Author

Global **Transmission** Report

Knowledge Partner

HITACHI

GRIDS IN TRANSITION: SOUTHEAST ASIA



©Global Transmission Report, November 2026

All rights reserved. The information provided in this document should not be reproduced, republished, resold or otherwise distributed in any medium without the prior written permission of Global Transmission Report.

Global Transmission Report takes every possible care to provide information using resources it believes are the most accurate and reliable. It, however, shall not be liable for any losses or consequences, if any, arising from the use of the information contained in this document.

We would like to acknowledge Hitachi Energy for its peer review and technical insights contributed to this report.

Cover image credit: Shutterstock

CONTENTS

EXECUTIVE SUMMARY 1

1. INTRODUCTION 3

2. A CHANGING POWER SYSTEM 6

3. EMERGING GRID CHALLENGES 10

4. ENABLING GRID TRANSFORMATION 13

- 4.1 Adopting Integrated Long-Term Planning 13
- 4.2 Deploying Mature Advanced Grid Solutions 15
- 4.3 Strengthening Supply Chains and Procurement 16
- 4.4 Scaling Regional Integration 17
- 4.5 Modernising Regulation and Markets 19

5. CONCLUSION 20

EXECUTIVE SUMMARY

Southeast Asia accounts for more than 6% of global economic output[1] and has contributed 10% of global energy demand growth since 2015[2]. Electricity demand grew by an average of 6% annually between 2015 and 2025 and is projected to more than double by 2050[2]. Data centres, industrial electrification, cooling and electric vehicles (EVs) are adding new demand, often where grid capacity is already constrained.

The region's generation mix is also changing. Solar and wind capacity is expected to expand ninefold by 2050[2], while coal is likely to retain a substantial role over the coming decade. The region's coal-fired plants average less than 13 years of age[3], and rapid retirement presents economic and operational challenges. Tightening domestic gas supplies are expected to make Southeast Asia a larger net gas importer by 2035[2], increasing exposure to international liquefied natural gas (LNG) markets. Without appropriate measures, the regional energy import bill could rise from more than USD80 billion in 2024 to around USD160 billion in 2026 and USD245 billion by 2035[4].

Shipping disruption through the Strait of Hormuz in 2026 caused volatility in global energy markets and a sharp rise in Asian LNG prices[5,6]. Energy security therefore reinforces the need for more diverse power systems, and greater use of domestic renewable resources can reduce exposure to fuel price volatility and supply disruption.

The region's power infrastructure is also exposed to climate-related hazards. Around half of Southeast Asia's solar photovoltaic and hydropower capacity is located in cyclone-prone areas, and more than 20% of the region's electricity grids are exposed to tropical cyclones[7]. Typhoon Kajiki in 2025 disrupted electricity supply for around 1.6 million people in Vietnam[8].

The existing network configuration limits flexibility in responding to these pressures. Electricity systems have developed mainly within national borders, and networks in archipelagic Indonesia and the Philippines are organised largely around individual islands. Of approximately 10.2 GW of cross-border transfer capacity, only around 2.8 GW is grid-to-grid[9].

Meeting the rising demand, maintaining energy security and sustaining the region's socio-economic progress depend on the capacity and reliability of power networks. Grids must deliver substantially more electricity than at present, connect renewable resources located far from consumption centres, accommodate large industrial and digital loads, and manage variable generation and extreme weather.

The International Energy Agency estimates that Southeast Asia's transmission and distribution networks will need to more than double in length by 2050, requiring more than USD300 billion of grid investment between 2025 and 2040, a 72% increase compared to investment during 2009–2024[10].

Five priority areas can accelerate grid expansion and transformation:

Long-term integrated system planning. Generation, transmission, distribution, storage, flexibility and interconnection should be assessed together. Demand forecasts should include data centres, industrial electrification, cooling, EVs and distributed energy resources. Transmission investment should proceed ahead of fully contracted demand where future needs are clear.

Mature advanced grid solutions. Utilities should combine conventional expansion with technologies that increase network utilisation, stability and flexibility: dynamic line rating, high-temperature low-sag conductors, high-voltage direct current (HVDC) transmission, storage and digital monitoring. HVDC suits remote and island renewable resources

and subsea cross-border links. Wider deployment requires harmonised standards and appropriate regulatory frameworks.

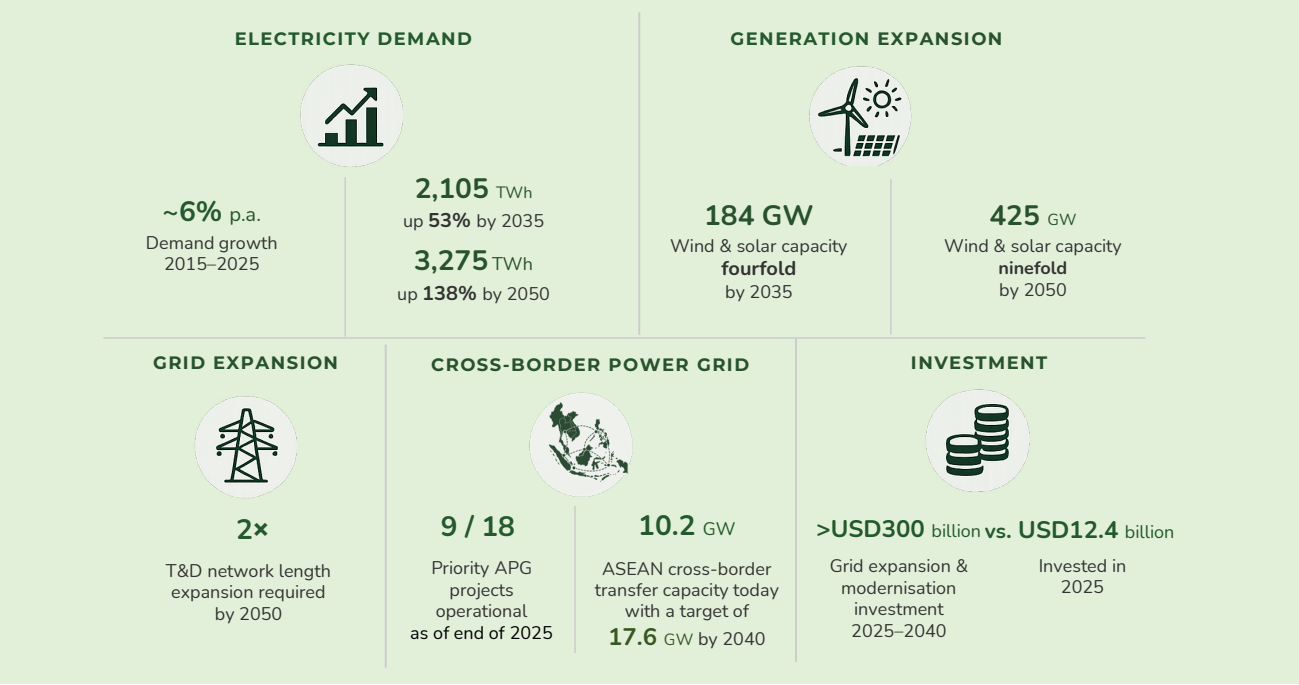
Supply chains and procurement. The region has very few high-voltage equipment manufacturing facilities and relies on European, Japanese, Korean and Chinese suppliers for HVDC systems, subsea cables and large transformers[11]. Utilities can provide clearer long-term demand signals through multi-year procurement plans, standardised specifications and earlier supplier engagement. Coordinated procurement can secure manufacturing slots. Where demand is sustained, local manufacturing capacity can be developed, as indicated by the subsea cable factory proposed in Vietnam[12].

Regional integration. As of 2025, nine of the 18 priority Association of Southeast Asian Nations (ASEAN) Power Grid interconnection projects were operational, mostly generation-to-grid capacity linked to specific projects rather than grid-to-grid trade[9]. Expanding grid-to-grid interconnection would allow countries to share reserves, use diverse renewable resources and reduce reliance on imported fuels.

Regulation and markets. Frameworks should support timely network investment and value flexibility. Grid codes should evolve with renewable expansion, covering voltage control, frequency response, fault ride-through, forecasting and cybersecurity. Storage and demand response should provide system services where appropriate.

Southeast Asian countries differ in income, electricity access, generation mix, institutional capacity and power industry structure. National governments, regulators and utilities lead energy policy and its implementation, with ASEAN providing a cooperation framework. Priorities and investment needs therefore vary between markets. Regional cooperation can support the exchange of technical expertise, regulatory experience and project lessons, which countries can adapt to national circumstances. ■

Figure 1: Southeast Asian Grids in Transition



Notes: APG: ASEAN Power Grid; ASEAN: Association of Southeast Asian Nations; GW: gigawatt; p.a.: per annum; T&D: transmission and distribution; TWh: terawatt-hour; USD: US dollar. Demand projections are based on the IEA Current Policies Scenario.

Sources: IEA (2026), Southeast Asia Energy Outlook 2026; IEA (2026), Financing the ASEAN Power Grid; ASEAN Centre for Energy (2026), ASEAN Energy in 2026; Asian Development Bank, ASEAN Power Grid.

INTRODUCTION

1

Rising electricity demand and expanding renewable generation are changing where electricity is produced, transported and consumed across Southeast Asia.

Demand growth is driven by continued urbanisation, industrial expansion, transport electrification and new loads from data centres. Eight countries have announced net-zero targets[2]. Solar and wind capacity is growing, although coal, natural gas and hydropower continue to play major roles in the generation mix. Distributed energy resources (DERs), battery storage and nuclear power are also featuring in national power plans. These developments require electricity networks that can connect new generation, serve growing demand centres and maintain reliable system operation.

Existing transmission and distribution (T&D) networks in the region were designed for large, centralised fossil-fuel generators, relatively predictable demand and unidirectional power flows, and were organised largely on a national basis.

They must now connect renewable resources located far from demand centres, manage variable solar and wind output, integrate DERs with bidirectional flows, and serve large industrial and digital loads.

Infrastructure must also address exposure to extreme weather, fuel supply disruption and cybersecurity risk. Grid development should therefore combine additional network capacity with improvements in flexibility, reliability and resilience.

