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ASEAN Green Future Policy Brief

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Accelerate Malaysia's Energy Transition by Leapfrogging Over Natural Gas

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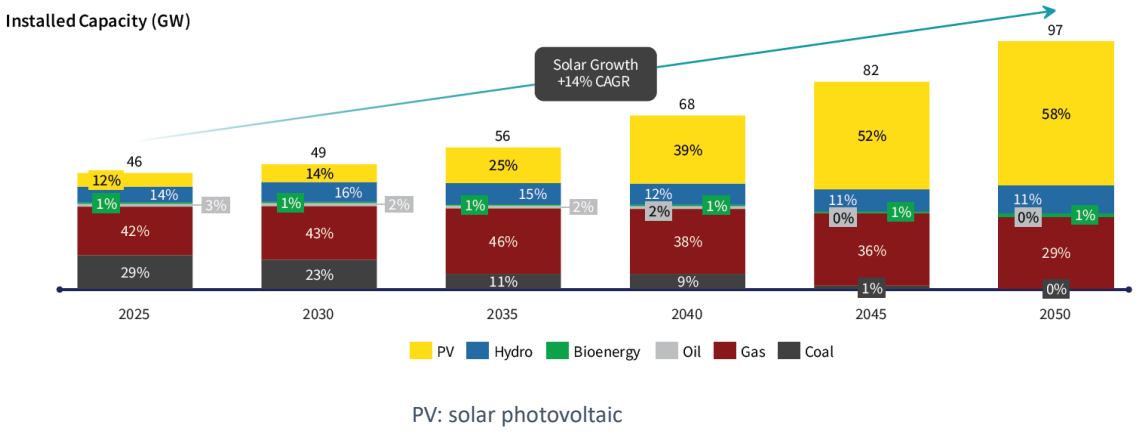
Executive Summary

- The rapid deployment potential of solar and supporting technologies necessitates a re-evaluation of the extent to which natural gas should be relied upon as a bridge fuel as recommended in the National Energy Transition Roadmap (NETR). The rapid advancements in the technologies that harness, and store renewable energy, are likely to mean that a cheaper and cleaner energy transition can be achieved by replacing planned natural gas power plants with solar power and storage expansion.
- Given the vast potential of solar power in Malaysia as well as its increasing affordability and its key role in all energy transition scenarios, Malaysia should unlock its solar power potential with coordinated investments in solar and storage technologies, and grid upgrades. Regulations on the power industry should be correspondingly updated.
- The key components of the global energy transition are electrification, energy efficiency, solar, wind, energy storage, and energy transmission. Policymakers should explore creative incentives and funding mechanisms to accelerate the development of each component e.g. to build a smart grid infrastructure that integrates renewable energy that is time-varying in supply and generated in dispersed locations.
- Biomass power and biogas power should play bigger roles in the renewable energy mix. The potential scale of biomass power must be assessed in the context of a comprehensive land-use study and supply chain analysis.
- Similarly, the assessment of the potential for animal waste-based biogas production must also consider benefits like circular waste management, methane emission reduction, water purity protection and poverty alleviation.
- The key to unlocking the most cost-effective and reliable path to decarbonising Malaysia's power supply lies in a regional ASEAN approach. This approach prioritises strategic interconnections of national grids over isolated national expansion of renewable energy capacity to allow cost-competitive sourcing and backup power during outages. This vision necessitates a two-pronged planning approach: a long-term vision for a regional ultra-high voltage direct current backbone grid and the near-term optimisation of the current ASEAN Power Grid plan.

1. Evaluating Power Generation Pathways

1.1 The National Energy Transition Roadmap (NETR) is not a roadmap to net zero carbon emissions

- Figure 1, drawn from the National Energy Transition Roadmap (2023), shows that Malaysia plans to grow the generation capacity of renewable energy - which consists of solar power, hydropower and bioenergy - from 27% (12 GW) in 2025, to 41% (23 GW) in 2035 and to 70% (68 GW) in 2050.



PV: solar photovoltaic

Figure 1: Projected power system installed capacity mix 2050 (National Energy Transition Roadmap 2023)

- With the natural retirement of existing coal power generation plants and the ban on their new construction, NETR anticipates coal-fired power generation capacity to decline from 29% (13 GW) in 2025 to 11% (6 GW) in 2035 and to zero by 2050.

