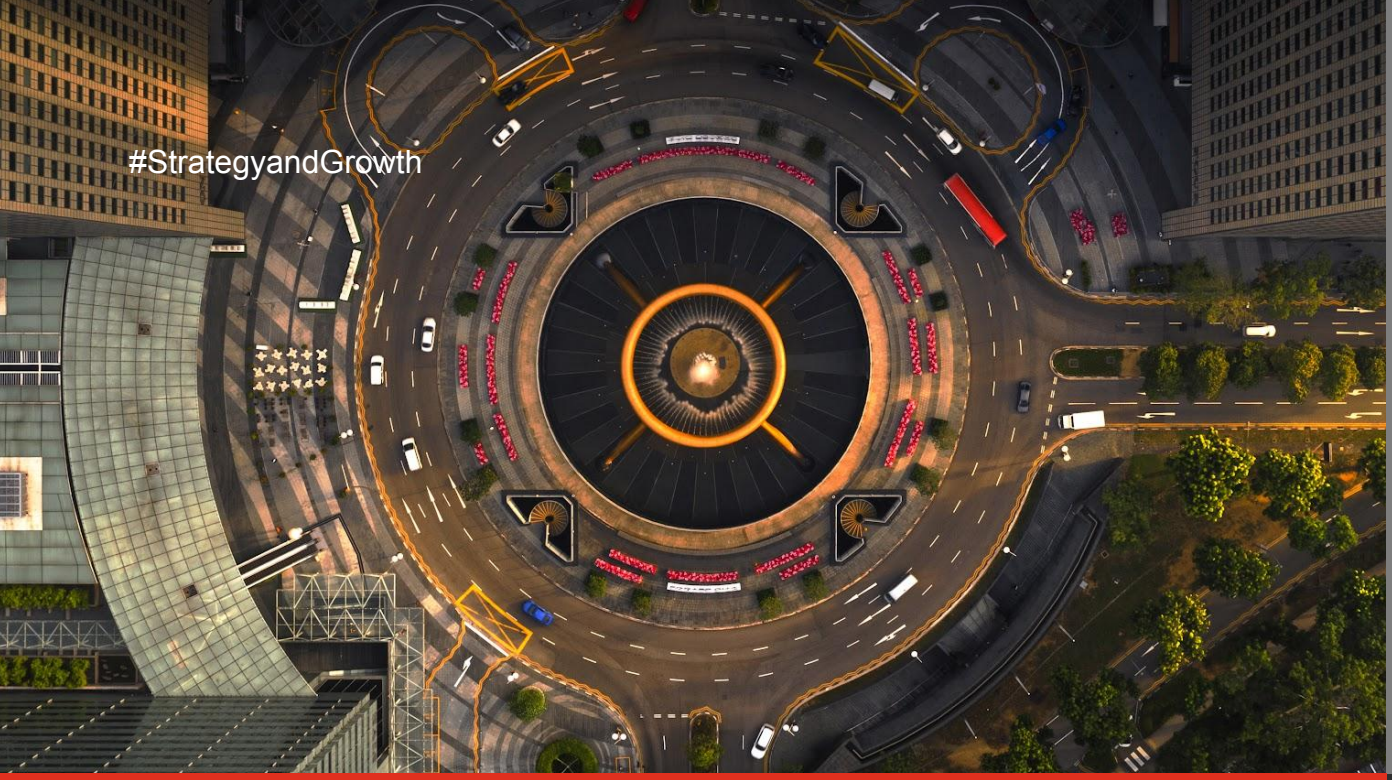


Energy transition readiness in Southeast Asia

The road ahead to a cleaner and energy efficient future

September 2021

pwc

Contents

Executive summary

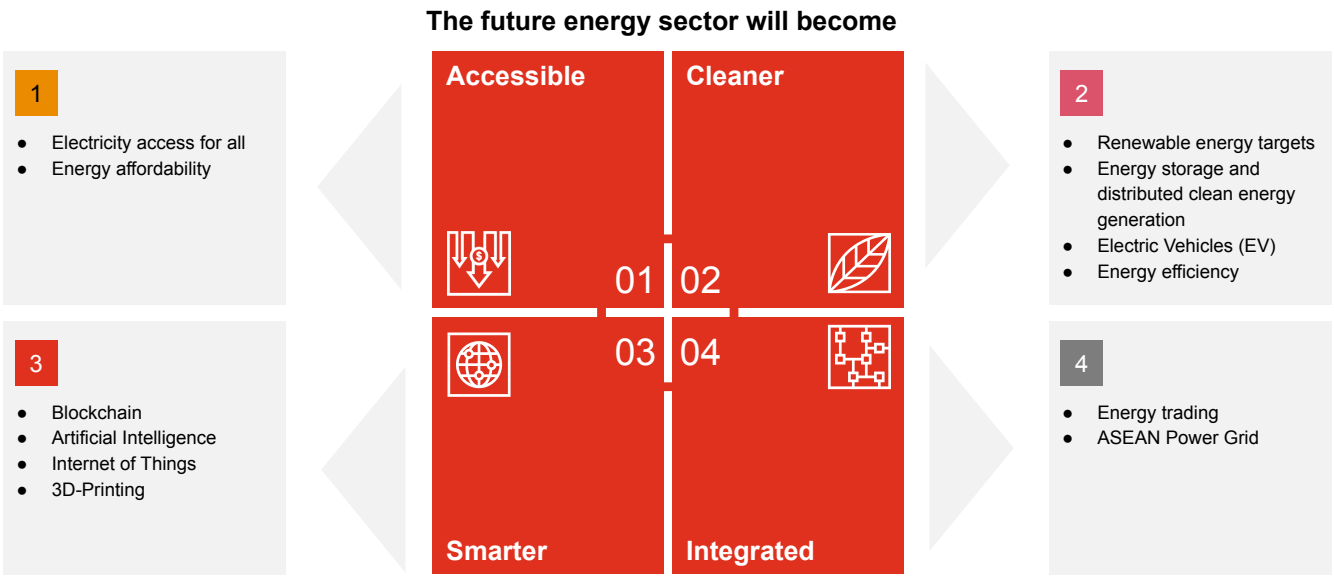
Southeast Asia's energy sector overview

Southeast Asia's energy demand is expected to increase by 60% by 2040 in line with the region's rapid economic growth led by increasing industrial activities, growing population and rising incomes[1]**.**

Today, Southeast Asia remains a net importer of energy products, with more than 40% imports to meet its total energy requirement. With depleting reserves, the region needs to import more fossil fuels to cater to the rising demand. This brings the regional energy sector to a crossroad in terms of its energy future, with an urgent need to diversify its sourcing and supply, in order to cater to the growing demand. This makes the region's transition to a cleaner and more energy efficient future a key imperative.

However, in the energy transition journey, the Southeast Asia countries have different levels of readiness. In this report, we have highlighted **six key criteria, including Energy accessibility, Energy reliability, Energy affordability, Energy sustainability, Energy smartness, Energy trading,** to assess Southeast Asia's readiness for energy transition. From the assessment, we have identified three sub-groups of countries based on their current position, while mapping their potential future developments (Exhibit 7).

Exhibit 1: Future of Southeast Asia's energy sector



[1] IEA (2019). Southeast Asia Energy Outlook, https://www.iea.org/reports/southeast-asia-energy-outlook-2019

Growing energy demand in Southeast Asia and its readiness for energy transition

Growing energy demand

Southeast Asia is one of the fastest developing regions around the world, housing more than 650 million people, with a combined GDP of over USD 2.8 trillion in 2019[2]. Over the next two decades, Southeast Asia is expecting to see a rapid economic growth, driven by increasing industrial activities, growing populations, and rising incomes (Exhibit 2).

Despite the sharp contraction in economic growth amid the COVID-19 pandemic, the region's energy demand is expected to increase sizably. The energy demand is largely driven by growing ownership of air conditioners and household appliances, more affordable goods and services as the region becomes more affluent. As such, this places a huge pressure on the energy sector due to insufficient indigenous fossil fuel resources to meet its growing energy demand[3]. This has resulted in increasing concern about local resources falling short, which continues to put pressure on regional energy security[4].

Exhibit 2: Growth in the energy sector in Southeast Asia

723m

Estimated population by 2030, making Southeast Asia the 3rd largest in terms of population globally[5]

4.5%

Expected GDP growth per annum (2021 - 2025) as the Southeast Asia's economy recovers well from 2020's sharp contraction[6]

4th

Largest global economy in the world by 2050 overtaking EU and Japan[5]

USD2tr

Infrastructure investment opportunities required by 2030 to maintain the economic growth[2]

60%

Expected growth in overall energy demand between now and 2040[3].

[2] US-ASEAN Business Council (2019). What is ASEAN?, https://www.usasean.org/why-asean/what-is-asean
[3] IRENA (2020). SIEW: Global Renewables Outlook – Key Technologies and Trends for the Energy Transformation, https://www.irena.org/events/2020/Oct/Singapore-International-Energy-Week---Roundtable
[4] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[5] Athira Nortajuddin (2020). The Future Of Consumption In ASEAN, The ASEAN Post, https://theaseanpost.com/article/future-consumption-asean
[6] IMA Asia (2020). Asia's 2021 Prospects Are Not Quite as Bright as Some Believe, https://www.imaasia.com/ima-asia-brief-dec2020/

Growing energy demand in Southeast Asia and its readiness for energy transition

As Southeast Asia faces depleting energy reserves coupled with exponential growth in energy demand, renewable energy is expected to be a solution to meeting the energy demand.

Today, Southeast Asia remains a net energy importer and continues to import more than 40% of its total energy supply[7]. As reserves continue to deplete, the region will need to import more fossil fuels to cater to its rising demand. This brings the sector to a crossroad in terms of its energy future, with an urgent need to diversify its energy supply and cater to the growing demand.

