



Why grid flexibility matters more than ever for ASEAN's prosperity

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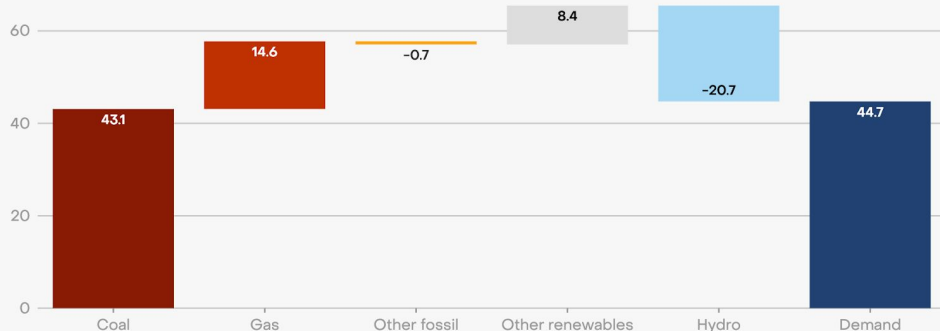
The background of the bottom right corner features a network diagram consisting of numerous light blue dots connected by thin, light blue lines, forming a complex web-like structure. The Ember logo is overlaid on this diagram.

ASEAN's power generation in 2023

Growth in ASEAN's fossil generation far outweighed the demand rise in 2023

Change in generation 2022 vs 2023 (TWh)

Coal Gas Other fossil Other renewables Hydro Demand



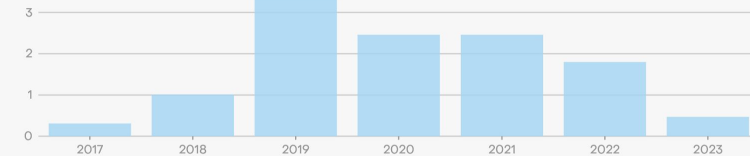
Source: Annual electricity data, Ember
'Other renewables' include solar, wind, bioenergy and geothermal

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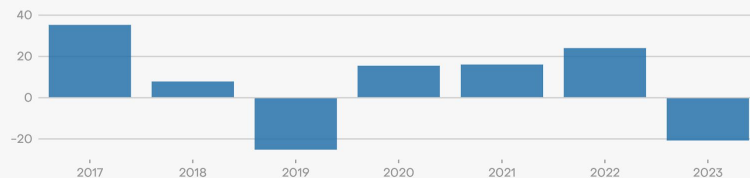
Despite continuous growth in the ASEAN region's hydro capacity, hydro power generation has been volatile

Annual change

Capacity additions (GW)



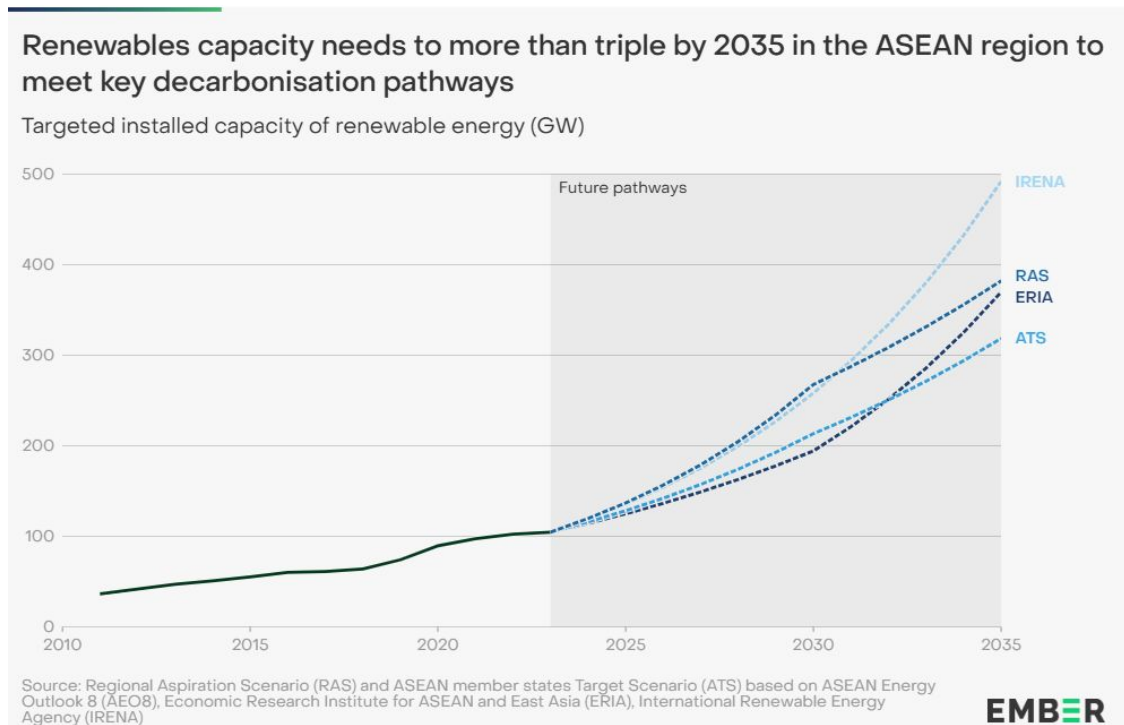
Generation change (TWh)



