Opportunities for Singapore to Drive ASEAN's Green Transition

Courtney Weatherby

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Executive Summary

Singapore has an ambitious target to become a net-zero economy by 2050, which will require major changes and buildout of new power generation and transmission infrastructure. Given its geographic nature as a small island state with limited domestic power resources, Singapore's energy system is highly dependent on imported fossil fuels and will require major structural changes to meet net-zero. This includes changes to transportation and industrial sectors as well as overhauling where Singapore gets its electricity from. A 2022 study by Singapore's Energy 2050 Committee explored various scenarios for Singapore's energy future, all of which included electricity imports from other countries in the Association of Southeast Asian Nations (ASEAN).

The Energy Market Authority of Singapore (EMA) currently has a peak demand of 7,789 MW, and the vast majority of this comes from natural gas. EMA has committed to importing 4,000 MW of low-carbon electricity by 2035, a major increase of imports from only about 1.3% of Singapore's peak demand in 2022 to about 30% of the projected energy demand in 2035.[i] The amount of electricity that Singapore needs to import will be relatively small compared to regional energy demand as ASEAN has a projected tripling of electricity needs between 2017 and 2040.

When it comes to regional power trade, Singapore has an opportunity to drive positive change regionally by ensuring its electricity imports are not only low or zero carbon, but also that they exclude other avoidable environmental impacts, particularly from dams that disconnect rivers, block fish migrations, and threaten local livelihoods and food security. While this requires collaboration among a range of stakeholders, including other emerging import markets such as Vietnam, Singapore can use its early mover advantage to drive positive change regionally through establishing environmental quality standards and best practices for green electricity trade.

As Singapore greens its energy supply, it is driving innovations in energy generation and transmission, such as offshore wind and undersea direct current (DC) cables. This presents an opportunity for Singapore to create and capture economic growth within ASEAN through investment in new energy technologies, sharing lessons learned with neighboring economies, and supporting human capacity building efforts and investment needs related to clean energy transition. This brief provides a snapshot of Singapore's projected energy needs, explores options for future electricity imports, and identifies how Singapore can both advance and benefit from the regional green energy transition while minimizing negative avoidable social and environmental impacts.

Key Recommendations

- To reduce environmental and social externalities from projects in power exporting countries, the Energy Market Authority of Singapore should explicitly include non-emissions related sustainability considerations when reviewing and approving proposed power import projects.

- The Ministry of Foreign Affairs should target future technical and capacity building efforts in neighboring ASEAN countries towards renewable energy integration, near-real time solar radiance forecasting, and Renewable Energy Certification to support effective uptake of solar and wind and improved regional uptake of renewables.

- Singapore should use its role as a regional leader on energy conversations through HAPUA and Singapore International Energy Week to push regional coordination on energy planning to avoid mismatches between power generation and market access.

- A range of government, private sector, and technical institutions in Singapore should take steps to share lessons learned from Singapore's experiences with rooftop solar and floating solar with stakeholders elsewhere in ASEAN.

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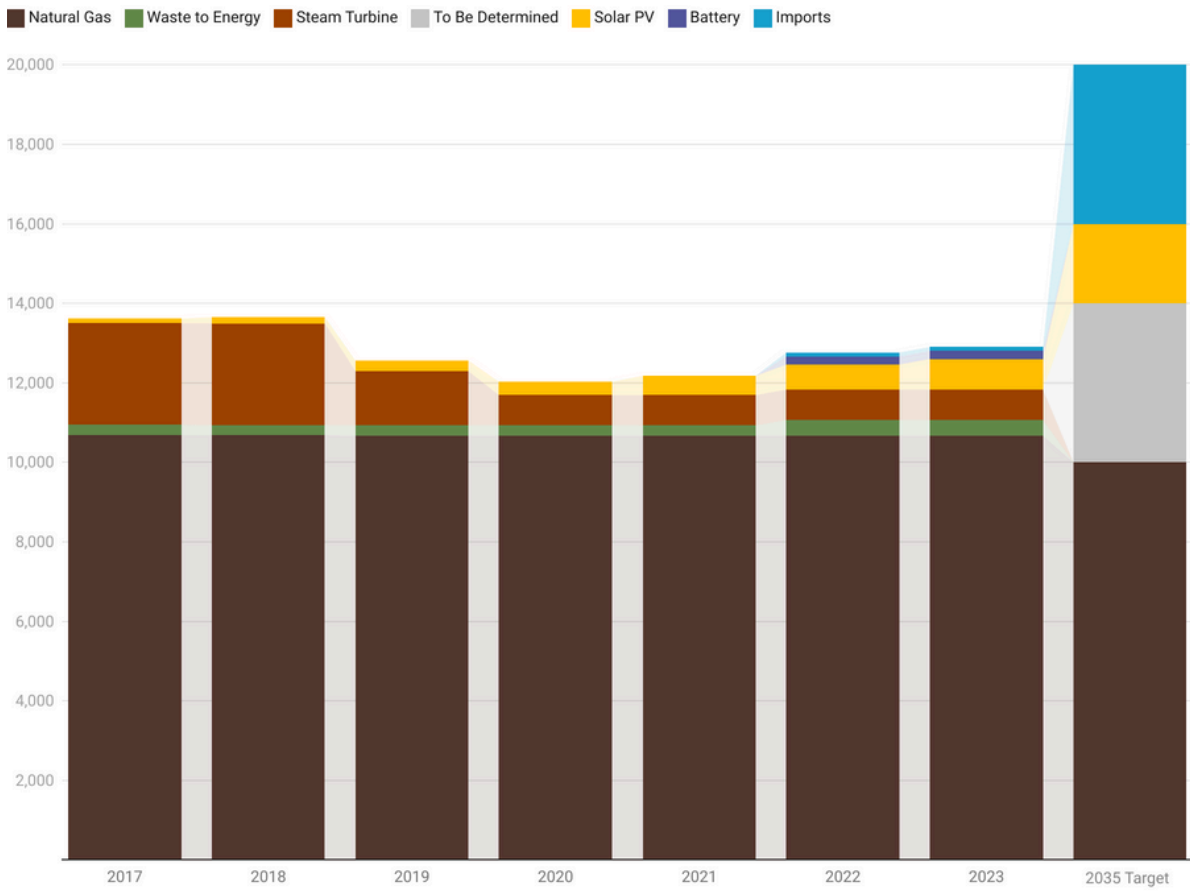
Singapore's Energy Needs