The shortage in domestic fuel supply and the urgent need to reduce greenhouse gas (GHG) emission accelerated renewable energy adoption which is expected to be the solution to meeting the growing energy demand within Southeast Asia. In the past two decades, Southeast Asia's renewable energy capacity has increased at a CAGR of c. 9.7% (excluding hydro) from 4.4GW in 2000 to 25.8 GW in 2019[8] . This is largely driven by the move towards a more sustainable future as well as pressures on phasing out fossil fuels. The expansion in renewable energy capacity was also supported by declining cost of renewables, such as solar photovoltaics (PV) and onshore wind, which helps to drive the business case for renewable energy. **With growing demand for renewable energy, the countries in the region will have to collaborate with each other to accelerate energy transition and strengthen energy resilience.**

[7] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[8] EIA database (2021). https://www.eia.gov/international/data/world

Growing energy demand in Southeast Asia and its readiness for energy transition

Southeast Asia's energy transition readiness

Between 2006 and 2016, the region saw more than USD 27 billion invested in the renewable power sector in the six major Southeast Asia markets – Thailand, Indonesia, Malaysia, Vietnam, Singapore and the Philippines[9].

Two major Southeast Asia-wide initiatives were developed to facilitate the energy transition in the region.

(1) ASEAN Plan of Action on Energy Cooperation (APAEC) Phase II

At the heart of the energy transition within the region, this roadmap highlighted seven key strategies and areas of focus, including the ASEAN Power Grid (APG), Energy Efficiency and Conservation and Renewable Energy. The APAEC Phase II "lays out the key strategies to shape the regional energy landscape by addressing energy challenges and seizing opportunities in building up responsive and cohesive energy pathways for Southeast Asia"[10], as the region copes with the impacts from the COVID-19 pandemic.

The regional efforts in the energy sector includes establishing more ambitious regional targets to enhance energy security and sustainability. Southeast Asia has set targets to achieve 23% and 35% of renewable energy in total energy supply and installed power capacity respectively by 2025[11].

One of the key developments under APAEC Phase II includes the first multilateral power trade which was successfully initiated under the Lao PDR, Thailand, Malaysia and Singapore Power Integration Project (LTMS PIP) for the APG. Established in the late 1990s, the APG was introduced to facilitate integration of renewable energy into the power system as well as sharing of variable resources across the Southeast Asia countries to meet the rising electricity demand[12]. This integrated power grid is expected to improve energy security and resilience in the region.

(2) ASEAN Interconnection Masterplan Study (AIMS) III

This ongoing study is expected to provide insights on how to optimise regional cooperation on electricity and increase penetration of renewable energy. The study is supported by the USAID Clean Power Programme which is an assistance programme across five years seeking to promote integration between higher renewable energy penetration and power planning. The study aims to provide a new and updated plan for the realisation of multilateral power trading to meet renewable targets set out in the APAEC 2016-25 while maintaining system reliability and quality of power supply.

In late October 2020, a trial of importation of 100 MW from Malaysia to Singapore for two years was announced as an important first step for Singapore to accelerate its energy transition towards diversification of energy mix with a focus on clean energy.

In 2019, Laos has agreed to sell 5,000 MW of electricity to Vietnam by 2030. It is currently exporting over 300 MW and is expected to supply 1,000 MW by 2020 and 3,000 MW by 2025.

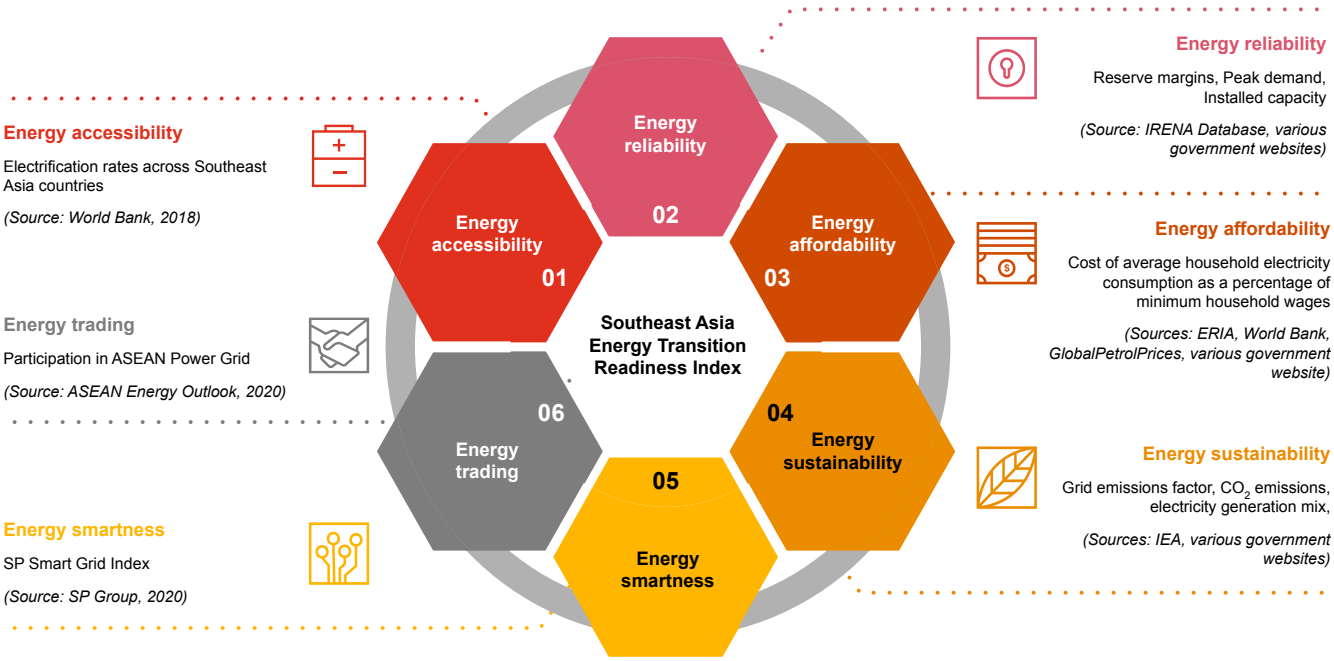
[9] IRENA (2018). Renewable Energy Market Analysis - Southeast Asia, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_2018.pdf
[10] Nella N (2020). APAEC Phase II (2021-2025): Accelerating Energy Transition and Strengthening Energy Resilience through Greater Innovation and Cooperation, ASEAN Centre for Energy, https://aseanenergy.org/the-asean-plan-of-action-and-energy-cooperation-apaec-phase-ii-2021-2025/
[11] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[12] The ASEAN post team (2018). Building ASEAN's power grid, The ASEAN Post, https://theaseanpost.com/article/building-Southeast Asias-power-grid

Growing energy demand in Southeast Asia and its readiness for energy transition

Southeast Asia countries have different levels of readiness for the energy transition

In this report, we have identified 6 key criteria to assess the readiness of the Southeast Asia countries in their energy transition journey (Exhibit 3).

Exhibit 3: Key criteria to access energy readiness in Southeast Asia



The criteria above are designed to assess the energy transition readiness of the countries in a holistic manner. The most basic criteria assessed is energy accessibility where households are able to readily access energy supply in an appropriate form, such as electricity. These could be measured by electrification rates and initiatives for rural electrification such as targets and regulation set to attain universal electrification.

Energy reliability and affordability measure the stability of energy supply as well as its price which ensures that energy consumption is affordable to everyone. The reserve margin is a good indicator of energy reliability, showing the gap between peak demand and installed capacity. A high reserve margin indicates sufficient supply to meet energy demand and vice versa. The cost of average household electricity consumption as a percentage of minimum wage was used as a proxy for energy affordability.

Having met the basic needs of accessibility, reliability and affordability, countries are then able to look further ahead to the future. The sustainability of energy supply of individual countries can be measured by the carbon emissions from the electricity generation mix (carbon intensity or grid emission factor).

Energy smartness is a tool to accelerate the energy transition by allowing energy needs to be monitored in real time and electricity to be dispatched more efficiently. The SP Smart Grid Index helps to quantify the smartness of the grid by looking at seven dimensions of the grid including monitoring and control, data analytics, supply reliability, Distributed Energy Resource (DER) integration, green energy, security and customer empowerment and satisfaction.

To facilitate the energy transition, a key accelerator in the process is the collaboration within the Southeast Asia countries. The ASEAN Power Grid, an initiative for regional interconnection of power grids is expected to help alleviate energy accessibility, reliability and affordability issues in the region.

Growing energy demand in Southeast Asia and its readiness for energy transition

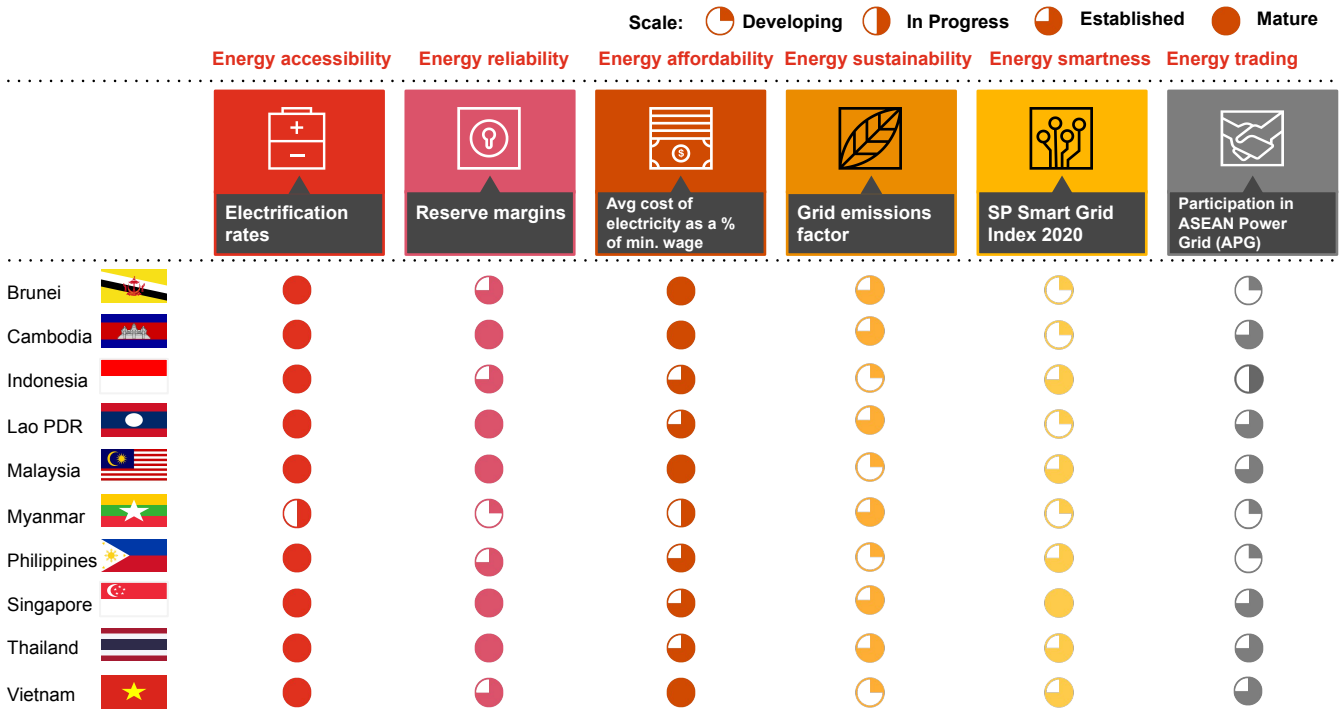
Exhibit 4: Energy transition readiness assessment criteria

