	Assessment
System planning with interconnectors	Emerging	Malaysia's NETR (August 2023) identifies cross-border interconnection as a planning pillar with targets to 2050, though at policy level. The Generation Development Plan (updated in 2025) treats imports and exports as exogenous. Interconnector energy is non-firm unless secured by firm PPAs and reflected in the Export and Import Plan.
Grid infrastructure readiness	Established	Mature 132/275/500 kV Peninsular grid with high reliability (99.79% availability, ~1.6% losses, no recurring load shedding) and cross-border links to Singapore and Thailand. GSO operates within TNB under Energy Commission oversight using SCADA/EMS with real-time monitoring. Key constraint is fragmented grids (TNB, SEB, SESB), though the Sarawak-Sabah interconnection was energised in January 2026.
Domestic grid codes provisions for interconnectors	Established	Published Grid Code applies to high-voltage transmission projects. CBES defines connection and access arrangements, System Access Agreements, compliance with Malaysian Grid Code, capacity limits, dispatch co-ordination, scheduling, and metering/settlement. CBES-RE chapter integrates grid access with ENEGEM auctions, providing an end-to-end pathway from connection to dispatch and settlement. Malaysia's Grid Code (2010, amended 2020) includes operational provisions for interconnector scheduling and dispatch, applied to links with Singapore and Thailand. The Energy Commission enforces these rules. Regulatory fragmentation across Peninsular, Sarawak and Sabah, each with separate grid codes and oversight regimes.
Domestic experience with relevant grid technologies	Established	300 MW HVDC to Thailand (longstanding operation), 230 kV submarine power cables to Singapore (200 MW, upgraded 2022), 500/275 kV HVAC backbone in Sarawak (SCORE corridor), and SEB's prior engineering work on the Bakun HVDC/subsea cable project. TNB's nine-country international operations also provide advanced grid engineering exposure.
TSO data collection relevant to cross-border infrastructure	Established	Malaysia actively participates in LTMS-PIP, as transit country and 100 MW supplier (since 2024). ENEGEM provides centralised data, pricing and settlement. The CBPTIA (September 2024) formalises Malaysia-Singapore operations. The Grid Code standardises data reporting; GSO, TNB and Energy Commission publish operational and cross-border data.
Finance and commercial		
Domestic financing conditions	Established	Currency stability: 10-year annual appreciation against USD of 0.1%, with moderate volatility. Short-term and long-term currency hedging products available. Depth of domestic capital markets: Commercial lending available at competitive rates relative to international lenders and regional peers, including experience with large-scale renewable energy projects . Active sukuk (Islamic bond) market, consisting of around half of new government bond issuance .
Creditworthiness of the utility	Established	TNB is rated A- , with moderate leverage ratios (2.3x net debt/EBITDA). Cost-reflective retail tariffs allow for cost recovery.
Financing model and asset ownership options	Emerging	TNB owns transmission lines, typically financed on balance sheet, with private sector participation limited to debt provision. Non-recourse finance is being considered for cross-border subsea cables such as Sarawak-Singapore and Viet Nam-Peninsular Malaysia.

