SINGAPORE

1. INTRODUCTION

1.1 CRAFTING A SUSTAINABLE AND RESILIENT ENERGY FUTURE FOR SINGAPORE

As a small island nation with limited natural resources, Singapore faces systemic challenges in addressing the complexities of the Energy Trilemma. Heavily reliant on imports of energy sources such as petroleum products, crude oil and natural gas, energy security is of paramount importance for Singapore. With more than 90% of power generated in Singapore supplied by natural gas, the government recognizes the need to diversify its supply of natural gas through regional pipelines and global LNG imports. A cleaner fuel source compared to coal and fuel oil, natural gas is necessary for Singapore to mitigate concerns surrounding energy security and environmental sustainability but comes at a higher cost and has greater price volatility. To ensure affordable and reliable energy access for the population, policies ranging from energy efficiency grants to subsidies for lower-income households are introduced.

Singapore's journey towards a sustainable and secure energy future is guided by a comprehensive and adaptive strategy that aligns closely with the insights from the 2024 World Energy Trilemma Report. Recognizing the potential benefits of a regional power grid, Singapore has been doubling down on efforts to boost energy cooperation among neighbouring countries. With growing number of solar installations, Singapore has also made strategic investments in a diverse portfolio of energy storage technologies to increase stability and resilience of the grid. By strategically addressing energy security through diversification, enhancing energy equity through targeted support and efficiency programs, and driving environmental sustainability through innovative clean energy technologies, Singapore is well-positioned to navigate the complexities of the energy trilemma.

Driven by its ambitions to be a sustainable and resilient nation, a "Four Switches" approach has been adopted to diversify Singapore’s energy sources and increase sustainability in power generation, while ensuring energy security and cost-competitiveness. The Four Switches are: natural gas, solar energy, regional power grids, and emerging low-carbon alternatives.

Furthermore, the nation's proactive approach to exploring new frontiers, such as nuclear energy, and its commitment to leveraging technological advancements and regional collaborations underscore the importance of resilience and adaptability. Continuous improvement and inclusive policymaking are also crucial to ensure that the benefits of the energy transition are equitably distributed, and that the nation remains resilient in the face of future challenges.

Beyond the supply of energy, Singapore has also been actively driving adoption of digital tools and technologies to support the energy transition such as adopting a digital twin of the power grid, and other AI and IoT solutions within the power management ecosystem.

By fostering a collective vision and engaging all stakeholders in the energy transition process, Singapore can secure a sustainable, equitable, and prosperous energy future, setting a benchmark for other nations to follow. The journey is ongoing, and with a steadfast commitment to innovation, collaboration, and inclusivity, Singapore will continue to progress and evolve in the global energy transition.

1.2 SINGAPORE'S ENERGY TRILEMMA

As a small island nation with limited natural resources, Singapore faces systemic challenges in addressing the complexities of the Energy Trilemma. Singapore's position on the triangle reflects its achievements and ongoing challenges:

- Moderate Energy Security: Singapore's energy security is bolstered by its efforts to diversify supply sources and develop storage technologies but offset by high dependence on imported natural gas. Import independence is possible through a diversified supply of gas from regional pipelines and global LNG imports. However, diversity in electricity generation sources remains low, as renewables contribute only minimally due to land constraints. Energy storage is developing, with battery and other storage initiatives enhancing grid stability, though scalability and cost remain challenges to broad deployment.
- Strong Energy Equity: Singapore performs well in ensuring affordable, reliable energy access for nearly the entire population, supported by government policies focused on efficiency and sustainability. Regulations are in place to maintain affordability for all residents, while investments in smart grids and energy storage bolster distribution efficiency and reliability.
- Moderate Environmental Sustainability: Singapore is advancing energy sustainability through solar adoption and clean energy imports from resource-rich neighbours. However, its reliance on natural gas challenges long-term net-zero targets, especially with projected power demand increases from energy-intensive sectors like data centres.

2. SINGAPORE'S KEY POLICY FRAMEWORK IN PLACE TO TACKLE THE ENERGY TRILEMMA

Driven by its ambitions to be a sustainable and resilient nation, a "Four Switches" approach has been adopted to diversify Singapore's energy sources and ensure energy security, while increasing sustainability of the power supply and maintaining cost-competitiveness.

The Four National Switches:

- Natural Gas: Strengthens energy security through reliable supply and diversification, maintains energy equity through competitive pricing, and contributes to environmental sustainability by serving as a cleaner fossil fuel option that aids the transition towards renewable sources.
    - Currently, natural gas is Singapore's primary source of electricity generation, accounting for approximately 95% of total. As Singapore transitions to cleaner energy, natural gas remains a critical "bridge," ensuring stability in the energy grid while renewable sources expand.
    - The country plans to establish a second LNG Terminal at Jurong Port which will feature a floating storage and regasification unit with a capacity of 5 million tonnes per annum—a 50% increase in LNG capacity to ~15 Million Tonnes Per Annum.
    - To bolster supply security, Singapore is establishing a central gas entity, Gasco, by the end of the current financial year. This fully government-owned entity will centralize gas procurement, allowing for longer-term contracts and more favourable terms.