Limited land area and locally available natural resources have constrained Singapore from developing energy sources domestically. The energy system in Singapore is currently supplied almost entirely by imported natural gas—as of late 2022, 92%. The remainder is supplied by renewable energy (solar, biomass, and waste-to-energy, 4.4%), petroleum products (2.6%), and coal (1%).[ii] Although natural gas' share remains high, 92% is a decrease from 95%-98% in recent years and reflects a concerted effort by government to transform the energy mix. The government, driven by a mix of climate pressures, cost considerations, and interest in diversification to reduce vulnerability to major global shocks such as COVID19 and the energy crisis in Ukraine, has set a long-term target of reducing the share of natural gas to 50% by 2035.

The energy system in Singapore is small compared to its neighbors, Singapore's peak demand required 7,789 MW of installed capacity in 2022.[iii] For context, that is about a tenth of Vietnam's power system. But consumption is projected to rise significantly. Consumption growth rates averaged only 2.2% since 2012, but projections indicate that future demand will increase rapidly because of the electrification of transportation, continued digitalization, and growth in the energy-intensive technology sector. As a result, the government projects peak demand to rise to over 13,300 MW by 2035.[iv] And as Singapore transitions towards higher amounts of variable wind and solar, additional capacity is required to build redundancy and ensure energy security.

Singapore Electricity Capacity by Source

This chart shows Singapore's electricity generation capacity by source between 2017 - 2023, and with a projection to 2035. Peak demand may rise to approximately 13,333 MW by 2035 due to digitalization, Internet of Things, and electrification of transport. While the final 2035 needs and power mix is still to-be-determined, this chart reflects stated targets for domestic solar capacity, power import capacity, and a percentage target for natural gas. If Singapore's reserve margin remains at 50%, Singapore might need 20,000 MW of power generation capacity available by 2035 to meet peak demand.



2023 data includes statistics through the first half of the year.

Source: Data from Energy Market Authority Annual Reports from 2017 to 2023. Projections drawn from stated targets and calculated reserve margin. • Created with Datawrapper

Even as demand grows, Singapore's Energy Market Authority (EMA) of Singapore, the government agency responsible for operating Singapore's transmission and power system and regulating electricity production, is seeking to diversify and decarbonize the power mix. Singapore's Nationally Determined Contributions under the Paris Agreement recognize that the power sector is responsible for 40% of emissions and that the power mix will need to change. The EMA lays out "Four Switches" in its 2019-2020 annual report to respond to climate change and energy security needs: (1) domestic renewable energy buildout; (2) electricity imports from neighbors through a regional power grid; (3) diversification and cleaning of the natural gas supply via carbon capture; and (4) low-carbon alternatives including hydrogen. The latter two are longer-term efforts, but the first two are already shaping regional energy dialogues.