Singapore: Assessment of domestic enablers for interconnector development

Criterion	Singapore	Assessment
Governance		
Sustained political support for interconnectors	Established	Clear and sustained political commitment. Established the LTMS-PIP in 2022, which was the first multilateral power trading in the ASEAN region. Issued conditional approvals and licences for potential electricity imports from Australia, Cambodia, Indonesia, Malaysia and Viet Nam. Consistent policy direction, active pursuit of new interconnections, including subsea imports, and a target to import 6 GW of clean energy by 2035 reinforce the commitment. In addition, Singapore's strategy also emphasises diversifying electricity imports across multiple source countries to strengthen energy security.
Cross-institutional co-ordination mechanisms	Established	The EMA leads oversight of cross-border interconnections. SGEI was established in April 2025, appointed by the government to develop and operate cross-border electricity interconnections to enable power imports into Singapore.
Public consultation frameworks	Emerging	The Ministry of Trade and Industry and EMA routinely conduct formal consultations on legislative and regulatory changes, including the May-June 2024 Electricity Act amendments. However, there is limited evidence of project-level consultation requirements for large grid projects. Infrastructure-related consultation occurs mainly through planning or environmental processes, rather than broad project-wide public consultation. No public record of litigation related to grid or cross-border electricity projects was identified.
Interconnector project experiences (land based)	N/A	Existing interconnection between Malaysia and Singapore is subsea. LTMS Phase 1 (2022: 100 MW import from Lao PDR to Thailand and Malaysia into Singapore) and Phase 2 (2024-2026: 200 MW); Sembcorp Power 50 MW pilot trial for power imports from Malaysia under ENEGEM; conditional approvals granted to long-distance projects including Australia, Sarawak and Viet Nam.
Interconnector project experiences (subsea cable)	Early	Several agreements have been announced: 1) Sarawak-Singapore project , expected to commence operations around 2035, with plans in place to transmit electricity from hydropower in Sarawak via subsea cables spanning > 700 km; 2) Singapore-Indonesia , which includes the development of a subsea interconnector to import electricity from Indonesia to Singapore; and 3) Singapore-Viet Nam , with a signed agreement to develop a new electricity link, including subsea cables from Viet Nam to Peninsular Malaysia and then to Singapore.
Regulatory		
Cross-border interconnection and trade rules	Established	Key regulatory frameworks include the EMA Guide to Electricity Imports (2022), Chapter 4 (EMA, 1 Jan 2024), Section 1.1.1A; and the Electricity Act 2001, Part 3, Section 6(1)e regarding prohibition on unlicensed import and export, Section 9(1)e - EMA's authority to license import/export as well as Section 3(3)(ea)(iii) - EMA's authority to develop import/export infrastructure in or outside the country. There are also guidelines for Deployment and Repair of Submarine Cable Systems .
Permitting framework clarity	Established	Electricity Act 2001, Part 3, Article 9: EMA may grant or extend electricity licences, including transmission licences. The EMA Guide to Electricity Imports (2022) with provide details on the electricity import licensing process and responsibilities. EMA also provides preliminary signals of regulatory support via a conditional approval, followed by a Conditional Licence, en route to the final award of an Importer Licence
Domestic RECs framework	Established	The Singapore Standard 673: Code of Practice for Renewable Energy Certificates provides guidance to market actors on credible REC transactions within the Singapore context. Commercial REC instruments, I-RECs and TIGRs, are in common use and each have their own designated REC issuers.