Source: Yearly electricity data, Ember

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Renewable ambitions would require a new infrastructure playbook

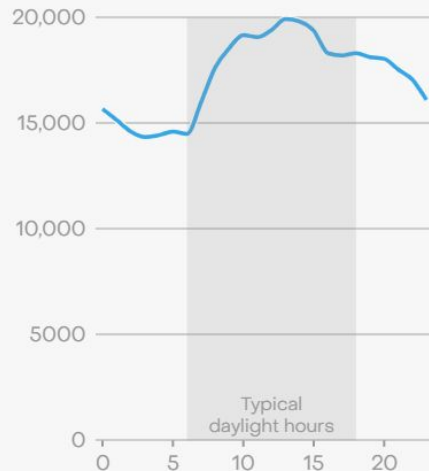


Solar provides the right opportunity

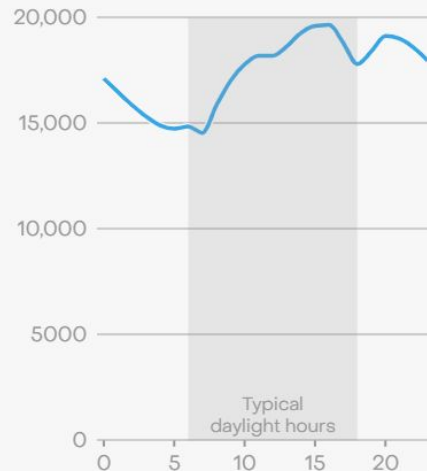
Surges in peak demand during daylight hours present solar opportunities for some ASEAN countries

Average daily load profile in 2023 (MW)