Figure 2: Southeast Asian Economies and Power Systems at a Glance

REGIONAL MAP



KEY ECONOMIC AND POWER SYSTEM INDICATORS

Country	GDP (USD billion, 2024)	Population (million, 2024)	GDP per capita (USD, 2024)	Electricity access (%, 2024)	Dominant source (share of generation, 2025)
Brunei	15.7	0.5	34,872	100	Gas (79%)
Cambodia	47.1	17.2	2,744	99.2	Coal (57%)
Indonesia	1,402.6	281.6	4,981	99.9	Coal (69%)
Lao PDR	14.9	7.7	1,945	96.5	Hydro (77%)
Malaysia	439.7	33.5	13,142	100	Coal (45%)
Myanmar	64.3	54.5	1,179	80.4	Gas/hydro (46% each)
Philippines	470.1	113.2	4,154	94.8	Coal (59%)
Singapore	530.7	5.9	89,370	100	Gas (91%)
Thailand	528.9	70.3	7,527	100	Gas (62%)
Timor-Leste	2.0	1.4	1,454	94.3	Oil (~100%)
Vietnam	468.5	100.8	4,649	100	Coal (48%)
Southeast Asia	3,984.6	686.4	5,805	~97.0	Coal (48%)

Notes: GDP figures are nominal (current US dollars); GDP: gross domestic product; IEA: International Energy Agency; IMF: International Monetary Fund; USD: US dollar.

Sources: IMF World Economic Outlook, October 2024 (GDP, population, GDP per capita; 2024 estimates); World Bank World Development Indicators (electricity access); IEA Southeast Asia Energy Outlook 2026 (regional electricity access); Ember (dominant generation source)

Figure 3: Power Sector Structures in Southeast Asian Countries

Country	Market Model	Transmission, Distribution and Generation
Brunei Darussalam	Vertically integrated	DES • Berakas Power Company (BPC, state-owned, about 40% of supply) • IPPs mainly for own use
Cambodia	Single buyer	EDC for transmission and distribution • IPPs supply about 98% of generation
Indonesia	Single buyer, vertically integrated	PLN (transmission and distribution; generation through subsidiaries) • IPPs
Lao PDR	Single buyer, export-oriented	EdL • EdL-Gen (generation) • EdL-T (230 kV and above; 90% owned by China Southern Power Grid) • IPPs, including for export
Malaysia	Single buyer	TNB (Peninsular), SESB (Sabah) and Sarawak Energy (Sarawak), each vertically integrated • IPPs
Myanmar	State-controlled	Ministry of Electric Power: EPGE (generation), DPTSC (transmission and system control) • IPPs
Philippines	Competitive wholesale (WESM)	TransCo (state-owned) owns transmission • NGCP operates the system under concession • IPPs and NPC generate
Singapore	Competitive wholesale (NEMS)	SP PowerAssets owns the network and SP PowerGrid operates it • EMA is the power system operator • private generation companies
Thailand	Single buyer	EGAT (generation, transmission, system operation) • MEA and PEA (distribution) • IPPs, SPPs and VSPPs
Timor-Leste	Vertically integrated	EDTL (generation, transmission, distribution)
Vietnam	Evolving into a competitive wholesale (VWEM)	EVN and subsidiaries, including EVNNPT (transmission) • NSMO (system operator, under MOIT since 2024) • IPPs

Notes: DES: Department of Electrical Services; DPTSC: Department of Power Transmission and System Control; EDC: Électricité du Cambodge; EdL: Électricité du Laos (EdL-Gen: generation subsidiary; EdL-T: transmission company); EDTL: Eletricidade de Timor-Leste; EGAT: Electricity Generating Authority of Thailand; EMA: Energy Market Authority; EPGE: Electric Power Generation Enterprise; EVN: Vietnam Electricity; EVNNPT: National Power Transmission Corporation; IPP: independent power producer; MEA: Metropolitan Electricity Authority; MOIT: Ministry of Industry and Trade; NEMS: National Electricity Market of Singapore; NGCP: National Grid Corporation of the Philippines; NPC: National Power Corporation; NSMO: National Power System and Market Operator; PEA: Provincial Electricity Authority; PLN: Perusahaan Listrik Negara (State Electricity Company); SESB: Sabah Electricity Sdn Bhd; SP: Singapore Power; SPP/VSPP: small/very small power producer; TNB: Tenaga Nasional Berhad; TransCo: National Transmission Corporation; VWEM: Vietnam Wholesale Electricity Market; WESM: Wholesale Electricity Spot Market.

Sources: Japan International Cooperation Agency (JICA) & The Institute of Energy Economics, Japan (IEEJ) (2025), Study on ASEAN Power Grid: Final Report, June 2025; Global Transmission Report

Regional interconnection can complement domestic investment by enabling electricity exchange, improving access to diverse generation resources and strengthening energy security. Realising these benefits will require coordinated planning, appropriate regulatory arrangements and investment in both physical infrastructure and grid operation.

This report examines the drivers of change across the 11 countries of Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste and Vietnam. Their electricity systems differ considerably in stage of development, generation mix and network structure.

Electricity access ranges from 80% in Myanmar to universal access in Brunei Darussalam, Malaysia, Singapore, Thailand and Vietnam[13] (Figure 2). Indonesia relies on fossil fuels for around 82% of its electricity generation[14], while Lao PDR's hydropower-based system exports electricity to neighbouring countries. Network requirements also vary, from Singapore's compact urban grid to the multi-island systems of Indonesia and the Philippines.

Power sector structure also differs (Figure 3).

Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Thailand and Timor-Leste are served by state-owned or government-linked utilities, or by government departments, that hold transmission and system operation responsibilities, with independent power producers (IPPs) supplying part of generation in most cases. The Philippines and Singapore operate competitive wholesale markets with separate transmission companies. Vietnam is moving from a state-owned single buyer towards a more competitive market.

The report assesses how rising demand, a changing generation mix and increasing system risks affect resource adequacy, network capacity, system stability, flexibility and resilience. It presents five priorities for grid expansion and transformation: long-term integrated system planning, mature advanced grid solutions, supply chains and procurement, regional integration, and regulation and markets.

Differences in economic conditions, power sector structures and grid maturity mean that the measures presented in this report will need to be adapted to national circumstances. Their applicability will depend on each country's economic and institutional capacity, the structure and ownership of its power sector, and the level of development of its electricity network. A uniform approach across the 11 countries is therefore not feasible. Priorities, implementation timelines and technology choices will vary according to financing capacity, market arrangements and network characteristics. Regional cooperation can facilitate this process by enabling the exchange of technical expertise, regulatory experience and established practices. ■

A CHANGING POWER SYSTEM

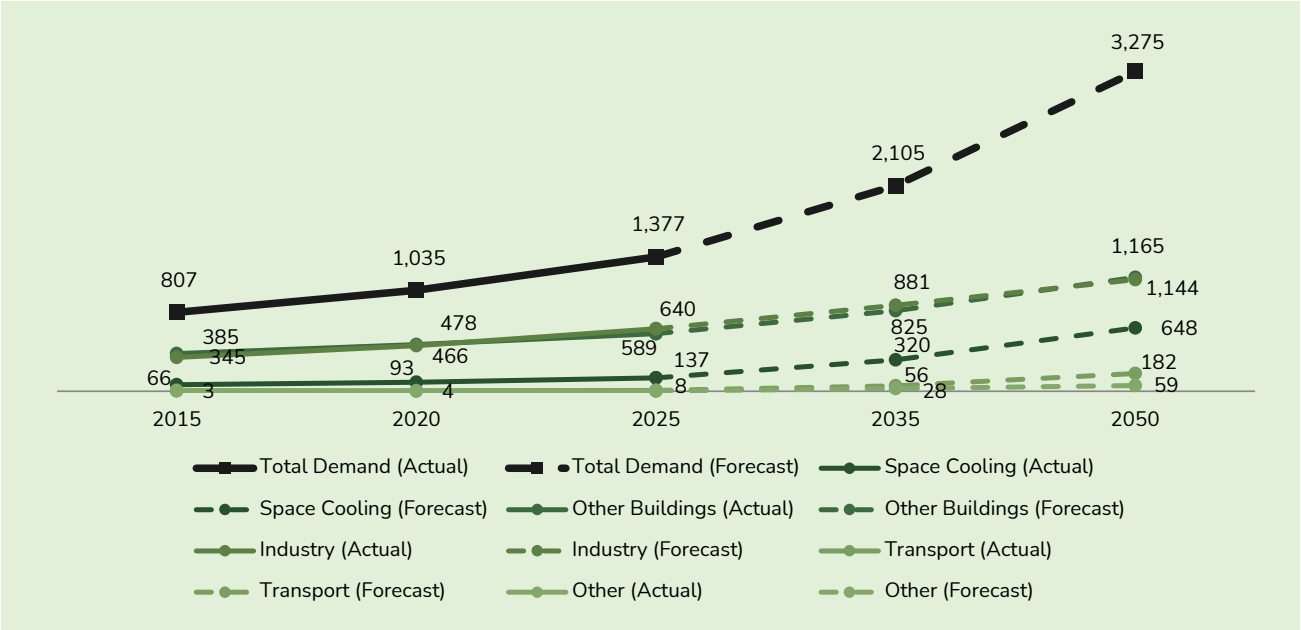
2

Southeast Asia's power systems need to meet rising electricity demand and integrate a wider range of generation sources, while reducing dependence on imported fuels. These objectives place greater demands on power system planning, investment and operation.

Electricity demand is growing and becoming more concentrated. Southeast Asia's electricity demand grew by an average of 6% annually between 2015 and 2025, driven by urbanisation, rising incomes and industrialisation[2]. The region accounts for over 6% of global gross domestic product (GDP) in purchasing power parity (PPP) terms[1]. Electricity consumption has grown at almost twice the rate of region's total energy demand and of the global electricity demand growth[2]. The region has contributed 10% of global energy demand growth since 2015[2]. Under the Current Policies Scenario (CPS), the International Energy Agency (IEA) projects demand to reach 2,105 TWh by 2035 and 3,275 TWh by 2050, more than double the 2025 level[2]. Under the Announced Pledges Scenario (APS), which assumes that national climate pledges are met in full and on time, the IEA projects demand of around 4,000 TWh by 2050[2]. Electricity's share of total final energy consumption is projected to rise from around 23% in 2024 to 26% by 2035 and 31% by 2050 under the CPS, and to a higher share under the APS[2].