Solar has historically been a focus for domestic renewable energy given high levels of sunshine and the ability to install solar in a distributed manner. Singapore's first solar target was set in 2014, with a goal of 350 MWp solar by 2020 and 1,000 MWp by the early 2020s.[1] These targets were met in 2020 and 2023 respectively.[v] Looking ahead, the EMA has set domestic solar capacity goals of 1,500 MW by 2025 and 2,000 MW by 2030.[vi] The vast majority of Singapore's solar power will come from rooftop solar, although a portion is from floating solar projects on reservoirs or ground-mount systems built on vacant land. Singapore is on track to meet and even surpass these targets with increases in solar panel efficiency as well as innovations currently on trial that could allow for vertical solar on buildings. There are also efforts to explore geothermal potential, which initial studies suggest may be commercially feasible but which needs further study.[vii]

However, Singapore's lack of available land will continue to constrain large solar or geothermal power plants. Its success in ramping up renewable energy by 2035 thus depends on expansion and diversification of electricity imports.

Options for Singapore's Future Imports

Singapore has a set target of 4,000 MW of electricity imports by 2035 and has signed memorandums of understanding (MOUs) with Malaysia, Thailand, Laos, Indonesia, Cambodia, and Vietnam, which are more than sufficient to meet that. However, this target could increase if regional connections work well, particularly amid post-COP28 pressure to hasten the transition away from fossil fuels.

Singapore's expansion of electricity imports coincides with broad consensus that regional electricity trade through the ASEAN Power Grid (APG) is necessary for countries to meet their climate commitments. Southeast Asia's electricity demand is projected to more than triple between 2018 and 2040.[viii] This will require a massive buildout of power, and under current policies much of this is projected to come from fossil fuels.[ix] However, many ASEAN countries have updated their renewable energy targets and commitments, and all ASEAN countries except for the Philippines have set a net zero emissions target date.

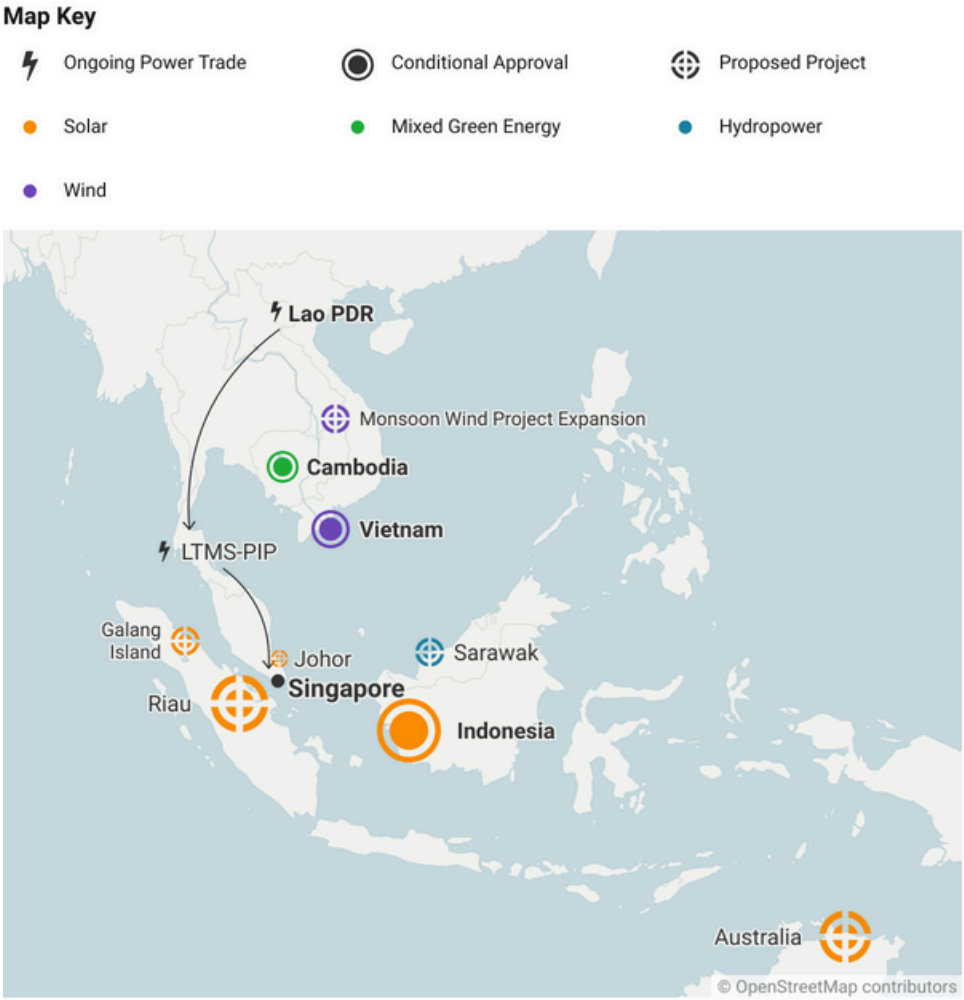
The COP28 global commitment to triple renewable energy in coming decades will require major policy shifts and improved regional interconnections. Given difficulties of managing variable electricity sources as well as differences in supply and demand between countries, developing the regional power grid can accelerate the renewable energy transition. This will be accomplished through both improving efficiency of available energy as well as increasing the integration of solar and wind into a larger market, which can absorb localized surges in production and make up for localized dips as weather shifts. Studies have shown that the APG makes economic sense, with an estimated saving of $1.87 billion by 2025 projected in the 2010 ASEAN Interconnection Master Plan Study (AIMS) II.[x]

