NEW ZEALAND
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# Singapore - navigating the energy trilemma

MARKET INTELLIGENCE REPORT

# Summary


- Singapore is ardently working to transform its energy sector away from a heavy reliance on oil and natural gas toward more renewable forms of power generation. In doing so, it must make trade-offs between security and reliability, affordability, and sustainability.

- Singapore's geography makes most forms of renewable energy difficult to harness, further complicating its efforts.

- Singapore is evolving its electricity profile across four domains: 1) managing and optimising its reliance on and consumption of natural gas; 2) maximising solar potential as the most viable form of domestic renewable energy generation; 3) looking offshore for low-carbon electricity imports; and 4) backing concerted efforts to explore other low-carbon electricity sources, particularly hydrogen, but also potentially geothermal.

- In parallel, Singapore is seeking to avert any unmanageable demand growth for electricity, and is seeking to improve the resilience and operation of the electricity grid itself.

- For its transport sector, Singapore is actively working to electrify its car and bus fleet by 2040. The uptake of sustainable aviation fuel (SAF) remains a key focus for the aviation sector, and a SAF refinery, the world's largest, commenced operations in Singapore earlier this year. Transition to low-carbon maritime fuels, particularly hydrogen-related and bio-LNG, are central to Singapore's maritime sector decarbonisation strategy.

- Innovation will remain key to Singapore's ambitions for its energy sector, and can be expected to drive consistent demand for cleantech solutions, offering considerable opportunities for companies operating in that sector.

# Report

Singapore's green energy transition is on a steep trajectory as it makes concerted efforts to diversify and transform its energy sector, which currently relies on burning oil and natural gas for the large proportion of its electricity and wider energy needs. According to Singapore's Energy Market Authority (EMA), the power sector alone in Singapore accounts for 40% of emissions. Singapore's central organising challenge in this respect is "navigating the energy trilemma" of balancing environmental sustainability, energy reliability, and energy affordability. It is the principal lens through which decisions on energy policy are made.

Due to its geography and limited size, Singapore approaches this challenge from a position of natural disadvantage with no viable pathway toward domestic generation for most forms of renewable energy: in particular, hydropower; wind; geothermal (with an emerging caveat, see paragraphs 18-19); and tidal. Solar has been deployed with considerable success and will remain important to Singapore's energy future, but upper limits remain on its scalability. Options for nuclear power bring their own set of associated challenges and appear unlikely to feature in Singapore's energy landscape, at least in the medium term.

## Electricity supply side: The Four Switches

"Four Switches to Power Singapore's Future" remains the organising framework for Singapore's energy supply strategy and has been embedded under Singapore's Green Plan (which sets out its 10-year road map for meetings its commitments under the Paris Agreement and UN Sustainable Development Agenda).

**Switch 1: Natural gas**

Singapore's reliance on natural gas arose in large part from its concerted effort to shift away from more carbon intensive forms of energy generation – principally oil – for its electricity generation. In 2000, natural gas accounted for only 34% of Singapore's electricity supply (according to energy think tank Ember). This figure reached 95% in 2014 and has held steady since. All Singapore's natural gas is imported and converted into electricity at its multiple gas power generation facilities. These imports comprise both natural gas from direct pipelines with Malaysia and Indonesia, in addition to liquid natural gas (LNG) imports predominantly from Australia, but also the United States, Qatar, and Equatorial Guinea. Overall, Indonesia has historically dominated Singapore's import share for gas, which stood at more than 75% in 2013, but its market position is slowly eroding, dropping to below 50% in 2022.

Given the shortage of scalable renewable options and the reliability of gas-generated power, Singapore's consumption of gas as a percentage of its overall electricity supply is judged unlikely to fall in the medium term. As a price-taker for natural gas, Singapore remains highly exposed to fluctuations and shocks in the global energy market. This vulnerability has been further underlined by the negative energy supply shocks following Russia's invasion of Ukraine. Singapore is actively seeking out pathways to manage and minimise this vulnerability. Recent bilateral announcements with Australia offer one example of this. Both sides agreed to include energy security as one of the three focus areas for the Australia-Singapore Supply Chain Working Group, established in September 2022. More broadly, Canberra has made political level commitments to be a "reliable supplier of energy" to Singapore with particular reference to gas. Collaboration on cross-border electricity trade is also a key feature of the Australia-Singapore Green Economy Agreement, signed in October 2022.

