Scaling up cross-border renewable electricity trade: Opportunities and enablers for scale-up in ASEAN

Executive Roundtable - Summary of outcomes

Energy Asia | 27 June 2023

About the roundtable

Scaling up cross-border renewable electricity trade: Opportunities and enablers for scale-up in ASEAN

On 27 June 2023, an executive roundtable was held at Energy Asia 2023 in Kuala Lumpur.

The objective of the roundtable was to catalyse more robust and impactful dialogue on the benefits, trade-offs, and enablers required to scale-up cross-border renewable electricity trade in Southeast Asia. In addition, the roundtable explored how an interconnected ASEAN grid could contribute towards socioeconomic benefits and just energy transition objectives of the region. The roundtable fostered an atmosphere of collaboration and unity, welcoming a diverse set of participants and perspectives– towards building a powerful coalition to catalyse action on this critical topic.

There were over 30 participants comprising senior leaders from the public sector, power sector regulators, power producers, power offtakers, subject matter experts, and cross-ASEAN integration entities contributed diverse diverse perspectives and viewpoints on the topic. The roundtable focused on the size of opportunity from cross-border renewable electricity trade and what is required to enable it including trade-offs to manage, barriers to unblock, and enablers to establish.

The roundtable was hosted and facilitated by Gentari and the Boston Consulting Group.

About Energy Asia

Energy Asia 2023: Charting Pathways for a Sustainable Asia

Energy Asia advances the region's Net Zero ambitions by bringing together policy makers, industry captains, and energy professionals through actionable solutions for a just and responsible energy transition.

Spanning 3 days from 26– 28 June 2023, the Energy Asia conference is poised to deliver riveting thought leadership discussions alongside a showcase of cutting-edge technologies and solutions.

About this report

This report aims to present a comprehensive summary of the outcomes derived from the roundtable discussions, highlighting key points, recommendations and actionable insights generated. Leveraging these perspectives, we want to inspire action across ASEAN to further progress cross-border renewable electricity trade in the region.

Scaling up cross-border renewable electricity trade

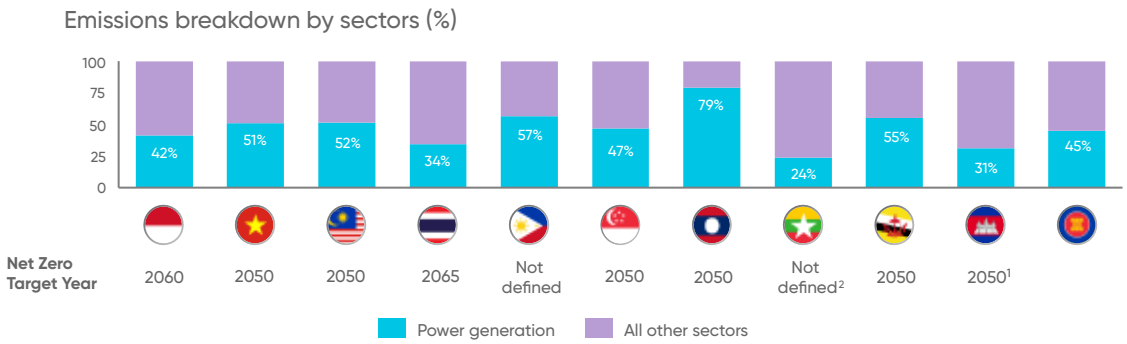
Demand: The power sector decarbonisation imperative in Southeast Asia

From a country standpoint, 8 ASEAN member countries have committed to national Net Zero or carbon neutrality targets[1] . A majority of countries have set 2050 as the target year to achieve Net Zero, with only Indonesia (2060) and Thailand (2065) committing to target years beyond 2050. To achieve these Net Zero ambitions as well as near-term Nationally Determined Contributions (NDCs), the decarbonisation of the power sector as a major source of emissions is critical.

Across Southeast Asia, the power sector contributes to 45% of total emissions. In the four highest emissions countries in the region which collectively contribute more than 80% of the region's emissions, the power sector emissions contribution is significant – Indonesia (42%), Vietnam (51%), Thailand (34%), and Malaysia (52%). A key contributor to the emissions of the power sector is the prevalence power generation using fossil fuel - with coal and natural gas being the dominant fuel sources - which makes up approximately ~75% of ASEAN power sector generation.

Figure 1: Power generation emissions contribution by ASEAN countries

Power sector contributes ~45% of ASEAN's total emissions – key to decarbonise sector to achieve country Net Zero and NDCs



Note: NDCs = Nationally Determined Contributions
1. Carbon neutral pledge 2. Myanmar commits to achieve net-zero from land use, land use change and forestry (LULUCF) by 2040
Source: IEA

From a corporate standpoint, Net Zero and decarbonisation commitments have also accelerated, where ~130 companies domiciled in Southeast Asia have made commitments to science-based targets (SBTi), a stark increase from 9 companies in 2020. The offtake of renewable energy is key to corporate efforts to achieve Net Zero, as a key lever to decarbonise purchased energy or Scope 2 emissions of corporates. Corporates are also committing to RE100, which requires signatories to comply to a minimum of 50% renewable electricity share across global operations by 2025 and 100% by 2050[2]. Currently, over 25% of RE100 companies worldwide have operations based in Southeast Asia.

The effects of corporate renewable energy demand are already being felt in the region. The redemption of international renewable energy certificates (i-RECs), representing a key mechanism for corporates to offtake renewable power, has increased from 3 TWh (2020) to 9 TWh (2022) and 11 TWh (Jan-Apr 2023) in Southeast Asia. These trends are expected to continue as an increasing number of corporates translate their decarbonisation targets to execution in the coming years.

From a consumer standpoint, demand is expected to remain relatively nascent, contingent upon the demand for renewables at both national and corporate levels. However, with increased green consumer consciousness, the contribution of consumer demand on renewable electricity demand is also expected to grow.

1. Cambodia with a carbon neutral 2050 target, Philippines without a Net Zero target, Myanmar with targets only on LULUCF emissions
2. However, RE100 signatories have also voluntarily made more ambitious targets, with RE100 average target year to achieve 100% renewable energy offtake of signatories currently standing at 2031

Figure 2: Corporate demand for renewable energy in Southeast Asia

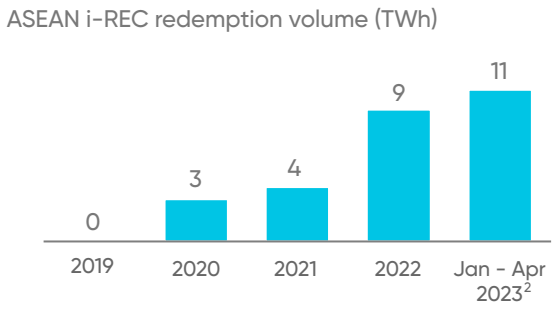
Corporate demand for renewable power is increasing, fueling fast growing REC demand growth in the region

Growing corporate commitments to decarbonise and offtake renewable energy...

26% of RE100 companies worldwide have operations in ASEAN

128 ASEAN companies have made SBTI commitments in 2023

...increasing i-RECs demand as a means for corporates to offtake renewable power

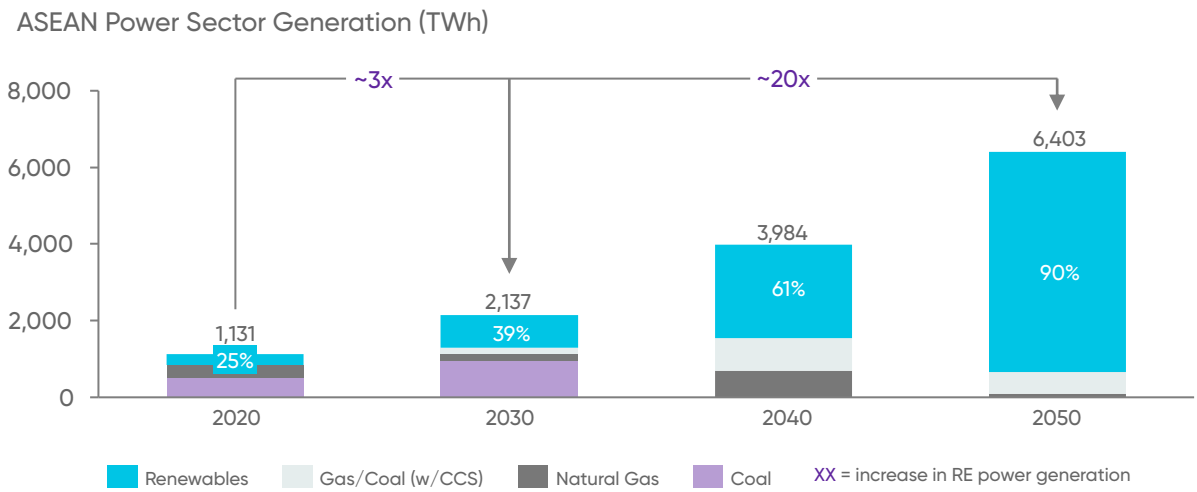


1. International Renewable Energy Certificates (IRECs) are the internationally used standard to certify the renewable origin of electricity, each IREC accounts for 1 MWh of renewable electricity consumed; 2. As of 30th April 2023
Source: The RE 100, Science Based Targets, S&P Global