Criterion	Singapore	Assessment
Regulatory (continued)		
Subsea cable regulation	Established	Relevant frameworks include the Electricity Act 2001, Part 10, Article 85, which addresses damage to submarine electricity cables, and the Singapore-Australia Cross-Border Electricity Trade Framework, Singapore's guidelines on regulatory approvals for large-scale electricity imports with specific guidance on regulatory process, timelines and relevant government agencies.
Transparent transmission tariffs and cost allocation	Established	Network charges and use-of-system charges are published online. While the specific formula for calculating transmission charges is not published, the overall approach (cost recovery plus allowable return) is documented.
Revenue mechanism for transmission investor	Established	Regulated revenue calculated from costs and an allowed return on SP PowerAssets (SPPA) regulated asset base under "commonly accepted economic and financial principles". SPPA financial reports indicate return on equity of between 9-12% in 2023 and 2024. SGEI may participate in co-developing specific interconnectors, however its revenue model is not known.
Technical		
System planning with interconnectors	Established	Singapore plans electricity infrastructure on a rolling 10-year horizon, updated annually and incorporating interconnector needs.
Grid infrastructure readiness	Established	SP PowerGrid operates a meshed 230 kV and 400 kV high-voltage network, with EMA noting Singapore's strong electricity system reliability. EMA/SP Group's Future Grid Capabilities Roadmap and ongoing investments aim to accommodate larger power imports. The HVAC link with Malaysia has been operational since the 1980s and was recently upgraded to a capacity of 2 x 500 MVA.
Domestic grid codes provisions for interconnectors	Established	Relevant frameworks include the EMA Transmission Code and EMA's Guide to Electricity Imports .
Domestic experience with relevant grid technologies	Emerging	Singapore has no operational power HVDC interconnector but has practical cross-border import experience through LTMS-PIP using the HVAC link with Malaysia, operational since the 1980s. HVDC and subsea power experience remains prospective, although conditional approvals were granted to several long-distance projects, including Australia, Sarawak and Viet Nam.
TSO data collection relevant to cross-border infrastructure	Established	Singapore participates in the LTMS-PIP operational data-sharing platform (day-ahead, intra-day and next-business-day schedules). EMA publishes comprehensive annual electricity statistics, market data and generation mix. SP Group operates advanced SCADA/EMS with real-time network monitoring.
Finance and commercial		
Domestic financing conditions	Established	Currency stability: 10-year annual appreciation against USD of 1.1%, with exchange rates managed against a trade-weighted basket of currencies. Freely convertible currency with short-term and long-term hedging products available. Depth of domestic capital markets: Singapore is a major financial hub with domestic financial institutions lending at competitive rates and deep bond markets.
Creditworthiness of the utility	Established	SP Group has an AA+ credit rating and 0.9x net debt/EBITDA , supported by fully cost-reflective retail tariffs and EMA-regulated allowable return on equity. SGEI may participate in co-developing specific interconnectors, but its financial position is not known.
Financing model and asset ownership options	Emerging	The national grid remains fully state-owned through SP Group. While private ownership is being considered for electricity import projects, SGEI (established in 2025) may develop and operate cross-border electricity interconnectors and may co-develop or invest in such interconnectors where there is a strategic case to do so.

Thailand: Assessment of domestic enablers for interconnector development

Criterion	Thailand	Assessment
Governance		
Sustained political support for interconnectors	Emerging	Participation in LTMS-PIP and multiple bilateral arrangements with Lao PDR and Malaysia. However, future expansion of cross-border trade focused on bilateral generation-to-grid arrangements. There is still uncertainty with the existing HVDC interconnection with Malaysia as it is reaching the project lifetime.
Cross-institutional co-ordination mechanisms	Emerging	EGAT acts as the lead institution, with limited public information of co-ordination with other institutions from Thailand (e.g. other ministries, regulator, TSO). Under LTM system access agreement and LTMS Energy Wheeling Agreement , EGAT was involved together with other national utilities (i.e. EDL, TNB) under the APGCC and HAPUA.
Public consultation frameworks	Emerging	In large-scale energy projects, EGAT is required to perform an EIA , which involves mandatory public consultations and stakeholder engagement. No public information of former litigation cases.
Interconnector project experiences (land based)	Established	Established track record of projects , including Thailand-Malaysia 300 MW HDVC interconnection 2002; Thailand-Lao PDR grid-to-grid interconnection; Thailand-Lao PDR generation-to-grid interconnection (5 943 MW in total capacity, COD 1998-2020).
Interconnector project experiences (subsea cable)	N/A	Not applicable.
Regulatory		
Cross-border interconnection and trade rules	Emerging	EGAT Act, B.E.2511 , Section 6 and Section 9, include relevant clauses but do not explicitly address cross-border interconnectors.
Permitting framework clarity	Emerging	All construction of transmission networks is EGAT's responsibility. The Energy Industry Act B.E. 2550 (2007) permits other applicants to obtain an electricity transmission licence, though EGAT is the only entity which has been awarded. Connection to the transmission grid requires a PPA with the Metropolitan Electricity Authority (MEA), Provincial Electricity Authority (PEA) or EGAT, including requirements on grid connectivity and metering. Grid connectivity is regulated by the MEA and PEA regarding safety standards, equipment, etc.
Domestic RECs framework	Established	Thailand has an active domestic REC market. EGAT is the designated local issuer . Thailand uses I-RECs, which met international standards requirements (e.g. RE100) and provided key quality references for the Greenhouse Gas Protocol Scope 2 Guidance .
Subsea cable regulation	Emerging	Relevant established regulatory frameworks include Act on Navigation in Thai Waters B.E 2456, Section 209-211; Telecommunications Business Act B.E 2544 (2001), Section 44, 72, 73 . EGAT implements and constructs subsea cable projects . PEA is responsible for procuring and managing power distribution, substations and submarine power cables to Thai islands and remote provinces. All subject to approval of the Cabinet. No approval timeline is specified.
Transparent transmission tariffs and cost allocation	Established	Transmission service fee published online as component of wholesale electricity rates and designed to reflect costs. Tariff formula not published, but approach for cost recovery is documented.
Revenue mechanism for transmission investor	Established	EGAT revenue based on cost recovery plus allowable rate of return on invested capital, with a range of 4.7-5.7% in 2015.