Singapore's focus moving forward is threefold 1) searching for further efficiency gains in its natural gas power plants as well as ensuring these plants are sufficiently resilient to plug unexpected supply gaps; 2) reducing its overall reliance on natural gas where possible for its electricity supply over the longer term (see switches 2-4 below); and 3) monitoring its natural gas supply chain in order to minimise and mitigate disruptions where possible.

**Switch 2: Solar**

Singapore views solar as the most viable form of renewably energy that can be domestically generated, particularly when considered against Singapore's "energy trilemma". Singapore has set a target of producing 2GW-peak of solar energy by 2030, accounting for 3 percent of total electricity needs – equating to sufficient energy to power 350,000 households annually. EIU predicts that Singapore will actually reach 2.5GW of solar energy as early as 2032.

Singapore sees significant economic opportunities across the solar value chain arising from its ongoing solar rollout. This includes in respect of manufacturing (some solar panels are made in Singapore), installation services, operations and maintenance, and recycling.

Singapore already enjoys a high concentration of solar panels across the city-state, driven in large part by the SolarNova programme launched nearly 10 years ago to help promote and aggregate demand for solar and drive the growth of Singapore's solar industry. Straits Times has calculated that solar installations reached 5,733 in June 2022. According to the EMA, solar deployment in Singapore totalled 742MW-peak as of Q3 2022, representing good progress against 2030 targets – and a 70-fold growth on 2012 data. It is expanding its solar panel "fleet" through further installations on buildings, rooftops, water catchments and marine areas (i.e. "floating" solar farms on top of bodies of water, both catchments and open sea areas), overhead covered bridges, bus roofs, and other spaces.

Although Singapore enjoys a high degree of sunshine and therefore relatively consistent supply of solar energy, it must still control for weather fluctuations which directly impact solar-generated supply. As such, Singapore has developed Energy Storage Systems (ESS) to help integrate and balance intermittent generation into its grid. ESS is viewed by Singapore as "game-changing technology". In February this year it opened the largest ESS facility in South East Asia on Jurong Island, capable of storing 285MW hours of energy.

Longer-term, the land-intensive space requirements for solar places upper limits on its scalability in Singapore. For instance, EMA estimates that when compared with a combined cycle gas turbine (CCGT) power plant, a solar farm producing an equivalent amount of electricity would require a land surface requirement more than 300 times greater than that of the power plant. EMA projects that the maximum deployment of solar will be reached by 2050. This will account for just under 10% of projected electricity demand, equal to 8.6GW-peak.

**Switch 3: Regional low-carbon imports**

In mid-2022, Singapore began to search regionally for low-carbon electricity imports, which it hopes will account for 30% of its electricity supply by 2035 – equal to 4GW of electricity. This form of supply takes place via business-to-business level arrangements, with regulation from Singapore's EMA.

Two projects are already under way: 1) hydropower imports of 100MW from Laos PDR to Singapore via Thailand and Malaysia using existing energy grid interconnectors; and 2) a cross-border electricity purchase for supply of 100 MW of energy from Malaysia. This electricity will be generated from fossil fuels, but it is anticipated to open the door for renewable energy exports from Malaysia in the future.

This form of supply is on a trajectory to scale up rapidly. Conditional approval by the EMA of various commercial projects with Indonesia could facilitate the import of up to a whopping 2GW of electricity (largely solar) over the next five years. Singapore energy importers are also closing in on a deal that could see up to 1GW of energy imported from Cambodia annually, comprising hydropower, solar, and (possibly) wind via over 1000km of underwater cabling. Combined with existing projects, Singapore would appear to be well on its way to meeting its 2035 targets.

A high ambition plan to export solar energy to Singapore via an undersea cable from Darwin also remains alive, notwithstanding some headwinds encountered earlier in 2023. Projected to cost upward of A$30billion (based on conservative estimates), this project will require an undersea power cable more than 4000km in length, the longest ever attempted by some margin. If successful, it could reportedly carry 1.75GW or more of electricity to Singapore from Australia. However, it is yet to secure approval from the Singapore EMA.