The composition of demand is also changing. Cooling, industry, transport and data centres are the main sources of new demand. Cooling demand has doubled since 2015 and already accounts for 10% of regional electricity consumption[2]; this share could reach 20% by 2050 under the CPS[2]. Industrial electricity demand has increased by around 75% over the past decade[2], with growth concentrated in nickel

Figure 4: Growth in Electricity Consumption, 2015–2050 (TWh)



Note: Total forecasted data is based on IEA's Current Policies Scenario (CPS).

Source: IEA (2026), Southeast Asia Energy Outlook 2026

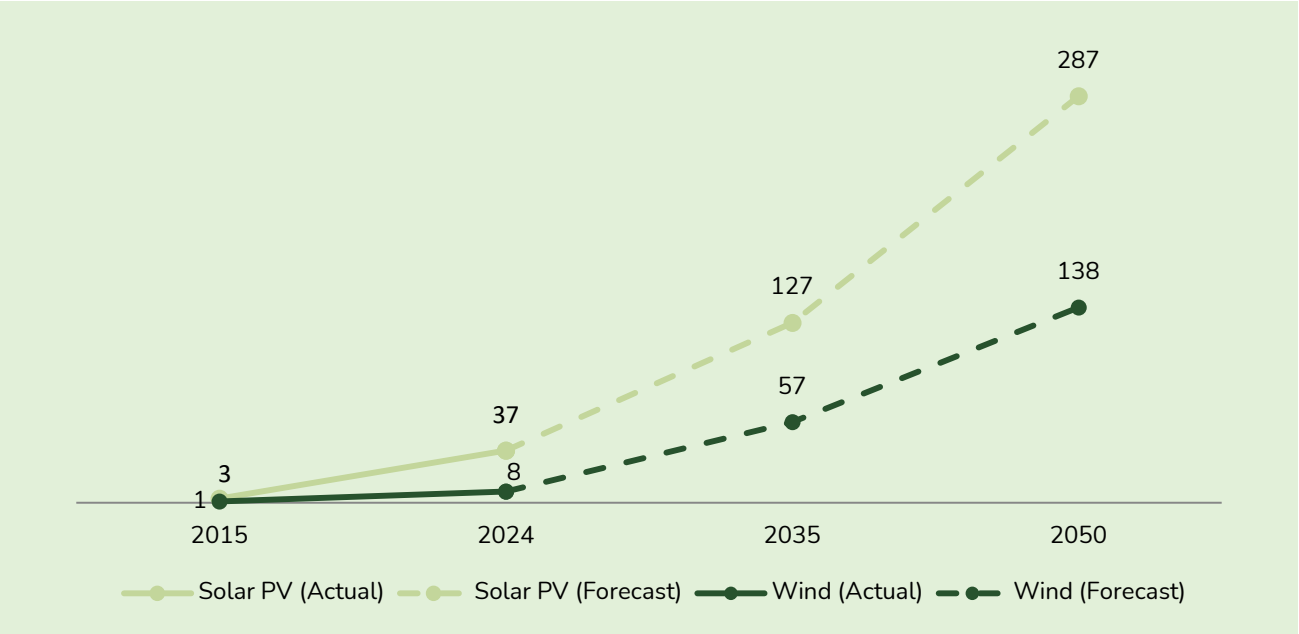
processing in Indonesia and cement, iron and steel production in Vietnam. Electric vehicles (EVs) are expected to add to electricity demand as transport electrification expands. Thailand's EV30@30 policy, for example, targets zero-emission vehicles at 30% of total vehicle production by 2030[15].

Data centres are another source of concentrated demand. They already consume more than 10 TWh of electricity annually, around 10% of the Asia-Pacific total, and investment is extending beyond Singapore into Johor, Jakarta and Bangkok[2]. In Johor, data centre capacity is around 1.5 times the state's current electricity demand[16]. Malaysia's Ministry of Energy Transition and Water Transformation projects data centre demand of 7.7 GW by 2030[17], and the government estimates that data centres could account for 31% of Peninsular Malaysia's peak demand, around 10 GW, by 2035[18]. However, resource constraints are slowing some projects. Johor stopped approving data centres with high water demand in late 2025[19].

Generation capacity is expanding and diversifying, although fossil fuels will continue to supply a large share of electricity over the next decade. Southeast Asia's solar and wind capacity increased eleven-fold between 2015 and 2024, from around 4 GW to 45 GW[2]. Almost 19 GW of renewable capacity was awarded through competitive auctions in 2025 alone[2], around half of it in the Philippines, where the fourth Green Energy Auction (GEA-4) awarded about 9.4 GW of solar, onshore wind and solar-plus-storage capacity[20]. Under the IEA's CPS, combined solar and wind capacity is projected to reach around 184 GW and under the APS to around 429 GW by 2035[2]. Hydropower remains the region's largest renewable source by installed capacity, increasing from 43 GW in 2015 to 60 GW in 2024[2].

Coal continues to provide a large share of baseload generation, reflecting abundant coal reserves in Indonesia and Vietnam. The coal fleet in the region averages less than 13 years of age[3]. This, together with energy security and affordability concerns, has slowed planned coal phase-outs. Coal-fired capacity increased from 62 GW in 2015[2] to around 121 GW in 2025[21], with further additions planned. Indonesia accounts for a substantial share of the regional fleet: coal represents around 54% of its approximately 101 GW of installed generation capacity, and its latest power development plan includes a further

Figure 5: Growth in Wind and Solar Capacity, 2015–2050 (GW)



Note: Forecast data is based on IEA's Current Policies Scenario (CPS).

Source: IEA (2026), Southeast Asia Energy Outlook 2026

6.3 GW of coal capacity by 2034[22]. Under the CPS, Southeast Asia's coal capacity could reach 177 GW by 2050, compared with 63 GW by 2050 under the APS[2]. Given the age of the fleet, many plants could remain in operation for several decades unless policy, economic or market conditions change.

Nuclear power is a longer-term option. Indonesia, Vietnam and the Philippines are developing plans that could contribute up to 29 GW by 2050[2], and Indonesia aims for 500 MW of nuclear capacity by 2034[22].

DERs remain small relative to utility-scale generation but are expanding in several markets. Rooftop solar is the main source of distributed generation. Vietnam had 9.5 GW of rooftop solar capacity by mid-2024[23] and aims for 50% of office buildings and households to install rooftop solar for self-consumption by 2030[24]. Thailand's rooftop solar capacity reached 3.3 GW in 2024[25]. Malaysia's Solar Accelerated Transition Action Programme (Solar ATAP), which replaced the Net Energy Metering scheme in 2026[26], and Singapore's SolarNova programme[27] also support rooftop solar deployment.

Growth in rooftop solar and behind-the-meter batteries will change electricity flows at the distribution level and increase the need for better visibility of DERs. Distribution networks will need to accommodate two-way power flows and greater variation in net demand.

Fuel imports expose electricity systems to external shocks. The region is exposed in particular to liquefied natural gas (LNG) markets. Disruption to shipping through the Strait of Hormuz, following the escalation of the conflict in the Middle East in February 2026, showed the sensitivity of global energy markets to interruptions on major supply routes. The World Bank described the resulting disruption as the largest oil supply loss on record[5], and the IEA reported the loss of almost 20% of global LNG

Figure 6: Peak Demand and Renewable Capacity Projections for Selected Southeast Asian Economies

PEAK DEMAND		RENEWABLE CAPACITY
35 GW (2025) → 54–57 GW (2037) → 74–80 GW (2050) ▲ 111–129%	Thailand	16 GW (2023) → 57 GW (2037) ▲ 256% Solar-led, 14.5 GW storage
65 GW (2025) → 80 GW (2034) ▲ 23%	Indonesia	16 GW (2025) → 58 GW (2034) ▲ 263% Solar, hydro & wind-led, +10.3 GW storage
20 GW (2024) → 33 GW (2030) → 63 GW (2050) ▲ 215%	Malaysia	25% (2025)→ 64% (2050) RE share ▲ 40% Nuclear from 2035 + cross-border power
19 GW (2025) → 81 GW (2050) ▲ 326%	Philippines	10.5 GW (2025) → 128.8 GW (2037) ▲ 1,127% Wind-led, with solar & hydro, +4.8 GW nuclear
54 GW (2025) → 90–100 GW (2030) → 206–229 GW (2050) ▲ 282–324%	Vietnam	24.5 GW (2025) → 82.0–120.9 GW (2030) ▲ 235–393% Solar & wind-led, +10–16 GW storage, +4–6.4 GW nuclear

Note: Data for Malaysia refer to Peninsular Malaysia.

Sources: Thailand: Energy Policy and Planning Office (EPPO), draft Power Development Plan (PDP) 2026 (2026–2050); Indonesia: Perusahaan Listrik Negara (PLN), Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2025–2034; Malaysia: Energy Commission (Suruhanjaya Tenaga); Philippines: Department of Energy (DOE), PDP 2023–2050; Vietnam: Government of Vietnam, Revised Power Development Plan VIII (PDP8) (Decision No. 768/QD-TTg, 2025)

supply[6]. Asian spot LNG prices, which influence the marginal cost of gas-fired generation across much of Southeast Asia, increased by more than 90% in March 2026[6]. A comparable effect occurred in 2022, when Europe's LNG imports rose by more than 60% as it replaced Russian pipeline gas, pushing up spot prices and crowding price-sensitive emerging Asian buyers out of the spot market[28].

Extreme weather and cyber risks affect system reliability. Electricity infrastructure across Southeast Asia is exposed to flooding, extreme heat, droughts, tropical cyclones and coastal hazards. Dense, low-lying cities, including Jakarta, Ho Chi Minh City and Yangon, face risks from sea-level rise and flooding, while changes in rainfall can affect hydropower output in the Mekong basin[7]. The IEA estimates that more than 52 GW of thermal generation capacity and nearly 4 GW of solar photovoltaic (PV) capacity are located in areas exposed to flood depths of at least one metre[2].

