MITSUBISHI POWER

THE RENAISSANCE OF NATURAL GAS IN SOUTHEAST ASIA: FUELING THE ENERGY TRANSITION

Mitsubishi Power is a power solutions company of Mitsubishi Heavy Industries.

MOVE THE WORLD FORWARD

MITSUBISHI HEAVY INDUSTRIES GROUP

In the early 2000s, despite the heritage of coal in the region, natural gas had the highest share of installed capacity for power generation in Southeast Asia. Within less than two decades, coal has retaken the top spot, with various projections showing that it will remain the highest contributor to the region's electricity generation for at least the next 20 years unless drastic actions are taken. Today, with clarion calls to significantly reduce coal usage and ramp up adoption of less carbon intensive energy sources, the spotlight is on natural gas as a key transition fuel.

THE EVOLUTION OF SOUTHEAST ASIA'S ENERGY SYSTEMS

The last few decades have seen rapid electrification in Southeast Asia, with 170 million people across the region gaining access to electricity between 2000 and 2017[1]. By 2018, over 90% of the region's population had electricity, up from 79.3% in 2000[2].

Contributing factors include strong GDP and manufacturing growth, the expansion of national grids and the development of off-grid systems to service rural areas (Figure 1).

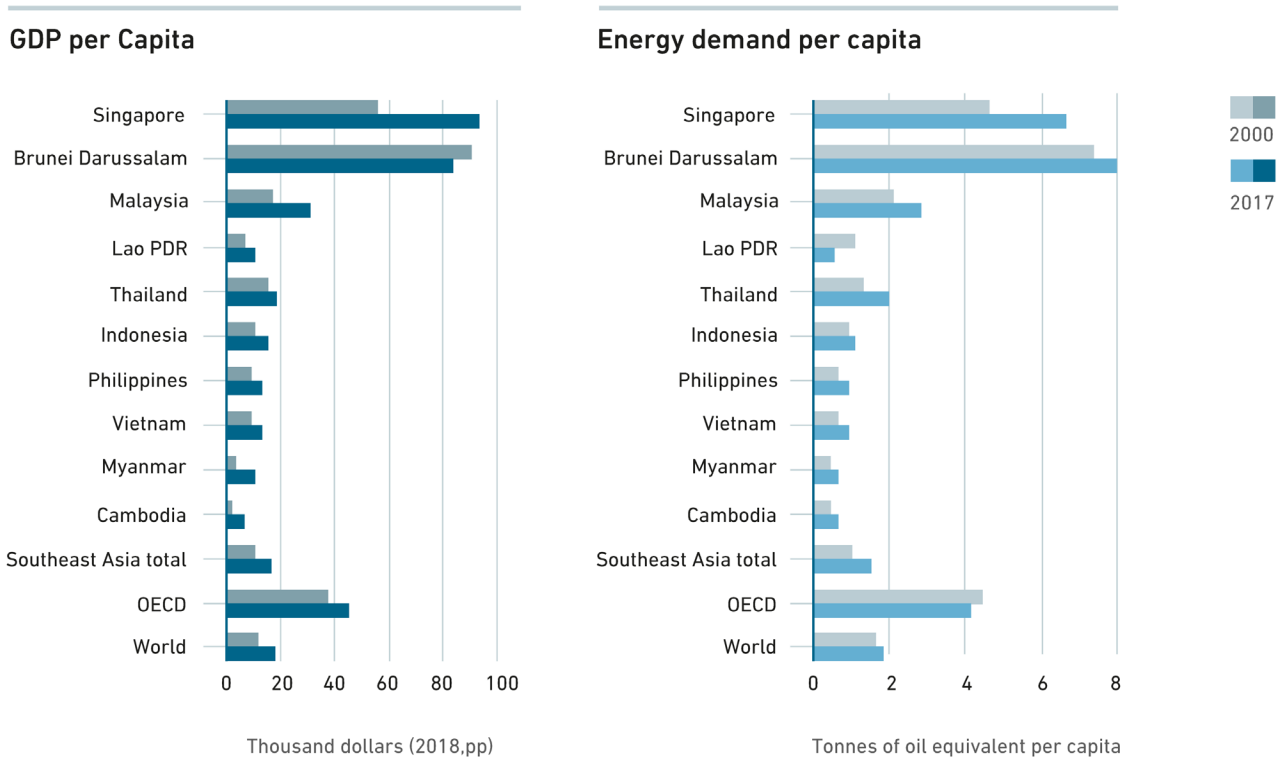

Figure 1: Energy demand per capita grows in tandem with GDP growth
Source: IEA Southeast Asia Energy Outlook 2019

1 https://www.iea.org/commentaries/bringing-electricity-to-all-corners-of-southeast-asia
2 https://www.unescap.org/sites/default/d8files/knowledge-products/Publication%20Regional%20Energy%20Trends%202020%20-%20Tracking%20SDG%207%20in%20the%20ASEAN%20Region.pdf

Another key driver of electrification is the rise of different fuel sources.