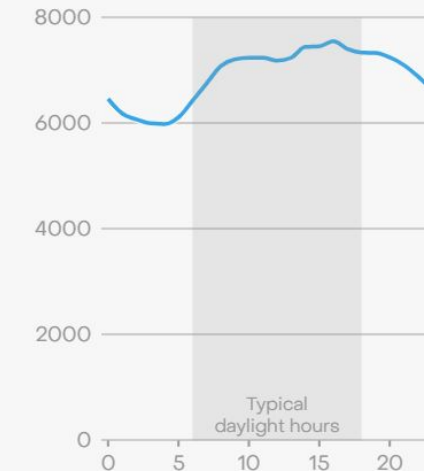
Philippines



Peninsular Malaysia



Singapore

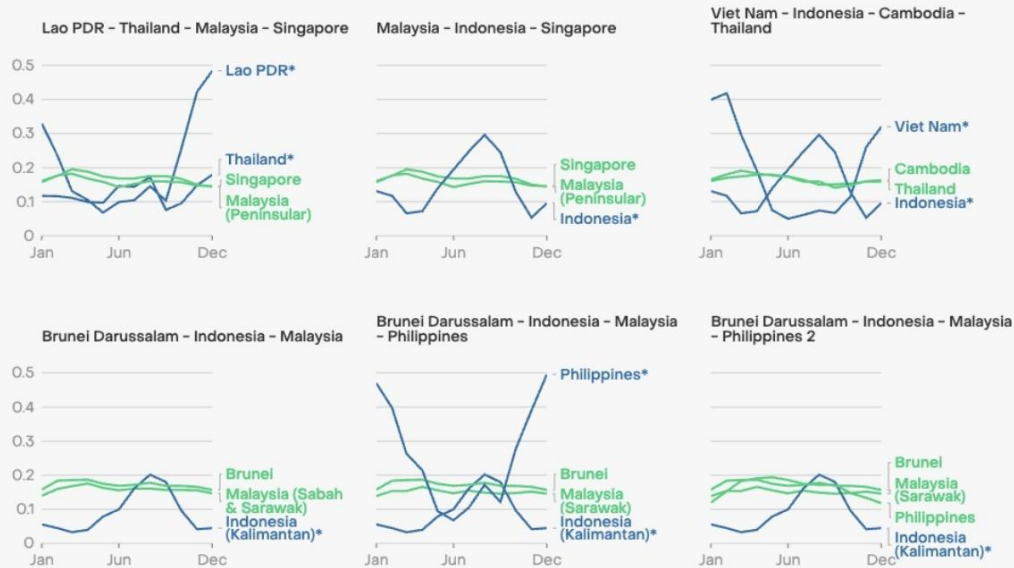


Source: Grid System Operator (GSO) Malaysia, Det Norske Veritas (DNV), Energy Market Company (EMC) Singapore
NEMS Market Data, National Grid Corporation of the Philippines (NGCP)

Exploit the complementarity

Wind and solar exhibit good complementarity in ASEAN making regional interconnections a key lever

Capacity factors for **wind** and **solar**, for each month of the year

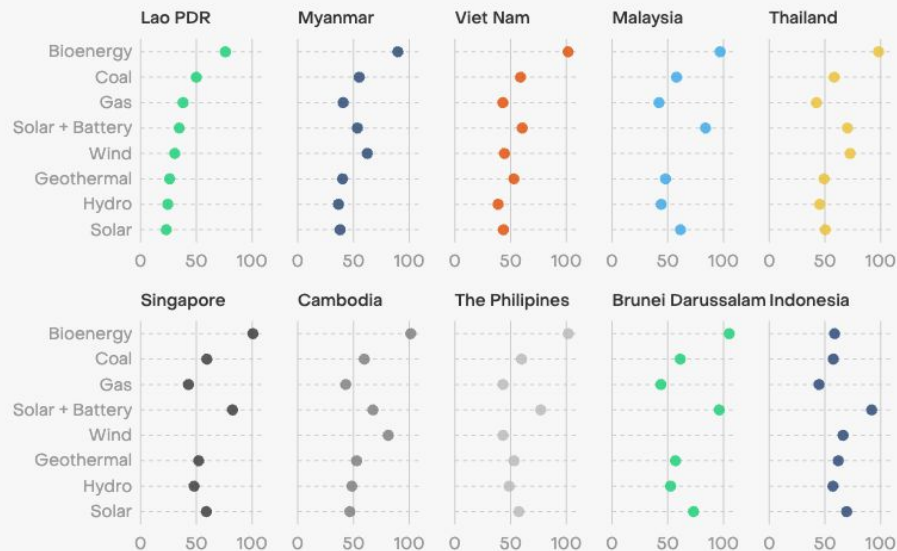


Source: Open Meteo, Ember's calculation
*Wind data, otherwise solar

Economise on generation

Solar, hydro and geothermal are cheaper than bioenergy in most ASEAN countries

Levelised cost of electricity in 2023 (USD per MWh)