Recent events illustrate the scale of potential disruption. Natural disasters caused estimated economic losses of USD11 billion across Southeast Asia between 2015 and 2020[29]. Typhoon Yagi affected more than 6 million electricity customers in northern Vietnam in 2024[2], and Typhoon Kajiki in 2025 disrupted electricity supply for around 1.6 million people in Vietnam[8]. Super Typhoon Uwan (international name Fung-wong) took 36 transmission lines out of service across Luzon and the Visayas in November 2025, interrupting supply in several provinces[30].

Digitalisation improves system visibility and control but also increases cyber exposure, and cyber incidents have affected utilities in the region. Indonesia's state electricity utility, Perusahaan Listrik Negara (PLN), was the subject of reported leaks of customer data involving about 17 million records in 2022[31] and 44 million in 2023[32]. Ransomware groups targeted Vietnam Electricity (EVN) in December 2023[33].

Southeast Asia's power grids therefore face requirements arising from demand growth, generation expansion, fuel price exposure and additional system risks. ■

EMERGING GRID CHALLENGES

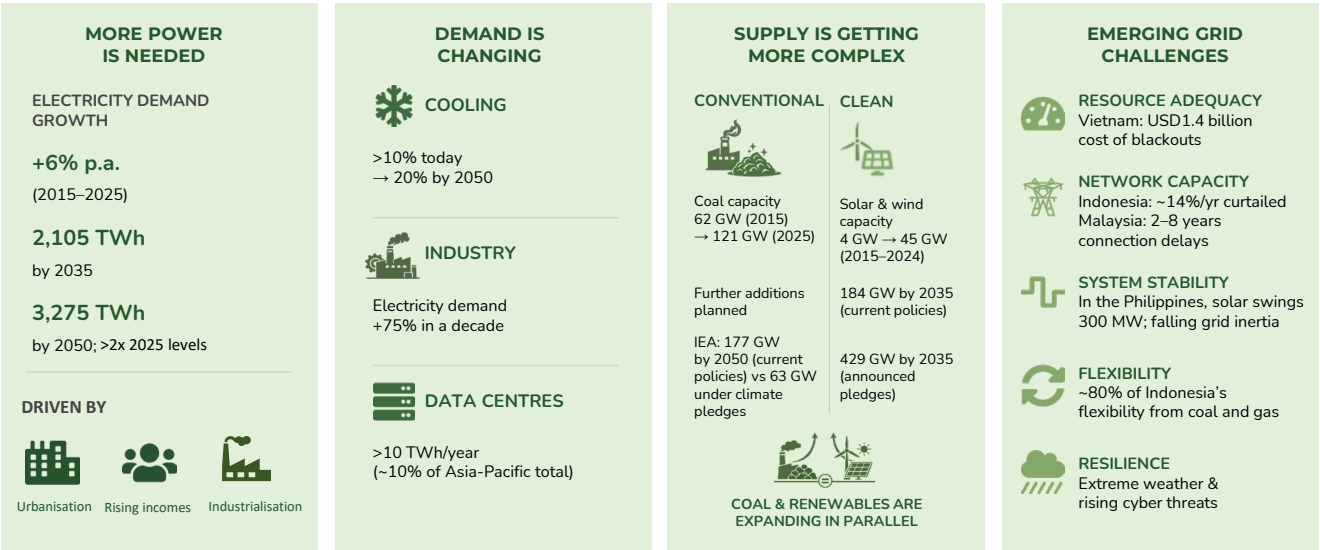
3

The changes in demand and generation are placing greater requirements on resource adequacy, network capacity, system stability, flexibility and resilience. These pressures are not uniform across the region. Some systems face tight capacity margins, while others have substantial contracted overcapacity. Network constraints are often localised and are emerging quickly in areas with high concentrations of variable generation.

Resource adequacy challenges take different forms across Southeast Asia. Rolling blackouts across northern Vietnam in June 2023 illustrate the consequences of insufficient available supply. The blackouts, caused by drought-related hydropower shortages, ageing coal plant outages and transmission constraints, were estimated to have cost the economy USD1.4 billion, around 0.3% of GDP[34]. By 2025, the northern reserve margin remained at only 3–4% as demand continued to outpace supply[35].

Thailand presents the opposite situation: excess contracted capacity. Its reserve margin was roughly 55% in 2025, down from around 70% in 2020 and well above the roughly 15% level generally considered adequate[36]. Seven of Thailand's privately owned gas plants, with more than 11 GW of combined capacity, operated at capacity factors below 10% in 2025[36]. The Electricity Generating Authority of Thailand (EGAT) and electricity consumers have paid an estimated USD5.02 billion since 2023 to maintain contractual availability of this underused capacity[36]. Thailand's surplus does not threaten supply, but capacity contracted well beyond demand raises electricity costs, commits

Figure 7: Grid Expansion and Modernisation Challenges



Notes: GW: gigawatt; IEA: International Energy Agency; p.a.: per annum; RUPTL: Rencana Usaha Penyediaan Tenaga Listrik (Electricity Supply Business Plan); TWh: terawatt-hour. Projections are from IEA scenarios (CPS and APS).

Sources: IEA (2026), Southeast Asia Energy Outlook 2026; IEA (2025), World Energy Investment 2025; IEA (2022), Enhancing Indonesia's Power System; World Bank via VnExpress International (2023); The Edge Malaysia (2026); Power Philippines (2026); PLN, RUPTL 2025–2034.

investment to plants that operate infrequently and can limit room for new generation.

These cases indicate that adequacy depends on more than the volume of installed generation. Planning needs to account for demand growth, available capacity, fuel constraints, transmission limits and the contractual structure of generation investment.

Network capacity constraints are emerging through connection delays, congestion and curtailment. The locations of new generation and demand often do not match existing transmission capacity. Indonesia illustrates this challenge. Renewable resources are concentrated on outer islands including Sumatra, Sulawesi and Kalimantan, while the Java–Bali system accounts for most electricity consumption. In Sumatra, solar curtailment of around 14% annually has been observed during periods of low demand and high solar output, partly because take-or-pay power purchase agreements (PPAs) limit the ability to adjust generation[37].

Large new loads are also facing connection constraints. Data centre developers in Malaysia report connection delays of two to eight years in congested areas[38]. In the Philippines, delays affecting major transmission projects, in some cases extending beyond nine years, have contributed to congestion in major corridors as demand rises[39]. Network investment therefore needs to be coordinated with the location and timing of new generation and demand, in addition to expanding transmission capacity.

System stability requirements are changing as the generation mix changes. Conventional thermal and hydropower plants use synchronous machines, which inherently provide inertia and system strength. Solar and wind plants connect through power electronic inverters instead. As the share of inverter-based resources grows, system operators need stronger capabilities for voltage control, frequency response and system strength, together with greater system flexibility and advanced grid solutions to maintain reliability. These services can be supplied in new ways: modern inverter-based resources, particularly grid-forming inverters paired with storage, can provide fast frequency response and voltage support when grid codes require and markets reward these services.

The Philippines illustrates how higher solar output changes system operation. In January 2026, the National Grid Corporation of the Philippines (NGCP), the country's transmission operator, warned that increasing reliance on solar generation could create operational challenges for system stability, following a voltage fluctuation in North Luzon associated with rapid changes in renewable output[40]. At the San Marcelino solar farm in Zambales, brief cloud cover caused output changes of up to 300 MW[41]. Coal plants, with slower ramping capability, cannot respond as quickly to such changes, which increases the need for fast-responding resources. The warning coincided with NGCP's support for the 2,500 MW MTerra Solar project, which includes a 1,125 MW/4-hour battery energy storage system (BESS)[41]. The project illustrates the scale of flexibility and control required as larger volumes of solar generation connect to the grid. Indonesia shows similar effects. A study of PLN's 192 MW Cirata floating solar plant, connected to the 500 kV Java–Bali transmission network, found that higher levels of inverter-based generation can reduce system inertia and affect frequency response following disturbances[42].

Renewable generation now influences daily dispatch decisions. Inaccurate forecasting of renewable output can lead to inefficient scheduling and higher curtailment. System operators will therefore need improved forecasting, faster voltage and frequency controls, flexible generation and storage, and grid codes that require renewable projects to provide appropriate system services.

Flexibility is the ability to balance electricity supply and demand over timescales ranging from seconds to seasons. It is currently provided mainly by thermal and hydropower plants, with limited contributions from storage and demand response. In Indonesia, around 80% of system flexibility is supplied by coal and gas generation[22]. Much of this capacity operates under long-term PPAs and take-or-pay

fuel arrangements, which can limit the ability of operators to adjust output in response to changing system conditions. An analysis by the Indonesian Electrical Power Society found that Southeast Asia can meet around 25% of its renewable energy target without major changes to the grid. Beyond that point, meeting higher targets will require targeted investment in flexibility[43].

Storage deployment remains limited but is expanding. Regional battery capacity was estimated at around 1 GW in 2024 and could reach 8 GW by 2035 under the IEA's CPS and 61 GW under the APS[2]. Deployment has been constrained by market structures and regulatory frameworks that make it difficult for storage projects to recover their costs. A 2026 joint white paper by the ASEAN Centre for Energy (ACE), the energy body of the Association of Southeast Asian Nations (ASEAN), and IEA concluded that the main barriers to battery storage in the region are regulatory and market-related rather than technical[44]. In single-buyer markets, legacy take-or-pay PPAs can reduce opportunities for storage to earn revenue by shifting generation or reducing curtailment. Storage may also lack clear routes to payment for services such as frequency response and voltage support. Unclear rules on its classification, ownership and participation in electricity markets add uncertainty, while high capital costs and foreign exchange risk can make financing more difficult.

Several projects indicate that more storage deployment is under way. Singapore's Energy Market Authority (EMA) and Sembcorp commissioned a 200 MW/285 MWh lithium iron phosphate BESS on Jurong Island in December 2022[45]. Malaysia commissioned a 60 MW/80 MWh BESS in Sejingkat in December 2024[46]. Indonesia is developing a large-scale solar-plus-storage project in Nusantara[47], while Vietnam commissioned a 50 MW/100 MWh utility-scale grid-connected BESS in Hanoi in July 2026[48]. These projects span several markets, but scaling storage requires clearer market rules, technical requirements and revenue mechanisms that value the services it provides.