To decarbonise the power sector, the scale-up of renewables will be critical. To be compatible with a 1.50C world, estimates indicate that renewable penetration will need to increase to 90% of the total power generation mix by 2050 for Southeast Asia which represents a ~20 times increase compared to current levels of renewable power generation. Countries have also begun to announce renewable power penetration targets compatible with country decarbonisation pathways. For example, Malaysia recently announced a target of 70% renewable power generation share by 2050 which is a ~9 times increase from current levels; whilst Indonesia has announced a target of 100% renewable power generation by 2060 which is a ~30 times increase from current levels.

Figure 3: Projected renewable energy requirements in ASEAN to meet climate goals

Scale-up of renewables renewables° is key for 1.5° pathway - need to to achieve ~40% renewable share of power generation by 2030 and ~90% by 2050



1. Projection of power sector generation breakdown required to reach net-zero emissions globally by 2050 based on IRENA 1.5-S 90% renewable energy pathway; where ASEAN achieves close to 90% renewable energy penetration overall with country-level variations on level of penetration
Source: IRENA

Supply: ASEAN's advantaged endowments for renewable energy production

Southeast Asia's natural endowments provide tremendous potential for large-scale, cost-competitive renewable power production. These endowments, among others, include high solar irradiance due to its proximity to the equator, hydropower and geothermal potential from its natural landscape and bioenergy potential due to complementarities with a large agriculture sector. Collectively, the region has the potential to produce over 17 TW of renewable power, which is 6 times the amount needed to meet capacity requirements to achieve 90% renewable power penetration in Southeast Asia for compatible with a 1.50C world.

Despite the natural endowment advantages, the region is barely scratching the surface in realising its full renewable power production potential. For most renewable power sources, less than 1% of the total renewable power potential is being realised in most countries, especially in geothermal, biomass, solar, and wind. Indonesia and Myanmar represent the countries with the largest renewable power production potential in the region, and both these countries have realised less than 1% of the renewable energy production potential across all sources of renewable power in the country. Countries have differentiated advantages in various sources of renewable power production, with the largest geothermal and wind energy potential in some particularly concentrated and certain countries in the region.

Figure 4: ASEAN's renewable energy technical potential and current potential realised

Region has tremendous technical potential for renewable production – less than 1% of potential is being realised

ASEAN's Renewable Energy Technical Potential for Power Generation[1] (GW)

	Solar	Onshore Wind	Offshore Wind	Biomass	Hydro	Geothermal	Total
Myanmar	5,310	2	-2	1	40	-	5,353
Indonesia	2,898	20	589	43	95	30	3,675
Thailand	3,509	32	30	18	15	-	3,604
Cambodia	1,597	3	89	-	10	-	1,698
Viet Nam	844	31	322	9	35	0.3	1,241
Lao PDR	983	12	-	1	26	0.1	1,022
Malaysia	337	-	53	4	29	-	423
Philippines	123	4	69	0.2	11	4	211
Brunei	2	-	-	-	0.1	-	2.0
Singapore	0.3	0.1	-	-	-	-	0.4
Total	15,603	104	1152	77	261	34	17,230

% of Total Potential Realised: >50% | 10%-50% | <10%

1. Technical potential calculated based on data provided by national bodies or extracted from the PLEXOS World model
Source: IRENA, US EIA

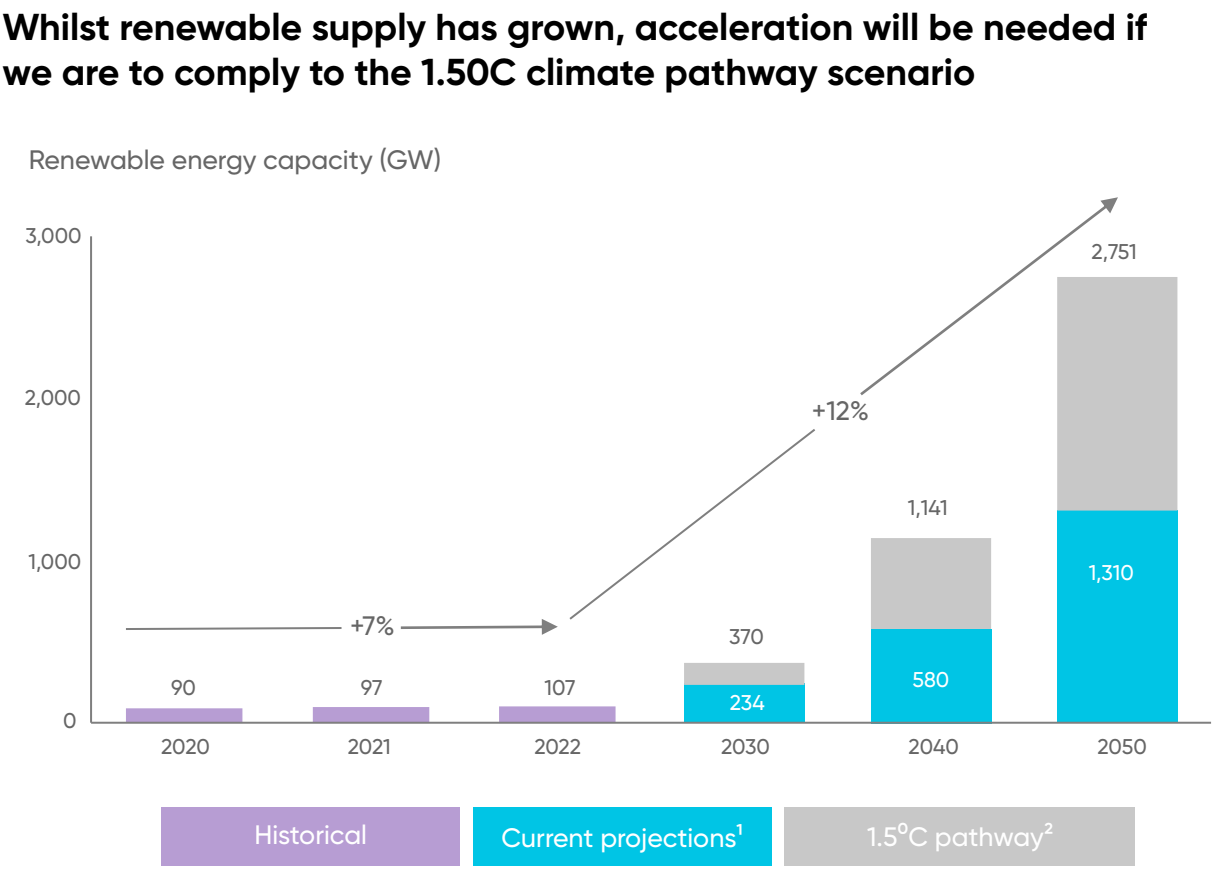
Renewable development outlook falling short versus climate pathway scenario needs

Countries have progressively announced more ambitious renewable power penetration targets through various power development plans released over time. Based on current plans, expected objectives, and policies in place at the end of 2022, the collective renewable capacity of the region is expected to morethan double between 2022 to 2030 from 102 GW to 234 GW, and increase to 580 GW by 2040 and 1,310 GW by 2050.

Whilst the step up in renewable power capacity outlook is noteworthy, the region will fall short of the anticipated renewable power capacity required to be compatible with a 1.50C scenario. Moreover, the gap between the renewable capacity required against the renewable capacity planned increases with time, rising from 36% (2030) to 49% (2040) and 52% (2050). By 2050, an incremental amount of ~1,400 GW renewable energy capacity will need to be added across the region over current plans.