Criteria	Methodology
Energy accessibility	• Electrification rates • Developments for rural electrification, including targets and regulations designed to achieve universal electrification
Energy reliability	• Reserve margins from peak demand and installed capacity
Energy affordability	• Cost of average household electricity consumption as a percentage of minimum wage
Energy sustainability	• Grid emission factor based on the amount of carbon dioxide emissions and electricity generation mix
Energy smartness	• SP Smart Grid Index 2020
Energy trading	• Participation in ASEAN Power Grid

Source: PwC Analysis

Using the above methodology, we ranked each member state on the six criteria identified on a scale, ranging between 'Developing', 'In Progress', 'Established' and 'Mature' (Exhibit 5). Based on the preliminary analysis, majority of the countries within the region has achieved some form of meeting basic energy needs for its people. However, more can be done in terms of deriving its energy from cleaner sources, enhancing energy smartness and participation in the wider Southeast Asia energy integration through the ASEAN Power Grid.

Exhibit 5: Energy readiness across Southeast Asia

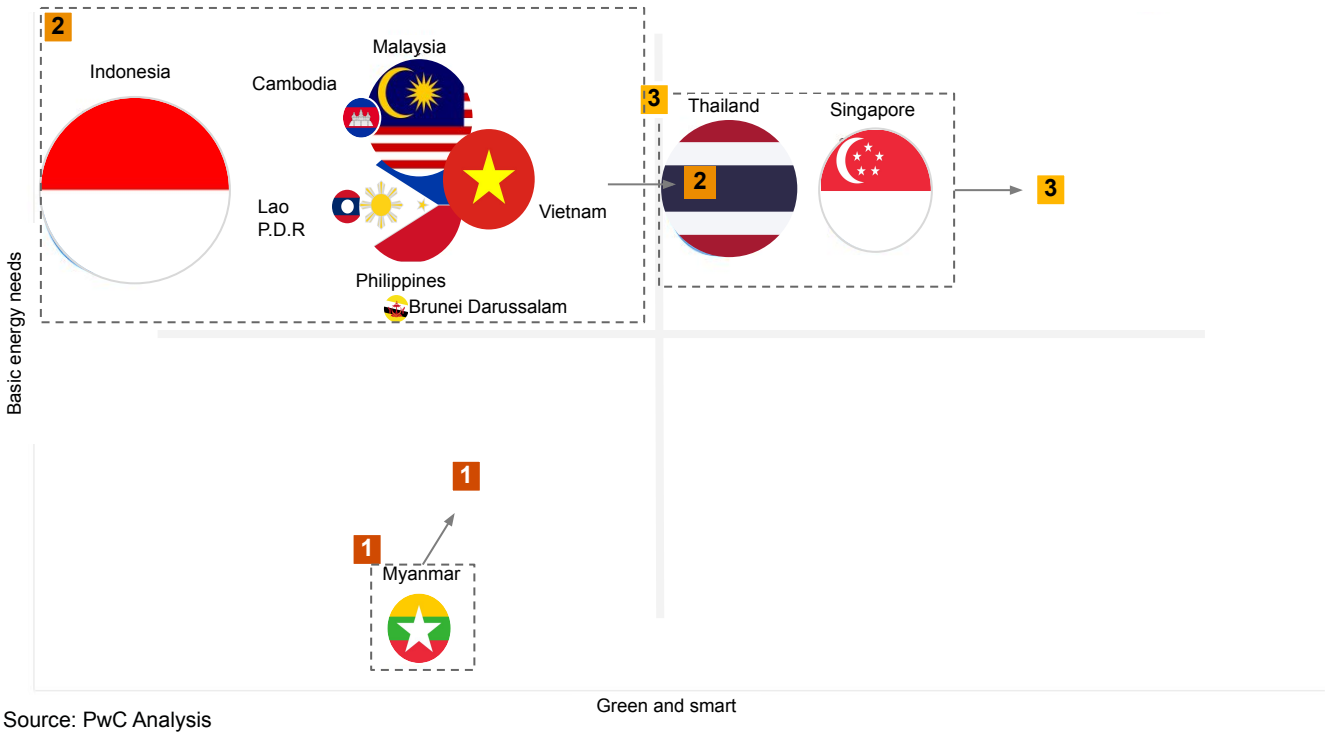


Source: PwC Analysis

Growing energy demand in Southeast Asia and its readiness for energy transition

Using the readiness index, each country is positioned based on the countries' maturity in meeting basic energy needs against energy sustainability and smart energy systems in each country (Exhibit 6). The bubble size represents the GDP of each country.

Exhibit 6: Energy maturity across Southeast Asia



Source: PwC Analysis

We have identified three sub-groups of countries based on their position and mapped their potential future developments.

Group 1 – Meeting basic energy need requirement

For Myanmar, it is observed that there is an urgent need to meet the basic energy needs of people. The country should focus on improving electrification and reserve margins to ensure that people have access to reliable electricity. This may include reducing reliance on hydroelectric power, diversifying its generation sources, and continuing to invest in rural electrification.

Group 2 – Improving the quality of energy supply

Most countries in Southeast Asia falls within the second group. Most member states have achieved the basic energy needs for its people – in terms of electrification and access to affordable and reliable electricity. However, more can be done in terms of making the future energy mix cleaner and smarter.

Group 3 – Driving innovation and energy excellence

The third group consists of countries such as Thailand and Singapore. Both countries have achieved basic energy needs, while achieving some success in their pursuit of making energy cleaner and smarter. However, more developments surrounding these areas such as increasing renewable share, higher penetration of EV, growing distributed solar generation in the power sector are expected in the near future.

The six criteria we have used to rank each member state are further elaborated in the following pages.

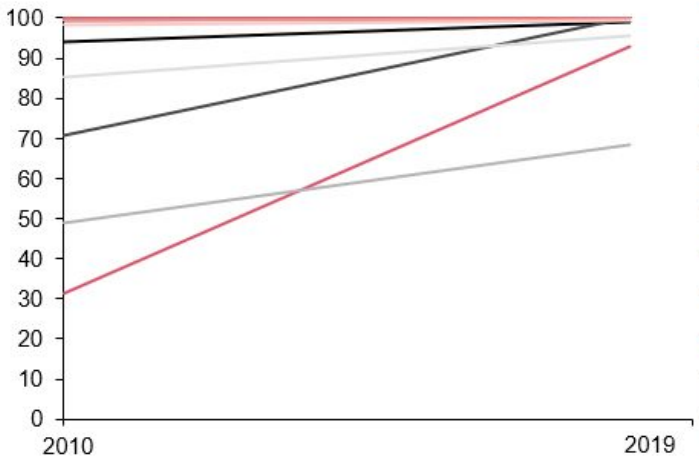
Criteria 1: Energy accessibility

Methodology

We assessed the energy accessibility in each country based on 1) latest available data on electrification rate, and 2) whether the governments of these countries have set targets and initiatives to achieve universal electricity access within the next few years.

Southeast Asia is on track to achieve universal electrification by 2030, given the significant progress over last two decades. Between 2000 and 2016, regional electrification rate rose from 62% to 90%, with over 170 million people gaining access to electricity[13]. In 2019, almost all of Southeast Asia countries have achieved universal or near-universal electrification apart from Myanmar, which reached 68% electrification rate from 49% in 2010 (Exhibit 7). Cambodia has seen the most substantial change in the percent of its population with access to electricity, moving from 31% in 2010 to 93% by 2019[14].

Exhibit 7: Access to electricity in 2010 vs. 2019 (% of population)



Country	2019	Energy accessibility
Brunei	100%	Mature
Cambodia	93%	Mature
Indonesia	99%	Mature
Laos	100%	Mature
Malaysia	100%	Mature
Myanmar	68%	In progress
Philippines	96%	Mature
Singapore	100%	Mature
Thailand	100%	Mature
Vietnam	99%	Mature

Source: PwC Analysis

[13] IEA (2017), Bringing electricity to all corners of Southeast Asia, https://www.iea.org/commentaries/bringing-electricity-to-all-corners-of-southeast-asia
[14] World Bank database

Criteria 1: Energy accessibility

Trends

To achieve universal electrification, these countries have established ambitious targets, programmes and regulations to pave the way for energy access for all (Exhibit 8).

Exhibit 8: Rural electrification targets, programmes and regulations

	Targets	Initiatives
	• Access to electricity in all villages **by 2020** • Access to quality grid electricity among at least 70% of households **by 2030**	Power to the Poor (P2P) Programme
	• Universal electricity access **by 2020***	Rural electrification regulation
	• Universal electrification **by 2030**	World Bank National Electrification Programme and 2014 Electricity Law
	• Universal electrification **by 2022**	Philippine Development Plan 2017–22

Source: PwC Analysis

* The electrification rate in Indonesia was 99.2% which was lower than the target for 2020 which was at 100%.