Demand-side flexibility remains less developed. Formal demand response programmes are limited across most markets, while market and contractual arrangements often provide few incentives for consumers or generators to adjust their electricity use or output.

Resilience requirements are increasing as exposure to extreme weather and cyber threats grows (see Chapter 2). For T&D networks, this means accounting for extreme weather-related hazards in infrastructure design and maintenance, improving visibility of system conditions, and ensuring that utilities can isolate faults and restore service promptly. Higher temperatures also reduce the capacity of lines and transformers, so climate conditions need to be reflected in equipment ratings as well as asset protection. Cybersecurity also needs to be integrated into operational technology, digital control systems and recovery procedures as utilities become more connected. Resilience measures should therefore be reflected in network planning, equipment specifications and operating practices, with requirements tailored to the hazards and vulnerabilities of each system.

These five challenges are already visible across Southeast Asia and are likely to become more difficult to manage as electricity demand grows and the share of solar and wind generation rises. Earlier investment in flexibility, digital capabilities and resilient infrastructure can reduce future system costs and the need for reactive upgrades. ■

ENABLING GRID TRANSFORMATION

4

Southeast Asia will need to expand and modernise its electricity networks at a much faster pace than in the past. T&D networks will need to more than double in length by 2050 to accommodate demand growth, new generation and greater system flexibility. The IEA estimates that more than USD300 billion will be required for grid investment between 2025 and 2040, 72% above investment in 2009–2024[10].

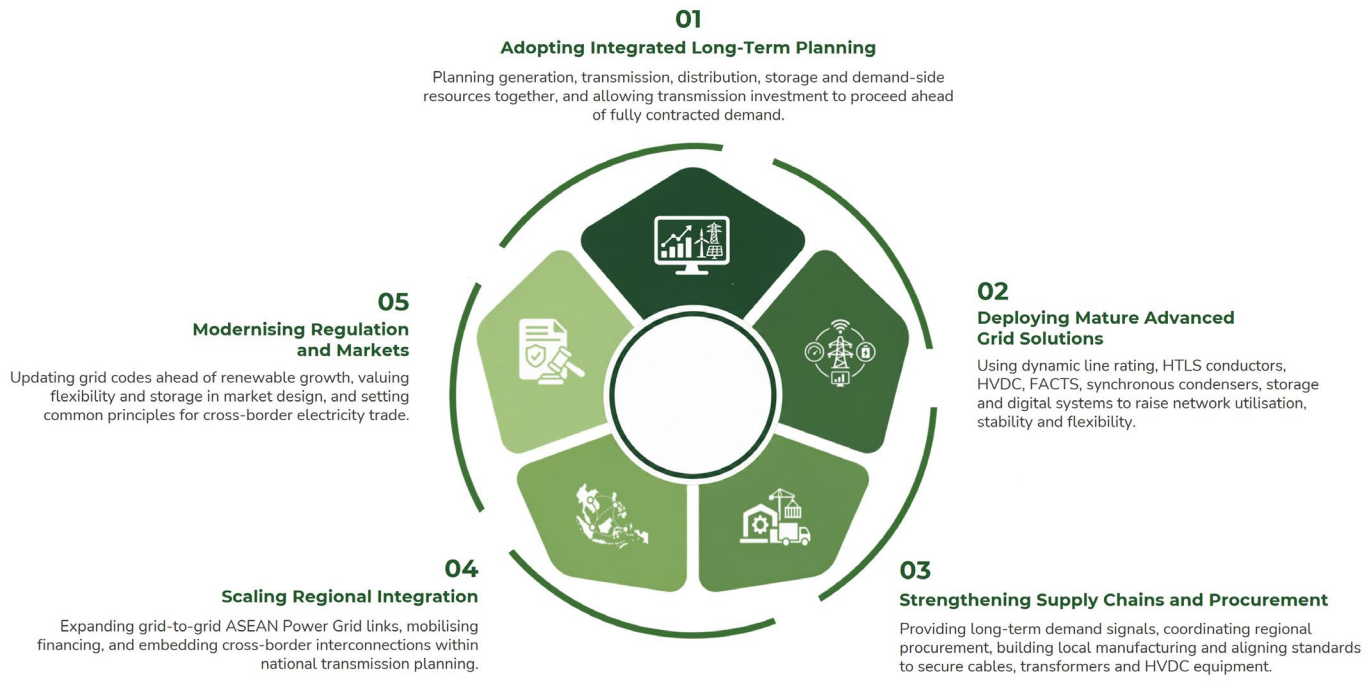
National electricity sector development plans reflect the need for this higher investment. Indonesia plans to add 47,758 km of transmission lines by 2034, a 66% increase from 2024[22]. Vietnam plans to add 43,527–46,627 km by 2035, equivalent to a 77–83% increase from 2025[24].

Five priority areas can accelerate grid expansion and transformation.

4.1 Adopting Integrated Long-Term Planning

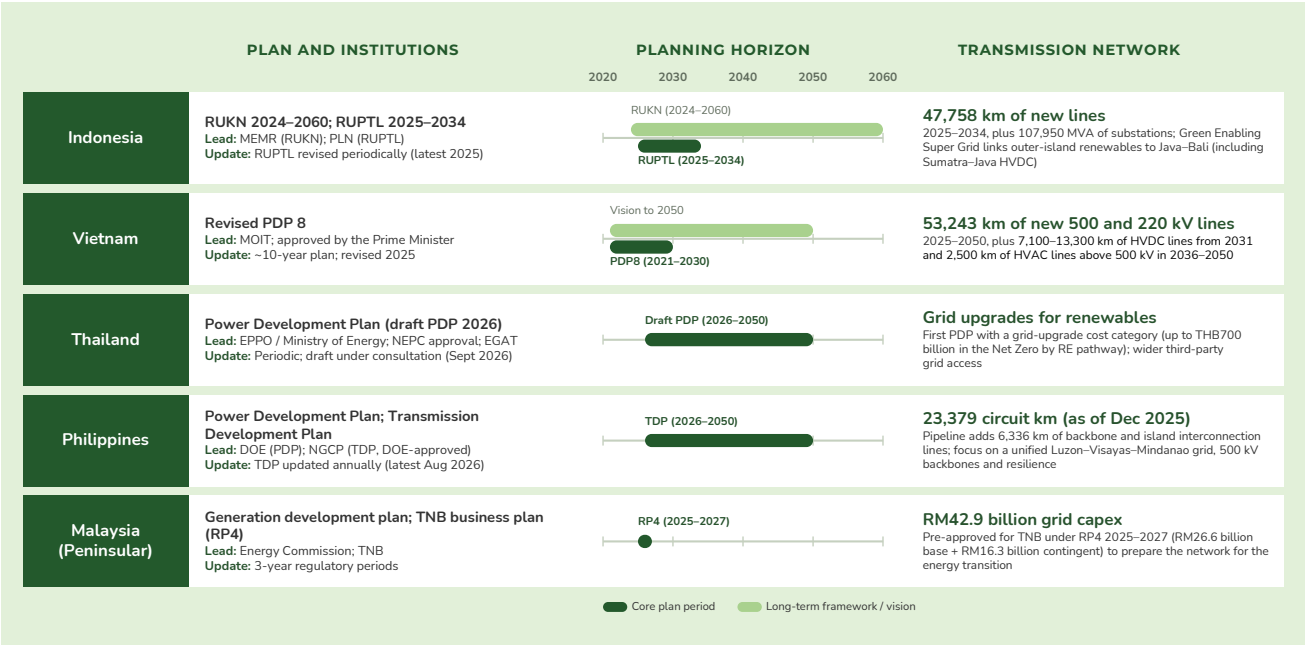
Electricity demand in the five largest Southeast Asian economies increased 2.6-fold between 2005 and 2024[49], while transmission planning has often remained focused on connecting individual generators or serving specific load centres. This approach is less suited to a system in which demand, generation locations and electricity flows are changing, and with them the location and timing of network requirements. Generation projects and large industrial loads can often be developed within two to

Figure 8: Priority Areas for Southeast Asian Grid Transformation



Notes: FACTS: flexible alternating current transmission system; HTLS: high-temperature low-sag; HVDC: high-voltage direct current.
Source: Global Transmission Report.

Figure 9: Power System Planning Frameworks in Selected Southeast Asian Countries



Notes: Capex: capital expenditure; DOE: Department of Energy; EGAT: Electricity Generating Authority of Thailand; EPPO: Energy Policy and Planning Office; HVAC: high-voltage alternating current; HVDC: high-voltage direct current; MEMR: Ministry of Energy and Mineral Resources; MOIT: Ministry of Industry and Trade; NEPC: National Energy Policy Council; NGCP: National Grid Corporation of the Philippines; PDP: Power Development Plan; PDP8: Power Development Plan VIII; PLN: Perusahaan Listrik Negara (Indonesia's state electricity company); RE: renewable energy; RM: Malaysian Ringgit; RP4: Regulatory Period 4; RUKN: National Electricity General Plan; RUPTL: Electricity Supply Business Plan; TDP: Transmission Development Plan; THB: Thai Baht; TNB: Tenaga Nasional Berhad.

Sources: PLN RUPTL 2025–2034; Government of Vietnam, Revised PDP8 (Decision 768/QD-TTg, 2025); EPPO draft PDP 2026; NGCP Transmission Development Plan 2026–2050; Energy Commission Malaysia, RP4 determination (2024).

three years, while transmission projects can require five to ten years. In many markets, transmission investment is triggered only after demand or generation has been contracted, and anticipatory planning is limited.

All major Southeast Asian economies have long-term electricity planning frameworks, but their scope and implementation differ. The main challenge is aligning transmission planning with energy and climate objectives, demand growth, distribution needs and regional interconnections.

Indonesia follows a more integrated planning process. The government sets long-term direction, which PLN translates into its ten-year plan. Vietnam's revised Power Development Plan VIII (PDP8), approved in 2025, integrates generation expansion with transmission investment, renewable energy zones, storage and cross-border interconnections. Thailand coordinates generation and transmission planning through its Power Development Plan and its energy efficiency and renewable energy plans. In the Philippines, the Department of Energy (DOE) establishes planning priorities and NGCP prepares the country's transmission development plan.