Criterion	Thailand	Assessment
Technical		
System planning with interconnectors	Emerging	Power development plan (PDP) is not regularly updated, and timelines are inconsistent. The latest draft PDP 2026-2050 was released for public consultation in September 2026, following the draft PDP 2024-2037 which was not formally adopted while the last official PDP was PDP 2018 revision 1 approved in 2020. Prior to the draft PDP 2026-2050, while cross-border interconnectors were incorporated into PDP, planning remains limited to single-scenario analysis despite a long-term horizon and regional market ambitions. The draft PDP 2026-2050 included four scenarios although not officially adopted.
Grid infrastructure readiness	Established	The connection rules in the EGAT grid connection code 2568/2025 are applicable for grid-to-grid and large-scale generation-to-grid projects in other countries (foreign >90MW). It has been applied to several projects. Thailand operates a meshed 500/230/115 kV transmission network with multiple interconnections, including AC links with Malaysia and a 300 kV HVDC link with Malaysia. System reliability is high, supported by grid support devices, wide-area monitoring, grid-code synchronisation with Lao PDR and interconnection capacity of around 1.5 GW (about 5% of peak demand).
Domestic grid codes provisions for interconnectors	Established	EGAT grid code (operation code) has minimum technical standards for grid interconnections from other TSO. Existing challenges in domestic harmonisation first, i.e. PEA and MEA operate two distinct grids without harmonised grid codes.
Domestic experience with relevant grid technologies	Emerging	Thailand has operational HVDC experience through the 300 MW, 300 kV Thailand-Malaysia link and a mature high-voltage backbone, but no operational power-sector subsea cables or offshore grid assets. Offshore wind remains at an early planning stage. Subsea experience is limited to telecommunications cables, including international systems such as TalayLink and ADC.
TSO data collection relevant to cross-border infrastructure	Established	LTMS-PIP participants exchange operational schedules through EGAT's LTMS web-based platform, covering day-ahead, intra-day and next-business-day timelines. The long-term vision includes progressive enhancements , e.g. real-time power flow monitoring, emergency event reporting, flow-based capacity calculations, and the development of Common Grid Models for harmonised regional operational planning. However, beyond LTMS, formal bilateral data-sharing mechanisms do not exist.
Finance and commercial		
Domestic financing conditions	Established	Currency stability: 10-year annual appreciation against USD of 1.1%, with rising volatility. Only short-term hedging instruments available. Depth of domestic capital markets: Thailand has an active and deep domestic project finance market. Thailand corporates have also tapped the green bond market to raise capital. Cost of debt from domestic financial institutions is very competitive (~3-4%) relative to international lenders.
Creditworthiness of the utility	Established	EGAT is rated BBB+ , with relatively strong financial fundamentals , including low leverage ratios of 1.0x net debt/EBITDA and high operating cash flow ratios (103%). Cost-reflective retail tariffs improve financial sustainability.
Financing model and asset ownership options	Early	100% state ownership in transmission is required, with private sector participation limited to lending to EGAT.