Natural gas has had an important role to play in enabling the region's electrification, with its abundance and wide network of pipelines connecting domestic gas fields directly to power generation facilities. In 1990, natural gas contributed 26 TWh to the region's power generation capacity[3]. By 2017, it was at 357 TWh[4].

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Usage of natural gas made sense especially for countries like Brunei Darussalam, Malaysia and Thailand which boasted vast domestic reserves. Since the sources were within their borders, governments developed relevant infrastructure and made massive investments into production and utilization of this fuel.

The growth in pipeline connectivity has been a major factor in the increased use of natural gas, as intra-regional export of the fuel became easier. Between 1991 to 2015, there were 13 international gas pipelines built across Southeast Asia, covering a total of 3,673 km – roughly the distance between Hanoi and Tokyo[5]. The longest regional pipeline ends in Singapore, which receives a large portion of its supply from Indonesia through the 656-km West Natuna–Singapore gas pipeline.

NECK TO NECK: NATURAL GAS AND COAL

Natural gas remains a critical component of energy systems in many Southeast Asian countries today. It often ranks among the top three fuels in contribution to power generation and is the dominant fuel in Thailand and Singapore, accounting for around 70% and 95% of the countries' respective energy mixes[6].

The first few years of the millennium saw natural gas leading the energy mix in the region[7]. According to the ASEAN Centre for Energy (ACE), in 2005, natural gas led in the share of installed capacity for power generation at 52 GW, followed by coal at 22 GW. Actual generation followed the same order, with gas at 263 TWh ahead of coal at 140 TWh.

However, coal usage has increased rapidly. Throughout the first 15 years of the 2000s, natural gas accounted for at least 40% of the region's actual power generation. In that same period, coal's share grew gradually from 21% in 2000 to 33% in 2015.

3 https://aseanenergy.org/3rd-asean-energy-outlook/
4 https://aseanenergy.org/the-6th-asean-energy-outlook/
5 https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/110718-analysis-trans-asean-gas-projects-losing-relevance-amid-the-fast-paced-lng-growth
6 https://www.oxfordenergy.org/publications/emerging-asia-lng-demand/
7 https://aseanenergy.org/the-6th-asean-energy-outlook/

COAL'S RESURGENT DOMINANCE

By 2017, the order for share in actual power generation had flipped, albeit near parity: 38% coal, 36% natural gas. By 2020, installed capacity for power generation by coal and natural gas were at 102 GW and 93 GW respectively.

In the ACE's Baseline and ASEAN member states' Target Scenarios[8], coal's current dominance in both installed capacity and actual generation is projected to last until 2040. The International Energy Agency (IEA) even found that coal-fired generation has been expanding in Southeast Asia – in Indonesia, Vietnam and the Philippines[9].

There are several fundamental reasons for this trend across the region. Today, coal-fuelled power is the least costly way to expand thermal capacity in Southeast Asia from a total system cost perspective. Coal can reliably deliver baseload power especially vis-à-vis variable renewable energy systems.

Supplies are available globally, so consumers need not be dependent on the security of supplies and stability of only one region. Indonesia, Vietnam and the Philippines have significant domestic coal supplies, adding a much-desired national security element to the decision-making framework of governments and energy system planners.

Coal is also easier to transport than natural gas, further widening the cost difference. While both can be imported via barge or ships, natural gas has more specific shipping and storage conditions. On land, natural gas requires purpose-built pipeline networks to reach end users, whereas coal can be transported from

8 The Baseline Scenario assumes that the ASEAN Member States' energy systems continue to develop along historical trends, mainly using fossil fuels, without significant changes. It also assumes relatively low efforts are made to meet the agreed-upon energy efficiency and renewable energy targets. The AMS Targets Scenario assumes that Member States do what is needed to fully achieve their own national energy efficiency and renewable energy targets, as well as their NDC commitments – but do not make adjustments to reflect ASEAN regional targets.