Malaysia has separate planning arrangements for Peninsular Malaysia, Sarawak and Sabah. Tenaga Nasional Berhad (TNB), the power utility for Peninsular Malaysia, operates under an incentive-based regulation framework, in place since 2015, under which investment programmes are pre-approved for multi-year regulatory periods[50]. The current period, Regulatory Period 4 (RP4), covers 2025–2027[51]. This provides a mechanism for anticipatory investment that is less common elsewhere in the region. It applies only to TNB's

system, however, and does not provide a framework for coordinated planning across Malaysia's three grids or with neighbouring systems.

Planning should also become more comprehensive, assessing generation, transmission, distribution, storage and demand-side resources together. Demand forecasts should explicitly incorporate data centres, industrial electrification, cooling, EVs and DERs. Transmission investment should be able to proceed ahead of fully contracted demand where future system needs are sufficiently clear. Permitting and right-of-way delays are major constraints, and early stakeholder engagement and faster permitting would shorten project lead times.

4.2 Deploying Mature Advanced Grid Solutions

Grid expansion remains necessary, but network investment alone will not meet the region's changing power system needs. Technologies that increase the utilisation of existing networks, improve system stability and provide greater operational flexibility can complement conventional investment.

Dynamic line rating (DLR) allows transmission operators to adjust line capacity according to weather conditions and conductor temperature instead of fixed ratings. High-temperature low-sag (HTLS) conductors can also increase transfer capacity using existing towers and rights-of-way. Network topology optimisation and advanced power flow control can further improve utilisation by redirecting power through underused parts of the network. TNB has piloted DLR on its 275 kV Segar–Pantai–Ayer line, where real-time ratings were around 30% higher than conventional static ratings for much of the operating period[52].

High-voltage direct current (HVDC) technology is particularly relevant for long-distance and submarine connections. The Philippines' 450 MW Mindanao–Visayas Interconnection Project, which reached full bipolar operation in 2024, connected the country's three major island groups into a single national grid, showing how HVDC can integrate previously separate power systems[53]. Voltage source converter (VSC) HVDC provides independent control of active and reactive power and suits some weak-grid and multi-terminal applications, which makes it relevant to future regional interconnections.

Subsea interconnectors, relatively uncommon in the region, are expected to account for more than three-quarters of Southeast Asia's transmission investment from 2030 onwards[10]. These projects typically require HVDC technology, and several interconnectors under the ASEAN Power Grid (APG) are already planned as HVDC projects, including the proposed Peninsular Malaysia–Singapore, Sarawak–Peninsular Malaysia, Peninsular Malaysia–Sumatra, Sabah–Philippines and Singapore–Sumatra corridors[54].

National plans show a similar trend. Indonesia's Green Enabling Super Grid includes three new ±500 kV HVDC corridors covering around 3,700 km and is expected to be one of the region's largest near-term transmission projects[22]. Vietnam's revised plan includes HVDC investment to connect the central and northern regions and support offshore wind development, with 3,500–6,600 km of new HVDC lines planned for 2031–2035 and a further 3,600–6,700 km for 2036–2050[24].

System stability will also require technologies that provide voltage support, inertia and system strength. Flexible alternating current transmission system (FACTS) devices, including static synchronous compensators (STATCOMs) and static VAR compensators (SVCs), provide rapid reactive power and voltage support. Synchronous condensers provide inertia, fault current and system strength as conventional generators operate for fewer hours.

Energy storage can provide flexibility by reducing congestion, absorbing excess renewable generation and delivering balancing services. Utility-scale battery deployment is beginning in Malaysia, Vietnam and Indonesia, but it needs supporting market rules and operating frameworks. Inflexible thermal generation contracts and limited flexibility

markets restrict efficient system operation in many countries in the region.

Digital technologies support the operation of systems with more power electronics. Advanced forecasting, real-time monitoring, energy management systems, advanced distribution management systems (ADMS), wide area measurement systems (WAMS) and digital twins improve network visibility and allow operators to identify constraints before they affect system security. These capabilities become more valuable as DERs, storage and cross-border electricity trading expand. ACE has begun work on interoperability and digital coordination through the Lao PDR–Thailand–Malaysia–Singapore Power Integration Project (LTMS-PIP)[55], which indicates the need for compatible operational platforms across interconnected systems. Digitalisation also makes cybersecurity part of grid investment, requiring secure operational technology, continuous monitoring and recovery planning from the outset.

Governments and regulators should enable faster adoption of these technologies through updated technical standards, regulatory frameworks and investment incentives, while utilities should incorporate these solutions into planning and procurement processes.

4.3 Strengthening Supply Chains and Procurement

Expanding Southeast Asia's power infrastructure depends on access to the equipment required to build modern grids. Global demand for grid infrastructure has risen as countries accelerate renewable deployment, electrification and network reinforcement. This has created supply constraints for high-voltage cables, large power transformers and switchgear, with lead times for some components more than doubling in recent years as utilities compete for limited manufacturing capacity[56]. Analysis by the Asian Development Bank (ADB) suggests that at least 12 GW of subsea interconnection capacity, spanning more than 4,000 km, may be needed in the region by 2040[57]. Southeast Asia has no HVDC equipment manufacturing. European manufacturers account for about two-thirds of the global HVDC market, and manufacturing slots are heavily booked through 2028–2030[11]. ACE has warned of waiting periods of 10–12 years in some cases for subsea cables and converters[58].

Utilities should provide clearer long-term demand signals through multi-year procurement plans, standardised specifications and early engagement with manufacturers. TNB is pursuing closer regional collaboration on procurement to address differences in supplier ecosystems, regulatory frameworks and trade policies across Southeast Asia[59].

Supply chain constraints can slow cross-border interconnector projects, which require large investment in subsea cables, high-voltage lines, transformers and control systems. The IEA states that delivering regional cross-border interconnections through 2040 will require a shift from project-by-project procurement to coordinated supply chain planning, with earlier engagement among utilities, governments and manufacturers[10]. Regional utilities have used coordinated approaches before. EGAT, TNB, Électricité du Laos (EdL) and SP PowerGrid ran a joint working group with technical, commercial, legal and tariff task forces to deliver the LTMS-PIP[60]. A similar multilateral initiative, the Brunei Darussalam–Indonesia–Malaysia–Philippines Power Integration Project (BIMP-PIP), is under feasibility study[61]. Coordination of this kind could be extended to equipment procurement, with shared demand forecasts, standardised specifications and joint procurement frameworks giving manufacturers greater visibility of the regional pipeline. The Terms of Reference (ToR) for the Submarine Power Cable Development Framework (SPCDF), due for completion in 2026, cover legal and regulatory, technical, commercial and governance components and aim to establish common regional arrangements for subsea cable procurement and delivery[62,63].

Southeast Asia has substantial clean energy manufacturing capacity. Vietnam and Malaysia are major solar manufacturing centres, producing cells,

modules, inverters and power electronics. Capacity for large transformers, cables and other grid equipment is more limited and concentrated among a small number of global suppliers. Regional production of high-voltage cable is under consideration in Vietnam. In August 2025, LS Eco Energy, the Vietnamese subsidiary of the Korean manufacturer LS Cable & System, signed a joint development agreement with PetroVietnam Technical Services Corporation (PTSC) to develop a high-voltage submarine cable plant. The partners are considering a factory and dedicated wharf at Phu My port[12]. The plant is intended to supply offshore wind projects, north–south transmission within Vietnam and proposed submarine HVDC links among Vietnam, Indonesia and Singapore. The project indicates that local manufacturing can be developed where demand is sustained and visible to suppliers. Targeted industrial policies, technology partnerships, workforce development and manufacturing investment could strengthen regional production.

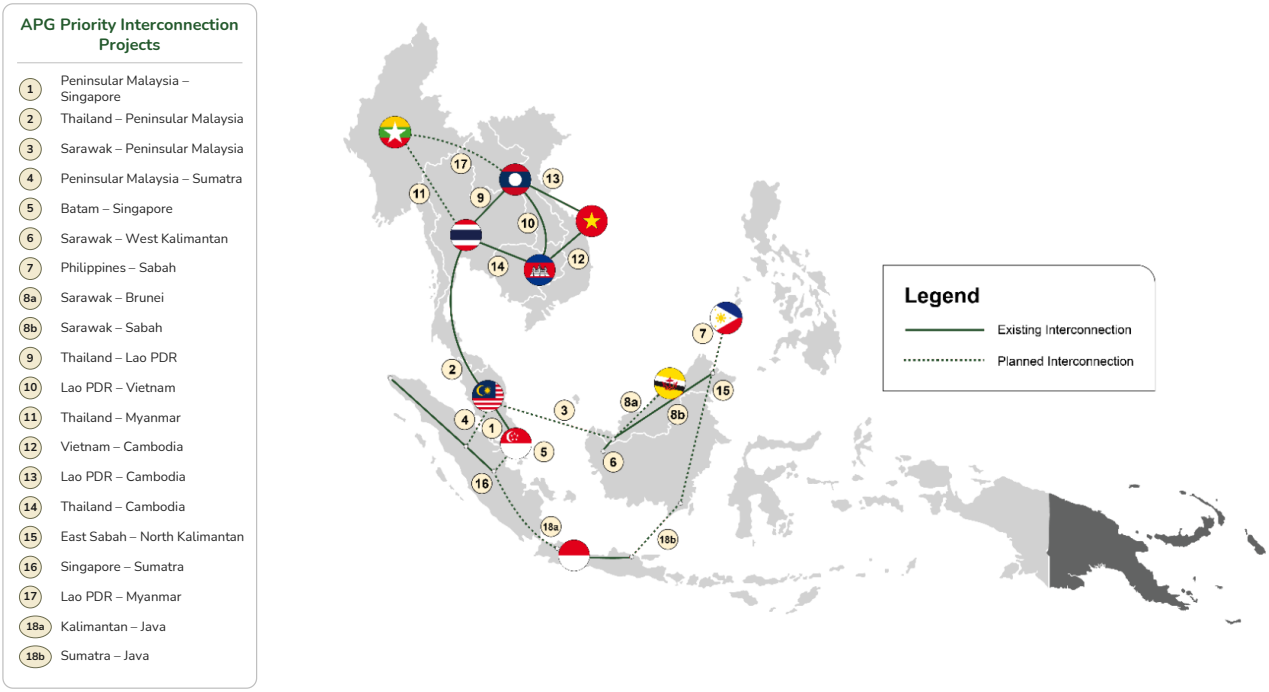
Common technical standards can also reduce supply chain constraints. Aligning grid requirements with international standards, such as International Electrotechnical Commission (IEC) standards 61850 for digital substations and 60076 for power transformers, would allow manufacturers to serve multiple markets with fewer design modifications, reducing procurement complexity and deployment times. Harmonised climate resilience standards would also support infrastructure design that reflects the region's exposure to extreme weather.