Critically, the renewable endowments of the region collectively are not a limiting factor. Even with the incremental ~1,400 GW of renewable energy capacity needed, Southeast Asia will only be realising ~16% of its total renewable power production potential. This raises the inevitable question– what are the key barriers preventing the scale-up of renewable power development and how can these barriers be unblocked in order to realise the potential of the rich renewable endowments across the region.

Figure 5: Renewable energy capacity outlook compared to climate pathway scenario needs



1. Planned Energy Scenario: Projections based on current plans and other expected objectives/policies in place as of Oct 2022
2. 1.50C Scenario : Projections of renewable energy capacity required to reach net-zero emissions globally by 2050 with 90% renewable energy pathway; where ASEAN achieves close to 90% renewable energy penetration overall with country-level variations on level of penetration. Source: IRENA

Closing the Gap: Unblocking barriers to catalyse renewable power scale-up

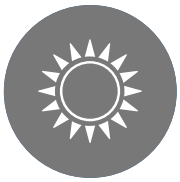
There are both thematic regional and country-specific barriers which are preventing the scale-up of renewable power in Southeast Asian countries. Specifically, we explore three critical and inter-related barriers which prohibit the acceleration of renewable power scale-up in the region:

Figure 6: Key barriers preventing the scale-up of renewable energy in Southeast Asia

Several key barriers exist in Southeast Asia that are preventing the scale-up of renewable energy

Large scale investment and private capital

Project and renewable integration costs



Limited natural endowment in specific ASEAN countries

Mobilisation of large-scale investments

Large-scale investments into both renewable generation development, energy storage, and grid infrastructure will be required for the scale-up of renewables. A recent study by IEA showed that the US$ 10 billion of average annual capital expenditure that has been deployed into solar PV and wind power over the last five years in Southeast Asia represents one of the lowest level of investment globally, only exceeding Sub-Saharan Africa. One of the drivers was a heavy reliance on public capital. In Southeast Asia, private capital constitutes only 60% of renewable power investments, compared to around 90% in advanced economies[3].

> **"In Southeast Asia, private capital constitutes only 60% of renewable power investments, compared to around 90% in advanced economies[3].**

However, the financial risk-weighted attractiveness of private sector investment in Southeast Asia falls short of developed markets. Return risks of renewable projects remain high given a range of development, operational, and economic risks– including risks such as curtailment from grid congestion – compounded with gaps in regulatory frameworks to ensure appropriate risk allocation. Other cited challenges include limited capital for early-stage project development, sub-scale projects, and the lack of a robust pipeline of renewable energy projects, which has reduced the bankability and increased the cost of capital for renewable investments. Mobilising various sources of finance such as blended finance will also be needed to unlock capital for key grid infrastructure upgrades required to accommodate higher levels of renewable power penetration.

Moreover, the full revenue upside potential of renewable resources or are not being fully realised due to limitations in market-based instruments, channeling green corporate green corporate demand into green premiums for power producers. For example, corporate virtual power purchase agreements (vPPAs) which enable corporates to offtake renewable power from an offsite renewable energy source are only available in Singapore and Malaysia within Southeast Asia.

3. Research published by IEA 2023, " ASEAN Renewables: Opportunities and Challenges ASEAN Renewables: Opportunities and Challenges "

Renewable project costs and renewables integration cost impact

Despite technology improvements decreasing the levelised cost of electricity (LCOE) for renewables globally, project costs remain relatively inflated in Southeast Asia. This is driven by several factors including the lack of deployment scale and limited maturity of the supply chain amid high local content requirements. To strengthen cost competitiveness, enhanced certainty in the pipeline of projects and increased attractiveness of demand opportunities will be key to incentivise supply chain players to invest at-scale into capital machinery, technology, and building skills and capabilities.

Beyond the cost of renewable projects, driving down the overall system cost impact of renewable integration is key. Given the intermittency of renewables, investments into grid infrastructure, energy storage solutions, or strengthening buffers through the reserve margin will be needed, in addition to grid infrastructure investments to connect sources of renewable supply and energy demand. The combination of these investments need to create inflationary pressures on system costs, posing a trade-off along energy trilemma dimensions of sustainability and affordability for end consumers.

Natural resource endowment limitations of certain Southeast Asian countries

Whilst Southeast Asia represents a renewable rich region, the natural renewable endowments are not evenly distributed across countries in the region. Primarily limited by factors of production, including land space, countries such as Singapore or Brunei are significantly constrained in their ability to scale-up domestic renewable power in a cost-competitive manner given current technologies. Moreover, limitations in mechanisms for cross-border renewable power trade limits the ability of these resource- scarce countries to channel domestic demand towards the development of renewable power elsewhere in the region with enhanced renewable resource endowments.

Cross-border power trade and its role in driving renewables scale-up

The most apparent benefit of cross-border trade is to lower the overall cost of decarbonisation by concentrating renewable power generation where the cost of generation is most competitive, and connecting this to meet demands centres where the need for renewable power is greatest across the region. This allows renewable resource rich countries to monetise their comparative advantage in cost-competitive renewable power generation, while resource scarce countries can benefit by having access to renewable power at a relatively lower cost. However, the benefits of cross-border power trade extend far beyond as there are significant benefits which can be unlocked through a large electricity grid network.

Reduced reserve margins and energy storage investment needs

Cross-border trade will provide member countries access to a larger grid which will enable electricity tobe supplied at acceptable levels of reliability with a lower reserve margin. Currently, reserve margins are optimised on an individual country-level in Southeast Asia, which requires a higher reserve margins compared to pooled and optimised reserve margins at a regional level. Lowering the reserve margins will reduce the need for country investments into capacity, in particular peaking capacity, which increases with high variable renewable energy (VRE) penetration. For example, the Western European interconnection of the EU grid enabled reserve margin requirements to reduce by 7-10%.

> **"The Western European interconnection of the EU grid enabled reserve margin requirements to reduce by 7-10%[4]**

In addition, the need and costs of energy storage will decline as energy storage capacity can be pooled and developed cost competitively. Collectively, this will reduce the system costs of member countries, and these system cost benefits will increase in tandem with the level of renewable energy penetration.

4. Research published by UN 2006, "Multi Dimensional Issues in International Electric Power Grid Interconnections"

Demand-side load balancing curve and supply-side seasonal complementarities

Southeast Asian countries have differing load curves given differences in consumer consumption profiles, time differences, and seasonality variations which result in different peak power demand across the region. Enabled by interconnectivity, the larger combined grid would, as a result, benefit from the "flattening" of the load curve which represents a reduction in the ratio of annual peak hours to non-peak hours. This enables the reduction of system costs, as baseload generation plants benefit from a higher capacity factor. It also results in cost savings as power plants run more efficiently with higher utilisation.

Beyond demand-side complementarities, there are also significant supply-side complementarities across various sources of VRE production in the region. One example is hydropower resources, where the dry season in Laos and Vietnam, where hydropower production is low, coincides with the wet season in Malaysia and Indonesia, and vice versa. Other examples include complementarity across various renewable sources including solar and wind sources across the region. Collectively, this also reduces therisk of curtailment due to local country demand deficiency at a point in time.

System reliability, flexibility, and security

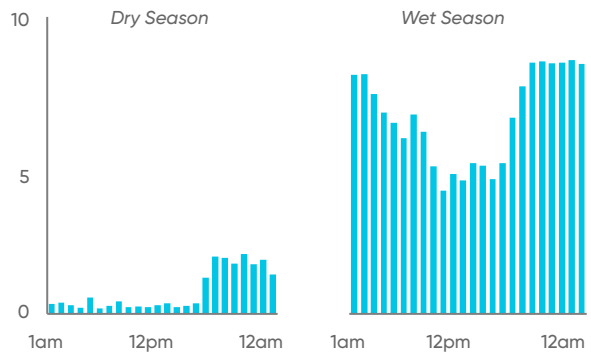
A larger grid also provides strengthened reliability and flexibility for demand response, especially in a system with high intermittency due to VRE penetration. For example, solar power generation is influenced by the amount of cloud cover, and with a larger geographically distributed grid, the risks or power system reliability impacts due to VRE is significantly reduced. This is a significant value proposition especially for industrial consumers. Interconnections also strengthen energy security through the shaping of the provision of operating reserve, especially during times of emergencies.