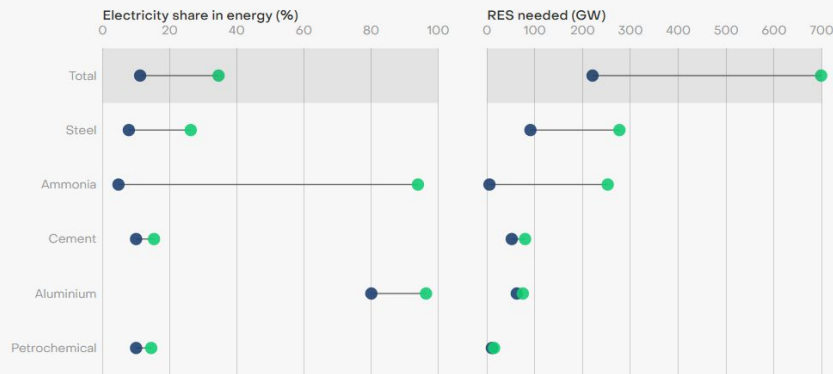
Source: Ember's analysis using NREL's Annual Technology Baseline (ATB) workbook, World Development Indicators for GDP, PWC (2024) and CPI (2023)

Electrification: A major theme across sectors

Green electrification of India's heavy industries could triple their 2050 electricity share in energy use and RES requirements

Electricity as a share of energy consumption & RES required to green electricity

● Existing technologies ● Advanced electrification technologies



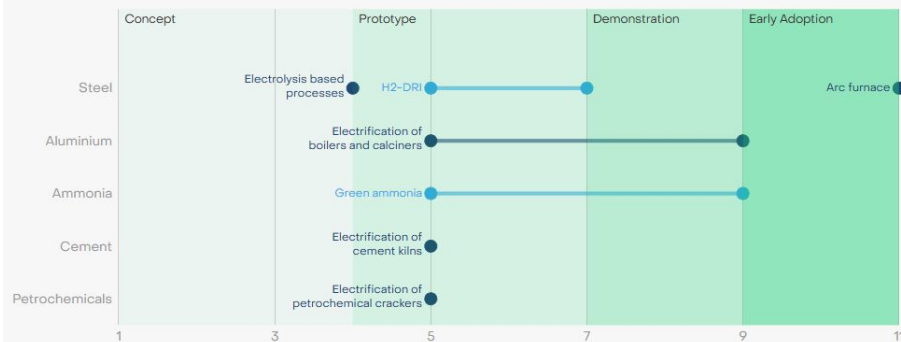
Source: Ember's analysis based on the electrification potential of various industrial sectors and average capacity factor of renewable energy based on the 14th National Electricity Plan. Assumes that major new technologies, currently under development, electrify the existing thermal processes in the industries wherever possible by 2050. RES refers to renewable energy sources that include solar, wind, small hydro and bio.

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Technologies to electrify thermal processes of various industries are at different readiness levels

Technology readiness level, score from 1 (basic idea) to 11 (maturity)

Electrification: ● Direct ● Indirect



Source: Ember's analysis of technology readiness levels data from the International Energy Agency, World Steel Association, Energy Transitions Commission, European Aluminium and Ramboll. H2-DRI refers to hydrogen in the direct reduction process. Technology readiness level is based on the scale proposed by the IEA for different clean energy innovations.

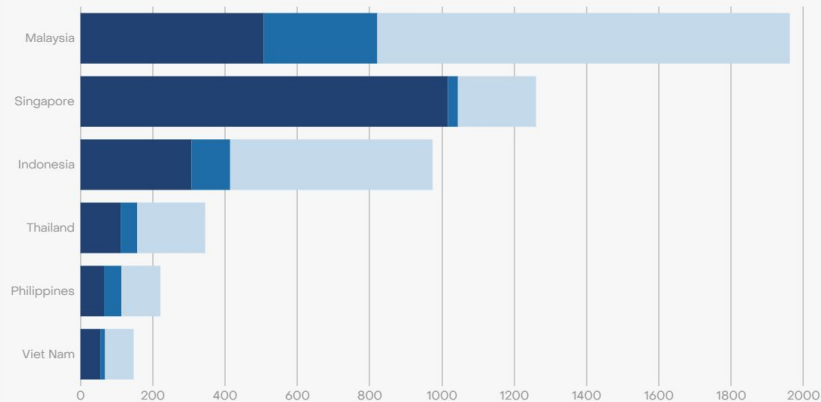
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Taking a share in the digital revolution