- Figure 1 shows a projected initial rise and subsequent decline in natural gas capacity relative to the total energy mix by 2050, from 42% in 2025 to 46% in 2035 and then to 29% in 2050. The emphasis in Figure 1 on the energy share of gas-powered pants obfuscates the fact that the absolute capacity of gas power plants would increase steadily over time, from 19 GW in 2025 to 26 GW in 2035 and 28 GW in 2050. *Ceteris paribus*, NETR would allow a steady increase in the amount of greenhouse gases emitted.

- Natural gas is currently positioned as a "bridge fuel" for reliable baseload power generation. However, natural gas emits significant greenhouse gasses (estimated at 490 gCO_2-eq per kWh), undermining long-term sustainability goals. Therefore, a critical re-evaluation of the NETR strategy is necessary to achieve net zero emission of CO_2.

1.2 Global trends: solar and storage

- The global energy sector is undergoing a significant transformation driven by the rapid growth of renewable energy, electrification, and energy efficiency. Clean technologies like solar photovoltaics (PV) and battery storage are experiencing significant cost reductions over time due to learning curves (Figure 2 and Figure 3). For instance, lithium-ion battery cost reached a record low of $139/kWh in 2023 (BloombergNEF 2023). This downward trend, combined with their universal applicability and rapid scalability, positions renewables as a disruptive force against traditional energy sources. (Rocky Mountain Institute 2024)