A more recent and forward-looking study by DNV indicates that investment savings of $800 billion could be achieved by 2050 through high levels of energy integration and reduced power generation needs , compared to a business-as-usual where most countries seek to supply energy security through domestic sources.[xi]

Singapore's power import targets are not static. The EMA created an Energy 2050 Committee made up of experts from the private sector, academia, and government to explore long-term power trends and options. In March 2022, the committee released a report that included three scenarios for how Singapore could meet its future energy needs. The least dependent scenario among these set electricity imports as 25% of Singapore's 2050 target, but a trade-oriented scenario set imports as high as 60% of Singapore's electricity consumption by 2050.[xii] These scenarios indicate that there is scope to significantly increase projected imports in the longer-term. With that in mind, it is worth exploring the range of viable options on the table for meeting Singapore's future electricity needs.

Power Imports to Singapore

Singapore has a target to import 4 GW of power from around the region by 2035. The Energy Market Authority of Singapore has granted conditional approval to imports from Cambodia, Vietnam, and Indonesia, but there are numerous proposals for additional projects and expansions which are still under consideration. The markers are scaled based on projected power.



Source: Dataset curated by Courtney Weatherby at the Stimson Center, drawing on public announcements, press releases, and media coverage of proposed projects. • Created with Datawrapper

Lao PDR and the LTMS-PIP

Singapore's only existing cross-border power connection is with peninsular Malaysia. This interconnection has been used for small-scale imports as ASEAN's first multinational electricity trade in the form of the Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP). The LTMS-PIP, which involved lengthy negotiations over standards and pricing, led to an agreement to trade 100 MW of power from Laos to Thailand to Malaysia and ultimately to Singapore. Singapore was the final signatory and signed on four years after power began flowing to Malaysia in 2018, with a trial period set from 2022 through 2024.[xiii]

The LTMS-PIP was a major milestone: it marked the first renewable energy import for Singapore, and the first multilateral power trade agreement in ASEAN. While there are many bilateral interconnections in ASEAN, the LTMS-PIP is an example of how multiple countries can trade power on a long-term basis. It sets a precedent for a wider conversation about turning APG into reality, and lessons learned will be valuable for negotiations elsewhere in ASEAN such as the Brunei-Indonesia-Malaysia-Philippines Power Integration Project.

The Energy Purchase Wheeling Agreement between Laos, Thailand, and Malaysia already aims to increase power trade to 300 MW soon.[xiv] Singapore could feasibly expand power imports from LTMS-PIP well beyond that target in coming decades, although this would require upgrading the interconnections and national grids to accommodate higher electricity flow. On the investment side, Keppel Infrastructure has signed agreements to explore expanding the Monsoon Wind Power Project in southern Laos by 1,000 MW for potential export to Singapore.[xv] However, the actual route that this power would take is unclear—it could be sent via LTMS-PIP, assuming that Thailand is willing to consider cross-border wind electricity trade, or through new transmission lines.

Malaysia

Given its nearby location and existing interconnection, Malaysia will play an important role in power trade. In addition to LTMS-PIP, in 2021 the EMA called for proposals to trial an additional 100 MW of imports from peninsular Malaysia. This will begin in 2024.[xvi] Some of this could come from the Malaysian province closest to Singapore, Johor, where the ruler has indicated interest in developing large-scale solar production as part of the Johor-Singapore Special Economic Zone.[xvii] There is also discussion about importing hydropower from Sarawak via undersea cables.[xviii]

However, both countries face political sensitivities related to increasing power trade. In Malaysia, pressures to meet domestic climate commitments may raise concerns about large-scale export of power to Singapore. This has been an obstacle in the past: in 2021 the government restricted export of renewable energy to Singapore to keep locally produced renewable energy inside national borders and meet Malaysia's renewable energy targets.[xix] At the time, renewable energy's contribution to Malaysia's electricity supply was minimal, as coal and gas were responsible for nearly 94% of the total supply.[xx] The government lifted the ban in May 2023 arguing that this would attract international investment and catalyze renewable energy domestically.[xxi] However, such concerns remain,[xxi] and the recent proposal to sell Sarawak hydropower to Singapore raised questions among some groups about why locally produced renewable energy should be sold to Singapore instead of the Malaysian mainland.[xxii] Such political considerations may limit the amount of local renewable energy exports to Singapore.