9 https://www.iea.org/reports/electricity-market-report-december-2020/2020-regional-focus-southeast-asia

RE-ESTABLISHING GAINS FOR NATURAL GAS

Natural gas is an important transition fuel for the region. Burning coal emits twice the amount of CO_2 compared to natural gas – between 93 kg to 97 kg per million British thermal units (mmBtu) depending on the type of coal versus 53 kg of CO_2 per mmBtu for natural gas[11]. Natural gas-fired power generation is also significantly more efficient and more flexible than coal-fired power generation and can address intermittencies as variable renewable energy grows in the region.

The energy sector should treat natural gas-fired systems as catalysts to introduce even lower carbon or zero carbon fuels into the mix like hydrogen, ammonia and traditional renewables. But to take full advantage of its benefits and usher in the next phase of natural gas in the region, we see three main changes that will need to occur.

1. **Supply of natural gas to Southeast Asia will need to increase to meet growing demand. Given the challenges with expanding domestic natural gas production, imports of liquified natural gas (LNG) will be a critical solution to this issue.**
2. **Gas markets will need to be reformed and liberalized, thereby helping to improve access to necessary infrastructure and drive down cost.**
3. **Though gas-fired power generation is less carbon intensive than coal-fired, natural gas power systems can still be further decarbonized.**

11 https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

EXPANDING NATURAL GAS SUPPLY

Natural gas production has plateaued in countries like the Philippines

Surging demand for natural gas, especially for electricity production, is speeding the depletion of domestic natural gas reserves in countries across Southeast Asia[12].

In the **Philippines**, the only significant gas development is the Malampaya field which started production in 2001. This field is expected to decline from around 2022 and there are few prospects for further significant gas discoveries.

For **Thailand**, which has been consuming gas for power generation since 1981, supplies were initially derived from domestic production, mainly offshore from the Gulf of Thailand. Pipeline imports from Myanmar began in 1998, but since then, domestic production has plateaued and is declining.

In **Vietnam**, significant gas production started in the mid-1990s and has plateaued at around 10 billion cubic meters per annum since the early 2010s.

One major challenge to domestic expansion is the fact that the bulk of gas found in the region are either unconventional, deep-water reserves or contain high levels of CO_2. Several potential gas reserves are also in politically volatile areas with overlapping claims of sovereignty, which are difficult to consider for exploration. Enormous investments are therefore required to extract and clean the fuel[13].

12 https://www.oxfordenergy.org/publications/emerging-asia-lng-demand/
13 https://www.iai.it/sites/default/files/iaip2122.pdf

IMPORTING LNG: CHALLENGES AND OPPORTUNITIES

Thailand and other Southeast Asian countries have started importing LNG

Under these circumstances, the most common solution to meet growing demand for natural gas in the region is to import it in liquefied form from exporters such as Australia, Qatar and the United States. Southeast Asian buyers such as Singapore, Malaysia and Thailand are already importing LNG, with the Philippines and Vietnam following suit soon[14].

Still, LNG is not a silver bullet and has its own set of challenges to overcome.

Countries will need to enact legislative reform, provide financial incentives to enhance relevant infrastructure and mitigate upfront investments for building integrated LNG systems.

Importing inherently carries a risk of eroding energy self-sufficiency. By relying more on LNG, countries lose the national security benefit of domestic fuel reserves and become much more susceptible to shifts in global markets over which they have little control.

Development and integration of LNG terminals are expensive, and cost can also be somewhat variable[15]. As the Oxford Institute for Energy Studies reports: "For subsidized wholesale price gas markets, LNG prices significantly above $6/mmbtu may be problematic while prices above $8/mmbtu may rule out any significant expansion of imports for these markets because the required subsidies may be too large for governments to sustain"[16].

For LNG to grow in the region, countries will need to enact legislative reform, provide financial incentives to enhance relevant infrastructure and mitigate upfront investments for building integrated LNG systems.

14 https://www.oxfordenergy.org/publications/emerging-asia-lng-demand/
15 https://www.lngindustry.com/liquid-natural-gas/05082021/globaldata-southeast-asia-to-increasingly-rely-on-lng-imports/
16 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/10/Challenges-to-the-Future-of-LNG-NG-152.pdf

LIBERALIZING THE REGION'S NATURAL GAS MARKET

The success of natural gas and LNG is contingent on having entire ecosystems conducive to their adoption.

In many countries across Southeast Asia, gas markets are heavily controlled by the state, which must consider multiple, complexly interlinked factors when making decisions related to energy and development of fuels. Monopolies exist across various parts of the natural gas value chain – from the regasification facilities to the pipelines delivering the gas to end users – thus limiting third-party access to key resources and infrastructure.

