CASE for Southeast Asia

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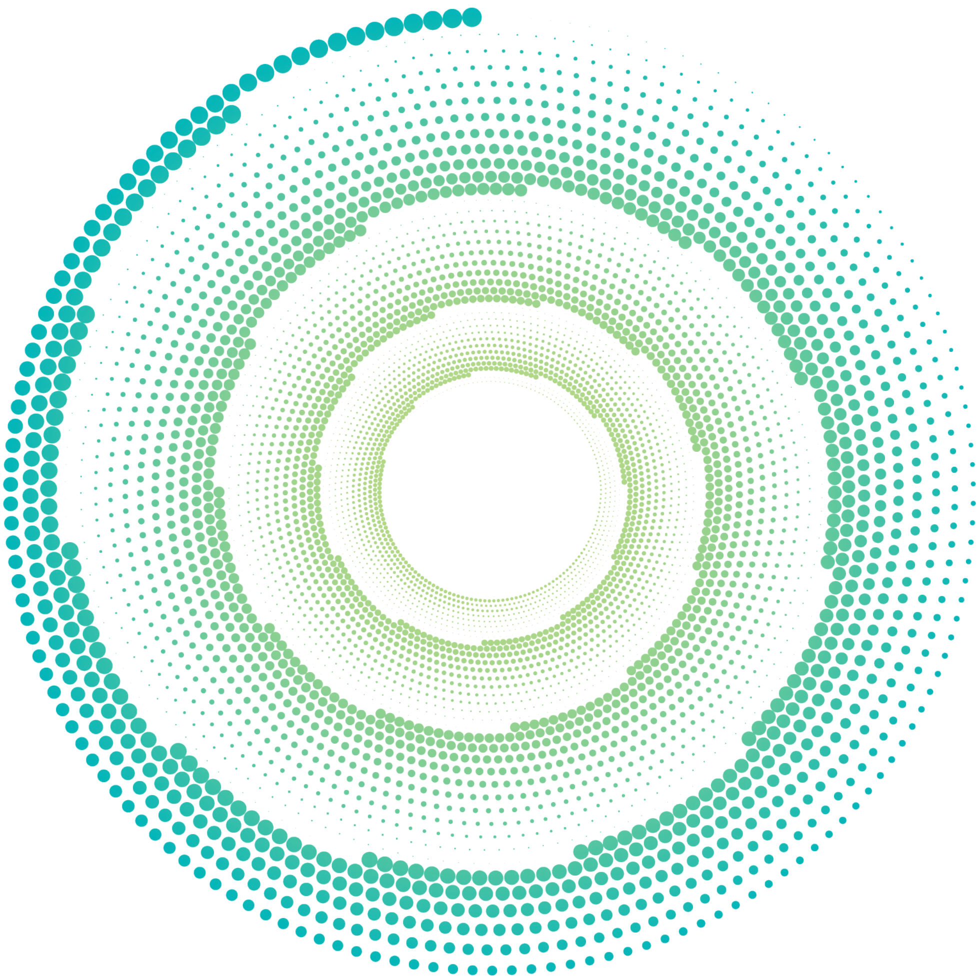
TECHNOLOGY BRIEF

The Role of Renewable Hydrogen in the Power Sector

August 2025



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Agora Energiewende

NewClimate Institute

IESR Institute for Essential Services Reform

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Key insights

1

Renewable hydrogen offers potential to support Southeast Asian power systems by meeting seasonal storage and peaking demands. Its use should be reserved for periods of scarcity, when the short-run value of electricity is highest.

2

Viet Nam, Indonesia, and Thailand are considering co-firing hydrogen and ammonia in coal and gas plants to cut emissions during baseload operations. This approach tends to be cost-inefficient, delivers limited emission reductions and carries the risk of prolonging reliance on fossil fuels.

3

Prioritising renewable energy and grid infrastructure helps lower electricity and hydrogen costs, boosts competitiveness in global green markets (such as steel and ammonia) and stimulates economic growth through job creation and investment.

Introduction

In recent years, hydrogen has emerged as a focus in both global and Southeast Asia's energy transition discussions. As energy demand in the region continues to rise – driven by population growth, urbanisation, industrial development and more recently, artificial intelligence – policymakers are increasingly looking to renewable hydrogen for its potential to lower emissions, support deep decarbonisation and enhance energy security.