While Myanmar has the lowest percentage of its population with access to electricity, the country has set the target of achieving universal electrification by 2030. To achieve universal power access by 2030, the Myanmar government, together with the World Bank and the United Nations, developed the National Electrification Program (NEP) in 2014. The World Bank has committed USD 400 million out of the USD 567 million investments required for the first phase of NEP, covering efforts during 2015-2021[15].

With these targets in place, most Southeast Asia countries are expected to achieve universal electrification within the next few years. Delay in achieving it in Myanmar may be expected due to the current domestic situation there. Moreover, electrification plans in Southeast Asia are in line with goal 7.1 of the United Nations Sustainable Development Goals (UNSDG), which aims to achieve universal access to affordable, reliable and modern energy service by 2030.

Microgrids or mini grids could be a potential solutions for electrification of remote settlements in rural, mountainous and island areas which cannot access electricity easily due to the prohibitive cost of grid extension and limited capacity of consumers to pay. Yoma micro grid in Myanmar set up a good example with potential to scale domestically and regionally in the future (Exhibit 9). With the declining cost of renewable energy and storage, microgrids or mini grids can play a key role in achieving universal electrification in Southeast Asia reliably and sustainably.

[15] World Bank (2018). Myanmar National Electrification Project Environmental and Social Management Framework, https://documents1.worldbank.org/curated/en/630691468322766145/SFG1097-REVISED-V1-IPP-P158303-PUBLIC-Disclosed-7-17-2018.pdf

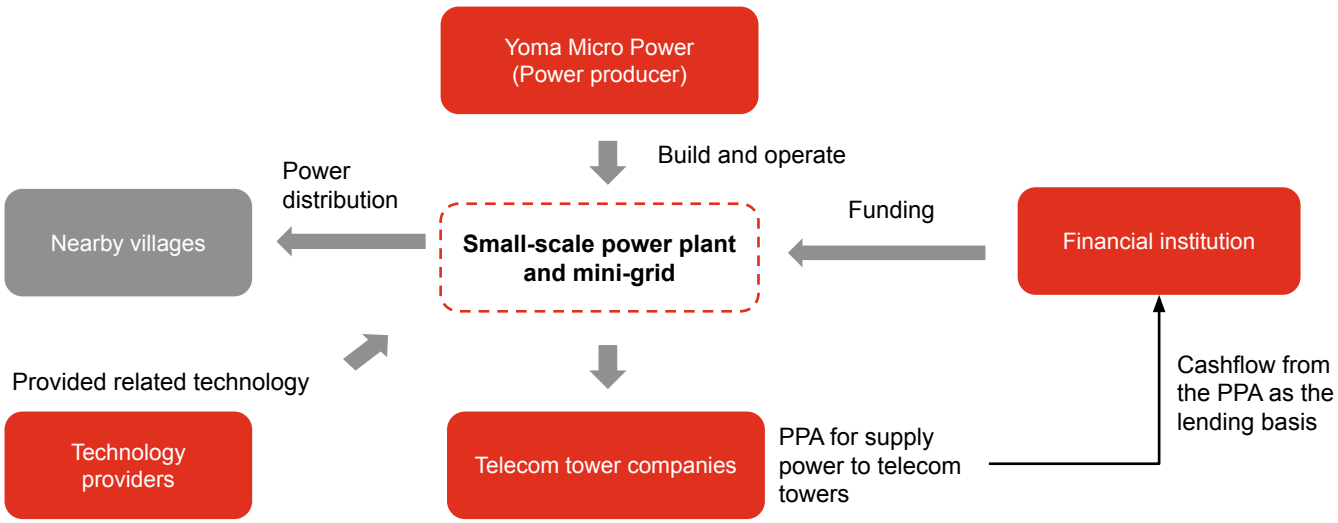
Criteria 1: Energy accessibility

Case study: Yoma Micro Power

In March 2020, Yoma Micro Power finished building 250 micro solar-hybrid power plants which will help power off-grid telecom towers that previously relied on diesel power. The connection is extended to nearby communities which include households, schools, shops and businesses through mini-grid distribution networks. The firm is targeting to build more than 2,000 sites by 2023 which would help power more rural communities.

Funded by the private parties, the power producer has successfully demonstrated an off-grid electrification model that is bankable. Under this model, the power producer builds small-scale solar hybrid power plants close to telecom towers in off-grid locations, and provides reliable power and uptime guarantees via service level agreements with telecom tower companies. Such power and uptime guarantee is enabled with InfraTech including performance management and monitoring systems. The service agreements is one of the key elements for the projects to successfully obtain bank financing. At the same time, the power plant supplies power to neighbouring communities via mini-grids. Without such mini-grid, the local villages wouldn't receive power over the next 10 years.

Exhibit 9: Commercial model of Yoma Micro Power



Challenges

Despite significant progress, more than 45 million people in the region continue to remain without access to electricity[16]. A key challenge in the way of achieving universal electrification in the region is the need for financing. Investment of more than USD 580 billion is expected to be needed to meet the region's energy needs between 2018 and 2040[17]. This is required to develop the electricity supply chain from power generation to transmission and distribution.

Financing from domestic institutions, both public and private, is unlikely to be enough to close the gap and hence international financing is essential in alleviating the accessibility of energy in the region. This would require policies and initiatives in place to incentivise the creation of a pipeline of bankable and shovel ready projects and provide an attractive risk weighted return to investors.

Microgrids or mini grids, together with renewable energy generation sources, could be a potential solutions to those people in some remote areas or islands which cannot access electricity on the national grid.

[16] IEA (2017), Bringing electricity to all corners of Southeast Asia, https://www.iea.org/commentaries/bringing-electricity-to-all-corners-of-southeast-asia
[17] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/

Criteria 2: Energy reliability

Methodology

Electricity system reserve margin is one of the indicators of energy supply reliability. As demand for electricity grows in the region underpinned by accelerated economic activity, population growth and urbanisation, each member state must increase their installed power capacity in line with the growing energy demand. Moreover, new electricity uses such as electric vehicle (EV) charging will further add to the demand for electricity in the region.

Trends

Overall, Southeast Asia countries generally have high to medium reserve margins of 30% and above (Exhibit 10), indicating that electricity systems in these countries can, for the most part, meet demand. However, some countries such as Cambodia and Myanmar are still seeing underdeveloped electricity services that are unreliable. Cambodia's existing transmission infrastructure is reaching capacity, resulting in transmission losses in major provinces and power shortages in some others. To alleviate this, the country is currently improving the capacity and stability of its transmission network with a USD 127.80 million loan from the Asian Development Bank (ADB)[18].

Challenges

In addition to reserve margins, the reliance on imported fuel for electricity generation is also an indicator of energy supply reliability. Over-dependence on particular types of fuels, especially those imported from outside the region, poses a challenge for long-term security of electricity supply. According to a study done by ASEAN Centre for Energy (ACE), ASEAN is expected to become a net importer of natural gas by 2024 and net importer of coal by 2035. ASEAN has been a net importer of oil since before 2005[19]. These fossil fuels make up a significant portion in the generation mix – about 76.5% of the total in 2018. The study forecasts continued reliance on fossil fuels, especially coal and natural gas by 2040.

Nonetheless, net importers such as Singapore, Thailand and Cambodia have sought to strengthen their energy security through reliance on renewables and improving energy efficiency. Cambodia, for example, plans to increase the share of solar power from 8.1% of total installed capacity in 2020 to 12.3% in 2021, and at the same time slightly decrease total share of imported power from close to 32% of total power generated in 2020 to 29% in 2021[20]. To achieve the target, the ADB has approved a $7.64 million loan to support the construction of a 100 MW solar park in Cambodia.

While our current assessment of energy reliability focuses on reserve margins of each country, continued reliance on imports of fossil fuels may challenge the energy security of the region in the long term.

Exhibit 10: Reserve margins in Southeast Asia

Country	Reserve margin	Energy reliability
Brunei	15-40%	Established
Cambodia	>40%	Mature
Indonesia	15-40%	Established
Laos	>40%	Mature
Malaysia	>40%	Mature
Myanmar	<15%	Developing
Philippines	15-40%	Established
Singapore	>40%	Mature
Thailand	>40%	Mature
Vietnam	15-40%	Established

Source: PwC Analysis

[18] ADB (2018). Proposed Loan and Administration of Grants Kingdom of Cambodia: Grid Reinforcement Project, https://www.adb.org/sites/default/files/project-documents/53324/53324-001-rrp-en.pdf
[19] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[20] Electricity Authority of Cambodia (2020). Salient Features of Power Development in the Kingdom of Cambodia - Consolidated report for the Year 2020, https://eac.gov.kh/uploads/salient_feature/english/salient_feature_2020_en.pdf

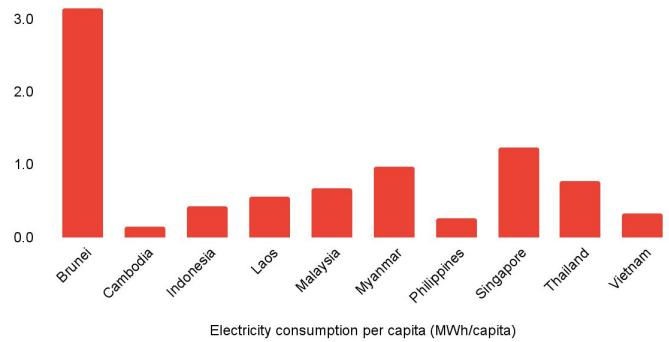
Criteria 3: Energy affordability

Methodology

In addition to providing universal access to electricity, the price of supply within the limits of capacity to pay off economically weaker sections of society is crucial to achieving development goals, citizen welfare and sustainability goals in the region.