Despite these challenges, gas demand is still rising, but different markets will contribute variously to the forecasted growth.

Singapore relies heavily on natural gas, with cleaner alternatives also on the horizon

Take Singapore, for instance. Currently, the island nation uses natural gas for 95% of its power generation needs, but its trajectory is changing. In 2021, the country announced that it intends to import low-carbon fuel sources for 30% of its electricity needs by 2035[17], meaning that it will gradually reduce its demand for natural gas. A feasibility study project showed how Singapore can import up to 100 MW of renewable hydropower from Laos via Thailand and Malaysia using existing interconnectors in 2022[18]. There also are plans to buy electricity produced from solar energy in Australia, which will be transmitted via a submarine power cable and supply up to 15% of Singapore's electricity needs starting from 2028[19].

The shift in Singapore, however, does not necessarily indicate a regional fall in demand. Singapore made the transition to gas as its main source for electricity generation decades before most of its neighbors, and as it switches out its gas, other Southeast Asian countries are expected to move from using more carbon-intensive fossil fuels to natural gas as a transition fuel.

17 https://www.ema.gov.sg/media_release.aspx?news_sid=20211024ouxMNg5jwnht
18 https://www.straitstimes.com/singapore/environment/singapore-to-trial-import-of-renewable-hydropower-from-laos-in-cross-border
19 https://renewablesnow.com/news/indonesia-okays-route-for-usd-218bn-australia-asia-solar-power-link-754924/

ATTRACTING INVESTMENT IN NATIONAL LNG SYSTEMS

One way to help drive down cost is to open the regional natural gas market to more players, both local and international. Increasing competition will help ensure more efficient resource allocation.

There is also a need for natural gas and LNG contracts to be more attractive to investors. Existing contractual frameworks are highly controlled by government bodies and have pre-determined terms when it comes to critical factors such as gross production sharing and split of operational costs. In many markets, concession and franchising contracts have been set for domestic reserves, whereas frameworks specific to LNG have yet to be developed. Contracts must be more flexible and responsive to short-term price signals.

MAKING LNG PRICING MORE TRANSPARENT

To be more cost competitive than coal, the price of natural gas must also be better insulated against global volatility.

Long-term LNG supply contracts can be structured in several ways, such as via a Japan Customs-cleared Crude Oil Price (JCC)-linked price, a gas-based index or the Platts Japan Korea Marker (JKM). The JCC, published by the Petroleum Association of Japan, is the average price of customs-cleared crude oil imports into Japan and is the main base for LNG long-term contracts. The JKM, which has gained traction as a pricing mechanism to settle spot trades, was created in 2009 to offer an alternative to oil price-linked contracts.

Asia accounts for most of global LNG demand and most of its LNG long-term contracts are still indexed off oil prices (Figure 2). Any rise or fall in oil prices is likely to directly impact gas prices and therefore the costs of producing electricity from this fuel.