ASEAN's data centre boom is spreading, with the pipelines led by Malaysia, Indonesia, and Thailand

Data centre capacity load (MW)

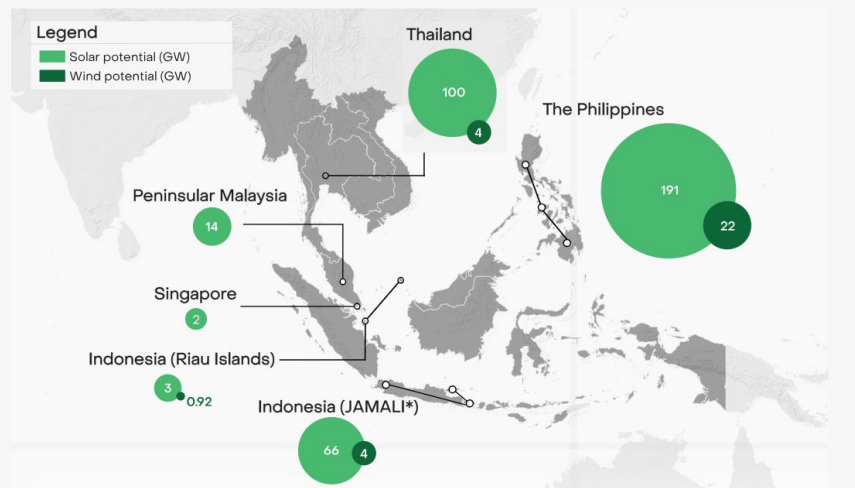
■ In operation ■ Under construction ■ Planned



Source: Cushman and Wakefield (2025)

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ASEAN data centre hotspots have opportunities to tap into solar and wind potential surrounding the grids



Foundation for a renewable dominated grid

Clean flexibility options for ASEAN

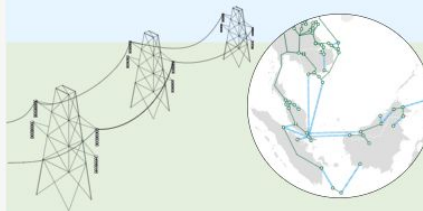
Pumped hydro

Pumped hydro systems move water to a higher reservoir during off-peak and release it to generate electricity when needed.



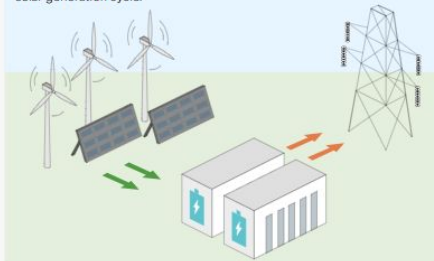
Grids and interconnections

Grids and interconnections enhance flexibility by balancing energy supply across regions and seasons, optimising power line use, and reducing grid constraints.



Battery-storage

Battery storage absorbs excess electricity when generation surpasses demand and releasing it when needed, aligned with the solar generation cycle.