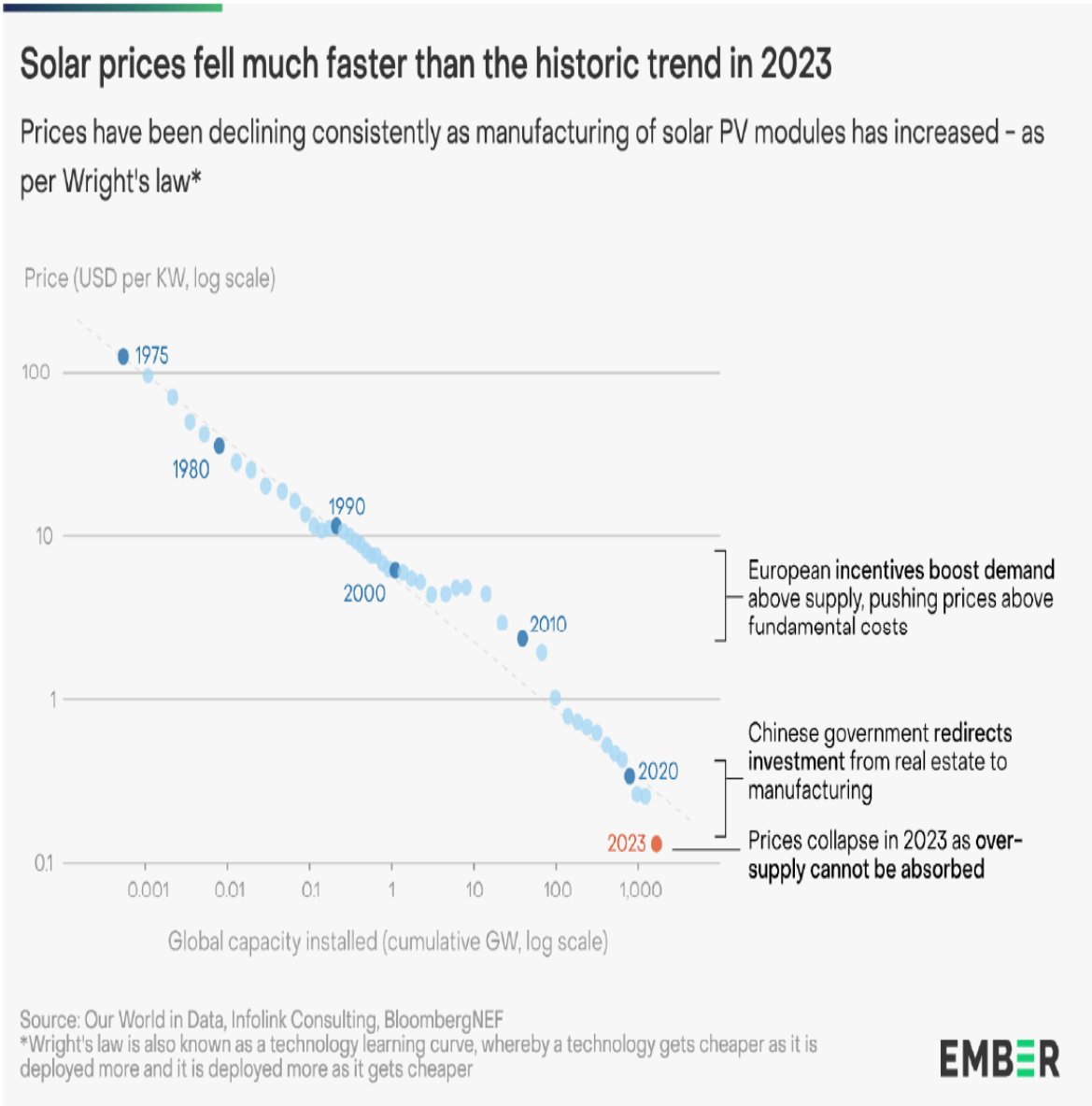


Figure 2: Global solar prices falling (Ember 2024)

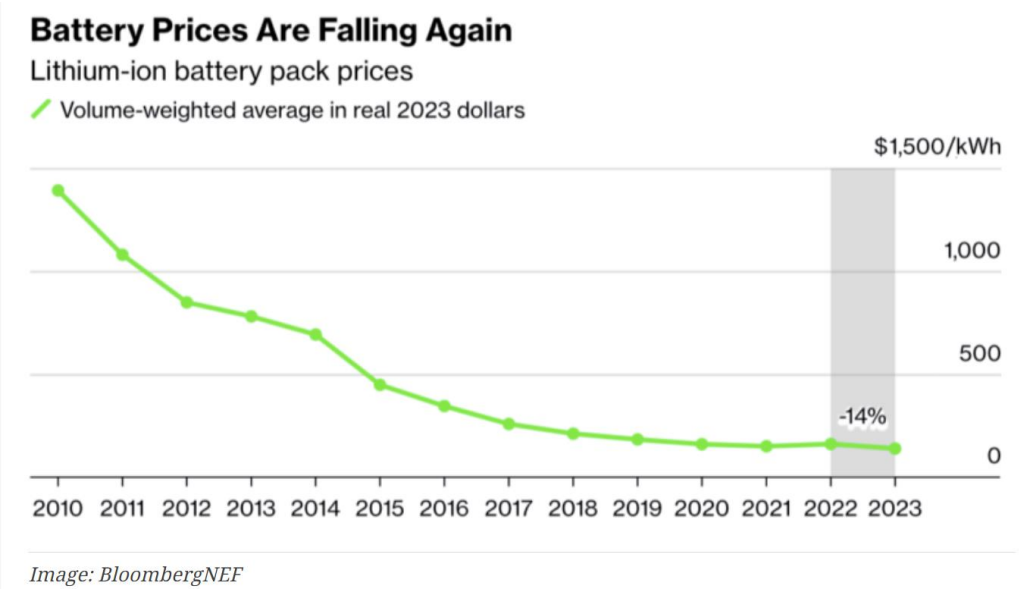


Figure 3: Global battery prices falling (BloombergNEF 2023)

- These technological trends are likely to be further accelerated by increasing concerns about energy security, China's continued huge investments in clean technology innovation, and international pressures to reduce greenhouse gas emissions. A shift towards clean energy strengthens energy independence and positions nations favourably in the global "race to the top" for cleantech leadership. (Rocky Mountain Institute 2024, International Energy Agency 2024)

- Projections in Figure 4 suggest that solar power is poised to become the dominant source of electricity generation in the world, potentially surpassing all other forms of capacity after 2025. Additionally, battery storage is expected to experience significant growth, potentially overtaking pumped hydro as the preferred storage solution soon. (Rocky Mountain Institute 2024)