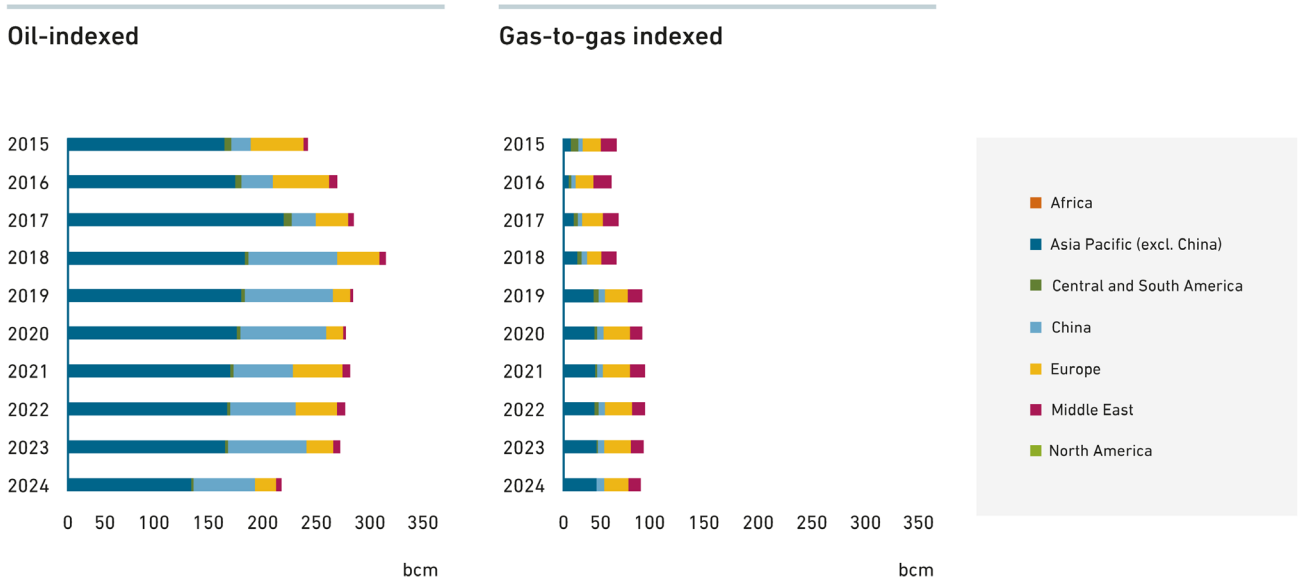

Figure 2: LNG import contract volumes with oil-indexed and gas-to-gas pricing by region and country (2015-2024)
Source: IEA Gas Market Report, Q4 2021

Crude oil prices have been increasing over the last two years. Average Brent crude price was $42/barrel (bbl) in 2020 and rose sharply to almost $71/bbl in 2021[20]. In early 2022, oil prices started a steep climb, hitting intra-day peaks of over $130/bbl in March due to the crisis between Ukraine and Russia, the latter of which has been a top oil and gas exporter. Apart from global geopolitical tensions, other reasons for this upward trend include the move towards decarbonized fuels, the shortage of investments in oil and gas production during the COVID-19 pandemic and oil producers' current unwillingness to increase production.

Soaring crude oil prices will mean higher LNG prices, which could incentivize reverting to cheaper energy sources such as coal and reduce gas demand in the short term. In the longer term, sustained high prices could also attract investment back into oil production and exploration, which could stabilize and lower prices through increased supply.

Ironically, persistently high oil prices could also curtail investments in costly renewable energy projects as spending power in public sector shrinks and governments try to assuage voters who are upset over high energy prices. This would slow both demand and supply for relatively more expensive renewable energy and could instead lead to increased natural gas demand for the region.

REGULATORY REFORM AND REGIONAL COOPERATION

Country regulations around natural gas (and LNG specifically) will need to be revised to encourage growth of natural gas adoption and utilization. Updating regulation will help facilitate the liberalization of natural gas markets, incentivize investments in upstream infrastructure and manage cost and pricing.

As a bloc, ASEAN can do more to collaborate on areas like regional price benchmarking and increasing sharing of infrastructure such as regasification facilities and pipelines. Fortunately, work to open up gas and energy markets is underway in various Southeast Asian markets.

In 2020, the Philippines issued a moratorium on new coal-fired power plant projects, possibly ushering in a new wave of natural gas-fired power generation[21].

In Vietnam, the government plans to liberalize the electricity market in phases from 2016 to 2023. Changes to Vietnamese investment laws including a 2020 public-private partnership law have been positive developments for investors in LNG-to-power projects[22].

In March 2022, B. Grimm Power became the first private company licensed to import LNG for Thailand, with the first commercial shipment set to arrive in early 2023[23].

20 https://www.eia.gov/outlooks/steo/report/prices.php
21 https://www.reuters.com/article/philippines-energy-idUSL4N2HQ1Z9
22 https://blogs.adb.org/blog/viet-nam-s-public-private-partnership-law-and-running-what-s-next#:~:text=In%20June%202020%2C%20Viet%20Nam
23 https://www.bangkokpost.com/business/2279903/b-grimm-hails-first-private-import-of-lng

FUNDING LNG TERMINALS

Government support and funding are crucial for developing LNG terminals. Singapore LNG (SLNG), which is backed by the Singapore government, owns and operates Asia's first open-access, multi-user, LNG terminal, which was built in 2013 at a cost of S$1.7 billion (about US$1.3 billion). Singapore has a thriving private sector but securing such a heavy investment purely from companies would have been difficult, given that the country has no domestic gas production.

Countries which produce natural gas may be better able to secure funding from purchasing nations. For example, banks from Japan and Korea – two of the world's largest LNG importers – lent $1.5 billion to a consortium to build the Donggi-Senoro LNG terminal in Indonesia[24].

SHIFTING GAS TRADE FLOWS

Besides regional growth from foreign investment, trade treaties such as the Regional Comprehensive Economic Partnership (RCEP) agreement[25], will further lift intra-ASEAN trade and growth.