Diversification and Underseas Cables

Singapore must also consider its own energy security. This involves avoiding overreliance on one energy source or one transmission line given potential shocks to the system. For instance, a glitch on a single power cable bringing 1,300 MW of power from Laos caused a large part of Thailand to lose electricity in 2018, highlighting the risk of relying on one transmission point.[xxiii] The single interconnection between Malaysia and Singapore has a 1,000 MW carrying capacity.[xxiv] While it may be cheaper to upgrade existing interconnections, meeting Singapore's import target and ensuring energy security will require building new lines to increase capacity and ensure multiple import channels.

Singapore has granted conditional approval to 4,200 MW of projects in Cambodia, Indonesia, and Vietnam to meet its current target, all of which will require undersea cables. These would allow for more distant connections and avoid reliance on neighboring grids and the single interconnection with Malaysia. The proposed undersea cable projects are ambitious. The world's longest undersea power cable in Europe is only 764 km long. Many of the proposed cables would be much longer, including the Sun Cable with Australia which would transmit solar power across 4,000 km.[xxv]

Cambodia

In March 2023, the EMA granted conditional approval for the import of a mix of solar, hydropower, and wind power from Cambodia. This would come via subsea cable and would provide up to 25% of Singapore's projected electricity import needs by 2035.

There has not been any public announcement of the proportion of solar, wind, and hydropower in the import mix or the specific projects involved, but Cambodia's Royal Group would be the local partner responsible for sourcing and developing the power projects.[xxvii] Royal Group is involved in several coal and hydropower projects, but in November 2023 signed an agreement with Singapore-based Total Energies to explore renewable energy projects and decarbonization opportunities.[xxviii] Royal Group's total energy portfolio could reach 2,500 MW, of which only a portion would be sent to Singapore with the rest supplying Cambodia's own rapidly rising electricity needs. Such investment could be catalytic for new investment in solar and wind: in early 2024, the Royal Group signed an MOU with Blue Circle for the first wind project in Cambodia which referenced the Keppel partnership as a driver of expansion.[xxix] The government has also recently upgraded its original target of 1,000 MW of solar by 2030, doubling it to 2,000 MW by 2030 in December 2023 just half a year after signing the agreement with Singapore.[xxx]

It is very likely that some portion of this will be a large-scale pumped storage hydropower (PSH) project: in October 2023 and again in April 2024, Minister of Energy and Mines' Keo Rottanak discussed plans for a 1,000 MW PSH project, and that multilateral power exchanges would support renewable energy developments.[xxxi] PSH is attractive given reliability concerns for traditional hydropower, which often sees drastic drops in output during the dry season and drought years. Hydropower production across Asia fell nearly 18% in the first half of 2023 due to low rainfall, low river flow, and low reservoirs levels caused by extreme drought.[xxxii] PSH also helps better integrate variable solar and wind, essentially acting as a huge battery.

While no specific site has been publicly suggested for the PSH project, a global study of PSH identified 190 potential greenfield locations in Cambodia, largely along Cambodia's coastal rivers.[xxxiii] Some would involve the construction of new dams to create a closed-loop system, using altitude differences between reservoirs to generate anywhere between 5 and 150 GWh of electricity. A closed-loop PSH between two reservoirs will generally have fewer environmental impacts than a system connects to a river. Site selection and high-quality environmental and social impact assessments will be crucial to minimize negative impacts to ecosystems and local communities from such projects. There is space for outside technical partners to assist in this process.

Vietnam

Vietnam is a regional powerhouse when it comes to wind and solar power, with about 22 GW of installed capacity. Vietnam also has some of the largest offshore wind potential globally, with the Asian Development Bank (ADB) estimating over 500 GW of technical potential.[xxxiv] The government has plans to significantly expand offshore wind power in coming decades. But Vietnam's power grid is struggling to integrate the 22 GW of solar and wind power that recently came online, and this challenges the rapid scale-up of solar and wind for domestic use. Power exports to Singapore could avoid destabilizing the national grid while supporting further investments in solar and wind.

Singaporean company Sembcorp has already taken the first move by partnering with PetroVietnam Technical Services Corporation (PTSC) to survey offshore wind potential with the goal of exporting offshore wind to Singapore.[xxxv] This is a major development given that no other company in Vietnam has received a license to survey and assess marine resources to develop offshore wind. The EMA has issued conditional approval to import 1,200 MW from Vietnam via a 1,000 km undersea cable starting in 2033.[xxxvi] This project's success will require finalization of offshore wind regulations and building the world's longest undersea power cable.