Hydrogen is already used across several sectors in the region, notably as an industrial feedstock. Renewable hydrogen is widely recognised as a key solution for decarbonising hard-to-electrify sectors, such as shipping and aviation, and to some extent also the steel industry. In the power sector, hydrogen holds potential as a long-term energy storage option, helping to integrate variable renewable energy sources like wind and solar into the grid.

Reflecting this rising interest, several Southeast Asian countries have established national hydrogen strategies or integrated hydrogen in their power sector planning. Their approaches often focus on hydrogen and ammonia co-firing as a medium-term pathway for lowering emissions in the power sector, particularly to delay the early retirement of fossil fuel assets (Len, 2025). Co-firing is the co-combustion of fossil and renewable fuels – such as hydrogen or its derivative, ammonia – by blending them with coal or fossil gas in thermal power plants to generate electricity. Some countries, for example Viet Nam, plan for the full conversion of existing and under-construction coal and gas power plants to 100% hydrogen or ammonia combustion (Nguyen, 2025).

Southeast Asia remains heavily reliant on fossil fuels – particularly coal and fossil gas – with nearly 80 gigawatts (GW) of operating coal-fired capacity and an average plant age of 15 to 20 years (Agora Energiewende, 2023). Retiring these relatively young fossil plants early, well before the end of their operational lifespans, would entail financial losses to plant operators and might pose risks to energy security if it is not replaced with renewable capacity. Co-firing with hydrogen and ammonia in existing fossil plants is presented as a way to reduce emissions while continuing to utilise existing infrastructure.

Another narrative for hydrogen uses in Southeast Asia focuses on its potential to reduce energy import dependencies. The region is projected to become a net fossil gas importer by as early as 2027 (Agora Industry and Agora Energiewende, 2024). Some countries, like Viet Nam and the Philippines, are also increasingly reliant on coal imports (Varadhan, 2024). In this context, shifting towards domestically produced renewable hydrogen and ammonia as substitutes for imported fossil energy sources is seen as an urgent strategy.

Southeast Asia stands at a critical point in shaping its future energy systems. Introducing hydrogen as energy carrier on a wider scale will have implications on aspects, such as the need for grid infrastructure and storage, especially if all must be built from scratch. This policy brief examines the outlook for hydrogen-based power generation – referring to both co-firing and 100% hydrogen- or ammonia-firing – in the region, assesses its potential and key risks. The brief then offers policy considerations to help governments weigh its relevance within broader energy transition strategies.

How can hydrogen be used in the power sector?

Hydrogen can be produced in several ways, including through the electrolysis of water using renewable electricity or via steam reforming of fossil gas. Not all hydrogen production methods deliver emission reductions; using renewable electricity to make renewable hydrogen is one of the most effective ways to decarbonise. Once produced, hydrogen, which is a gaseous fuel, can be converted into ammonia, a liquid fuel that is more easily stored and transported. Both can be used to fuel power plants, either by co-firing with fossil gas or coal, or as the sole fuel.

Hydrogen can play a role in long-term storage and in supporting grid reliability, depending on the share of wind and solar photovoltaics (PV) and the seasonal demand structure. The absolute size of the need for hydrogen in the power sector depends on the availability of other flexibility and storage options. Excess renewable electricity can be used to produce renewable hydrogen with grid-connected electrolysers, mitigating curtailment and improving the economics of renewable power projects. This renewable hydrogen can be stored in underground storage and later used in hydrogen gas turbine power plants during long-periods of supply shortage.

Peaker plants designed to operate on 100% hydrogen could play an important role in future power systems for decarbonising "the last mile" of power generation. Such plants could offer fast and flexible electricity and help to maintain grid stability during high demand periods, providing a renewable alternative to fossil fuel-based peaker plants. However, it is unclear if the combination of hydrogen storage and hydrogen-fired power plants will be cost competitive compared to lithium-ion battery storage or pumped hydro storage, especially in geographies with little seasonality in demand or supply (ASEAN Centre for Energy, 2021). Hydrogen supply constraints may also limit the extent to which hydrogen-ready power plants will run on the renewable fuel, with gas blending being the more likely alternative in the near term.

How can hydrogen support Southeast Asian power systems?

Hydrogen contributes to renewable energy integration by providing long-duration storage and peak load coverage

Hydrogen can serve as a seasonal storage option. In Southeast Asia, this is particularly relevant for countries with strong seasonality (winter/summer) or where solar irradiation varies significantly over the year. Here, excess solar power could be seasonally stored through hydrogen. As hydrogen-based generation can provide dispatchable power near load centres, it could further help mitigate transmission constraints where this is a concern. Given its scarcity, however, it is important that any available renewable hydrogen should be reserved for situations when the grid needs it the most – or in economic terms, when the real-time value of electricity is high. Hydrogen peaker plants with few running hours can do just that, providing short-term flexibility and ancillary services to the system.