Viet Nam: Assessment of domestic enablers for interconnector development

Criterion	Viet Nam	Assessment
Governance		
Sustained political support for interconnectors	Emerging	Existing bilateral interconnections (notably with Cambodia , China and Lao PDR) and growing engagement with Singapore and Malaysia. With Lao PDR: under strategic agreement and MoU signed between the two governments. With Cambodia and China: through PPAs between the two governments. However, expansion into broader multilateral trade remains at negotiation stage and uncertain long-term policy direction on exports.
Cross-institutional co-ordination mechanisms	Emerging	For the cross-border interconnector development or electricity trade, EVN is the lead institution under the guidance of the Ministry of Industry and Trade (MOIT).
Public consultation frameworks	Emerging	Under the Law on Environmental Protection 2020 and Decree 08/2022 (amended by Decree 05/2025) , large infrastructure and power projects must conduct EIA with mandatory public consultation. Project owners must consult affected communities and local authorities, including meetings and written feedback, covering at least two-thirds of affected persons. No strong record of court litigation; disputes are typically administrative.
Interconnector project experiences (land based)	Established	Lao PDR-Viet Nam 500 kV Interconnector Monsoon; Viet Nam-Cambodia 230 kV Interconnection; China-Viet Nam: 220 kV transmission lines, Malungtang-Ha Giang and Maquan-Lao Cai, total capacity 550 MW. Malaysia (TNB/Petronas); Singapore (Sembcorp), and Viet Nam (PetroVietnam Technical Services Corporation) trilateral agreement in mid-2025 for offshore wind export through subsea cables.
Interconnector project experiences (subsea cable)	Early	Singapore and Viet Nam signed an agreement to develop electricity link, including a feasibility study of exporting renewable energy from Viet Nam via subsea cable to Peninsular Malaysia, which will be transmitted overland to Singapore.
Regulatory		
Cross-border interconnection and trade rules	Emerging	Law on Electricity 2024 , Article 46, allows cross-border trade via the national grid or direct connections and assigns MOIT responsibility for planning, approvals, pricing and operating conditions. Circular No. 03/2025/TT-BCT , Article 3, specifies plan requirements for cross-border projects. MOIT Decision No. 1007/QĐ-BCT (April 2025) sets tariff ceilings for imports from Lao PDR and allows PPAs of up to 25 years.
Permitting framework clarity	Emerging	Law on Electricity 2024 , Chapter 4, sets the licensing basis for electricity activities, including transmission. Circular No. 03/2025/TT-BCT sets permitting procedures for cross-border projects and applies to EVN and other market participants. MOIT leads policy and approvals, the Electricity Authority of Viet Nam supports regulation, EVN acts as system operator and PPA counterparty, and PDP8 (approved by the prime minister) provides planning direction.
Domestic RECs framework	Emerging	An active voluntary REC market operates under the I-REC standard and TIGR, but no local entities are recognised as certified issuers and no national REC governance body has been designated.
Subsea cable regulation	Emerging	The Penal Code , Article 241, provides penalties for breaching safety rules in operating electricity works. The Law of the Sea of Viet Nam 2012 , Article 16(2), requires written approval from competent authorities for submarine cables and pipelines in the exclusive economic zone. Law No. 24/2023/QH15 on Telecommunications , including Article 5, provides for the safety and security of telecommunications infrastructure. No specified regulatory duration.
Transparent transmission tariffs and cost allocation	Established	Annually set transmission tariff subject to regulatory approval. The regulated annual transmission revenue is calculated based on capital costs, operations and maintenance costs, allowable profit and revenue adjustment, with methodology published in MOIT Decree 14/2025 .
Revenue mechanism for transmission investor	Established	The allowable profit is set using a target return on equity of 3% (in MOIT Decree 14/2025). This is consistent with a SOE-led sector, though would not be sufficient to attract private investment.