Figure 7: Supply-side complementarities due to seasonality effects for renewables

Cross-border trade will enable ASEAN countries to benefit from complementarities in seasonal hydropower resources

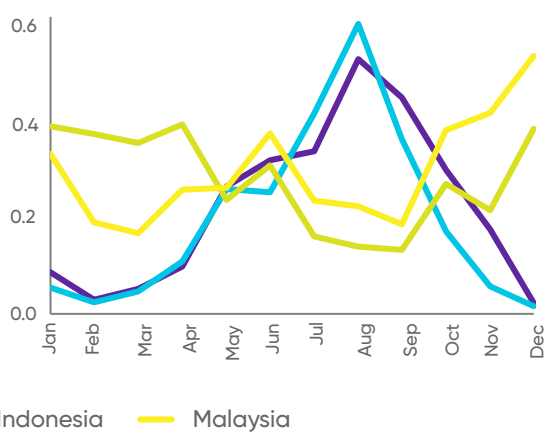
Significantly different hydropower output in dry and wet seasons

Projected hydro generation of Lao PDR in 2035 (GW)[1]



Vietnam-Laos and Malaysia-Indonesia have complementary wet-dry season timings

Average monthly precipitation[1] (mm/hour)

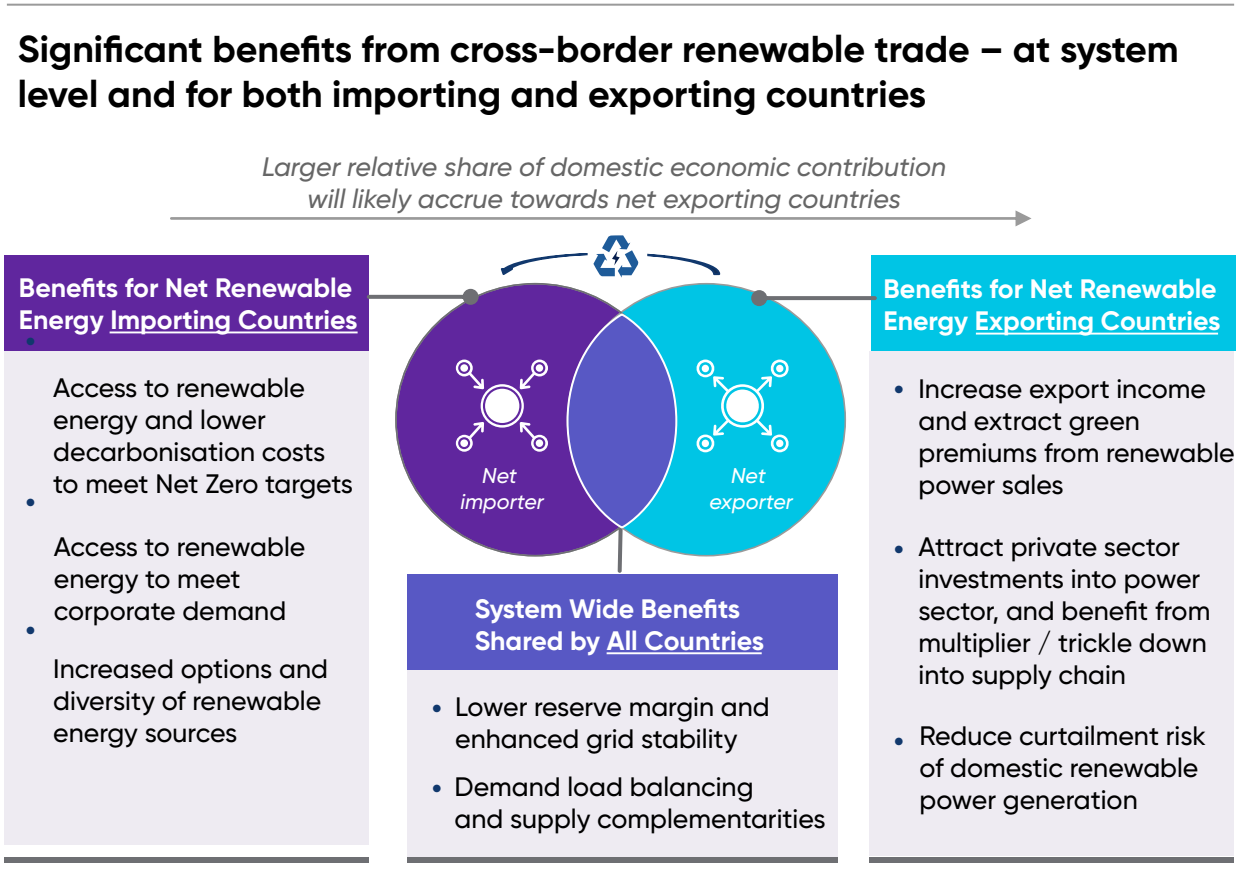


1. Calculated using PLEXOS projections with guidance from national power development plans and technical potential of Laos; 2. 2019 data; selected countries (Laos, Malaysia, Indonesia and Vietnam) are the top countries in terms of hydropower generation in ASEAN. Source: PLEXOS model, NASA MERRA, BCG analysis

Moreover, increased cross-border renewable power trade specifically addresses key identified barriers which are currently inhibiting the scale-up of renewables:

- **Increasing large-scale investment attractiveness:** Cross-border renewable power trade will enable green premiums to be realised from resource-scarce countries, increasing the attractiveness to private investors and power producers. Export incomes and green premiums from renewable exports can also be reinvested to enhance grid infrastructure and other enablers, reducing the risks of curtailment and further improving investment attractiveness. This creates a virtuous cycle in enhancing investment attractiveness. Moreover, renewable rich countries will be able to establish a pipeline of bankable renewable projects catering to both local and regional demand, which would enhance cost of capital benefits and investor attractiveness.
- **Lowering renewable project and system costs:** The system cost benefits of lowered reserve margins, demand-side load balancing and supply-side complementarities, and other factors brought about by an interconnected grid will increase the ability for countries to increase renewable penetration without an inflationary impact to consumers. Opportunities from strong renewables development fuelled by regional demand will also provide greater incentives for the supply chain to invest in enhancing competitiveness, including in large capital investments and skill development, strengthening the cost competitiveness of renewable projects
- **Overcoming natural resource endowment limitations:** Cross-border renewable trade will also enable renewable-scarce countries to access renewable energy in order to decarbonise towards Net Zero goals and to meet renewable demand from corporates. The demand for renewable power from renewable-scarce countries will be translated to premiums which benefit renewable-rich countries and support renewable power supply chain development across the region.

Figure 8: Benefits of cross-border renewable electricity trade



Socioeconomic impact from cross-border renewable trade

Scaling up cross-border renewable power trade will unlock various socioeconomic benefits for ASEAN member countries. There are two key sources of economic value add and jobs contribution.

Renewable energy and grid investments

- Firstly, GDP and jobs will accrue from investments into renewable production, grid interconnections, generators, and others to scale up the ASEAN Power Grid. This includes both indirect GDP and jobs from multipliers and spillover effects to the supply chain, as well as induced GDP and jobs
- Based on the findings of the ASEAN Interconnection Masterplan Study (AIMS) III[5], an additional ~26 GW of interconnection capacity will be required to meet ASEAN renewable energy targets, requiring short-term investment of USD 330 billion and long-term investment of USD 771 billion. This will create a GDP uplift of USD 31 billion annually and sustain 270,000 jobs
- The benefits from renewable power development will primarily accrue to renewable-rich countries whilst grid infrastructure enhancements will benefit countries where most upgrades are required to facilitate interconnection between countries

Re-invested cost savings from energy cost savings or avoided capital expenditures

- Secondly, GDP and jobs will accrue from re-invested cost savings realised by lower costs of renewable electricity, lower reserve margin requirements, and other cost savings which can be re-invested into other segments of the economy.
- Based on the findings of the IEA, cost savings of up to USD 3 billion annually[6] can be realised solely from optimising cross-border transmission links through multilateral trade. This is estimated to unlock a providing value add of USD 1.9 billion annually, assuming the cost savings are reinvested primarily into the energy sector
- These benefits will accrue to both renewable-rich and renewable-scare countries such as shared benefits of lowered reserve margins. Renewable-scare countries will also benefit from lower costs of decarbonisation, given access to renewable electricity from the region

Contribution of cross-border renewable trade to just energy transition of the region

In the specific ASEAN context, cross-border renewable trade can also be a key enabler to the equitable and just transition of countries in the region. Countries in the region with the lowest income per capita, such as Myanmar, Cambodia, and Lao PDR, possess significant renewable endowments relative to the size of the economy and domestic needs. In contrast, countries in the region with the highest income per capita, such as Singapore and Brunei, represent renewable-scarce countries in the region primarily constrained by land availability.