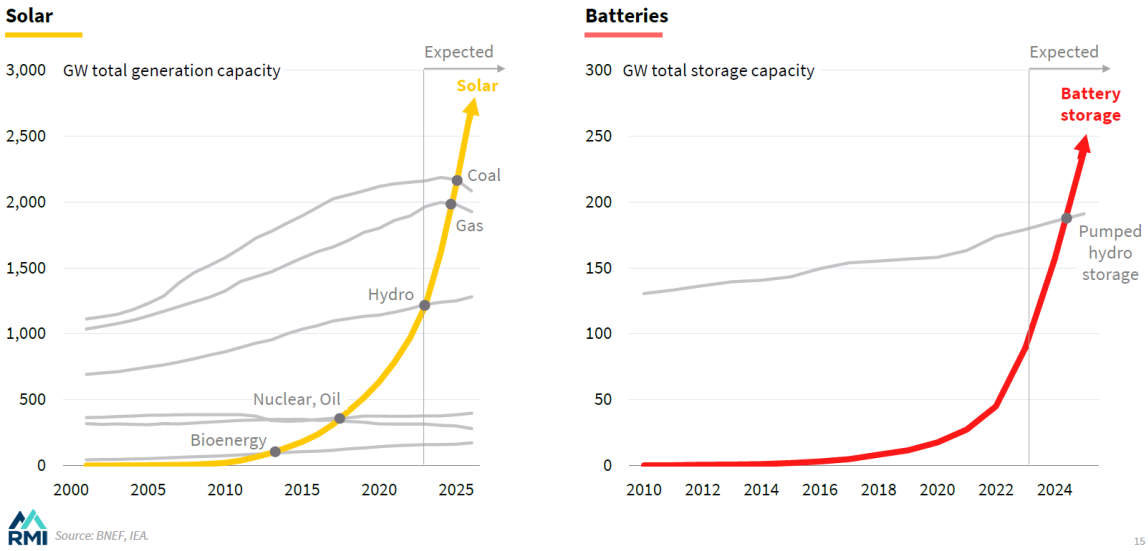


Figure 4: Solar and batteries' capacity growth trajectories (Rocky Mountain Institute 2024)

- As the world rapidly expands solar and battery storage capacity, a critical question emerges: can supply chains keep pace? Encouragingly, research by the Rocky Mountain Institute (2024) suggests that existing supply chains have the capacity to manufacture enough solar panels and batteries to support a net-zero emissions future (Figure 5).

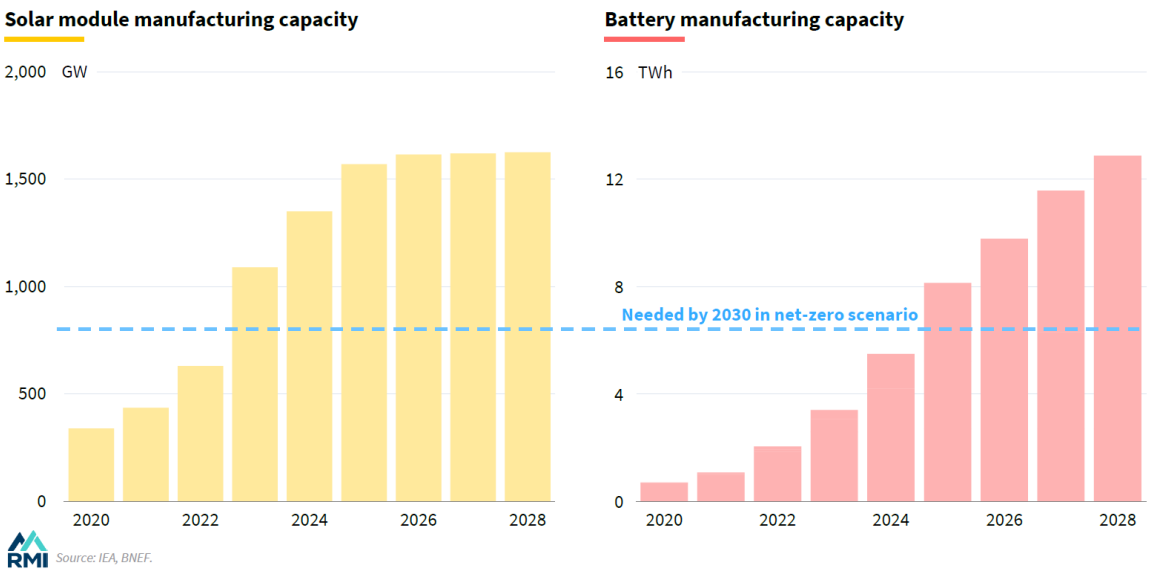


Figure 5: Historical and projected solar module and battery manufacturing capacities

- The rapid transformation of the electricity sector necessitates a focus on grid modernisation. Policymakers should explore incentives and funding mechanisms to accelerate the buildout of grid infrastructure that can effectively integrate a growing share of variable renewable energy sources, like solar, that is time-varying in supply and is generated in dispersed locations.