**Switch 4: Other low-carbon alternatives**

Singapore established the Low-Carbon Energy Research Funding Initiative in 2021 to incentivise exploration of low-carbon energy technology solutions. A total of S$55 million was spent in the first round of funding across 12 projects, largely focused on hydrogen power and carbon capture utilisation and storage (CCUS). It sees particular potential in hydrogen and considers that this could account for up to 50% of its power supply by 2050, dependent on technological developments in the intervening period. To that end it has set aside an additional S$129 million of funding, tagged to the transport, storage, and utilisation of hydrogen. CCGTs that are wholly fuelled with hydrogen is a technology gap that Singapore has identified (under its recently published Hydrogen Strategy) as a key enabler for its ambitions. These could become available by 2030 based on current technological development efforts.

While there is no surface (or near surface) geothermal activity across Singapore, there is thought to be high subsurface heat flow in the region. A localised study undertaken in Sembawang, Northern Singapore, by Nanyang Technological University (NTU) delivered some promising findings in July 2023, concluding that temperatures could reach up to 200 degrees Celsius at depths of 4-5km at the site.

To build on the NTU study, the EMA recently initiated a “Request for Proposals” to undertake a nation-wide assessment of Singapore’s geothermal potential at depths reaching up to 10km underground. Depending on the outcome of this future study, Singapore may be in a position to leverage cutting-edge geothermal technology to generate electricity from underground heat sources. This could also have dual-use functionality as a medium for geological carbon sequestration. However the timeframes and scalability of such an energy vector are not yet clear, and, being contingent on the EMA study, are likely to be some years off. Nevertheless, there is heightened interest in the prospect of geothermal options potentially becoming available to Singapore in the medium-to-long term.

Although Singapore’s geography largely rules out hydropower options, it could possibly be deployed as part of a potential underground drainage and reservoir system. The Singapore Public Utilities Board (PUB) indicated to Straits Times earlier in 2023 that it would undertake a feasibility study of such a system through to 2025. This system would be deployed to help tackle climate-related flooding, while building further resilience into Singapore’s water supply as a secondary benefit. Simply put, stormwater would be channelled to underground reservoirs via tunnels, flowing through turbines along the way. The energy generated from this system would be harnessed to pump water back to surface level on an as-needed basis.

# Electricity demand side: toward greater optimisation and efficiency gains

Beside its electricity supply strategy, Singapore is also rolling out a range of interventions designed to regulate electricity demand toward more efficient and cost-effective practices – "demand side management". Singapore is principally seeking to avoid unmanageable demand growth, given supply-side limitations, particularly in respect of renewables. This challenge is heightened by the impending electrification of Singapore's land transport sector, which will add a further significant demand burden onto its electricity grid.

In October 2022 Singapore established a 2-year "regulatory sandbox" pilot where commercial consumers can receive financial incentives for either A) reducing electricity consumption during periods of high electricity prices; or B) being on standby to reduce their committed electrical load during periods of actual supply squeeze. For residential premises, the EMA has rolled out a programme to introduce advanced electricity meters across Singapore (that provide real time app-based data on electricity use) and aims to complete 100% of installations by 2024.

# Singapore's electricity grid: toward greater resilience

In addition to Energy Storage Solutions, Singapore is taking steps to improve the resilience and operation of its grid as a whole. In 2022, it started a project to create a "digital twin" of its entire grid. This real-time virtual replication of the network has two use cases: 1) the ability to project and model maintenance needs in the grid's componentry; and 2) model different scenarios both on the supply side and demand side, for example greater demand from a growing electric vehicle fleet, or the introduction of new energy sources to the grid.

Singapore has also deployed "micro-grid" installations which are independent of the main grid and typically have their own source of energy and storage. A pilot has already been launched on the island of Pulau Ubin using solar power. By 2024 a larger microgrid at the Singapore Institute of Technology is expected to be completed.

# What about the transport sector?

In addition to its electricity grid, Singapore remains focused on moving its transport sector, writ large, to a more sustainable footing. The National Climate Change Secretariat calculates that land transport alone accounts for approximately 15% of emissions. Singapore's efforts to shift its light car and bus fleet to more low-carbon

alternatives include moving to electric or hybrid buses by 2040, and from 2030 limiting all vehicle registrations to green alternatives only. Singapore has deployed a range of tax incentives to encourage the uptake of electric vehicles and has stated its intention to install 60,000 EV charging stations across the city-state by 2030.