Trade treaties can also change the flow of imports of commodities such as natural gas into the region. US LNG exporters could find their market share whittled if lower import tariffs benefit sellers such as Australia, which is already the largest exporter of coal and LNG to China, Japan and Korea. In 2019, a third of US natural gas exports were sold to signatories of the RCEP treaty.

THE REGIONAL COMPREHENSIVE ECONOMIC PARTNERSHIP (RCEP) AGREEMENT

The 15-member RCEP agreement, signed in November 2020, is the world's largest free trade agreement. Parties to the treaty which include ASEAN, Australia, China, Japan, Korea and New Zealand, collectively account for 30% of global GDP and a third of the world's population. Beyond greatly reducing tariffs and increasing economic and manufacturing growth, there will also be technology transfers which could include clean technology and electricity cooperation initiatives.

24 https://www.mitsubishicorp.com/jp/en/bg/natural-gas-group/project/donggi-senoro-lng/
25 https://asean.org/rcep-agreement-enters-into-force/

Possibly lower natural gas prices as well as the elimination or reduction of tariffs could make natural gas power plants built by companies in Japan more attractive for Southeast Asia. Even prior to the RCEP agreement, the IEA already projected gas to be the top choice for new installed capacity from 2019 to 2040 (Figure 3). So while in the short term several Southeast Asian countries will still rely on coal, more gas power plants are expected to be built in the medium to longer term.

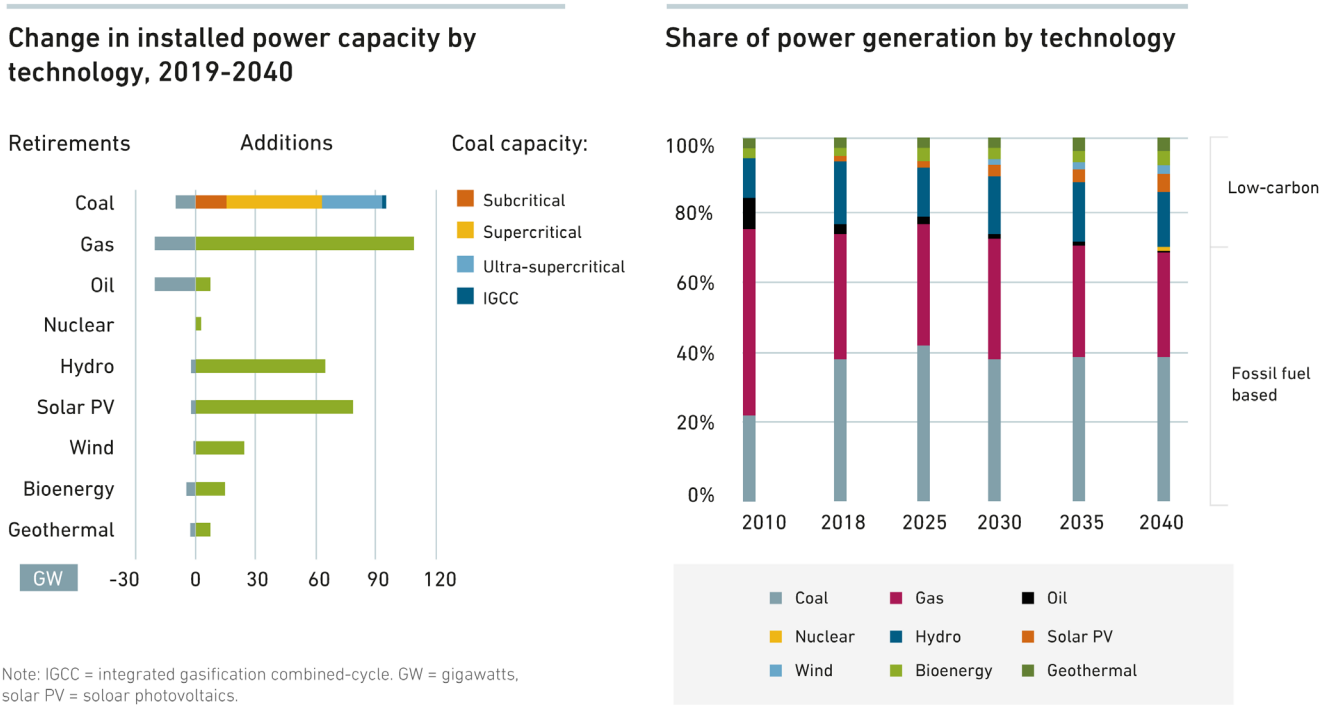

Figure 3: Change in installed power capacity and power generation by technology in Southeast Asia
Source: IEA Southeast Asia Energy Outlook 2019 - IEA's Stated Policies Scenario, 2019-2040

FURTHER DECARBONIZING GAS POWER GENERATION

At the end of the day, natural gas is still a fossil fuel comprising carbon-containing compounds like methane. As such, despite it being inherently less carbon intensive than coal, burning it will still inevitably generate carbon-containing byproducts including carbon dioxide.