While the initial 1,200 MW approval is modest, coastal provinces in Vietnam are embracing this concept and promoting other projects. Officials in Ca Mau, Bac Lieu, and Soc Trang have identified over 26,000 MW of solar and wind projects which they could potentially develop for export through undersea cables.[xxxvii]

Indonesia

Singapore and Indonesia have taken steps towards cross-border power trade and low-carbon energy cooperation over the last two years. Businesses began exploring the feasibility of solar and undersea cable exports in 2021, which could potentially be shorter than other undersea cables depending on project site and cable route. In January 2022 the Ministers of Industry and Trade of Singapore and Indonesia signed an MOU on energy cooperation.[xxxviii] In March 2023, they signed a MOU on renewable energy as the basis for collaboration on solar, hydrogen/ammonia, and battery energy storage with a view to electricity export to Singapore.[xxxix] And in September 2023, Singapore and Indonesia signed an MOU on electricity trade with direct reference to EMA's conditional approval for five specific projects in Indonesia to sell 2 GW of low-carbon electricity to Singapore.[xl]

This puts Indonesia on track to meet 50% of Singapore's electricity imports through 2035. The five projects granted conditional approval are solar farms and battery energy storage systems, with a planned start date for power exports by 2027.[xli] These projects will require subsea power cables, which are subject to approval by the Indonesian government.

Opportunities for Singapore to Support Regional Sustainability

Singapore has many options to meet its future import needs, and progress on hydrogen/ammonia, geothermal, advanced nuclear, and other technologies may present further opportunities. However, technical and political challenges related to the renewable energy transition and regional power trade could inhibit or delay progress. Issues with grid integration, regulatory challenges linked to new technologies, and standardization linked to cross-border power trade could all delay the realization of Singapore's regional power trade and approved projects. Apart from Laos and Vietnam, other potential exporters are all early in the process of scaling up renewable energy. Issues related to technical capacity, regulatory and approval processes, and institutional resistance have historically led to higher perceptions of risk by investors and slow rollout of renewable energy globally.

The following are recommendations and technology opportunities that could help minimize any social or environmental concerns surrounding Singaporean investments abroad, avoid non-emissions related negative impacts from key infrastructure projects, and set Singapore and ASEAN up for success in meeting sustainable energy targets. These build on and complement ongoing capacity building efforts related to Singapore's existing strengths on digitalization of the energy sector and energy efficiency.

Policy Opportunities for Government Agencies

- **The EMA should explicitly include non-carbon emission related sustainability considerations when reviewing proposed power import projects**. Given the many projects Singapore has to choose from, it can afford to be selective among the companies which have received conditional approval to import electricity and choose only those projects that avoid unnecessary social and environmental impacts. There are sensitivities related to non-carbon emissions impacts from power infrastructure projects, ranging from land-use tensions linked to large-scale solar and wind farms to negative impacts from hydropower dams on biodiversity, forest conservation, and local communities. Avoiding high-risk projects will reduce the risk of reputational damage, delays, and high-cost mitigation efforts later in the project lifecycle. For example, metrics exist to assess the impact of dams on fisheries and food security. As understanding of fish migration improves, these metrics are becoming increasingly accurate. There is a wealth of evidence against buying power from dams in the lower reaches of river systems that disconnect major tributaries from the mainstream.

- **The Ministry of Foreign Affairs can work with likeminded partners to support a series of interlocking Third Country Training Programs (TCTPs) to accelerate renewable energy integration**. Studies have identified key "pain points" related to renewable energy integration, ranging from weather forecasting to grid transmission standards. Singapore has expertise and experience to share from pilot projects which are relevant for countries just beginning to adopt similar approaches. The Singapore Cooperation Programme (SCP) recognizes climate change as a key global challenge and targeted two engagements in 2023 towards clean energy and emerging technologies.[xiii] Such engagements can be significantly expanded and formatted in a way that builds links with potential markets across ASEAN. Singapore is also home to the recently launched International Energy Agency's first regional office, and targeted trainings could tap into the IEA's network of technical expertise.

- **Provide ASEAN countries with technical support and exchange programs focused on near-real-time solar radiance forecasting and renewable energy integration**. Many ASEAN countries have low levels of renewable energy penetration and the challenges of integrating solar and wind will only increase as the amounts of variable solar and wind rise. The Solar Energy Research Institute of Singapore (SERIS) has successfully tested a solar forecasting model to anticipate power output and respond proactively using on-the-ground sensors, satellite imagery, and machine learning.[xliii] This is one of many useful steps that can be taken to track and forecast solar power production on a near-real-time basis, which can have concrete benefits for power supply management and solar integration. The EMA and Meteorological Service Singapore (MSS) have applied this model domestically and could share technical and management recommendations with countries that face similar challenges. There is also space to share experience with digital, smart-grid, or battery storage solutions which are currently being deployed in Singapore. Such trainings can be done independently, but long-term impacts would benefit from collaborating through the TCTP program with like-minded partners such as the United States, Japan, Australia, or New Zealand. Singapore can also use its position as chair of the Head of ASEAN Power Utilities/Authorities (HAPUA) Working Group on Distribution and Power Reliability and Quality to share experience with other regional utilities.