Renewable-rich countries stand to gain the significantly larger share of benefits– ranging from increased private investment into the power sector, spillover effects onto local supply chains, and increased export revenues– which can be a catalyst for socioeconomic convergence of the lowest income countries with the rest of the countries in the region. Furthermore, renewable-scare countries in the region stand to benefit from enhanced access to renewable energy in order to meet country decarbonisation targets and demands of corporates in the country and energy security from access to greater optionality in renewable energy import sources.

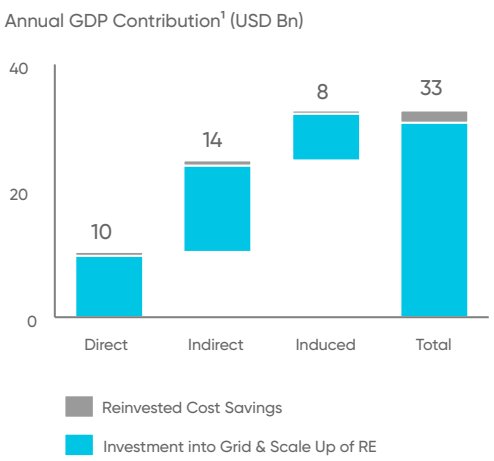
With lower costs of renewable power, the region also stands to gain in terms of export competitiveness especially where export product rely heavily on renewable power as a factor of production. This includes the competitiveness of Southeast Asian countries as a manufacturing hub or for new green growth areas such as hydrogen production, and others.

5. Based on findings from ASEAN Interconnection Masterplan Study (AIMS) III
6. Based on IEA Southeast Asia Energy Outlook, estimation corresponds to reduction in supply costs of around $1-3 per MWh

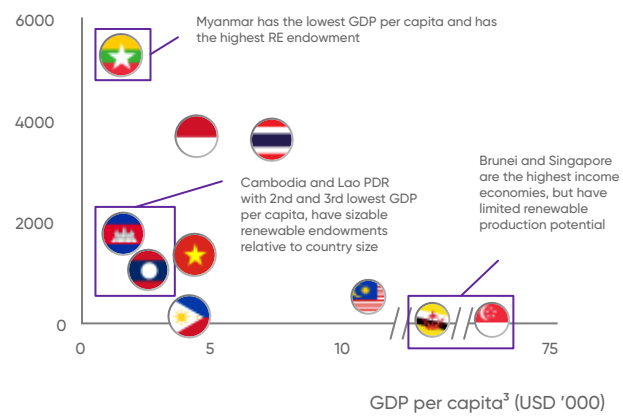
Figure 9: Economic impact from the scale-up of cross-border renewable power trade in ASEAN

Significant economic and jobs impact can be unlocked from ASEAN power grid – benefits to accrue strongly to lower income nations

Total economic growth impact from scaling up ASEAN Power Grid …



… expected to benefit renewable-rich and lower income countries the most in ASEAN



1. Calculated based on the ASEAN Interconnection Masterplan Study III (AIMS III) study on the investment required to scale ASEAN Power Grid to reach ASEAN RE targets and assumed annual cost savings of USD$3 billion from lower operating costs for the system via optimizing cross-border flows through multilateral trade is reinvested into related electricity distribution activity; 2. Based on IRENA analysis on renewable energy potential for ASEAN countries; 3. Based on 2021 data from World Bank
Source: ASEAN Centre for Energy, IEA, IRENA, World Bank, DOSM, BCG analysis

Countries will also be able to strengthen competitive advantages in key areas with an interconnected grid. For example, Lao PDR has the potential to leverage its large hydropower potential to act as the "battery" for the region, with the build-up of pumped storage infrastructure optimising the use of the LTMS interconnection. As a complement, countries with significant VRE potential such as solar resources in Vietnam can benefit from better balancing and reduced curtailment risk, monetising the strong cost competitive VRE generation potential. New green growth areas can also be unlocked through cost competitive renewable energy in the region, such as spurring electric mobility, green hydrogen production and fuels of the future such as e-fuels, to meet regional and global demand.

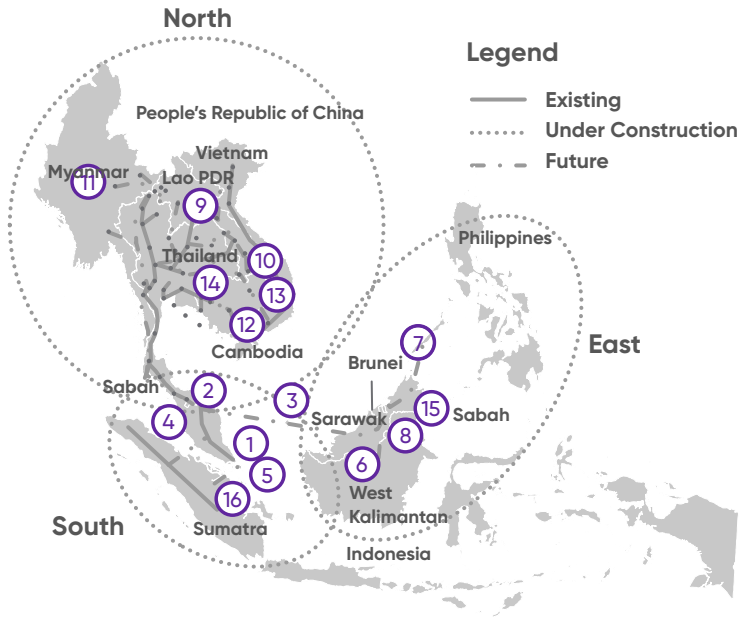
Historic developments in cross-border renewable power trade in Southeast Asia

Cross-border power trade in Southeast Asia has a long history– with the export of hydropower from Lao PDR to Thailand in 1971 representing the first instance of cross-border renewable trade. However, cross-border trade volume has only grown materially over the last decade following the establishment of electricity interconnection arrangements through the ASEAN Power Grid (APG). Since then, 7,720 MW of cross-border interconnections have been developed, facilitating 77 TWh of total power exports and imports in 2020, which are driven mainly by two sub-regional efforts– the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) and the Greater Mekong Subregion (GMS).

Strong progress has also been observed recently, such as the Singapore-Laos hydropower agreement, landmarking the first multilateral cross-border renewable power trade involving four ASEAN countries. Further developments are also expected with the lifting of Malaysia's ban on exporting renewable energy. Beyond increased electricity trade, various efforts to explore greater regional interconnectivity are underway, including the ASEAN Interconnection Masterplan Study III (AIMS III) which aims to provide comprehensive feasibility study and evaluation of requirements to scale up the APG.

Figure 10: ASEAN Power Grid interconnection developments

Interconnection developments across the ASEAN Power Grid



Connections	Status
1. Peninsular Malaysia – Singapore	Existing
2. Thailand – Peninsular Malaysia	Existing[1]
3. Sarawak – Peninsular Malaysia	TBC
4. Peninsular Malaysia – Sumatra	TBC
5. Batam – Singapore	TBC
6. Sarawak – West Kalimantan	Existing
7. Philippines – Sabah	TBC
8. Sarawak – Sabah – Brunei	2023
9. Thailand – Lao PDR	Existing
10. Lao PDR – Vietnam	Existing
11. Thailand – Myanmar	TBC
12. Vietnam – Cambodia	Existing
13. Lao PDR – Cambodia	Existing
14. Thailand – Cambodia	Existing
15. East Sabah – East Kalimantan	TBC
16. Singapore – Sumatra	TBC

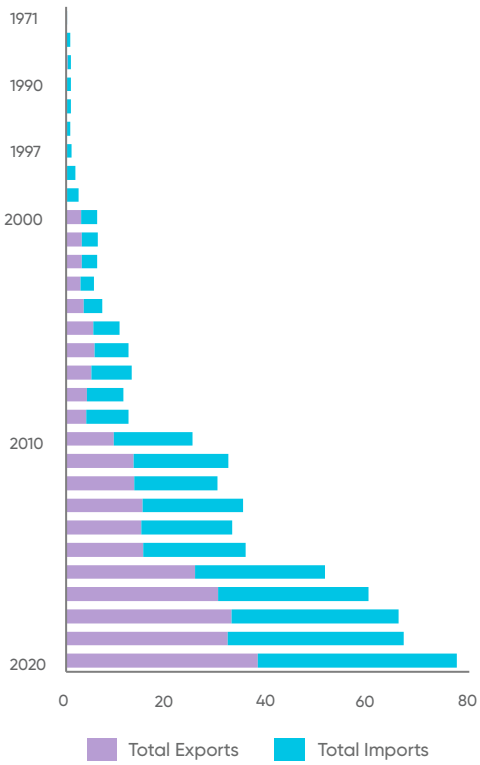
TBC stands for to be confirmed

1. Su Ngai Golok-Rantau Panjang connection is TBC
Source: ACE, Science Direct, Press search

Figure 11: Timeline of cross-border power trade developments in Southeast Asia

ASEAN cross-border electricity trade developments over time

Total Power Exports/Imports per year[1] (TWh)