New investments in coal have indeed received great criticism in the region, but natural gas projects have not been immune to such scrutiny. For instance, in 2021, the Asian Development Bank published a revised energy policy where it stated that it will not support coal mining, processing, storage and transportation, nor any new coal-fired power generation. In the same document, the ADB set out conditions for its future gas projects, including presentation of "evidence that projects employ high-efficiency and internationally best available technologies, reduce emissions by directly displacing other fossil fuel-based thermal power capacity, or result in a lower grid emission factor estimated as an average over its operational life"[26].

Still, the fuel and operational flexibility of natural gas-fired power generation systems make them especially useful in enabling the development of renewables and other low carbon energy solutions.

THE FLEXIBLITY OF GAS POWER

Compared to coal-fired systems with ramp up rates of 3-5% per minute, gas-fired power systems can ramp up at 8-12% per minute. Gas can therefore serve as backup fuel especially as more renewables, which can be intermittent in their power production, enter the grid. Indeed, there have already been instances of extreme weather events impacting output from renewables, causing supply volatility and necessitating the use of natural gas for energy security.

26 https://www.adb.org/sites/default/files/institutional-document/737086/energy-policy-r-paper.pdf

TECHNOLOGY TOWARDS HYDROGEN AND NET ZERO

Mitsubishi Power has technologies that help decarbonize natural gas-fired power generation. Even without hydrogen co-firing, our JAC gas turbines can reduce carbon emissions by 65% compared to conventional coal-fired power plants and operate at industry-leading efficiency of over 64%.

Shifting to natural gas provides power producers with more flexibility to bring hydrogen into the mix as the price of hydrogen is on a continued downward trajectory. Existing gas turbine technology in the market can already run with some proportion of hydrogen co-firing, with work ongoing to increase these levels. Gas turbine combined cycle plants can then be converted from natural gas to hydrogen with minimal costs and equipment modification, thereby prolonging the asset's lifespan. With exclusive hydrogen firing, power can be generated with zero carbon emissions.

To date, Mitsubishi Power has achieved 30% hydrogen co-firing in large-scale gas turbines, with work ongoing to develop technology to achieve 100% hydrogen firing within the decade. In 2023, we will start commercial operations of Takasago Hydrogen Park in Japan, the world's first center for validation of hydrogen-related technologies, from hydrogen production to power generation.