- **Implement a TCTP focusing on Renewable Energy Certification approaches and regional standards**. In 2021 the EMA, in collaboration with the National Environment Agency, Singapore Standards Council, and Enterprise Singapore, launched the Singapore Standard and Code of Practice for Renewable Energy Certificates (REC).[xliv] This standard manages the requirements for eligibility, clarifies roles of individual actors within the REC ecosystem, lays out registration processes, and provides guidance on verification processes and management of REC registries. The standards were developed in line with the International-REC Standard Foundation. Singapore's experience in designing and rolling out REC standards could provide valuable lessons for neighboring ASEAN members which are still in the process of developing domestic REC processes. This would also be a strategic longer-term investment given Singapore's longer-term ambitions to support regional power trade and the need to ensure that future purchases of electricity can meet Singapore's needs in a certifiable way. By starting the conversation about regional REC standards at a formative time for the REC process in other ASEAN countries, Singapore has an opportunity to ensure that its key considerations are part of a regional conversation about how to certify and track renewable energy across borders in a way which financially incentivizes adoption of such systems.

- **Prioritize discussion about higher-level coordination on regional demand projections and its implications for power buildout plans**. Given the evolution of the APG to meet rising demand for renewable energy, ASEAN countries should collaborate to ensure that national power plans accurately consider supply and demand. For instance, government planners in Lao PDR have historically assumed that there will be demand for hydroelectricity and included large-scale export targets in its national power development plans. But power exports have not always met these targets; over-investment in power generation assets with insufficient market uptake led to wastage of hydroelectricity from 1,500 MW of power plants in 2020, about 10% of Laos' total installed power capacity.[xlv] It also contributed to Laos' rapid increase in debt. High reserve margins in the region—over 50% in Laos, Malaysia, and Thailand—can compound these challenges by limiting offtake. High levels of ambition to export renewable energy from Vietnam, Cambodia, and Indonesia should be tempered to avoid expensive over-buildout and wastage.

Catalytic Technological Opportunities

At COP28, 123 countries committed to tripling renewable energy capacity by 2030—including Singapore, Malaysia, Brunei-Darussalam, and Thailand. While the other six ASEAN members did not sign on to this commitment, most have ambitious targets to scale up renewable energy over the coming decades and many have longer-term net zero commitments. Within this space, Singapore has a significant opportunity as a regional investor and technology leader to provide critical technical support and financial investments.

In the long-term, Singapore is already investing in building capacity and policy attention to issues such as innovative energy storage, hydrogen and ammonia, and carbon capture and storage. These may prove strategic investments in coming decades and all deserve additional analysis, but Singapore's existing interest in offshore wind and expertise in rooftop and floating solar offer significant opportunity to provide early support and investment for a nearer-term win. The following recommendations outline areas in which Singaporean companies or institutions have opportunity to both build market share and support regional ambitions for a more sustainable power sector.

Offshore Wind Development

Offshore wind will be a major component of the clean energy transition in ASEAN and is particularly important given that it could potentially replace coal in providing baseload. The World Bank estimates that Vietnam has 599 GW of technical offshore wind potential.[xlvi] For perspective, that is more than the combined installed power generation capacity for Cambodia, Laos, Myanmar, Thailand, and Vietnam as of 2023, and thus presents a massive investment opportunity. The World Bank also estimates wind potential of 277 GW for Indonesia and 178 GW for the Philippines.[xlvii] Vietnam's Power Development Plan 8 sets an ambitious target of 6 GW of offshore wind by 2030 and at least 70 GW by 2050.[xlviii]

Singapore is supporting the first offshore wind project in Vietnam. In the short term, this will help meet EMA's renewable energy target, but it also sets Singapore up with a long-term business opportunity as the region seeks large-scale investments to expand offshore wind. Vietnam alone has a massive need for clean energy generation and transmission investment, with estimates ranging between $4 and $14 billion annually. Much of this investment will have to come from international sources, as Vietnamese banks are already reaching the limits for lending in this space.[xlix] If companies like Sembcorp succeed in Vietnam, they will position themselves to gain market share across ASEAN.

- Singapore should target technical and regulatory assistance to Vietnam alongside private sector investment in offshore wind, leveraging partnerships like those with Sembcorp and Keppel to pilot emerging energy technologies and then scale them up.
- Enterprise Singapore, a government agency responsible for supporting small and medium enterprises (SMEs) with innovation and international expansion, can help businesses identify risk factors for offshore wind and other technologies that constrain Singaporean investment, and coordinate with likeminded partners to target assistance at specific regulatory issues.