Criterion	Viet Nam	Assessment
Technical		
System planning with interconnectors	Established	Viet Nam's PDP8, approved in May 2023 and revised in April 2025 (Decision 768), sets 2030/2050 targets with multi-scenario projections (150-236 GW by 2030) and explicit cross-border modelling for China and Lao PDR. It includes imports, HVDC studies, and ASEAN link research, but defines volumes top-down without corridor-specific targets. Implementation guidance (Decision 1509) followed within 45 days. ASEAN interconnections beyond China and Lao PDR remain largely aspirational, with quantitative modelling still at study stage.
Grid infrastructure readiness	Emerging	The National Power Transmission Corporation (EVNNPT), with dispatch separated to the National Power System and Market Operator (NSMO) since August 2024, operates 153 substations and 25 236 km of lines, including 7 996 km at 500 kV. The backbone has been strengthened (e.g. Quang Trach-Pho Noi, 2024), with operational links to China and Lao PDR. However, North-South congestion persists, with no HVDC or Flexible Alternating Current Transmission System deployed and incomplete wide-area monitoring.
Domestic grid codes provisions for interconnectors	Emerging	Law on Electricity 2024 , Circular No. 03/2025/TT-BCT and PDP8 provide the procedural basis for cross-border connections. Technical requirements are not consolidated in a dedicated interconnector grid code. Projects rely on national grid codes, EVN technical standards and bilateral technical arrangements at the border. Implementation is evidenced by Viet Nam-Lao PDR interconnections with approved tariffs, PPAs and grid integration. Viet Nam's transmission framework is governed by MOIT regulations and EVNNPT standards. The revised PDP8 (April 2025) mandates HVDC/UHVDC development and internationalised grid readiness. However, interconnections rely on back-to-back HVDC without harmonised grid codes, and no formally adopted provisions for interconnector-specific requirements are published.
Domestic experience with relevant grid technologies	Emerging	EVNNPT's 500 kV HVAC backbone and cross-border AC operations (China, Lao PDR) reflect strong large-scale transmission capability. PDP8 mandates HVDC/UHVDC studies and future ASEAN links, but no HVDC or subsea cables are operational.
TSO data collection relevant to cross-border infrastructure	Emerging	EVNNPT operates nationwide SCADA/EMS systems, with ongoing digitalisation and strengthened data governance following NSMO's separation (August 2024). Bilateral co-ordination with China demonstrates functional data exchange. However, cross-border data standards and protocols remain not fully formalised.
Finance and commercial		
Domestic financing conditions	Emerging	Currency stability: 10-year annual depreciation against USD of 1.6%. Short-term currency hedging markets, with low liquidity for long-term (>3-5 years) products. VND is not freely convertible and subject to controls by the State Bank of Viet Nam . Depth of domestic capital markets: Long-tenor loans (15+ years) available at competitive rates. However, there are concerns about whether the domestic market can support the scale-up needed for PDP8 and provide sufficient non-recourse project finance.
Creditworthiness of the utility	Emerging	EVN is rated BB+ with stable outlook. 5.2x net debt/EBITDA. EVN has faced financial pressures in recent years due to rising fuel prices and high feed-in tariff rates, though returned to profit in 2025 . Electricity tariffs are non-cost reflective, increasing exposure to fuel price volatility, and transitioning to cost-reflective tariffs .
Financing model and asset ownership options	Early	The Electricity Law (2024) includes provisions to attract "all economic sectors" to participate in energy sector investment, including transmission. However, EVN maintains state monopoly of important transmission lines of 220 kV and above, essentially limiting private sector equity investment to lower-voltage lines. Project finance models remain untested in Viet Nam.