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TAKASAGO HYDROGEN PARK

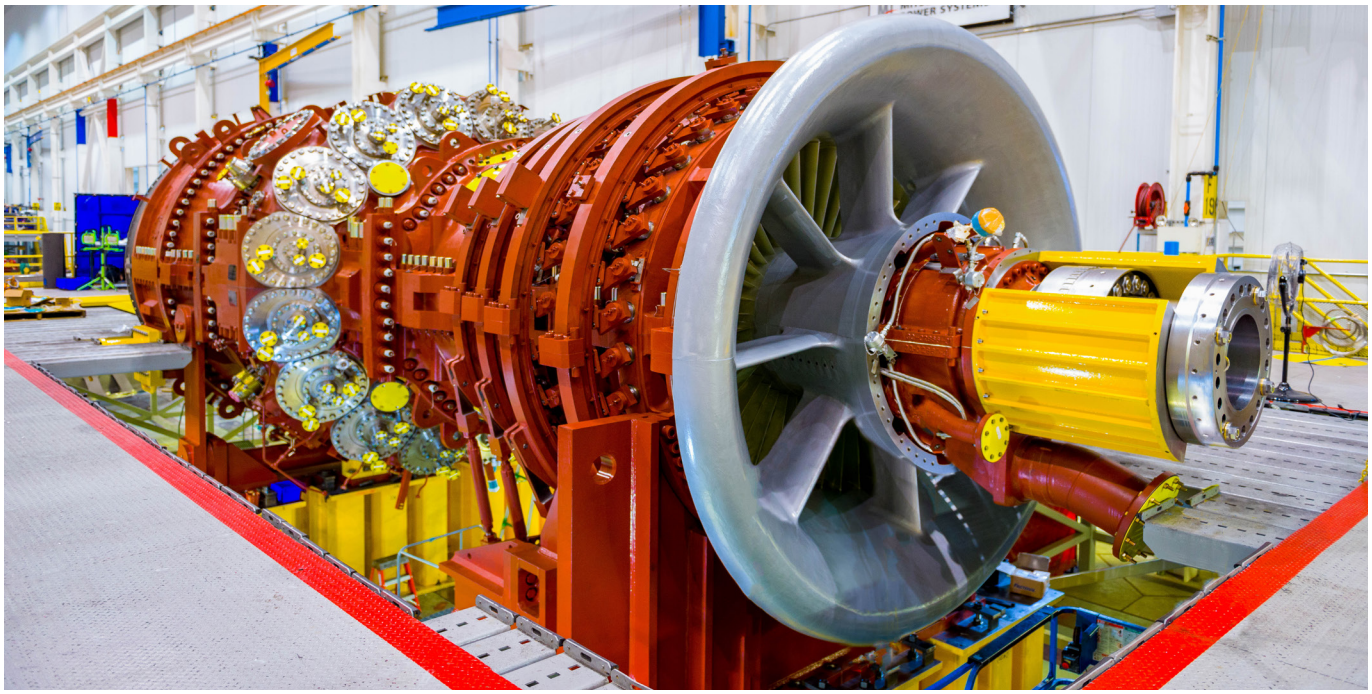
Set to be co-located at the gas turbine development and manufacturing facility of Mitsubishi Heavy Industries' Takasago Machinery Works in Hyogo Prefecture, Takasago Hydrogen Park will support the commercialization of gas turbines using hydrogen as fuel.

Mitsubishi Power is already beginning to test operations for hydrogen production utilizing a water electrolysis system, and there are plans to conduct successive testing and verification of other next-generation hydrogen production techniques such as methane pyrolysis.

To support the commercialization of hydrogen gas turbines by 2025, verification of our JAC gas turbine is being conducted at the adjacent T-Point 2 facility, starting at 30% hydrogen co-firing and increasing the proportion of hydrogen co-firing over time. Testing for 100% hydrogen firing of small- and mid-sized turbines will also be conducted using a H-25 class gas turbine.

Hydrogen can be produced from several ways and is not dependent on mineral deposits. For Southeast Asia, there are hydrogen production technologies that can incrementally scale the process while mitigating carbon emissions. For instance, using blue hydrogen – generated from fossil fuels and paired with carbon capture – is considered a critical step to ramp up hydrogen adoption. With such methods available, hydrogen can become a homegrown fuel for countries in the region in time to come.

Businesses and governments have continued to seek cheaper processes of producing hydrogen. In 2021, a group of entities from both public and private sectors including Mitsubishi Power banded together to launch the HyDeal LA initiative to achieve at-scale green hydrogen procurement at $1.50/kg in the Los Angeles Basin by 2030[27]. We are hopeful that similar initiatives will be in place in Asia Pacific in the near future.



Mitsubishi Power's gas turbines are hydrogen ready

27 https://power.mhi.com/regions/amer/news/20210518.html

THE FUTURE OF NATURAL GAS IN SOUTHEAST ASIA

Natural gas has changed the game for power generation in Southeast Asia. It has helped spur the region's electrification and, by extension, has contributed to the massive economic growth that the region has enjoyed in the last few years. Today, it remains a critical component of Southeast Asia's energy mix.

The next decade is critical for natural gas adoption in the region. Its role as a transition fuel is made even more important by the forecasted growth in the region, which will in turn require higher electricity production. Therefore, despite continued demand for coal, demand for natural gas will also continue to increase to help meet the steep incremental demand as Southeast Asia's energy needs continue to grow rapidly.

Both public and private sectors must collaborate to expand natural gas supply particularly through LNG imports, liberalize natural gas markets and continue R&D to decarbonize natural gas power systems. Industry must lead the innovation of technologies, while governments must make natural gas and LNG more prominent parts of their energy transition roadmaps and create regulatory environments that position natural gas as a gateway for even deeper decarbonization of energy systems.

With these changes, utilization of natural gas will increase significantly – helping countries to not only continue their trajectories of economic growth and development but also to reach their energy and emissions reduction targets.

Natural gas is key to powering progress in Southeast Asia

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