- **1971** – Hydropower export from Laos to Thailand
- **1981** – Formation of HAPUA (Head of ASEAN Power Utilities/Authorities)
- **1992** – Greater Mekong Sub-Region Cooperation Framework established
- **1997** – ASEAN Power Grid Concept formally adopted by ASEAN
- **1998** – Establishment of ASEAN Centre for Energy
- **1999** – First implementation of ASEAN Plan of Action and Energy for Energy Cooperation (APAEC)
- **2004** – Vientiane Action Plan launched with focus on developing ASEAN Power Grid)
- **2012** – MoU on the ASEAN Power Grid signed by all 10 ASEAN members
- **2016** – APAEC Phase 1: 2016-2020 published
- **2018** – LTM-PIP set up between Laos, Thailand and Malaysia, facilitating hydropower export from Laos to Malaysia
- **2021** – ASEAN Interconnection Masterplan Study III launched
- **2022** – Hydropower export from Laos to Singapore via LTMS-PIP
- **2023** – Malaysia lifts its export ban on renewable energy

Electricity Trade · Interconnections · Policy & institutional enablers

1. Total power exports/imports by ASEAN countries, inclusive of non-renewable energy and exports to and imports from outside the ASEAN region
Source: IEA, UN, ERIA, ACE, Press search, BCG analysis

Making it happen: Enablers for cross-border RE trade

Based on learnings from other interconnected grids, there are three key categories of enablers required to enable cross-border renewable trade– financial, technical, and institutional. The following section suggests what would be required for a fully integrated electricity market in ASEAN and propose what could be key practical steps along the journey.

Financial

Funding of interconnection projects

- Given the large capital investment outlay and shared benefits from interconnections, a framework and process for the prioritisation and funding of interconnection projects is required, including an efficient approval process for timely interconnection development
- Establishing agreements and systems across ASEAN member states to contribute towards the cost of the development of the ASEAN Power Grid, creating the right incentives for overall development whilst anchoring on fair allocation principles

Fair financial settlement and import-export exchange

- Establishing a standardised settlement and payment mechanism for cross-border renewable electricity trade through the ASEAN Power Grid
- Developing transparent wheeling charge methodology and loss compensation regime across ASEAN to enable trading cross ASEAN member countries regardless of borders

Technical

Technical feasibility of grid interconnections

- Harmonising technical standards and operational procedures such as grid codes required for inter-grid connections– which include but are not limited to harmonising power grid frequencies, establishing common frameworks on transmission and metering codes, and others
- Establishing forums to raise, assess, and resolve technical barriers efficiently as they evolve over time, responding to developments of the power sector

Secure and accurate flow of data and information

- Establishing data sharing agreements and integrated platform for data management– including data, accessibility, privacy, security, etc.– as foundations for multilateral power trading markets

Reliability of power transmission across countries

- Establishing legal and regulatory framework around power transmission including minimum capacity allowance, incentive-penalty structure for agreed transmissions, and others
  Ensuring that regional infrastructure plans support multilateral power trading and requirements required to ensure power system sustainability including the increased integration of renewables

Institutional

Fair governance and regulation

- Establishing a central governance body to establish a common working language, settlement and payment mechanisms, dispute resolution mechanisms, infrastructure development management, ensuring reliability and security of power transmission, and others for the ASEAN Power Grid

Forward-looking development for a robust interconnected grid

- Defining a blueprint for interconnection planning in line with growing demand– such as the prioritisation of key infrastructure projects to enable an integrated ASEAN grid market
- Defining clear processes for project approvals including roles of stakeholders, approval processes with timely reviews, assessment guidelines, and others
- Enabling grid access for power producers and purchasers across ASEAN– including the development of regulatory frameworks and mechanisms to enable third-party access, a key enabler in enabling vibrant participation of both power producers and purchasers for the scale-up of cross-border renewable energy trade and power exchange

Potential steps along the journey

A fully interconnected ASEAN power grid will not be realised in a single mega project. Instead, ASEAN will need to experience a gradual deepening of connections between member states, progressing from bilateral agreements to multilateral agreements which will expand towards an integrated Southeast Asia power system.

This includes building on bilateral renewable electricity trade which is already well established in the region, led by Lao PDR which has exported over 6,000MW of cross-border renewable electricity to Cambodia, Myanmar, Thailand and Vietnam. Multilateral power trade is also emerging in the region, with the most notable example being the Laos, Thailand, Malaysia, Singapore Power Integration Project (LTMS-PIP). Strong success and accrued benefits proven in these landmark bilateral and multilateral trades will catalyse participation across further countries and scale-up of existing trade flows.

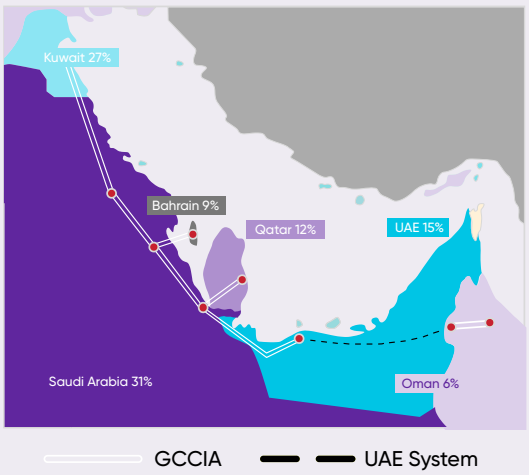
Public-private sector collaborations will be key to enabling the scale up of cross-border electricity trade through bilateral and multilateral agreements. For example, the LTMS-PIP efforts led by Electricité du Laos (EDL), Electricity Generating Authority of Thailand (EGAT), Tenaga Nasional Berhad (TNB) and Keppel Electric Pte Ltd, culminated in the first successful multilateral cross-border electricity trading initiative involving four countries in Southeast Asia

The move toward the integrated Southeast Asia power system will however require significant coordinated efforts across member states. Leveraging existing platforms such as the Heads of ASEAN Power Utilities and Authorities (HAPUA) will be key to accelerate the development of various enablers identified. In addition, harnessing the collective whilst expertise and perspectives of a wide range of stakeholders across the public and private sector and learning from lessons from other interconnected grids will also be critical to ensuring the effective setup of cross-border renewable power trade.

Case Study | Learnings from the Gulf Cooperation Council Interconnection Grid

The journey of the Gulf Cooperation Council Interconnection Grid which links Saudi Arabia, the United Arab Emirates, Qatar, Bahrain, Kuwait and Oman provides a potential pathway for ASEAN's journey towards an interconnected grid. These countries formed the GCC Interconnection Authority (GCCIA) to oversee the construction and establishment of frameworks to underpin the interconnected grid, such as the funding model, capacity and operation of the grid.
While the GCC interconnector was financed by the GCC states themselves, the GCCIA established a funding model that apportioned costs based on the potential reserve capacity savings of each member state and enables power transfer between states when this transfer delivers economic benefits.