1.3 A 100% renewable energy grid in Malaysia is possible

- Replacing planned natural gas power plants with solar and storage solutions warrants serious consideration as a long-term cost-effective and low carbon approach to reduce reliance on fossil fuels and propel the energy transition. This development strategy leverages Malaysia's existing high fossil fuel energy mix for grid stability during the integration of higher proportions of variable renewable energy.

- Investing in hybrid pumped hydro and battery storage systems can further enhance this strategy. These systems combine the long-duration storage capacity of pumped hydro with the short-term flexibility of batteries. This enhances grid resilience by ensuring reliable power during peak demand periods and enables the storage of excess renewable energy for overnight use.

- Achieving a 100% renewable energy grid in Malaysia is a viable possibility, as evidenced by studies like the one by Weber et al. (2024) which explores the effectiveness of a solar and pumped hydro storage combination.

- Pumped hydro offers a significant advantage: it's a well-established, cost-effective long-term storage solution readily available for large-scale implementation.

- A fully renewable energy grid in Southeast Asia necessitates a comprehensive strategy that optimises the potential of all available indigenous renewable sources. The ASEAN Green Future project exemplifies this approach. Led by the UN Sustainable Development Solutions Network (SDSN) and Climateworks Centre, this multi-year regional research initiative explores pathways for Southeast Asia to achieve net-zero emissions. This collaborative effort brings together nine country teams from universities and think tanks across the region to investigate the options in decarbonisation pathways for each ASEAN member state.

- ASEAN Green Future researchers employ advanced energy system optimisation modelling tools from the Stockholm Environment Institute – the Low Emission Analysis Platform (LEAP) and the Next Energy Modelling System for Optimisation (NEMO) – to develop pathways for a near-zero emissions power generation sector. The project's findings for Malaysia (Woo, et al. 2024) recommend this specific energy mix for 2050 from one of its least-cost optimised scenarios:

  Renewable energy sources:

  - 81 GW of solar PV
  - 140 GW of hydropower
  - 24 GW of biomass
  - 0.7 GW of biogas
  - 2.5 GW of offshore wind
  - 2.8 GW of onshore wind
  - 1.5 GW of municipal solid waste steam turbine

  Energy storage:

  - 4.5 GW of battery storage
  - 8 GW of pumped hydro storage

- **Invitation to a collaborative study:** The ASEAN Green Future project invites the Ministry of Energy Transition and Water Transformation and the Ministry of Economy to collaborate on a critical study to develop a comprehensive technology roadmap for:

- **Solar and storage solutions:** Explore strategies to increase solar PV deployment and integrate efficient energy storage for a reliable renewable energy grid.
- **Integrating more solar into the national grid**: Focus on grid modernisation solutions to accommodate a growing share of solar power in the national energy mix.

With the guidance from the ministries, ASEAN Green Future can do a more robust study.

1.4 Bioenergy

- This brief defines bioenergy as encompassing both biomass and biogas.

- The ASEAN Green Future project's findings for Malaysia (Woo, et al. 2024) recommend biomass power as a significant contributor to a 100% renewable energy grid. The study projects a substantial increase in biomass capacity, from 1 GW (0.8%) in the Optimised Existing Policy[1] scenario to 24 GW (17%) in the Optimised More Ambitious Policy[2] by 2050. However, large-scale biomass utilisation requires careful consideration of sustainability concerns.

- A comprehensive land-use study is crucial to ensure the long-term environmental and economic viability of biomass. Expansion should be strategically integrated with a broader land-use strategy that prioritises factors such as carbon storage, avoided emissions, biodiversity conservation, soil health, water requirements, and land rights. Prioritising these considerations will make the bioenergy industry more socially and politically acceptable, fostering long-term sustainability.

- The ASEAN Green Future study for Malaysia (Woo, et al. 2024) recommends a modest increase in biogas capacity, from 0.6 GW in the Optimised Existing Policy to 0.7 GW in the Optimised More Ambitious Policy by 2050. While biogas generation is expected to decrease slightly, its true value lies in its environmental and economic benefits:

    - **Sustainable waste management, reduce methane emissions and water pollution:** Biogas technology can convert agricultural residues and livestock farming waste into biogas through a controlled process,

[1] Optimised Existing Policy identifies the lowest-cost path within the Malaysian government's recent decarbonisation policies and roadmaps, including the National Energy Transition Roadmap (NETR) (2023), National Biomass Action Plan 2023-2030 (2023) and the Hydrogen Economy and Technology Roadmap (2023).
[2] Optimised More Ambitious Policy (OMAP) examines the least-cost path under more ambitious emissions reduction targets for both demand and generation.

significantly reducing potent methane emissions from decomposing waste and river pollution.