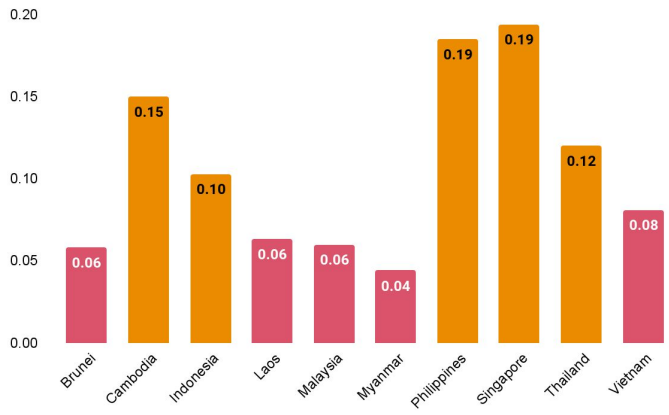
In order to assess the affordability of electricity within Southeast Asia, we compared the affordability of electricity to the households earning minimum wage. Each household was assumed to have 2 adults earning minimum wage. Using the average household electricity consumption (Exhibit 11 - published by ERIA and government statistical entities)[21,22,23,24,25] and electricity tariff of each member state (Exhibit 12), the cost of average household electricity consumption was derived as a percentage of minimum household wages (Exhibit 13).

Exhibit 11: Electricity consumption per capita (MWh/capita/year)



Source: ERIA

Exhibit 12: Average household electricity tariffs (USD/kWh)



Source: PwC Analysis

Based on the above analysis, most Southeast Asia countries have medium affordability with average household cost of electricity below 10% of average household earning minimum wage. The assessment is based on World Bank, WHO and IPA Energy's benchmark of 10-15%[26] of total household income/ expenditure on electricity.

Among the Southeast Asia countries, Brunei's per capita electricity consumption is among the highest in the world. The high power consumption is partly due to the heavily subsidised electricity tariff by the government. Even after the tariff system was changed from a regressive scheme to progressive in 2012, residential consumers continue to account for majority of consumption in the country. In 2017, residential consumers represented 43% of total electricity consumption[27]. Because our affordability index takes into account the average household electricity consumption, Brunei's average cost of household electricity consumption makes up 6.3% of its minimum household wage. However, we have ranked Brunei as 'Mature' in terms of affordability in our evaluation to account for the low tariff in the country.

[21] ERIA (2020). Brunei Darussalam Energy Consumption Survey: Residential and Commercial and Public Sectors, https://www.eria.org/publications/brunei-darussalam-energy-consumption- survey-residential-and-commercial-and-public-sectors/
[22] World Bank (2018). Beyond Connections - CAMBODIA - Energy Access Diagnostic Report Based on the Multi-Tier Framework, https://openknowledge.worldbank.org/bitstream/handle/10986/29512/124490.pdf?sequence=5&isAllowed=y
[23] K.A Rahman (2016). Energy Consumption Analysis Based on Energy Efficiency Approach: A Case of Suburban Area, MATEC Web of Conferences, https://www.matec-conferences.org/articles/matecconf/pdf/2017/01/matecconf_encon2017_02003.pdf
[24] Myanmar Energy Statistics (2019). Myanmar Energy Statistics, https://www.eria.org/uploads/media/0.ERIA-Myanmar_Energy_Statistics_2019.pdf
[25] Energy Market Authority of Singapore (2020). Average Annual Household Electricity Consumption by Planning Area and Dwelling Type, https://data.gov.sg/dataset/average-annual-household-electricity-consumption-by-planning-area-and-dwelling-type
[26] Samuel Fankhauser (2005). Can poor consumers pay for energy and water? An affordability analysis for transition countries, EBRD, https://www.ebrd.com/downloads/research/economics/workingpapers/wp0092.pdf
[27] ERIA (2019). Brunei Darussalam Energy Consumption Survey: Residential and Commercial and Public Sectors, https://www.eria.org/uploads/media/Research-Project-Report/RPR-2020-03-Brunei-Darussalam-Energy-Consumption-Survey/Brunei-Darussalam-Energy-Consumption-Survey-Residential-and-Commercial-and-Public-Sectors.pdf

Criteria 3: Energy affordability

Trends

Southeast Asia countries have different resource endowments and are at different stages of development. Hence, electricity affordability cannot be only measured via a common price. The region has to select the most economical option to meet electricity needs. In most cases, these represents the continual usage of fossil fuels as energy sources as can be seen in the projections in ASEAN Energy Outlook 6 (AEO6). With the cost of renewables reducing in recent times, power generation via renewables have started becoming more common across the region which will be discussed in later sections.

Challenges

The key challenge in electricity affordability in the region is balancing the apparent price of power such as Levelised Cost of Electricity (LCOE) with the socio-economic costs from environmental issues which often take secondary priority in the development of energy projects. The costs of investing in clean technologies such as carbon capture and utilisation / storage (CCUS) may deter individual Southeast Asia countries from making decisions that may benefit them in the long run.

Exhibit 13: Affordability Index (Average cost of household electricity consumption as a % of minimum household wages)

Country	Affordability index	Energy affordability
Brunei	6.3%	Mature*
Cambodia	2.2%	Mature
Indonesia	3.5%	Established
Laos	5.6%	Established
Malaysia	2.5%	Mature
Myanmar	7.5%	In progress
Philippines	3.5%	Established
Singapore	4.2%	Established
Thailand	3.8%	Established
Vietnam	2.7%	Mature

Source: PwC Analysis

As there is no standardised, widely adopted methodology to capture the negative impact of issues such as pollution, they are difficult to quantify and hence it would be difficult to compare the cost savings from standard technologies against clean technologies on a standardised basis.

Apart from the challenge in quantifying sustainable energy production, governments are also subsidising the retail electricity price to keep the electricity affordable for the public. This has added impact to lowering the cost artificially for electricity from coal which distorts the market price of electricity against renewable costs. The energy trilemma of affordability, sustainability and security is an issue which almost all countries are still trying to solve.

* As explained in the report, even though Brunei has one of the highest affordability index, it is still mature as the energy subsidy is high which indirectly results in much higher energy consumption compared to other countries.

Criteria 4: Energy sustainability

Methodology

Apart from becoming more accessible to the people in the region, the energy sector is also expected to become cleaner as clean technologies such as renewables and electric vehicles become economically competitive against traditional "dirty" fuels such as coal and gasoline.

Currently, Southeast Asia countries rank Developing to Established in terms of carbon emissions reduction (Exhibit 14) as coal has played an important role in supplying Southeast Asia's energy demand, given the abundance of coal reserves amongst member states such as Indonesia, Vietnam, Malaysia, the Philippines and Thailand[28]. In 2019, coal accounted for approximately 89GW of total installed power capacity in Southeast Asia. Despite the demand for coal continuing to decline globally driven by a switch towards more sustainable sources of energy, demand for coal in Southeast Asia is projected to increase from 139 Mtoe in 2017 to 329 Mtoe in 2040, with coal based generation capacity doubling within the same time period[29].

Although completely phasing out coal would be unlikely and impractical in the short term to ensure energy security within the region, three evident trends in the supply-side of the Southeast Asia's energy sector point to improved energy sustainability in the long term.

Exhibit 14: Grid emission factor

Country	Grid emissions (g/kWh)	Energy sustainability
Brunei	200-500	Established
Cambodia	200-500	Established
Indonesia	>500	Developing
Laos	200-500	Established
Malaysia	>500	Developing
Myanmar	200-500	Established
Philippines	>500	Developing
Singapore	200-500	Established
Thailand	200-500	Established
Vietnam	>500	Developing

Source: PwC Analysis

[28] Rika Safrina (2019). How Does ASEAN Coal Sector Look In The First Quarter Of 2019?, ASEAN Centre for Energy, https://aseanenergy.org/how-does-asean-coal-sector-look-in-the-first-quarter-of-2019/
[29] Alfred Gurning (2020). Why It's Too Early To Rule Out 'Sexy Killer' Coal in ASEAN's Energy Mix, ASEAN Centre for Energy, https://aseanenergy.org/why-its-too-early-to-rule-out-sexy-killer-coal-in-aseans-energy-mix/
[30] Leilani Chavez (2020). Philippines declares no new coal plants — but lets approved projects through, MONGABAY, https://news.mongabay.com/2020/11/philippines-declares-no-new-coal-plants-but-lets-approved-projects-through/

Criteria 4: Energy sustainability

Trends

1 - There will be a gradual phase out of coal as a power generation source

Member states are adopting more policies to ensure that coal utilisation will not impair the region's energy security and deter Southeast Asia from its targets to achieve a cleaner and more sustainable energy sector.

Philippines has issued a moratorium on new coal power projects, following a reassessment of the country's energy system. This could see a cancellation of over ~14 GW of new coal plants[30]. To accelerate the shift from coal to cleaner sources of energy, the Philippines government has also announced that it will now allow 100% foreign ownership in large-scale (USD 50 million or more) geothermal exploration, development and utilisation projects[31]. Thus, these regulations are expected to signal to investors in the region that the country is taking a turn to embrace renewable energy[32] and accelerate the country's transition 'from fossil fuel-based technology utilisation to cleaner energy sources to ensure more sustainable growth[33].

Indonesia, Southeast Asia's largest economy and one of the largest producers and exporters of coal globally, is finalising a draft regulation aimed at simplifying pricing for electricity from renewable sources[34]. The new regulation is expected to include an electricity feed-in tariff system for certain plants, reducing the need for power producers to engage in negotiations with the sole off-taker, PT Perusahaan Listrik Negara (PLN). With the improvement in the pricing formula, the government hopes that the green energy regulation will help achieve USD 20 billion of investment in new and renewable energy by 2024[35].

Singapore's top three local banks – DBS, OCBC and UOB – who had financed over 21 coal project deals since 2012, have announced their commitment to stop the financing of new coal-fired power generation plants to drive transition to renewable energy within the region[36]. Philippines's largest private domestic bank, Rizal Commercial Banking Corporation has also pledged to stop financing coal projects as of 2020. These have the effect of diminishing the financial attractiveness of coal projects as developers are unable to secure funds required to operationalise the facilities.

While coal-fired power plants are still prevalent in the region, some plans are being reconsidered and redeveloped as natural gas plants. Vietnam's Eighth Power Development Plan, to be announced in 2021 is expected to chart development plans with more emphasis on renewables and natural gas with 13 planned coal plants expected to be cancelled or postponed.