Abbreviations and acronyms

AC	Alternating current
ABOM	Agreement Between Operating Members
ACE	ASEAN Centre for Energy
ADB	Asian Development Bank
ACER	Agency for the Cooperation of Energy Regulators
AERN	ASEAN Energy Regulators Network
AIMS	ASEAN Interconnection Masterplan Study
AMRO	ASEAN+3 Macroeconomic Research Office
APG	ASEAN Power Grid
APGCC	ASEAN Power Grid Consultative Committee
APGF	ASEAN Power Grid Financing Initiative
ASEAN	Association of Southeast Asian Nations
ASEC	ASEAN Secretariat
BIMP-PIP	Brunei Darussalam, Indonesia, Malaysia and the Philippines Power Integration Project
CAPEX	Capital expenditure
CBA	Cost-benefit analysis
CBCA	Cross-border cost allocation
CBES	Cross-border Electricity Sales
CBPTIA	Cross-border Power Trade Interconnection Agreement
CDMER	Council of Directors of the MER
CRIE	Regional Electricity Interconnection Commission
DFI	Development finance institution
E&S	Environment and social
EBITDA	Earnings before interest, taxes, depreciation and amortisation
ECOWAS	Economic Community of West African States
EDL	Électricité du Laos
EDL-T	Électricité du Laos Transmission Company
EGAT	Electricity Generating Authority of Thailand
EIA	Environment impact assessment
EMA	Energy Market Authority (Singapore)
EMS	Energy Management System
ENEGEM	Energy Exchange Malaysia
ENTSO-E	European Network of Transmission System Operators for Electricity
EOR	Regional Operator (Central America)
EPR	Empresa Propietaria de la Red
ERERA	ECOWAS Regional Electricity Regulatory Authority
EVNNPT	Viet Nam's National Power Transmission Corporation
GCC	Green Certificate Company
GMS	Greater Mekong Subregion
HAPUA	Heads of ASEAN Power Utilities/Authorities
HVAC	High-voltage alternating current

HVDC	High-voltage direct current
I-REC	International Renewable Energy Certificate
IGMoU	Intergovernmental Memorandum of Understanding
IPP	Independent power producer
IRRP	Integrated Resource and Resilience Planning
ITP	Independent transmission project
IUMoU	Inter-Utility Memorandum of Understanding
kV	Kilovolt
LCC	Line-Commutated Converter
LTM-PIP	Lao PDR-Thailand-Malaysia Power Integration Project
LTMS-PIP	Lao PDR-Thailand-Malaysia-Singapore Power Integration Project
MDB	Multilateral development bank
MEA	Metropolitan Electricity Authority (Thailand)
MEMR	Ministry of Energy and Mineral Resources (Indonesia)
MER	Central America Regional Electricity Market
MOIC	Ministry of Industry and Commerce (Lao PDR)
MOIT	Ministry of Industry and Trade (Viet Nam)
MoU	Memorandum of Understanding
MW	Megawatt
NSMO	National Power System and Market Operator (Viet Nam)
OPEX	Operational expenditure
PCI	Project of common interest
PDP	Power development plan
PEA	Provincial Electricity Authority (Thailand)
PETRA	Ministry of Energy Transition and Water Transformation of Malaysia
PLN	Indonesia's state electricity company
PMI	Project of mutual interest
PPA	Power purchase agreement
REC	Renewable energy certificate
RERA	Regional Energy Regulators Association
RTCA	Regional transmission cost allocation
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SCADA	Supervisory Control and Data Acquisition
SEB	Sarawak Energy Berhad (Malaysia)
SEDA	Sustainable Energy Development Authority (Malaysia)
SGEI	Singapore Energy Interconnections Pte Ltd
SIEPAC	Central American Electrical Interconnection System
SOE	State-owned enterprise
SPPA	Singapore's SP PowerAssets
SPV	Special purpose vehicle
ST	Suruhanjaya Tenaga Malaysia
TIGR	Tradable Instrument for Global Renewables
TNB	Tenaga Nasional Berhad
TNBX	Tenaga Nasional Berhad subsidiary

TPA	Third-party access
TSO	Transmission system operator
TYNDP	Ten-Year Network Development Plan
UNCLOS	United Nations Convention on the Law of the Sea
VSC-HVDC	Voltage Source Converter High-Voltage Direct Current
WACC	Weighted average cost of capital
WAPP	West African Power Pool
WAPP-ITS	Interconnection transmission system

See the [IEA glossary](#) for a further explanation of many of the terms used in this report.

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