  - **Renewable energy:** Biogas can be used for electricity generation, heating, or cooking, displacing reliance on fossil fuels and further reducing greenhouse gas emissions.
  - **Improve soil fertility:** The digestate byproduct from biogas production is a nutrient-rich fertiliser, which can be used to improve soil health and agricultural productivity.
  - **Strengthen farmer resilience:** Biogas generation provides farmers with financial security by offering an alternative income source during periods of crop failure or price fluctuations.

- **Malaysia's untapped animal waste-based biogas potential:** Malaysia produces significant amounts of poultry waste (4 million tonnes/year) and ruminant/swine manure (nearly 6 million tonnes/year). While some utilisation for organic fertiliser and biogas exists, an oversupply exists in the chicken manure-based bio-fertiliser market. (National Biomass Action Plan 2023-2030)

- **Regional biogas cluster opportunity:** Two states, Johor and Pahang, are major contributors with poultry and cattle manure exceeding 1 million tonnes each annually. Perak and Malacca also boast significant manure production, exceeding 800,000 tonnes annually (National Biomass Action Plan 2023-2030). Importantly, Johor, Pahang, and Malacca are geographically close, offering a unique opportunity to develop a regional cluster for large-scale biogas and biomethane production.

- **Invitation to a collaborative study:** To better understand the future potential scale of biomass power, the ASEAN Green Future project invites the Ministry of Plantation and Commodities and the Sustainable Energy Development Authority to participate in an assessment of future sustainable biomass supply, alongside a comprehensive land-use study and supply chain analysis.

2. Regional Power Interconnection

- Achieving the most cost-effective and reliable decarbonisation of Malaysia's power sector necessitates a strategic shift – moving beyond isolated national efforts towards a coordinated regional approach. This collaborative strategy offers several compelling advantages:
    - **Enhanced resource sharing:** Regions with abundant solar or wind resources can share surplus energy with neighbours, reducing the overall need for individual renewable capacity and storage capacity. (DNV 2024)
    - **Cost savings and efficiency:** Large-scale, coordinated planning can optimise grid infrastructure development, minimising duplication across borders and saving costs.
    - **Smart material use:** Strategic planning minimises land and material needs for the clean energy transition by optimising renewable project locations and transmission grids.
    - **Enhanced security of supply:** A regional grid with diverse renewable sources and interconnected lines strengthens energy security by reducing reliance on single fuel sources or locations.
- The upcoming ASEAN Green Future phase 2.3 (second half of 2024) will investigate **strategic prioritisation of interconnections** in Southeast Asia. The study will consider existing and planned transmission lines, including their capacities and limitations.
- **Moving beyond simply increasing capacity**, the study will identify interconnections that offer the **greatest long-term benefits** in terms of:
    - **Cost-effectiveness:** Finding cost-efficient solutions for interconnection projects.
    - **Environmental impact:** Minimising the environmental footprint of grid infrastructure development.
    - **Grid stability:** Ensuring a reliable and stable regional power grid.
- **Two planning horizons** for a comprehensive strategy:
    - **Long-term vision:** This vision explores the potential of an ultra-high voltage (UHV) direct current (DC) backbone grid, significantly higher capacity (e.g., 1000 kV) compared to the existing 230 kV or 500 kV alternating current (AC) lines. This could transform the region by enabling efficient transmission of large-scale renewable energy across vast distances.

  - **Near-term optimisation:** This approach prioritises optimising the current ASEAN Power Grid plan while laying the groundwork for future integration with a potential UHV DC grid.

  By considering both long-term vision and immediate needs, the study aims to develop a comprehensive and adaptable strategy for regional power interconnection.

- **Optimising storage solutions:** The study will also explore the optimal location, capacity, and type of storage technology (battery, pumped hydro) across Southeast Asia. This integrated approach will ensure a comprehensive and efficient decarbonisation strategy for the region.

- **Invitation to a collaborative study:** The ASEAN Green Future invites the Ministry of Energy Transition and Water Transformation and the Ministry of Economy to participate in this crucial study. Collaborative efforts are essential to achieve a sustainable and secure energy future for Southeast Asia.

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