The private sector has also started gradually shifting away from coal projects in recent years. Ayala Corporation, traditionally a major coal plant developer in Philippines has pledged to divest from coal by 2030. Foreign investors such as CLP, KEPCO, Mitsui and Mitsubishi have also pledged to not build any new coal-fired power generation plants apart from those already under development with POSCO and JERA even pledging to achieve carbon neutrality by 2050. In addition, ADB, together with financial companies including Prudential, Citi, HSBC and BlackRock Real Assets are planning to develop a workable model to have early closure of Asia' coal-fired power plants, allocating around USD 1.7 million for feasibility studies covering Indonesia, Philippines and Vietnam[37].

[31] Kevin Adler (2020). Philippines announces moratorium on new coal-fired power, IHS Markit, https://ihsmarkit.com/research-analysis/philippines-announces-moratorium-on-new-coalfired-power.html
[32] Chloé Farand (2020). Philippines declares moratorium on new coal power plants, Climate Home News, https://www.climatechangenews.com/2020/10/28/philippines-declares-moratorium-new-coal-power-plants/
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[34] Reuters Staff (2020). Indonesian govt finalises new rules for renewable electricity, https://www.reuters.com/article/indonesia-renewables/indonesian-govt-finalises-new-rules-for-renewable-electricity-idUSL4N2HD1JS
[35] Alexander Richter (2020). New regulations in Indonesia on renewable energy feed-in-tariffs not including geothermal for now, THINK GEOENERGY, https://www.thinkgeoenergy.com/new-regulations-in-indonesia-on-renewable-energy-feed-in-tariffs-not-including-geothermal-for-now/
[36] DAVID FOGARTY (2018). Singapore banks finance SE Asia coal projects, The Nation Thailand, https://www.nationthailand.com/ann/30336794
[37] Clara Denina (2021). EXCLUSIVE ADB, Citi, HSBC, Prudential hatch plan for Asian coal-fired closures -sources, Reuters, https://www.reuters.com/world/uk/exclusive-citi-hsbc-prudential-hatch-plan-asian-coal-fired-closures-sources-2021-08-03/

Criteria 4: Energy sustainability

As a regional body, the ASEAN Forum on Coal (AFOC) is striving to facilitate regional cooperation through promoting carbon capture and utilisation / storage (CCUS) technology for the region. To promote the uptake of CCUS, AFOC will organise policy workshops, conferences and strategic outreach programmes to facilitate knowledge sharing in financial planning and technology advances in CCUS. A publication on the Strategic Report on Coal analysing the technical and socio-economic impacts of CCUS specifically focusing on energy security and sustainability will also be made available for developers to explore the feasibility of adopting CCUS technologies. A regional centre for research and development will be explored to focus on the development of CCUS in the energy transition plans for Southeast Asia countries.

Challenges

The adoption of CCUS has traditionally been deterred by the cost of the technology. For power generation, the current carbon capture cost is estimated to be from 40 to 80 USD/ton. For comparison, the carbon tax in Singapore has been set at 5 SGD/ton (3.60 USD/ton) and only expected to raise to 15 SGD/ton by 2030. Hence, even in the most economically developed nation in the region, there is no cost incentive for the adoption of CCUS. The Singapore government recently conducted a study which revealed a number of key obstacles such as expensive cost due to diluted CO_2 emission from industrial and power plant facilities, limited suitable geological formations for the permanent storage of CO_2, and the difficulty in utilisation of captured carbon for other uses.

Apart from cost, policies and regulations supporting CCUS have no clear implementation requirements across various Southeast Asia countries. Key drivers in the promotion of CCUS technologies are environmental regulations and policy initiatives. In areas with successful CCUS implementation, air pollution policies (such as in the US and EU) have a set time limit and standards for environment control as well as provisions for punishments against noncompliance. With the region still in development, energy availability and economic progress is often prioritised over environmental concerns. While there has been an increasing awareness of the consequence of increasing CO_2 emissions and environmental pollution, Southeast Asia countries have yet to have an overall plan for CCUS propagation.

2 – Renewables and clean energy will play a key role in the energy transition of Southeast Asia

Globally, we are observing a steep decline in the LCOE of renewable energy such as wind and solar PV. In the past decade, the LCOE of solar photovoltaic (PV) has declined over 82% and is expected to fall further (as much as 90%) in the next few years[38]. At the same time, the LCOE for onshore and offshore wind has also declined (between 29% and 39%) with greater cost reduction potential[38].

With the rapidly declining cost of renewable energy generation, the current cost of renewable energy is now close to conventional energy generation technologies and is expected to reach grid parity. Coupled with an increasing push towards sustainable energy sources, renewables are expected to play a significant role in the energy sector moving forward**.** This builds a strong business case for renewable energy to meet region's rising electricity demand in a cost-effective and sustainable manner[39].

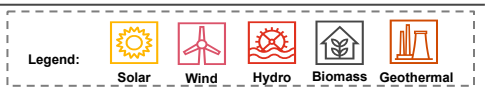
[38] Dolf Gielen (2020). ASEAN Energy Transition Outlook, SIEW, https://www.siew.gov.sg/docs/default-source/event/2020/asean-energy-transition-outlook_dolf-gielen_irena.pdf?sfvrsn=2
[39] The ASEAN post team (2020). Renewable Energy Challenges In Southeast Asia, The ASEAN Post, https://theaseanpost.com/article/renewable-energy-challenges-southeast-asia
[40] Thu Vu (2021). IEEFA: Vietnam's extraordinary rooftop solar success deals another blow to the remaining coal pipeline, IEEFA, https://ieefa.org/ieefa-vietnams-extraordinary-rooftop-solar-success-deals-another-blow-to-the-remaining-coal-pipeline/#:~:text=Vietnam%20made%20an%20impressive%20debut,power%20system%2C%20according%20to%20EVN.

Criteria 4: Energy sustainability

Solar energy is expected to lead the energy transition in Southeast Asia, given its declining cost and abundance of sunlight in the region. With the cost of solar reaching parity or even lower compared to conventional power sources such as gas-fired power generation, solar PV capacity has been climbing. In the first half of 2019, approvals for solar PV capacities exceeded that of coal-fired power plants. Vietnam has seen a spurt in solar installation since 2017 and currently has almost 16.5GW of solar capacity which exceeds that of the other Southeast Asia countries combined[40].

The growth in solar capacity has been driven by new policies, most notable of which is the implementation of feed-in-tariffs (FiT). The FiT in Vietnam has surged the solar installed capacity to 15-16GW in 2020 which is way beyond the modest 1GW target on solar as of 2020. Apart from FiT, competitive bidding for solar power plants has also been employed. Cambodia offered two phases tender projects under the Built-Own-Operate scheme with 60MW of solar capacity in the first phase and 40MW in the second phase while Malaysia has shortlisted 30 companies and awarded a total of 823.06MW of solar project in the fourth round of Large Scale Solar (LSS 4) with price ranges from 4.3 US cents/kWh to 6 US cents/kWh[41]. Southeast Asia will need to increase its solar PV capacity from 32 GW in 2020 to 83 GW to 2025 in order to achieve the APAEC regional targets by 2025[42]. Each Southeast Asia country has set targets on renewables capacity in their long-term power plans as well (Exhibit 15).

Exhibit 15 Renewable energy targets for individual Southeast Asia countries



- **10%** renewable energy share in installed power generation capacity by 2035
- **12%** share of renewable energy in national power generation mix by 2030
- **3%** of residential electricity demand met by rooftop solar PV by 2035
- **40%** share of renewable energy in electricity generation by 2020 (and 100% by 2050)
- **23%** share of renewable energy in primary energy supply by 2025 (31% by 2050)
- **2GWp** of solar capacity by 2030
- **30%** share of renewable energy in total energy consumption by 2025
- **30%** share of renewable energy in total final energy consumption by 2036 (and 20% share of renewable energy in electricity generation by 2036)
- **20%** share of renewable energy in power capacity mix by 2025 (and 9% share of renewable energy in electricity generation by 2020 and 20% by 2030)
- **32.3%** share of renewable energy in total primary energy supply by 2030 (and 44% by 2050)

Source: PwC Analysis

There is significant potential for wind energy within Southeast Asia, with substantial wind resources in countries such as Indonesia, Philippines, Thailand and Vietnam. An estimated 100GW of wind energy can potentially be harnessed in the Philippines and Vietnam[43]. Over the past decade, wind energy development has increased with a CAGR of 45.4%. At present, Thailand has the largest installed capacity base of wind power at ~1,500 MW. The growth of wind energy in the region has largely been driven by Thailand and Vietnam.

As with solar, the growth has been driven by policies. Stable, long term policies to mitigate investment risks are essential for businesses to invest in wind energy deployment. The Philippines, Thailand and Vietnam, three largest countries in terms of installed wind capacity all apply FiT for wind power which mitigates financial risks for investors[44].

[41] Christopher & Lee Ong (2021). Malaysia's Large Scale Solar 4 / LSS: Analysis of Results, Lexology, https://www.lexology.com/library/detail.aspx?g=368a6450-9ece-44ff-808d- c53d96a93327
[42] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[43] IRENA (2018). Renewable Energy Market Analysis - Southeast Asia, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_ 2018.pdf
[44] Badariah Yosiyana (2017). Wind Power Development in ASEAN: It's Promising!, ASEAN Centre for Energy, https://aseanenergy.org/wind-power-development-in-asean-its- promising/

Criteria 4: Energy sustainability

Countries such as Indonesia, Malaysia, Philippines, Thailand and Vietnam have abundant biomass resources (e.g.: rice, sugarcane) to provide feedstock for bioenergy projects. High productivity of the agriculture sector in the region generates considerable volumes of residuals that remain under-utilised. The table below provides estimate aggregated volumes of total availability of sustainable bioenergy for specific feedstock by 2025 in Indonesia, Thailand and Vietnam (Exhibit 16). These countries have large agricultural industries and hence significant amount of untapped biomass feedstock.