With these potential use cases, hydrogen could support the integration of variable renewable electricity generation sources into power systems, in addition to other flexibility sources such as grid enhancements, battery storage, pumped hydro power and demand side responses. Hydrogen's use cases are not applied at commercial scale at the moment, and careful consideration will be required to identify where hydrogen, as a comparatively expensive option, finds its place (ASEAN Centre for Energy, 2021).

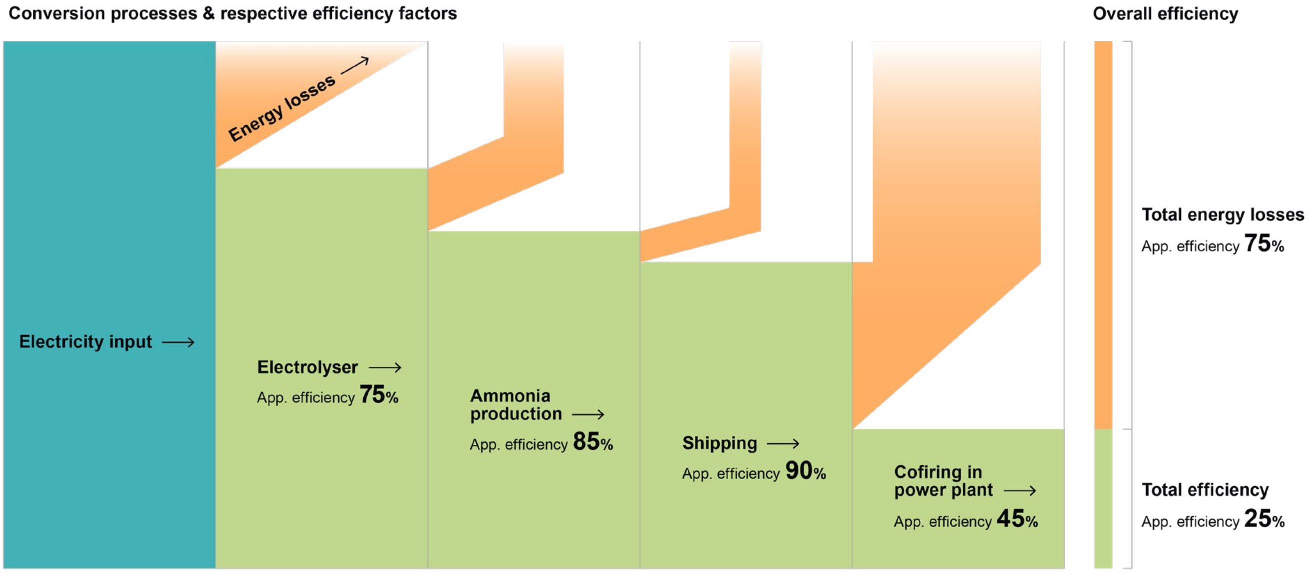
Electricity generated from hydrogen-based power plants is inherently more expensive than electricity from wind or solar sources

Burning hydrogen or its derivatives like ammonia in power plants to generate electricity comes with significant conversion losses. For example, when renewable ammonia is co-fired in coal plants, approximately 75% of the original electricity input is lost throughout the process (Figure 1). Due to high energy losses during the production process and transportation, renewable hydrogen and ammonia are more expensive on an energy-equivalent basis than fossil fuels. In Viet Nam, procuring ammonia is estimated to cost seven to nine times more than coal by 2030 (BNEF, 2023). The production of renewable hydrogen and its derivatives is resource-intensive, requiring vast quantities of land, water and renewable energy. Using renewable electricity directly, through new capacity additions, is more efficient, saves scarce resources and benefits energy consumers through cost savings.

Building and operating thermal power plants – whether for 100% renewable hydrogen combustion or for co-firing – is one of the most expensive power generation options in Southeast Asian countries. **Even at low co-firing ratios, such as 20% ammonia in coal plants, the projected costs exceed those of solar or wind by 2030 in countries like Indonesia and Viet Nam** (Figure 2) (Agora Industry and Agora Energiewende, 2024). In Viet Nam, the higher co-firing ratios needed for meaningful carbon dioxide (CO_2) emission reductions are more expensive than renewable energy systems paired with battery storage (BNEF, 2023).