Uptake of sustainable aviation fuel remains a key focus for Singapore's aviation sector. In addition to deploying SAF on Singapore Airlines and its low budget partner, Scoot, flights on a trial basis from July 2022, Singapore has also seen its domestic supply of SAF bolstered. Finnish renewable energy giant Neste expanded its operations in Singapore earlier in 2023, launching the world's largest SAF refinery capable of producing up to 1,000,000 tons annually, which can be blended with conventional jet fuel and made available to airlines directly at Changi Airport. Reliable access to SAF feedstock, which must be imported, remains an ongoing focus for Singapore. In the longer term, Singapore sees a significant role for hydrogen, both as an input into the production of SAF itself, but also potentially as a direct source of aircraft fuel.

In 2022 Singapore published a decarbonisation blueprint for its maritime sector, setting out the steps it intends to take to lift the sustainability of Singapore's port and maritime domains out to 2050. Marine fuels comprise one of the seven focus areas of this blue print. This blueprint envisages an eventual transition in marine fuel for international shipping, likely to bio-LNG, hydrogen, ammonia, and e-methanol, with biofuels and LNG offering interim options while these mid-to-longer term solutions are developed. Electrification and biofuels are seen as the energy of choice for domestic harbour craft.

To help enable a transition toward these alternative forms of energy, Singapore is pulling a number of levers. Labelled the "seven anchors" these include 1) technology trials and R&D including feasibility studies, pilot trials, and "regulatory sandboxes"; 2) shoring up supply with a focus on bunkering, storage, and distribution; 3) developing appropriate associated regulations and standards; 4) focusing on market structure and policy, particularly in respect of demand aggregation; 5) continuing to expand green financing options; 6) supporting the development of the necessary talent, knowledge, and operational expertise in its maritime labour force; and 7) partnering internationally, including for the purpose of harmonising standards for future marine fuels.

At the Government-to-Government level, a Climate Change and Green Economy pillar was added in 2022 to the Singapore-New Zealand Enhanced Partnership. Cooperation initiatives under this pillar that intersect with the energy sector include bilateral arrangements on both sustainable aviation fuel (to drive the development of a sustainable aviation eco-system) and low-carbon hydrogen (to collaborate on production, deployment, and research) as well as information exchanges on low-carbon shipping. This work continues apace.

# What are some of the opportunities for business?

With a Singapore-New Zealand Government-to-Government level framework in place, and clear interest in greater collaboration between both public and private sectors, the breadth and pace of activity to transform Singapore's energy sector offers clear opportunities for New Zealand business interests. Two events held regularly in Singapore offer a further window to engage with and examine these activities, and the ensuing opportunities.

**Singapore International Energy Week**

Since 2008, the Singapore EMA has annually organised and hosted Singapore International Energy Week (SIEW). It attracts significant local and international attendance. The 2023 instalment of SIEW was 23-27 October. Its theme this year centred on "energy transition toward a net zero world" and intended to provide a platform for public and private sector energy leaders to engage on the bigger questions around the shift toward low-carbon energy including the technological innovation and investment necessary to enable this transition.

**Cleantech Forum Asia**

Cleantech Forum Asia is another regular fixture on Singapore's events calendar. Hosted by Cleantech Group (a private sector organisation based in San Francisco) it brings together a breadth of actors in the cleantech sector, including start-ups, investors, government, and corporates. The agenda is broad and in 2023, in respect of energy, covered net zero technologies, sustainability in critical materials, grid management, energy storage, EV batteries, EV charging, and green hydrogen. It will next be held in 2024 (dates and agenda TBC).

**Cleantech opportunities**

The trends in Singapore's energy sector toward green alternatives continue to throw up a range of economic opportunities. Cleantech solutions remain central to meaningfully shifting the dial and unlocking many of Singapore's more intractable energy challenges. Some of the more prominent opportunities include energy storage solutions (particularly battery technology), carbon capture and utilisation and storage technology, hydrogen transportation, smart grid equipment (particularly solid-state transformers), EV charging infrastructure, and zero or low-carbon fuels. If Singapore's geothermal ambitions are judged viable, then this could be expected to drive demand for equipment needed to harness geothermal energy and any associated subsurface mapping technologies.

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