GCCIA[1] funding is proportionate to the potential reserve capacity savings of each member state (percentages indicate funding share of each state)

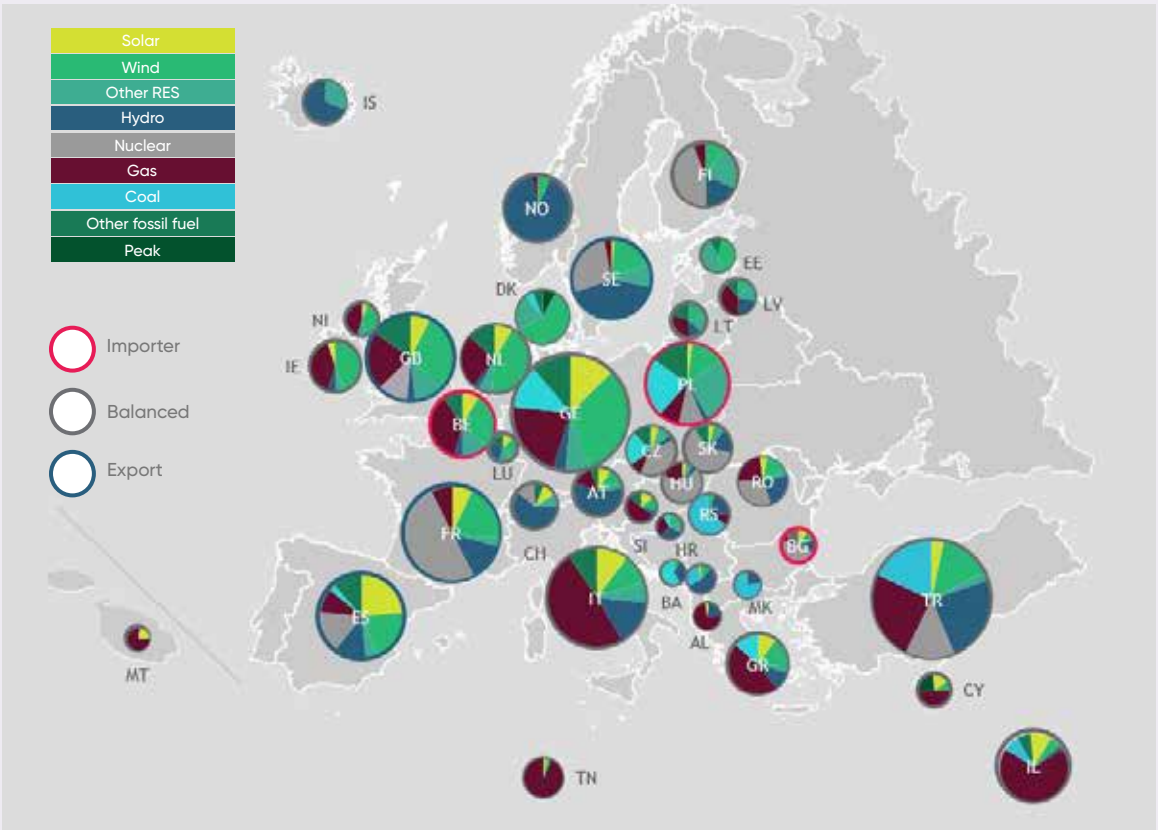


On the technical grid infrastructure front, the GCCIA developed frequency conversion to tie Saudi Arabia's 60Hz grid with the 50Hz grid of other GCC states and aligned on transmission and metering codes. Finally, from the institutional angle, the GCCIA established an operational control centre and developed systems for the trading of power between member states as well as dispute resolution frameworks.

Case Study | Learnings from the EU Interconnected Grid

The European Union (EU) Interconnected Grid is the most interconnected continental power network globally. The EU Interconnected Grid represents a single synchronous grid where all member states are responsible for always maintaining grid equilibrium– continually matching total power demand and total power. Enabled by the foundation of interconnectors built out across neighbouring countries to lower reserve requirements and strengthen resilience, the European Network of Transmission System Operators– Electricity (ENTSO-E) was established in 2009. The coverage of the EU Interconnected Grid has expanded over time and now caters to over 600 million people in over 40 countries when factoring in connectivity of the EU grid with other continents.

Overview of the optimised cross-border European energy mix in 2030



Harmonisation and Coordination

To enable trans-national harmonisation and coordination, the European Network of Transmission System Operators for Electricity (ENTSO-E) was established representing transmission system operators from 35 countries with a primary technical responsibility of ensuring the security of the interconnected power system in all time frames at the pan-European level and the optimal functioning and development of European interconnected electricity market. ENTSO-E also focuses on enabling the integration of electricity generated from renewable energy sources into the EU Grid.

Case Study | Learnings from the EU Interconnected Grid

In addition to ENTSO-E, the Agency for Cooperation of Energy Regulators (ACER) was also established to ensure the functioning of the single European market including support to formulate European network rules, monitoring of markets, and the coordination of national regulatory authorities. Bringing stakeholders together, the Energy Infrastructure Forum is held annually to remove technical barriers, enhance regional cooperation and promote regulatory convergence across TSOs, ENTSO-E, ACER and national regulatory authorities.

Legal and Policy Framework

Trans-European Network for Energy (TEN-E) Policy focuses on linking the energy infrastructure of EU countries with the identification of 11 strategic priority corridors, including 3 electricity corridors and 3 priority thematic areas for energy infrastructure. This enables countries in the priority corridors to develop enhanced connected energy networks and provides funding for new energy infrastructure project.

In addition, the TEN-E Regulation is established to create the regulatory framework for cross-border energy infrastructure, including contributing to EU emission reduction objectives by promoting the integration of renewables and new clean energy technologies into the energy system, whilst increasing trans-regional connectivity, enhancing existing cross-border interconnection and timely delivery of cross-border infrastructure.

TEN-E also outlines a process to establish on a two-yearly basis Union-wide lists of 'Projects of Common Interest' (PCIs) and has set an interconnection target of at least 15% by 2030 to encourage EU countries to interconnect their installed electricity production capacity. This means that each country should have in place electricity cables that allow at least 15% of the electricity produced on its territory to be transported across its borders to neighbouring countries. The Connecting Europe Facility for Energy (CEF) is an EU funding instrument for PCIs that are selected based on the criteria outlined in the TEN-E.

Market Mechanism

To facilitate cross-border electricity trade, an electricity supplier can either engage in over-the-counter (OTC) trading, involving bilateral transactions, or in power exchanges such as the European Power Exchange (EPEX), where transactions are cleared by the European Commodity Clearing (ECC). The ENTSO-E publishes relevant information to create a non-discriminatory and open access marketplace.

Three major markets on the power exchange include the capacity, wholesale / spot, balancing and markets:

- **Capacity Market**– industrial consumers buy capacity from suppliers, which guarantees that at any point suppliers will have the agreed amount of capacity to generate electricity for the consumer
- **Wholesale / Spot Market**– this consists of day-ahead and intraday markets. In day-ahead markets, suppliers and buyers are required to submit their orders at least 24 days in advance, and market clearing price is determined hourly the following day. In intraday markets, buyers can put in orders 15 minutes before the delivery of electricity. This consists of continuous trading with three European-wide auctions at pre-defined times.
- **Balancing Markets**– energy producers sell capacity to grid operators in order to maintain grid stability by ensuring that frequency remains at the equilibrium point of 50 Hz.

Case Study | Learnings from the EU Interconnected Grid

The Green Open Access Rules 2022, introduced by the Ministry of Power in India, aims to accelerate the country's renewable energy uptake by promoting the generation, purchase, and consumption of renewable energy.

The regulation addresses long standing challenges that have impeded the growth of renewable energy such as open grid access, enabling broader accessibility of renewable energy for consumers. This is in line with the national goal of ensuring availability of affordable, reliable, sustainable, and environmentally friendly green energy for all.

Key provisions of the Green Open Access Rules 2022 include:

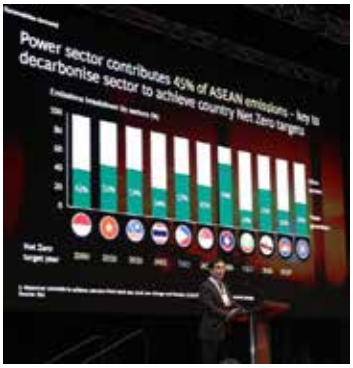
- Open access transaction limits for green energy to be reduced from 1 MW (megawatt) to 100 kW (kilowatt)– enabling even small-scale consumers to procure renewable power through open access
- Open access approval process to be streamlined through a national portal to promote uniformity and transparency– approval for Green Open Access must be granted within 15 days or it will be deemed to have been approved by default
- Consumers can demand supply of green energy from power distribution companies, and power distribution companies would be obligated to procure and supply green power to requesting consumer, where green energy consumption is proved through the award of green certificates
- Renewable Purchase Obligation (RPO) to be harmonised on all obligated entities in the area of a power distribution company, inclusive of fulfillment of green hydrogen and greenammonia obligations
- Improved clarity and certainty on open access charges, encompassing transmission charges, wheeling charges, cross-subsidy surcharge and standby charges

The implementation of Green Open Access Rules 2022 represents a significant milestone towards India's commitment of achieving 500 GW of non-fossil fuel energy by 2030.