Using hydrogen or ammonia in power generation requires the existing capacity and infrastructure to be retrofitted, entailing high upfront capital investments. For ammonia co-firing, this includes retrofitting coal plant's combustion chambers and fuel delivery systems, as well as constructing ammonia storage infrastructure. Hydrogen co-firing typically requires retrofitting plants' gas turbines, and fuel and combustion systems to stand the unique combustion characteristics of hydrogen, such as high flame speed, low energy density, high diffusivity and corrosiveness (Hanwha, 2023). Gas pipelines and storage infrastructure also require upgrades or new additions to address safety and combustibility concerns. Retrofit requirements increase with higher co-firing or blending ratios.

Globally, hydrogen and ammonia co-firing technologies are still in the demonstration phase, with few projects reaching commercial deployment. It is unclear if high blending levels can be achieved in older plants, and if so, whether the retrofitting costs would be economically viable. High capital investments coupled with high fuel costs render hydrogen use for baseload power capacity costly.



Note: Electrolyser efficiency varies depending on electrolyser technology (i.e. Alkaline electrolyser, proton exchange membrane (PEM) electrolyser, or solid oxide electrolysis cells (SOEC electrolyser). Efficiencies range from 63-84% (IEA, 2019) and will likely increase in the future. The graphic assumes an efficiency of 75% from the electrolyser. Ammonia production uses ~78% of total energy given as percentage of lower heating value of hydrogen (IEA, 2019). This graphic assumes an efficiency of 85% for ammonia production and a transport efficiency of shipping ammonia is 90% (Chartapatti et al., 2021). The efficiency losses of co-firing ammonia in a coal power plant depend on the age and location of the power plant. We assume a modern plant with an efficiency of 45% (IEA, 2019).

Figure 1:
Efficiency losses in co-firing coal with ammonia

NewClimate Institute (2023).

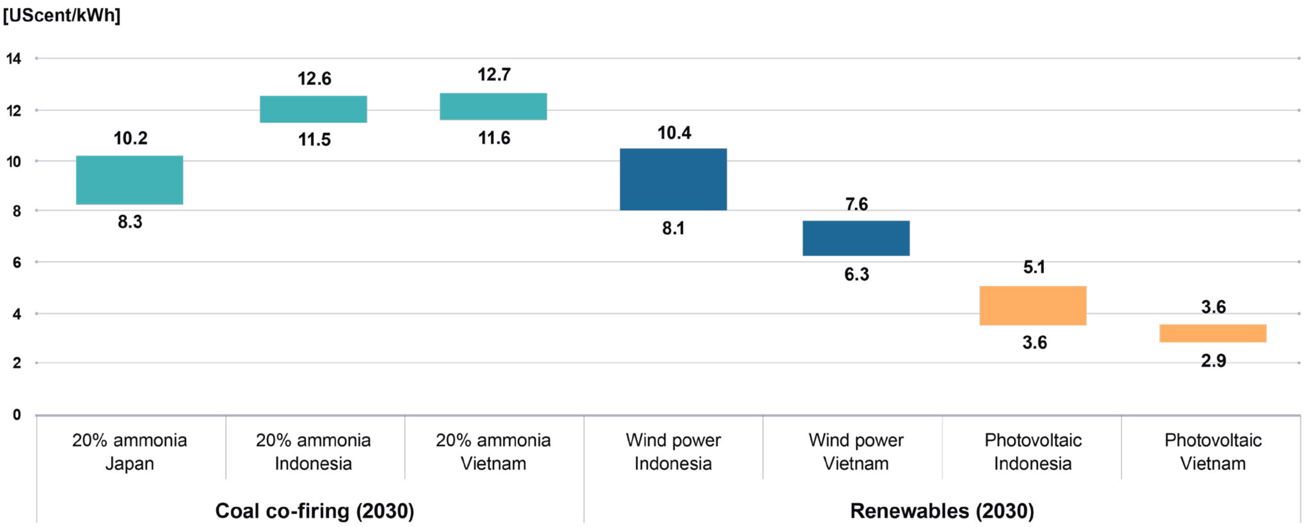


Figure 2:
Levelised cost of electricity (LCOE) for different technologies including ammonia co-firing in selected countries

Agora Energiewende (2024) based on BNEF (2022)