Rooftop Solar

Solar energy is widely abundant across ASEAN and a key component in most countries' renewable energy plans. While most planning agencies prioritize commercial solar plants, rooftop solar (RTS) has key advantages that complement solar plants. RTS avoids tensions over land-use by using existing space and can avoid transmission losses by siting power production close to where it is used. RTS also has challenges, however, as new inflows of electricity may require additional transmission and distribution upgrades and variability impacts on the grid will require improved forecasting and operational adjustments.

National utilities have concerns about how RTS will impact grid stability, and as a result most countries in ASEAN have been slow to develop RTS. Vietnam is the regional lead in installed RTS, which provides 9 GW out of Vietnam's 17 GW of installed solar power. Vietnam's Power Development Plan 8 sets a target of between 168-189 GW of solar capacity and a target of half of all office and residential buildings installing and locally using RTS by 2030.[l] Thailand had 857 MW of RTS installed by 2020, but is lagging behind a 2019 target of adding 50 MWp of RTS per year for residential buildings.[li] Laos and Cambodia have not set RTS targets although significant potential exists in both countries.

Singapore has installed over 1 GW of solar power and plans to expand to 1.5 GW by 2025 and 2 GW by 2030. While some of this will come from floating solar or installations on vacant land, most of the solar power is RTS or integrated into building facades. The government has a plan to support further deployment of solar through clear policies on pricing, aggregating, and streamlining payments and metering, and improving pathways to lease land for solar installations.

- EMA has an opportunity to share Singapore's experience incentivizing, permitting, and integrating grid connected RTS with national utilities across ASEAN that seek to increase RTS.
- Successful private solar installation and leasing companies from Singapore can expand to ASEAN markets that are struggling to bring RTS to market.
- Business associations can support these moves by analyzing factors that have supported or held back RTS deployment across ASEAN. These can be shared with key decision-makers responsible for implementing national clean energy targets.
- Integrating solar panels into windows or other building facades is an emerging opportunity for large cities across ASEAN. Singaporean universities and businesses in this space could partner with manufacturing hubs in ASEAN to commercialize and scale up this technology.
- Sembcorp and EMA have opportunities to share operational lessons-learned from the deployment of large-scale energy storage, such as Sembcorp's Energy Storage System. The 285 MWh system on Jurong island is currently the largest battery storage system in Southeast Asia and can provide lessons learned within the region for how to improve solar integration, particularly in industrial areas.

Floating Solar

Solar projects are increasingly facing challenges related to land availability. Floating solar projects circumvent such constraints. From a cost perspective, floating solar reduces potential land conflicts and avoids expensive land leases. Floating the solar panels on water allows them to cool more efficiently than on land given water's high heat absorption, with studies indicating significant gains in energy production of 6-15%.[lii] And within the context of rising drought and climate variability, solar panels also reduce evaporation losses from water bodies. If built on part of a reservoir, floating solar can plug into existing transmission lines and operate conjunctively with hydropower.

Floating solar is a relatively new technology but it has significant potential in ASEAN. A 2023 study estimates that Southeast Asia has between 134-278 GW of floating solar potential across 88 reservoirs, plus additional capacity on natural water bodies like lakes.[liii]

Singapore has a first-mover advantage when it comes to floating solar and a well-respected solar research institution in SERIS. Its energy and water utilities piloted a 1 MWp floating solar project in 2016, and Sembcorp followed that with the region's first large-scale floating solar project in 2021, providing 60 MWp of capacity to Singapore's grid. [liv] Thailand and Indonesia have large-scale floating solar projects under development, and their companies could expand across ASEAN. But Singapore has advantages in terms of length of experience, high-tech monitoring, and efficient management.

- The EMA and Public Utilities Board can share lessons learned from the floating solar project on the Tengeh Reservoir, including processes and standards to monitor and minimize environmental impacts. This is particularly valuable for countries that have yet to set up rules and regulations for floating solar and have significant space to expand floating solar.
- Sembcorp can build on its pilot project experience through partnerships with dam operators to build floating solar installations elsewhere in Southeast Asia.

Conclusion

Meeting Singapore's ambitious clean energy import targets will require concerted efforts, not just domestically but also in collaboration with regional partners. As renewable energy expands across ASEAN, meeting carbon emission reduction targets sustainably will require careful consideration of how to mitigate environmental impacts and manage tradeoffs. Singapore has an opportunity to support ASEAN in meeting shared clean energy and sustainability targets through early investment in key technologies, sharing lessons learned from pilot projects, and leadership on standards for regional power trade. Doing so will have long-term benefits for Singapore and ASEAN and ensure that the region's energy transition is not only net-zero, but also minimizes impacts on biodiversity and ecosystem services.

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