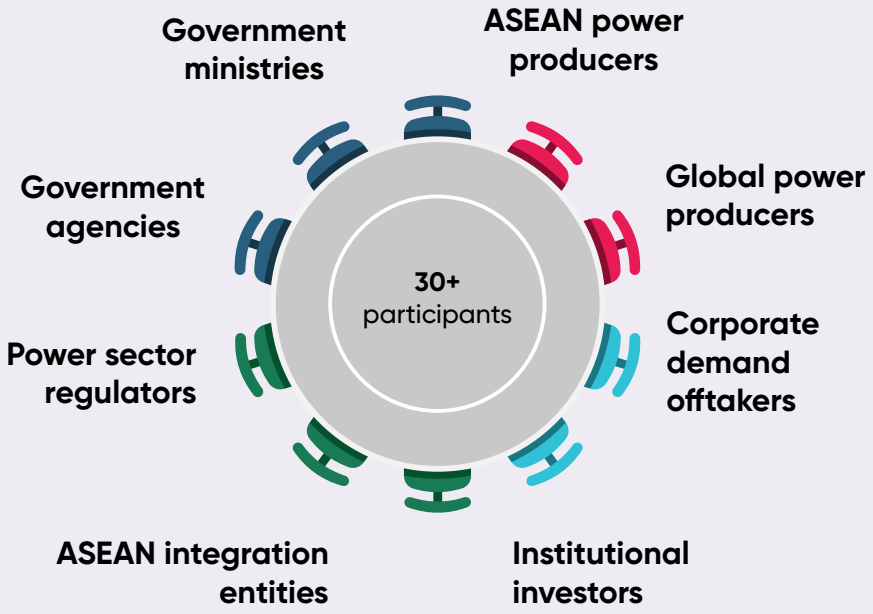
These rules play a pivotal role in facilitating the transition towards green energy sources, improving cash flow predictability for renewable power producers and enhancing India’s open-access renewable energy reserves. These changes have also been successful in incentivising renewable energy investors through the, mitigating of significant upfront risks and unlocking opportunities through the advancements in the power trading sector in India.

Roundtable Summary

Structure and key takeaways from the roundtable discussion



Roundtable Participants



Discussion topics for the roundtable

Table 1: Opportunities in cross-border renewable power trade

Discussion Prompts

- What **opportunities** can cross-border renewable power trade unlock across Southeast Asia?
- What **socioeconomic benefits** will accrue to renewable -rich countries in the region?
- To what extent will cross-border renewable trade unlock **private capital** to fund renewable transition?

Table 2: Key enablers to unlock cross-border renewable power trade

Discussion Prompts

- What are the **key enablers** which are needed to enable scale-up of cross-border renewable power trade?
- How can public and private sector stakeholders both **contribute** to the development of these key enablers?
- What are the **key trade-offs** that countries must effectively manage related to energy import and exports?

Roundtable Discussions: Summary of Outcomes

1. Demand for renewable energy exists; however, there is a scarcity in supply

> **"Availability of renewable energy is one of the top consideration for corporate offtakers when expanding their operations to new countries**

Corporate demand

- Availability of renewable energy stands as a primary factor of consideration for corporate offtakers when expanding their operations to new countries
- Corporate green Power Purchase Agreement (PPA) are usually substantially oversubscribed due to high demand from corporates
- Additional costs associated with green premiums are negligible to corporates due to their existing commitment to net zero targets and mounting pressure from by investors and consumers

Country-level demand

- Increasing demand for renewable energy from ASEAN countries driven by net zero targets, expected to increase over time as net zero target years draw nearer
- Countries such as Singapore will have a surge in demand for renewable energy due to their limited technical endowments for renewable energy production
- To meet increased demand, residential homes are one of the largest energy source in ASEAN, presenting a tremendous growth opportunity for residential play

2. Benefits of cross-border trade and scaling up of renewable energy are apparent

> **"Access to a larger market serves as a risk mitigation tool for renewable energy investments and projects**

System-wide efficiencies

- Clear opportunity for all ASEAN countries to reduce their current reserve margins by leveraging pooled margins from cross-border RE trade
- Comparatively efficient market ecosystem fostered by the multiple trade benefits, including the freedom to trade, price discovery and transparency, and the increased market efficiency

Increased attractiveness to investors

- Expanded project scale facilitated by access to a larger market leads to enhanced bankability of renewable energy projects
- Access to a larger market serves as a risk mitigation tool for renewable energy investments and projects. By expanding the customer base, diversifying revenue streams, and reducing dependence on limited local markets, projects are better equipped to navigate market fluctuations, regulatory changes, and other unforeseen risks

Green growth opportunities

- Tremendous revenue potential in green mobility with opportunities in electric- and hydrogen-powered vehicles
- Enhancement of interconnected grid holds the potential for substantial job and GDP contribution, such as through the building of battery storage required for grid stabilisation
- Malaysia is one of the only places outside of China where solar panels can be produced at scale– localising supply chains can bring huge potential value add to ASEAN's economy
  Existing oil and gas services and equipment (OGSE) industry vendors can pivot to renewable energy opportunities, boosting the development of small and medium enterprises

3. Key challenges present in scaling up cross-border renewable energy trade

> **"While benefits are apparent for all parties, there is a reluctance among potential stakeholders to take on the role of the initial risk-taker**

Lack of Investment

- Reluctance among potential stakeholders to take on the role of the initial risk-taker despite clear benefits for all parties
- Lack of initial willingness to invest the capital required for the construction of interconnections due to the high capital outlay required

Sub-optimal existing infrastructure

- Notable inadequacy in current grid infrastructure, underscoring the need for substantial enhancements
- Absence of data infrastructure to support effective coordination among ASEAN countries, particularly in matching of demand with supply
- Need for mechanisms such as grid third-party access to enable transactions of cross-border renewable trade and power exchange and to unlock funding required for grid investments

Trust deficit

- Security of supply is primarily approached from an individual country perspective– necessitating the establishment of trust among neighboring countries to foster a collective view of supply
- Lack of tangible proof-of-concept in the region, leading to ambiguous benefits to all parties

4. Essential enablers to scale up cross-border renewable energy trade

> **"Joint commitment is required from all ASEAN leaders, including having a shared vision and determination to build the interconnections**

Institutional enablers

- Political will– with joint commitment is required from all ASEAN leaders, including having a shared vision and determination to build the interconnections, proactively advancing the development of policies and implementing initiatives that encourage and supports cross-border renewable energy trade
- Alignment among ASEAN leaders regarding the timeline for the ASEAN Power Grid development, accompanied by clearly defined roles for each party

Financial enablers

- Establishment of clear frameworks to effectively segregate the costs associated with building interconnections between ASEAN member states, whilst ensuring clarity in the business case for each country and stakeholder involved
- Development of innovative business models to encourage private sector participation, designed to create mutually beneficial partnerships that support the scaling up of cross-border renewable energy trade within ASEAN

  Harmonisation of wheeling charges along with a standardised pricing mechanism to effectively "price" green energy

Technical enablers

Harmonisation of technical standards, starting with the establishment of the minimum standards required for both the ASEAN Power Grid collectively and for grid infrastructure in each member state

5. The importance of progress over perfection

> **"In the face of big aspirations, starting small, but designing for scalability is essential to progress development of the ASEAN Power Grid**

Through the various discussions, the importance of "progress over perfection" in the scale-up of cross-border renewable trade was emphasised by roundtable participants. In the face of big aspirations, starting small, but designing for scalability is essential for progressing the development of the ASEAN Power Grid. The initiation of a flagship project as a proof of concept, can demonstrate business model viability whilst paving the way for subsequent interconnections to be built. Notably, the Malaysia-Singapore project was discussed as a high potential proof-of-concept, with enthusiasm from multiple participants on the importance of "speed to action" such as targeting project initiation within 2023. Building upon the success of the proof-of-concept, cross-border renewable energy trade can then be scaled up, progressing from bilateral trade to multilateral collaboration in ASEAN.

However, transforming these aspirations into reality necessitates the convening of collaborative gatherings amongst country leaders and key stakeholders. Such gatherings will serve as crucial platforms to foster robust discussions, joint alignment and shared commitments, including on topics such as funding mechanisms for necessary interconnections. It is imperative that the principles of shared security of supply and mutual benefits for the entire region guide the funding decisions.

Despite the challenges that lie ahead, the strong determination exhibited by all roundtable participants underscores the group's resolve to translate these ambitions into tangible actions. Through concerted efforts, the roundtable participants seek to drive the growth of cross-border renewable energy trade in the ASEAN region, propelling the region towards a prosperous and sustainable future.

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