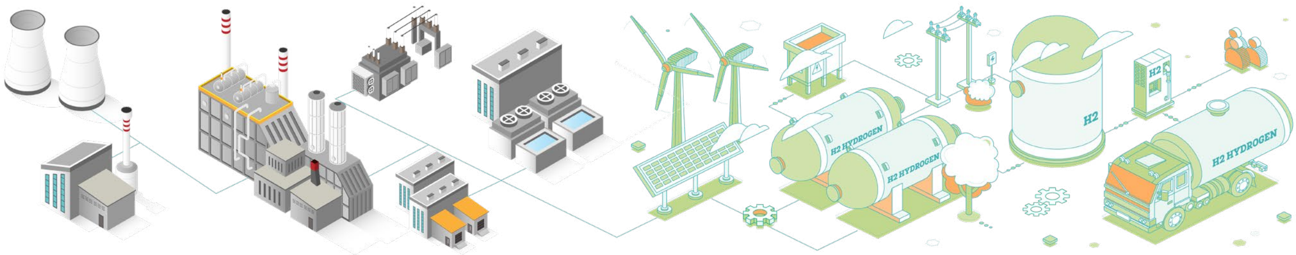
Co-firing hydrogen or ammonia in existing fossil infrastructure extends its operational life and slows the energy transition

Retrofitting coal-fired power plants to allow for co-firing, or building "hydrogen-ready" gas-fired power plants, would require continued investments in fossil infrastructure. Additional to the high electricity generation costs of these technologies, this risks extending the lifetime of fossil infrastructure and encountering lock-ins that delay countries' energy transitions.

Blending renewable ammonia or hydrogen with coal or fossil gas reduces direct CO_2 emissions at the point of combustion. However, at **ammonia co-firing rates of 20-50% in Southeast Asia, co-fired coal plants would still emit 500-800 grams of carbon dioxide per kilowatt hour (gCO_2/kWh), compared to the average emissions factor of 165 gCO_2/kWh required to be aligned with the International Energy Agency's net-zero pathway** (Kennedy, Tao and Lee, 2023). Research from Mitsubishi Heavy Industries shows that 30% hydrogen co-firing results in only a 10% reduction in CO_2 emissions compared to conventional gas-fired generation (Egawa et al., 2023).

If hydrogen or ammonia are produced from fossil sources combined with carbon capture and storage (CCS), non-permanence of storage and upstream leakage – methane or other greenhouse gas emissions during fuel extraction, transport, or processing – can significantly undermine climate benefits. Even a 100% combustion of renewable ammonia is not entirely emission-free, due to the emission of nitrous oxide (N_2O).

Further to greenhouse gas impacts, nitrogen oxides (NOx) may occur and cause environmental damage (BNEF, 2023). Increased risk of toxic air pollutants from hydrogen-based power generation are particularly acute in Southeast Asia, where many cities are already struggling with some of the world's highest air pollution levels (Setboonsarng and Wesshasartar, 2025).



Renewable hydrogen is limited in supply and best directed toward cost-effective, no-regret applications where no other decarbonisation options exist

Hydrogen produced from renewable electricity makes up a marginal share of global hydrogen supply (IEA, 2024). Renewable hydrogen project development has been slow, with only 4% of announced projects reaching final investment decision or entering construction by the end of 2023 (IEA, 2024).

Although hydrogen has a range of potential applications, limited supply means it should be reserved for sectors with limited cost-effective alternative decarbonisation options, such as long-haul transportation and high-temperature industrial processes. Inefficient allocation, for example towards co-firing, presents a supply chain risk for sectors without alternatives. Doubling down on direct electrification through rapid renewable deployment offers a reliable solution for the power sector, while allowing scarce renewable hydrogen to be reserved for heavy transport and industry.

Burning renewable hydrogen and ammonia in power plants would put enormous pressure on already limited supply. If used extensively across such inefficient applications, demand for hydrogen in Southeast Asia could reach up to 20 million tonnes (Mt) in 2050, more than five times the current level (Agora Industry and Agora Energiewende, 2024; Müller *et al.*, 2024). Similarly, if Southeast Asian coal plants implemented 20% ammonia co-firing (assuming a 2020 coal generation level of 494 TWh in the region), they would require over 45 Mt of ammonia, equivalent to seven times the region's current production and almost 30% of global ammonia production in 2020 (Agora Industry and Agora Energiewende, 2024; Müller *et al.*, 2024).