4.4 Scaling Regional Integration

Regional interconnection can complement domestic grid investment by allowing Southeast Asian countries to share reserves, improve generation utilisation and take advantage of differences in resource availability and demand patterns.

The APG, first proposed in 1997, provides the framework for regional electricity trade, but implementation has been gradual. By 2025, nine of the 18 priority interconnection projects identified under the ASEAN Interconnection Masterplan Study (AIMS) III were operational[9]. Southeast Asia has

Figure 10: ASEAN Power Grid Plan



Notes: APG: ASEAN Power Grid; ASEAN: Association of Southeast Asian Nations.

Source: ASEAN Centre for Energy (ACE), ASEAN Power Grid Updates 2025.

around 10.2 GW of cross-border transfer capacity, of which approximately 7.4 GW is generation-to-grid and 2.8 GW is grid-to-grid[9]. The APG targets 17.6 GW of transmission capacity by 2040[64].

The composition of existing interconnection matters. Generation-linked projects support specific bilateral power purchases, while grid-to-grid connections provide wider system benefits by allowing electricity to move between systems as demand, generation availability and system conditions change. The LTMS-PIP shows that multilateral electricity trade is feasible through cross-border scheduling, settlement and regulatory coordination: the participating utilities have established arrangements to wheel electricity across several national systems, and traded capacity is being expanded to 200 MW[65].

Greater connectivity would allow Southeast Asian power systems to make better use of regional energy resources. Hydropower is concentrated in the Mekong basin, solar resources are strong in Indonesia and the Philippines, and wind resources are concentrated along Vietnam's coastline. Stronger interconnection could also reduce exposure to imported fuel markets by enabling greater use of these resources. Thailand's available capacity, for example, could support neighbouring systems with tighter capacity conditions, including northern Vietnam.

Regional interconnection should be assessed together with domestic reinforcement and generation in national transmission planning, because cross-border connections cannot provide their full system value without sufficient domestic network capacity on both sides of the border.

Financing and institutional coordination are the main barriers. Cross-border grid-to-grid projects can be harder to finance than generation-linked projects because they often lack dedicated generation assets or long-term PPAs that provide predictable revenues, and subsea interconnections involve higher construction and technical risks. The APG Financing Initiative, launched in 2025 by ADB, the World Bank, the ASEAN Secretariat and ACE, mobilised initial commitments of USD12.5 billion for project development and investment[66]. Financing alone will not be sufficient.

Regional planning needs to identify priority grid-to-grid connections and integrate them into national transmission strategies. Governments and utilities also need clearer rules for grid access, transmission capacity allocation, tariffs, technical standards and operational risks. The Enhanced APG Memorandum of Understanding (MoU) renewed support for an integrated grid by 2045[67]. The accompanying ToR for APG bodies and the SPCDF recognise that cross-border electricity trade requires stronger national networks as well as interconnections[62].

Regional cooperation should also cover technical standards, procurement, cybersecurity, operational coordination and planning data, which would reduce project complexity and improve interoperability. At the 44th ASEAN Ministers on Energy Meeting in Manila in October 2026, ministers advanced the Enhanced APG MoU and a regional framework for submarine power cables[68], while the Philippines called for the 2045 interconnection target to be accelerated[69].

A 2025 EU-ASEAN Business Council report on APG development identifies a harmonised regulatory environment, including common grid codes, trading rules and interoperable information technology (IT) systems, as one of three pillars of regional grid integration, with infrastructure investment and financing as the others[70]. The objective should be to move from individual bilateral projects to a planned and financed regional pipeline of priority interconnections. The ASEAN Plan of Action for Energy Cooperation 2026–2030 prioritises strengthening institutional frameworks, regulatory capacity and the alignment of technical requirements to support multilateral power trade[71].

The APG should be treated as a regional asset for converting diverse energy resources into shared economic benefit, not only as physical infrastructure.

4.5 Modernising Regulation and Markets

Grid investment and technology deployment need to be supported by market and regulatory frameworks suited to a more interconnected and flexible power system. Southeast Asia's 11 national electricity systems operate under different market structures, grid codes and dispatch arrangements. Many countries use single-buyer models in which state-owned or government-linked utilities purchase electricity from generators. The Philippines and Singapore have more developed competitive markets, while Vietnam is moving from a state-owned single-buyer model towards a more competitive market. Dispatch intervals differ by market: 60 minutes in many single-buyer markets, 30 minutes in Malaysia, Singapore and Thailand, and five minutes in the Philippines[72]. Reform needs to reflect national market structures and system capabilities.

Grid codes need to evolve as renewable generation expands. Malaysia, Thailand and the Philippines already require solar and wind projects to provide services such as voltage control, frequency response and fault ride-through. Compliance monitoring is limited in several markets. In January 2026, following a voltage fluctuation in North Luzon associated with rapid changes in solar output, NGCP urged measures to protect grid stability as solar capacity expands[41]. Requirements for inverter-based resources should progressively cover advanced voltage and frequency capabilities, forecasting, storage integration and cybersecurity. Greater alignment of technical requirements across Southeast Asia would also improve interoperability and reduce project-specific requirements for developers and equipment suppliers.

Market arrangements also need to provide clearer value for flexibility. In many markets, congestion is managed through administrative curtailment, while frequency response and voltage support are procured mainly through bilateral arrangements, and storage and demand response have limited opportunities to provide system services. Recent reforms show that change is possible without full market liberalisation: Thailand is reviewing elements of its single-buyer model[73], and Vietnam has expanded direct PPAs to increase renewable electricity procurement by large consumers[23]. As renewable generation expands, regulators should introduce mechanisms that allow storage, demand response and other flexible resources to participate in balancing and ancillary services, and should review inflexible PPAs and fuel arrangements where they restrict efficient system operation.

Regional electricity trade requires a more consistent regulatory framework. Cross-border projects are often negotiated individually, with different approaches to tariffs, grid access, technical standards and risk allocation. The LTMS-PIP shows that multilateral trade is possible, but scaling it will require more consistent regional approaches. Southeast Asia should develop common principles for cross-border electricity trading, including harmonised technical requirements, transparent allocation of transmission capacity and clearer treatment of operational risks. The ToR endorsed for the ASEAN Regional Renewable Energy Certificate Framework[62] is a step towards such harmonisation, which would reduce transaction costs for future interconnections and increase investor confidence.

Southeast Asia's 11 power systems differ in ownership, market design and the allocation of planning, investment and operating responsibilities. These differences affect how each priority is implemented. Vertically integrated and unbundled systems, and state-owned, government-linked and private utilities, can differ in who plans and finances network investment, how generation and transmission planning is coordinated, how grid codes are set and enforced, and how flexibility and system services are procured and remunerated. These recommendations may therefore need to be selected and adapted to national market structures. ■

CONCLUSION

5

Southeast Asia's electricity systems will need to accommodate rising demand, a changing generation mix and new patterns of electricity consumption, while maintaining reliability and managing exposure to imported fuels, extreme weather events and cyber risks.

Generation and network planning require closer coordination, with investment decisions based on expected changes in supply and demand. Plans limited to committed projects defer infrastructure until congestion and connection constraints have already appeared.

New grid infrastructure remains necessary but needs to be complemented by measures that improve the performance of existing networks and strengthen flexibility, stability and resilience. The response therefore needs to extend beyond conventional grid expansion. DLR, advanced power flow control, HVDC, FACTS devices, synchronous condensers and storage can add capacity, improve stability and support variable renewable generation. Their contribution depends on technology selection, system conditions and the rules governing their use. Network development plans should include them with new lines, with choices based on cost, deployment time and operational need.

Transformers, cables, switchgear and other components have long procurement and manufacturing lead times. Earlier procurement, clearer visibility of future equipment needs and coordination between utilities, governments and manufacturers reduce delivery risk.

Greater cross-border transfer capacity can improve the use of available generation, support reserve sharing and reduce the capacity that each country maintains solely for domestic peak conditions. Realising these benefits requires further grid-to-grid interconnection, coordinated system planning and trading arrangements that address technical, commercial and regulatory differences. Interconnection should be assessed within national network plans, particularly where it can defer investment, improve reliability or lower operating costs.

Regulatory frameworks need to provide certainty for network investment and to remunerate flexibility, system services and efficient network use. Without these provisions, investment plans may not be delivered at the required pace.

Because economic maturity, power sector structure and grid development differ by country, the measures in this report should be adapted to national circumstances within common regional standards.