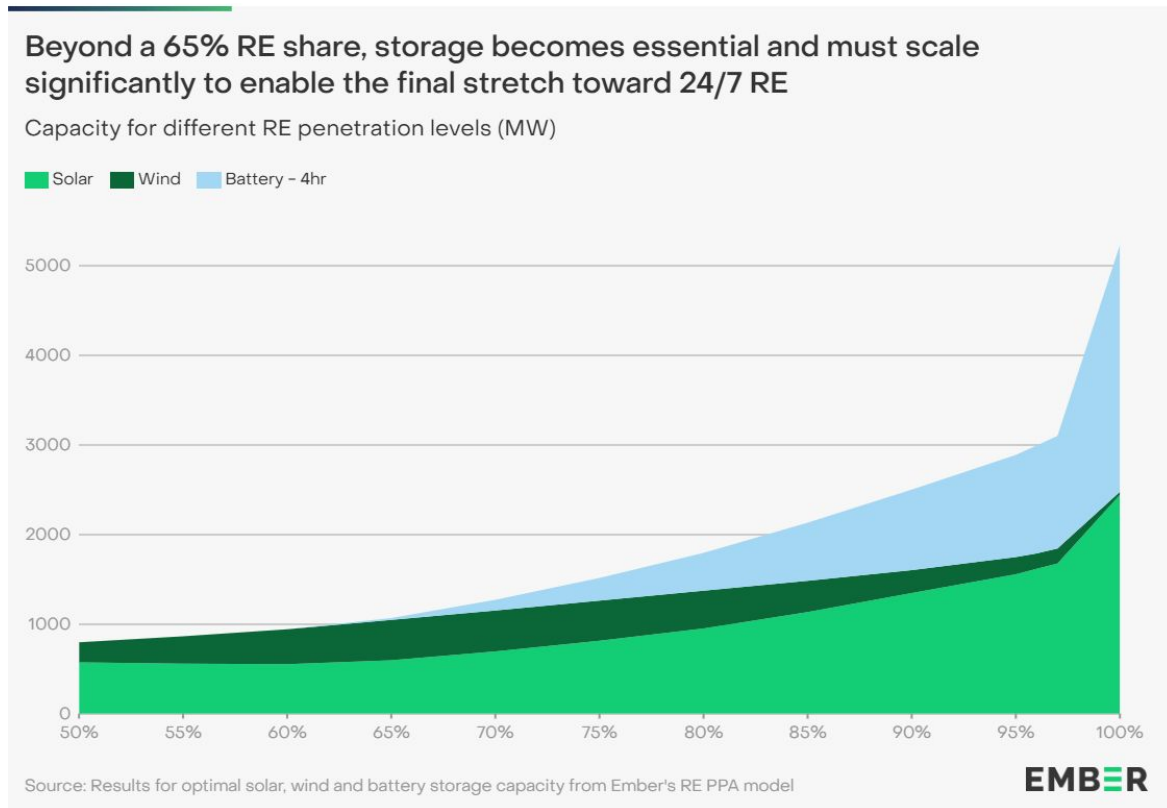


Demand-side management

Demand-side management adjusts electricity use by controlling end-user devices to enhance grid flexibility, in response to increased renewable energy integration.



Importance of storage for firm power



The ASEAN grid interconnections can unleash a robust regional renewable energy market

Existing and planned interconnections in selected locations* and 2030 electricity demand in the ASEAN region

Interconnection capacity in selected locations (MW)* # 2030 electricity demand in the ASEAN region (TWh)

123 Existing 123 Ongoing** 123 Future



Source: ASEAN Centre for Energy (2023), Global Energy Monitor, Findings of ASEAN Interconnection Masterplan Study (AIMS) III Phase 1 & 2 Update (2023), NREL (2020), Sani et al. (2021) and national policy documents.

*Lines includes selected projects based on the ASEAN Interconnection Masterplan Study (AIMS) III. Points in the map does not reflect the overall interconnection plan and grid infrastructure in ASEAN countries and particularly highlights cross-border interconnections. TBC: Planned lines according to ASEAN Interconnection Projects Plan.

**Ongoing projects up to 2024.

Balancing renewables over a larger control area becomes the cornerstone

Why some interconnection projects would give quick gains and should be prioritized ?

- 2 interconnections
- 1 exchange
- 0



Better understanding the challenges of grid integration

- Coordination among regional market operators
- Compensation mechanisms
- Better reserve and operations planning
- Critical ancillary services control



Thank you!


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The logo features the word "EMBER" in a bold, sans-serif font. The letter "E" is stylized with three horizontal green bars. The background of the slide includes a faint, light blue network diagram consisting of interconnected nodes and lines, resembling a molecular or web structure.

A background network diagram consisting of a series of interconnected nodes and lines. The nodes are represented by small circles, some in a light blue color and others in a light green color. The lines connecting them are thin and light blue. The network is more densely connected on the left side and becomes sparser towards the right.

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