Exhibit 16: Total availability of sustainable bioenergy in Indonesia, Thailand and Vietnam (million tones)

Country	2025	2030	2050
Indonesia	325.6	343.9	365.2
Thailand	108.6	114.7	121.7
Vietnam	41.3	43.6	46.3

Source: PwC Analysis

IRENA's "Global Energy Transformation – A roadmap 2050 report" reports that bioenergy is expected to become the largest energy source in the total energy mix in Southeast Asia, which is over 40% of total primary energy supply (TPES) in 2050 under Transformation Energy Scenario (TES). Majority of the biomass is used in Industry (40% of total TPES) and Transport sector (37% of total TPES).

Among the Southeast Asia countries, Singapore, Brunei and Malaysia have shown significant interest in hydrogen. The hydrogen supply chain demonstration together with Chiyoda, Mitsubishi Corp, Mitsui & Co and Nippon Yusen in Brunei aims to test the sea transport of hydrogen via an organic chemical hydride carrier. Sarawak, Malaysia on the other hand has introduced hydrogen fuel cell buses in Kuching operating on the Downtown Heritage Loop (14km) and Damai Loop (67km). The Singapore government has undertaken several initiatives to explore the potential of employing hydrogen in Singapore such as a consultancy study and other pilot trials for hydrogen in the country.

Challenges

The key hurdles to wide adoption of renewables in the region are financial, regulatory, geographical and technological challenges. Even though costs of renewable energy have largely declined, uptake may still be slow due to their capital-intensive nature. Countries such as Brunei are still exploring policy frameworks in regulating renewable energy development. As a result, there is a lack of coordination between government agencies and private sector which has hindered renewable projects development[45]. For solar application, there are land constraints in some countries in the region. For example, Indonesia and Philippines, which are archipelagos, have fragmented electricity grids that hinder effective deployment of solar technology as they are away from national grid systems to transmit electricity generated. Across the region, there has been a lack of an effective, coordinated policy in implementing biomass technologies.

Hydrogen has also yet to enter the policy agenda in many member states as an alternative fuel. The ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II expects to see greater efforts, including policy measures, taken to address and promote the hydrogen technology. There is a growing need to develop a clear strategy on how to promote hydrogen use in the transportation and power sectors including investing in research and development of hydrogen production and storage technologies, and setting targets.

[45] The ASEAN post team (2019). ASEAN's renewable energy challenges, The ASEAN Post, https://theaseanpost.com/article/aseans-renewable-energy-challenges
[46] ASEAN (2019). JOINT MINISTERIAL STATEMENT OF THE 37th ASEAN MINISTERS ON ENERGY MEETING, https://asean.org/wp-content/uploads/2021/08/AMEM37_JMS-Final.pdf

Criteria 4: Energy sustainability

3 – Energy efficiency is key in the energy transition pathway for the region

On the demand side, Southeast Asia has identified improving energy efficiency as key in reducing dependency on fossil fuels, strengthening energy security and lowering GHG emissions. Cost reduction has been increasingly realised by the private sector which also drives the acceleration of the energy efficiency project deployment. A study conducted by ADB has shown that an increase in energy efficiency by 1-4% can meet a quarter of projected energy increases across the next decade.

Southeast Asia has made significant developments in the reduction of energy intensity. The region saw a 24% reduction by 2020, exceeding the ambitious target of 20% reduction (based on 2005 levels)[46]. Since 2000, Southeast Asia has implemented various Energy Efficiency and Conservation (EE&C) programmes directed towards increasing energy efficiency in four priority sectors, including residential, commercial buildings, industry, and transportation. One initiative within Southeast Asia is the Energy Efficiency Standards and Labelling (EESL) programme adopted by five member states - Malaysia, Singapore, Philippines, Thailand and Vietnam. The harmonisation of minimum energy performance standards and labelling schemes can help to facilitate greater transformation of energy efficient appliances within the region.

The region has established a target to achieve a 32% reduction in energy intensity by 2025[47]. At the same time, UN SDG 7.3 has also established a target to improve energy intensity by at least 2.6% annually up to 2030[48].

Malaysia, Indonesia, Thailand, Singapore and Vietnam have developed robust frameworks and financial schemes/instruments to finance energy efficiency programmes. Thailand developed the Energy Efficiency Revolving Fund (EERF), allowing paid-back funds for energy efficiency projects when they are operationalised and implemented. Malaysia provides government guarantees to make such projects bankable for investors and also provides rebates in the adoption of efficient measures taken in households. Singapore has several financial instruments in financing energy efficiency projects. The Energy Efficiency Fund (E2F) for the industrial sector and the Green Mark Incentive Scheme (GMIS) for the residential sector are examples of schemes to incentivise energy efficiency projects. Similarly, Vietnam has the National Technology Innovation Fund (NATIF) and the Vietnam Environment Protection Fund (VEPF).

Challenges

However, the lack of data and varying localised test standards are preventing a uniformed system for EESL programmes in Southeast Asia. There is also a greater need for an Southeast Asia-level coordination entity to oversee overall progress on the harmonisation of standards across the region[49]. The varying national framework for environmental sustainability and financial policy in various Southeast Asia countries deters regulatory and financial systems within the region to align and collaborate on the regional goal stated in SDG Agenda 2030. Instead of mandates and incentives, the region's policies are largely voluntary, focusing on awareness and capacity-building programs. These hence would be less effective in countries lacking economic resources and strong government policies.

In addition, fossils fuel such as coal remain heavily subsidised and there is a lack of clear government policies and framework to implement energy efficiency measures. These include a lack of energy standards in the transport sector (such as the Euro standards for vehicles) and building standards. Apart from standards, a lack of financing framework and awareness disincentivises the diffusion of energy-efficient technologies.

[47] ASEAN Centre for Energy (2020). 6th ASEAN Energy Outlook, https://aseanenergy.org/the-6th-asean-energy-outlook/
[48] World Bank (2020). THE ENERGY PROGRESS REPORT TRACKING SDG 7 2020, https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/May/SDG7Tracking_Energy_Progress_2020.pdf
[49] Liu Yang (2019). Harmonising Energy Efficiency Standards and Labelling Programmes in ASEAN: Current Trends and Future Developments, Energy Studies Institute, https://esi.nus.edu.sg/docs/default-source/esi-policy-briefs/harmonising-energy-efficiency-standards-and-labelling-programmes.pdf?sfvrsn=2

Criteria 5: Energy smartness

Methodology

With the increasing integration of renewable energy in the electricity system, power grids are evolving to accommodate higher levels of complexity required for the flow of electricity from generation to consumption. Since renewable energy such as solar and wind have variable power output, “smarter” processes and technologies are needed to monitor and coordinate supply efficiently. Furthermore, power grids must meet expanding electricity demands of end-users such as the rise of EVs.

In Southeast Asia, smart grids are yet to be widely implemented by utilities in these members states. Indonesia, Thailand, Singapore, Malaysia, Vietnam and the Philippines are in initial stages of smart grid implementation, with some more advanced in their roll out compared to others. Exhibit 17 shows the smartness of power grids managed by utilities of each Southeast Asia country in the Smart Grid Index (SGI). Singapore’s SP Group ranks high in the index among utilities in the Southeast Asia countries due to its high scores in the dimensions Supply Reliability and Customer Empowerment & Satisfaction, as do Indonesia’s Tata power-DDL. However, these two utilities still fair low compared to those in Europe, USA, Australia, Taiwan and Hong Kong. Two other utilities from Indonesia scored much lower compared to Tata power-DDL, downgrading the overall rank of the country to medium. Brunei, Cambodia and Myanmar do not have smart grid plans yet, while Laos have taken initiative with a load dispatching centre project in Sisaket[50].

Exhibit 17: SP Smart Grid Index 2020

Country	Utility	Score	Energy smartness
Brunei	Not assessed		Developing
Cambodia	Not assessed		Developing
Indonesia	Tata power - DDL Tata power ltd PLN	40-75	Established
Laos	Not assessed		Developing
Malaysia	TNB Sarawak Energy	40-75	Established
Myanmar	Not assessed		Developing
Philippines	Meralco	40-75	Established
Singapore	SP Group	75-100	Mature
Thailand	MEA PEA	40-75	Established
Vietnam	EVN Hanoi EVN HCMC	40-75	Established

Source: PwC Analysis

[50] The ASEAN-German Energy Programme (AGEP) Team (2018). Study on Smart Grid Overview in ASEAN, ASEAN Centre for Energy, https://aseanenergy.org/study-on-smart-grid-overview-in-asean/

Criteria 5: Energy smartness

Trends

Thailand's Energy Policy and Planning Office (EPPO) launched a national smart grid master plan in 2015, with the plan divided into four phases: preparation 2015-16, short-term projects 2017-21, medium-term projects 2022-31 and long-term projects 2032-36[51]. Under the plan, state-owned utilities will spend up to 200 billion THB (around USD 6 billion) in implementing smart grid projects in the 20-year period[52]. One of the pilot projects in 2020-21 saw rollout of 116,000 smart meters in the city of Pattaya[53]. In Vietnam, the Smart Grid development plan developed in 2012 is being implemented in three phases and multiple initiatives. Some of the activities include installing SCADA/EMS project on distribution grid management, building Advanced Metering Infrastructure (AMI), and initiating smart home and smart city research program.

Within the region, the Southeast Asia Smart Grid has implemented various transmission and distribution automation software, advanced metering infrastructure and demand response technologies to ease the integration of distributed energy resources[54]. The use of sensors and smart technology, including smart devices, smart appliances and smart assistances can also help to improve energy efficiency and reduce electricity consumption.

Energy smartness goes beyond smart grids as technologies such as blockchain, AI and Internet of Things (IoT) will also have a role in improving the region's energy security. These technologies will facilitate more secure forms of trading and more efficient methods of operations and construction. In Singapore, SP Group has launched the world's first blockchain-powered trading of renewable energy certificates (REC). Smaller producers (i.e.: households) of renewable energy can now sell their excess electricity in the form of "green credits". The platform can help to facilitate the transactions of REC by matching buyers and sellers based on their respective requirements. Trading of REC can drive greater integration of renewable energy sources on the electricity grid, allowing organisations to achieve their green targets and strengthens cross-border sustainability efforts.