Southeast Asia already has substantial grid investment plans, established planning institutions, proven technologies and mechanisms for cross-border cooperation. The priority now is to align these elements and accelerate delivery. A reliable, affordable and secure regional power system depends on building networks ahead of demand, using existing infrastructure more effectively, strengthening equipment supply chains, enabling flexibility and connecting national systems where regional trade can improve system efficiency and security. ■

Endnotes

1. International Monetary Fund (IMF), 2024. World Economic Outlook Database, 22 October 2024.
2. International Energy Agency (IEA), 2026. Southeast Asia Energy Outlook 2026, 16 June 2026.
3. Climate Analytics, 2023. Phasing out coal-fired power in South and South-East Asia, 18 October 2023.
4. International Energy Agency (IEA), 2026. Strait of Hormuz Crisis Reinforces Need for Southeast Asia to Tackle Major Energy Vulnerabilities, 16 June 2026.
5. World Bank, 2026. Commodity Markets Outlook, April 2026, 28 April 2026.
6. International Energy Agency (IEA), 2026. Gas Market Report, Q2-2026, 24 April 2026.
7. International Energy Agency (IEA), 2024. Climate Resilience for Energy Security in Southeast Asia, 26 July 2024.
8. Viet Nam News, 2025. Provinces Struggle to Recover from Typhoon Kajiki's Devastation, 28 August 2025.
9. ASEAN Centre for Energy (ACE), 2026. ASEAN Energy in 2026, 3 February 2026.
10. International Energy Agency (IEA), 2026. Financing the ASEAN Power Grid, 10 March 2026.
11. Green Grids Initiative (GGI), 2026. Asia-Pacific High Voltage Transmission Supply Chain Project, 8 June 2026.
12. PetroVietnam Technical Services Corporation (PTSC), 2025. PTSC and LS Eco Energy Officially Sign Joint Development Agreement to Develop High-Voltage Cable Manufacturing Plant in Vietnam, 12 August 2025.
13. World Bank, 2026. World Development Indicators: Access to Electricity (% of Population).
14. Ember, 2026. Indonesia: Country Profile, 21 April 2026.
15. Thailand Board of Investment (BOI), 2023. EV Board Gives the Green Light to EV 3.5 Package, Press Release No. 119/2566, 1 November 2023.
16. Wood Mackenzie, 2026. Johor's Data Centres Could Consume 40% Electricity Demand by 2035, Testing Grid Expansion Plans, 18 June 2026.
17. TransitionZero, 2026. Malaysia Data Centres: Can Clean Energy Keep Up?, 24 February 2026.
18. The Edge Malaysia, 2026. My Say: For Sustainable Data Centre Growth, Upgrade State Capacity, 14 September 2026.
19. W.Media, 2025. Johor Stops Approving Tier 1 and Tier 2 Data Centers Due to Water Overuse, 28 November 2025.
20. Department of Energy, Philippines (DOE), 2025. Philippines Accelerates Renewable Energy Deployment Through the Fourth Green Energy Auction, 4 September 2025.
21. International Energy Agency (IEA), 2025. World Energy Investment 2025: Southeast Asia, 5 June 2025.
22. PT PLN (Persero), 2025. Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2025–2034, 26 May 2025.
23. The Investor, 2024. Rooftop Solar Power in Vietnam: Great Potential but No Specific Policies, 12 April 2024.
24. Government of Vietnam, 2025. Adjustment of the National Power Development Plan for the 2021–2030 Period, with a Vision to 2050 (Revised Power Development Plan VIII), Decision No. 768/QD-TTg, 15 April 2025.
25. Energy Tracker Asia, 2026. Renewable Energy in Thailand: An Alternative to LNG, 27 April 2026.
26. Sustainable Energy Development Authority (SEDA) Malaysia, 2026. Solar ATAP.
27. Energy Market Authority of Singapore (EMA), 2026. Solar, 10 September 2026.
28. International Energy Agency (IEA), 2023. Gas Market Report, Q1-2023, 28 February 2023.
29. ASEAN Secretariat, 2025. Disaster Risk Financing and Insurance in Southeast Asia: Trends, Challenges, and Strategic Approaches. ASEAN Socio-Cultural Community (ASCC) Trend Report No. 12, 2025.
30. GMA News, 2025. Super Typhoon Uwan Downs 36 Power Lines in Luzon, Visayas, 10 November 2025.
31. CNBC Indonesia, 2022. Jenis Data Pelanggan PLN yang Diduga Bocor Dijual Hacker, 20 August 2022.
32. Cyber Defense Insight, 2023. PLN Hit by Another Data Breach, 26 October 2023.
33. The Cyber Express, 2023. Vietnam Electricity Data Breach Claimed By BlackCat Group, 4 December 2023.
34. VnExpress International, 2023. Power Outages Cost Vietnam $1.4B: World Bank, 10 August 2023.
35. Refrigeration Electrical Engineering Corporation (REE Corp.), 2025. Annual Report 2024, March 2025.
36. Institute for Energy Economics and Financial Analysis (IEEFA), 2026. Thailand's Gas Conundrum, 26 February 2026.
37. International Energy Agency (IEA), 2022. Enhancing Indonesia's Power System: Pathways to Meet the Renewables Targets in 2025 and Beyond, 17 August 2022.
38. The Edge Malaysia, 2026. Malaysia's Data Centre Capacity to Double to 2,055MW by 2026 — JLL, 28 April 2026.
39. Southeast Asia Infrastructure, 2025. Philippines' Grid, 1 July 2025.
40. Philippine News Agency (PNA), 2026. NGCP Urges Caution on Renewable Energy's Impact on Power Grids, 7 January 2026.
41. Power Philippines, 2026. NGCP Backs MTerra Solar Capacity, Urges Measures to Protect Grid Stability, 7 January 2026.
42. Yayan, Y. W. G., Krismanto, A. U., & Muljanto, W. P., 2025. Impact Analysis of Cirata Floating PV Integration on Frequency Stability in the 500 kV Java-Bali Grid. Journal FORTEI-JEERI, 6(2), 95–105.

43. Arifin, Z., 2026. Readiness of Grids for Renewable Energy Integration – II. Masyarakat Ketenagalistrikan Indonesia (MKI) / Institut Teknologi PLN.
44. ASEAN Centre for Energy (ACE) & International Energy Agency (IEA), 2026. Accelerating Battery Energy Storage System for vRE Integration, 28 September 2026.
45. Energy Market Authority of Singapore (EMA), 2023. Southeast Asia's Largest Energy Storage System Officially Opens, 2 February 2023.
46. China Energy Engineering Corporation Limited (CEEC), 2025. CEEC First Large-Scale Electrochemical Energy Storage Project in Malaysia Connected to Grid, 3 January 2025.
47. Sembcorp, 2025. Sembcorp and PLN Nusantara Power Launch First Utility-Scale Integrated Solar and Energy Storage Project in Indonesia, 5 September 2025.
48. Energy-Storage.News, 2026. Hanoi Power Corporation Inaugurates the First 100MWh Battery Storage Portfolio in Vietnamese Capital, 28 July 2026.
49. Ember, 2026. Electricity Data Explorer.
50. New Straits Times (NST), 2018. IBR, ICPT: Time for Reflection, July 2018.
51. Malay Mail, 2024. TNB Eyes Higher Base Tariff for 2025–2027 in Peninsular Malaysia Starting July Next Year amid Energy Transition Push, 27 December 2024.
52. Aziz, M. H. A., Miswan, N. S., Mohd Kasran, F. A., Shokri, M. S. M., Noorfazly, N. M., & Abd Rahim, A. A., 2020. Pilot Project on Dynamic Line Rating (DLR) System for Optimal Use of Tenaga Nasional Berhad (TNB) Grid Capacity. Proceedings of the 2020 International Conference on Technology and Policy in Energy and Electric Power (ICT-PEP).
53. National Grid Corporation of the Philippines (NGCP), 2024. NGCP Holds Ceremonial Switch-On for PhP 51.3-B Mindanao-Visayas Interconnection, 25 January 2024.
54. ASEAN Centre for Energy (ACE), 2024. ASEAN Power Grid Interconnections Project Profiles, 18 November 2024.
55. ASEAN Centre for Energy (ACE), 2025. Powering Regional Grid Interoperability: The Crucial Role of Transmission System Operators in the LTMS-PIP, 26 March 2025.
56. Institute for Energy Economics and Financial Analysis (IEEFA), 2025. Expanding ASEAN Grid Supply Chains Could Mitigate Critical Transmission Equipment Shortages, 9 January 2025.
57. Phnom Penh Post, 2026. Why Southeast Asia Must Act Early on Subsea Power Cables, 5 October 2026.
58. ASEAN Centre for Energy (ACE) & Southeast Asia Smart Power Program (SPP), 2025. A Playbook for ASEAN Power Grid Interconnectors, 23 January 2025.
59. Bernama, 2026. TNB Builds Future-Ready Procurement Ecosystem Through Stronger Regional Collaboration, July 2026.
60. Tenaga Nasional Berhad (TNB), 2023. Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS PIP): Challenges and Lessons Learned, presentation, October 2023.
61. ASEAN, 2023. Joint Statement of the Brunei Darussalam–Indonesia–Malaysia–Philippines Power Integration Project (BIMP-PIP), 24 August 2023.
62. ASEAN, 2025. Joint Media Statement of the Forty-Third ASEAN Ministers on Energy Meeting (43rd AMEM), 16 October 2025.
63. Huda, M. S., 2026. Subsea Power Cables as Catalysts for the Energy Transition in Southeast Asia. Eco-Business (republished from ODI Global), 4 February 2026.
64. Asian Development Bank (ADB). ASEAN Power Grid.
65. Energy Market Authority of Singapore (EMA), 2024. Singapore Doubles Power Import Capacity Under LTMS-PIP Phase 2, 10 December 2024.
66. ASEAN Centre for Energy (ACE), 2025. ADB and World Bank Group Launch the ASEAN Power Grid Financing Initiative with the ASEAN Secretariat and the ASEAN Centre for Energy, 15 October 2025.
67. ASEAN, 2025. Chairman's Statement of the 46th ASEAN Summit, 26 May 2025.
68. ASEAN, 2026. Joint Media Statement of the Forty-Fourth ASEAN Ministers on Energy Meeting (44th AMEM), 8 October 2026.
69. Climate Home News, 2026. SE Asia Speeds Up Plan for Connected Clean Power Grid After Oil Shock, 13 October 2026.
70. EU-ASEAN Business Council (EU-ABC), 2025. Powering ASEAN's Net-Zero Future, October 2025.
71. ASEAN Centre for Energy (ACE), 2025. ASEAN Ministers Endorse APAEC 2026–2030 to Advance Regional Energy Cooperation, 16 October 2025.
72. International Energy Agency (IEA), 2025. Integrating Solar and Wind in Southeast Asia, 22 September 2025.
73. Energy Regulatory Commission of Thailand (ERC), 2025. Direct PPA Pilot Project, September 2025.

Global **Transmission** Report

www.globaltransmission.info info@globaltransmission.info