Meeting this demand with renewable hydrogen or ammonia without increasing import dependence would require a major scale-up in renewable energy capacity in the region. To supply just one-third of projected renewable hydrogen demand by 2050, some Southeast Asian countries would need to expand an additional 40-50 GW of solar PV capacity. Some countries, like the Philippines and Viet Nam, could face difficulties in achieving this, running into land-use constraints or driving up electricity costs in the process (Agora Industry and Agora Energiewende, 2024; Müller *et al.*, 2024).

Scaling up renewable hydrogen and ammonia production for inefficient uses like power generation risks creating competition for limited resources, potentially leading to shortages in more critical sectors. **Renewable ammonia is urgently needed to enhance food security in Southeast Asia by reducing reliance on fertiliser imports.** Diverting renewable ammonia toward the power sector could drive up prices, making fertilisers less affordable for smallholder farmers and potentially inflating food prices across the region (Agora Industry and Agora Energiewende, 2024). Other critical applications of renewable hydrogen and ammonia, such as heavy industry feedstock, shipping and aviation fuel and seasonal electricity storage, could also face supply shortages if these fuels are inefficiently diverted to co-firing.

Key considerations for hydrogen uptake in Southeast Asian power systems

Hydrogen and ammonia combustion is not a viable large-scale power generation option for Southeast Asia. The fuels and the adjustments required to co-fire them in existing power plants are expensive, commercially unproven and would deliver only minimal reductions in greenhouse gas emissions, if at all. Co-firing is also linked to increased air pollution and risks diverting limited renewable electricity and fuels away from sectors where they are most needed. Renewable hydrogen could serve as a long-term energy storage option, absorbing seasonal excess PV generation and making it available to other sectors throughout the year, or – depending on the seasonal power demand structure – be used to meet peak demand and for system flexibility services. As Southeast Asia's power systems move to higher renewable energy shares, these use cases should be weighed against the economic viability of potential alternatives.

Consideration 1:
Prioritise system efficiency when considering renewable fuels like hydrogen and ammonia

Southeast Asian countries should reserve renewable hydrogen and ammonia for critical applications, where they are the most cost-effective decarbonisation solution. These include fertiliser production, heavy industry (such as steel, chemicals), shipping, long-haul transport and seasonal energy storage. Using hydrogen and ammonia for co-firing in power generation risks causing supply shortages, increasing costs and slowing progress toward climate and energy goals. In end use sectors, the direct use of electricity leads to a more efficient system overall than a switch to hydrogen.

Consideration 2:
Double down on renewables and grid infrastructure

Scaling up investments in renewable energy, such as solar, wind, hydro and geothermal, offers Southeast Asian economies a more cost-effective path to decarbonised power systems than relying on hydrogen-based baseload generation. Sufficient domestic renewable energy capacity will be needed to produce hydrogen for no-regret applications. Both direct electrification and no-regret use of hydrogen render scaling renewables investment a key priority. This could be coupled with grid infrastructure upgrades and expansion to improve reliability and flexibility and supporting the development of storage and demand-side management. Prioritising this pathway would lower the costs for renewables and end-user electricity prices, enhance the competitiveness of green products (such as green steel or green ammonia) in global markets and support economic development through green job creation and increased investment opportunities.

Consideration 3:
Carefully explore the role of hydrogen power plants for peaking

Hydrogen power plants can support peak demand, provide flexibility and ancillary services and support the integration of variable renewables into the power system. Determining the potential for hydrogen as a flexibility solution requires further assessment based on the power system needs of each country and should be carefully compared to other storage and flexibility options. The most important considerations are the suitability and costs of other solutions (for instance grid enhancements, batteries or pumped hydro storage) and the local potential to produce hydrogen – avoiding transportation costs and import dependencies.

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About CASE
The project Clean, Affordable and Secure Energy for Southeast Asia (CASE) supports power sector transitions in Indonesia, Thailand, Viet Nam and the Philippines through evidence-based analysis and narrative change. The project supports decision-makers, industry leaders and consumers in enacting strategic reforms in the power sector in pursuit of the Paris Agreement goals and a just transition.

About Technology Brief Series
'The Role of Renewable Hydrogen in the Power Sector' is the first part of technology brief series published by the project Clean, Affordable and Secure Energy for Southeast Asia (CASE). The series will take up topics on present energy policy discussions and unbundle some myths. The series explores key topics in current energy policy debates and aims to unpack common misconceptions around emerging technologies. Designed for policymakers, practitioners, and energy transition stakeholders, each fact sheet provides a concise summary of current discussions and key facts to support informed decision-making in the region.

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