Challenges

Although adoption of smart grids decreases costs and maintains or improve grid reliability, the infrastructure required for their development is not yet readily available in some countries. Investment in a large range of technologies such as Information and Communication Technology (ICT) infrastructure and network management systems, is needed to transform the current system into a smart grid system. Transitioning from a traditional grid to a smart one also requires the new equipment to be compatible with the existing, legacy infrastructure. To overcome these technological hurdles, the regulatory environment needs to allow for entry of new market players that have the capital and knowhow. In Vietnam, for example, there is large curtailment due to the underdeveloped power grid and increasing deployment of solar power. The situation calls for use of smart grid technologies to balance the intermittent nature of solar but EVN has monopoly over transmission and distribution, making private sector involvement in grid infrastructure difficult.

[51] The Star (2020). Smart-grid plan aims to make Thailand the electricity hub of Asean, https://www.thestar.com.my/news/regional/2020/02/08/smart-grid-plan-aims-to-make-thailand-the-electricity-hub-of-asean
[52] Michell Christopher (2018). Thailand 4.0: The Smart Grid Project, OpenGov Asia, https://opengovasia.com/thailand-4-0-the-smart-grid-project/
[53] Jonathan Spencer Jones (2021). Thailand – lessons from a 116,000 smart meter rollout, Smart Energy International, https://www.smart-energy.com/industry-sectors/smart-meters/thailand-lessons-from-a-116000-smart-meter-rollout/
[54] Yahoo (2020). ASEAN Smart Grid Market 2019-2024: Focus on Product Offerings, Technology, End User, Communication Tech, Countries, Cost-Benefit, Investment, https://finance.yahoo.com/news/asean-smart-grid-market-2019-092854231.html

Criteria 6: Energy trading

Methodology

Currently, under the ASEAN Power Grid, more than 5.5 GW of interconnection capacity exists, with at least nine cross-border power grid projects established across the region. The majority of existing interconnections within the region (c. 65%) were constructed between Lao PDR and Thailand[55].

As with most electricity trading in the region, Thailand imports electricity from Lao under bilateral, long-term power purchase agreements. Malaysia also imports electricity from Lao PDR, under the LTMS-PIP, with Thailand acting as the wheeling country.

Lao PDR, having significant hydropower potential, has several memorandum of understanding (MOU) to export hydropower with Thailand, Vietnam and Cambodia. Investments from these Southeast Asia countries has greatly improved the country's electrification rate while also providing economic growth in the country. Laos currently exports more than 60% of its hydropower to neighbouring countries.

In 2019, we saw at least 35 TWh of electricity trade within Southeast Asia[56]. The ASEAN Power Grid is the key initiative in enhancing cross-border electricity trade and unifying the energy sector. As the region is expected to see rapid growth in energy demand, electricity trading is expected to improve energy accessibility, security, affordability and sustainability within the region. An integrated ASEAN power grid is expected to bring about significant benefits such as reduced cost and the ability to pool variable renewable sources from countries with endowment advantages to countries with significantly less resources. In addition, having an integrated power grid will allow countries to balance their power supply more efficiently by drawing required power from sources across the region. An integrated power grid would have more diversified and stable power sources. Hence, a plant failure would be less likely to significantly affect power supply across the region and the reserve margins can be minimised resulting in overall minimisation of cost.

Exhibit 18 Energy trading in Southeast Asia[55]

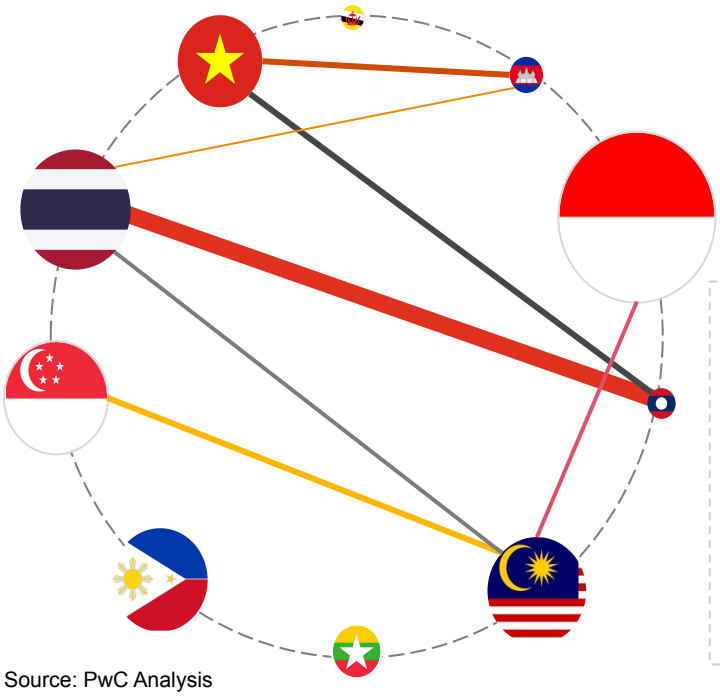
Country	Capacity (MW)	Energy trading
Brunei	No connection with other Southeast Asia countries	Developing
Cambodia	>300 MW	Established
Indonesia	<300 MW	In progress
Laos	>300 MW	Established
Malaysia	>300 MW	Established
Myanmar	No connection with other Southeast Asia countries	Developing
Philippines	No connection with other Southeast Asia countries	Developing
Singapore	>300 MW	Established
Thailand	>300 MW	Established
Vietnam	>300 MW	Established

Source: PwC Analysis

[55] IEA (2019). Establishing Multilateral Power Trade in ASEAN, https://iea.blob.core.windows.net/assets/37a2b2f0-bab0-47e0-a618-1a0259926b26/Establishing_Multilateral_Power_Trade_in_ASEAN.pdf
[56] IRENA (2018). Renewable Energy Market Analysis - Southeast Asia, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_2018.pdf

Criteria 6: Energy trading

Exhibit 19: Existing energy interconnections in Southeast Asia



5.5 GW of interconnection capacity with at least nine cross-border power grid projects across the region

35 TWh of cross-border electricity trade within the region in 2019

>19 GW of interconnection capacity planned for the APG

Existing interconnections

Interconnection	Capacity (MW)
Thailand - Lao PDR	3,584
Lao PDR - Vietnam	538
Vietnam - Cambodia	200
Thailand - Cambodia	120
Peninsular Malaysia - Singapore	450
Sarawak–West Kalimantan	230
Thailand - Peninsular Malaysia	380

Source: PwC Analysis

Trends

In the latest developments of the ASEAN Power Grid, Lao PDR, Thailand, Malaysia, and Singapore have announced their commitment to initiate up to 100 MW of cross-border power trade under the Lao-Thailand-Malaysia-Singapore Power Integration Project (LTMS PIP), which is the region's first multilateral electricity trade initiative within Southeast Asia. The plan is to transmit 100 megawatts (MW) from Laos to Singapore, via Thailand and Malaysia using existing interconnections from 2022 to 2023.

The rationale of LTMS-PIP is to export some of the excess hydropower from Laos to its southern neighbours, and for Singapore to tap regional power grids for access to clean energy and drive sustainability goals. Moreover, the LTMS PIP also serves as a trial of a broader power integration initiative, paving the way for a regional electricity market across Southeast Asia in the future.

Recently, Singapore has also announced plans to import additional 100 MW of electricity from Malaysia for two years. Despite having high reserve margins and 'ample spare capacity', importing additional electricity is expected to help Singapore 'strengthen its regional grid architecture', as well as achieve its sustainability agenda in reducing carbon emissions in electricity generation.

Challenges

However, significant challenges for APG remains due to the diverse economic and regulatory structures which exist in the region. Most existing trade within the APG occurs through bilateral agreements. As the region moves towards a more integrated trading model, **there will be an increasing need to develop appropriate market mechanisms and achieve standardisation of technical standards to drive power trading within the region**. More can also be done in terms of proving better institutional and policy support as well as financial incentives (e.g.: taxation, tariff for cross-border transaction, and regulations on PPPs) to support large scale power projects. This will help to bring about a more integrated electric market in the region.

Looking ahead: Future of energy sector in Southeast Asia

Many of the Southeast Asia countries have made great progress in meeting basic energy needs in terms of accessibility, reliability and affordability. There have been initiatives across the region to become greener, smarter and more interconnected – although to a varying degree of progress among the Southeast Asia countries. Key challenges to achieving maturity in these domains largely lie in inadequate financial support, regulatory barriers, lack of access to technology, and embrace of traditional primary energy sources.

As the region is still developing and economic growth is prioritised, fossil fuels will still play a prominent role in the coming years. But with declining costs of renewable energy, policy makers are seeing an opportunity to fulfil their energy accessibility goals while driving the transition to a cleaner and energy efficient future. Subsequently, this transition will require incremental uptake of smart grids to manage both supply and demand of electricity.

In order to improve on all the aforementioned criteria, the region has stepped up its collaboration efforts with the ASEAN Power Grid initiative. This development of interconnected grid systems will further increase uptake of renewable energy, boost energy security, and facilitate Southeast Asia's energy transition journey.

Southeast Asia's energy transition journey:

Transition 1 - The future energy sector will become fully accessible

- Southeast Asia is expected to attain **universal electrification** by the end of this decade
- **Strengthening energy security** in the region is a priority to ensuring access to all
- **Electricity affordability** is another key goal in keeping energy accessible for the region

Transition 2 - The future energy sector will become cleaner

Supply-side – Gradual phase-out of coal and increasing uptake of renewable energy

- There will be **a gradual phase out of coal** as a primary energy source
- Renewables will play a key role in the energy transition of Southeast Asia, especially **solar, onshore/offshore wind and biofuel**

Demand side – Improving energy efficiency

- **Energy efficiency** is also key in the energy transition pathway for the region

Transition 3 - The future energy sector will become smarter

- **Blockchain** to bring transparency in electricity trading
- **Artificial intelligence** to enhance energy sector data analytics and operation of smart grids
- **Internet of things** to enable seamless data collection and transmission
- **3D-printing** to accelerate energy equipment manufacturing process

Transition 4 - The future energy sector will become more integrated

Transmission infrastructure enhancement and **increasing volume of electricity trading** within Southeast Asia utilising ASEAN Power Grid.

The transition is happening, and the questions now are how fast it can be and how can Southeast Asia make it faster.

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