- Solar Energy: Promotes energy security by reducing dependence on imported fossil fuels, supports energy equity through potential reductions in electricity costs in the long-term, and drives environmental sustainability by significantly lowering carbon emissions.
    - Despite land constraints, Singapore is maximizing solar deployment by utilizing rooftops, offshore spaces, and reservoirs through innovative solutions like the Tengeh Reservoir Floating Solar Farm and HDB rooftop installations. As of 2024, Singapore has reached an installed solar capacity of 1.35 GWp, a fivefold increase since 2019. This progress keeps Singapore on track to meet its goal of at least 2 GWp by 2030.
    - To manage solar intermittency, Singapore commissioned a 285MWh battery energy storage system (BESS) on Jurong Island in 2022, the largest of its kind in Southeast Asia. EMA and Sembcorp are exploring expansion options to support stable solar output, enhancing the resilience of Singapore's energy grid.

- Regional Power Grids: Enhances energy security through diversified imports, supports energy equity by stabilizing prices, improving resource optimization, and enabling cross-border energy trade, and contributes to environmental sustainability by facilitating the import of renewable energy.
    - Singapore is diversifying its energy sources through regional power imports. Initially targeting 4 GW of low-carbon electricity imports by 2035, Singapore recently increased this goal to 6 GW, which will meet about one-third of its energy needs.

- The EMA has issued Conditional Licenses for five projects in Indonesia, providing Singapore with 2 GW of low-carbon electricity. Additional Conditional Approvals for 3.6 GW of imports from Cambodia, Indonesia, and Vietnam are also underway.
- Singapore is expanding cross-border electricity trade with Malaysia and has doubled its capacity to 200 MW under the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project. These efforts strengthen Singapore's energy integration with the ASEAN Power Grid.

- Emerging Low-Carbon Alternatives: Strengthens energy security through the diversification of energy sources, enhances energy equity by promoting new economic opportunities, and significantly advances environmental sustainability by focusing on low-carbon technologies.
  - Singapore has embraced a National Hydrogen Strategy, initiated in 2022, to explore hydrogen as a sustainable energy solution. Recent developments include a Request for Proposal to pilot low-carbon ammonia use on Jurong Island for power generation and bunkering. Two consortia have been shortlisted for Front-End Engineering Design studies to evaluate low-carbon ammonia supply chains by the end of this year.
  - Singapore's investment in hydrogen research also includes the Low Carbon Energy Research (LCER) Funding Initiative, which has allocated over $180 million since 2020. Earlier in 2024, Singapore launched the Centre for Hydrogen Innovations at the National University of Singapore, a first in Southeast Asia, to collaborate with industry on advancing hydrogen technologies.

3. NAVIGATING FUTURE CHALLENGES, SEIZING OPPORTUNITIES

Singapore's journey towards a sustainable and secure energy future requires a collective vision and a shared commitment from all stakeholders. The government, businesses, industries, communities, and individuals all have a role to play in shaping this future. Singapore's energy future is characterized by both challenges and opportunities:

Challenges:

- Balancing Energy Security and Affordability: Reducing reliance on imported LNG while ensuring affordable energy prices for businesses and consumers requires careful planning and strategic investment. The future energy mix of Singapore remains highly fluid, subject to developments in technologies, cost effectiveness and inter-governmental relationships.
- Land Scarcity for Renewable Energy: Singapore's limited land availability necessitates innovative solutions and regional collaborations to achieve its renewable energy targets.
- Managing the Pace of Energy Transition: Balancing the need for rapid decarbonization with the imperative of maintaining energy affordability and economic competitiveness requires a well-managed energy transition. The high capital costs of building resilient grid infrastructure for ASEAN interconnection require substantial financing and multilateral cooperation. This could affect electricity tariffs, raising concerns over the affordability and accessibility of imported clean energy.

Opportunities:

- Regional Energy Cooperation: Strengthening energy partnerships with neighbouring countries offers opportunities for joint renewable energy projects, cross-border electricity trading, and enhanced energy security through regional grids (i.e. LTMS-PIP). The growing renewable capacity in ASEAN—such as solar, wind, and hydropower—presents Singapore with a viable path to meet its green energy goals, provided the necessary transmission infrastructure is developed collaboratively.
- Technological Innovation: Singapore is well-positioned to become a leader in sustainable energy ecosystem technologies. For instance, smart grid technologies like the Intelligent Energy System and the Smart Nation Initiative aim to promote integration of digital technologies into energy systems. Investing in research, development, and deployment of innovative solutions such as green hydrogen and carbon capture can create economic opportunities while advancing environmental sustainability.

4. SINGAPORE'S ENERGY TRANSITION IN ALIGNMENT WITH THE 2024 WORLD ENERGY TRILEMMA REPORT

The 2024 World Energy Trilemma Report offers a suite of policy and strategy options that hold relevance for Singapore:

- Prioritizing Regional Energy Cooperation: The report's emphasis on regional collaboration resonates strongly with Singapore's approach. Strengthening energy partnerships with neighbouring countries through initiatives like the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) not only enhances energy security through diversification and resource sharing but also facilitates the integration of larger shares of renewable energy into regional grids.
- Strategic Investment in Energy Storage Solutions: The intermittent nature of renewable energy sources like solar necessitates robust energy storage solutions to ensure grid stability and reliability. The report emphasizes the importance of investing in a diverse portfolio of energy storage technologies, including battery storage, and emerging technologies like hydrogen storage. Singapore is actively pursuing these pathways, recognizing that energy storage is crucial for unlocking the full potential of renewable energy.
- Fostering Dynamic Public-Private Partnerships: Successful energy transitions require capital collaboration and technological innovation across all sectors. Singapore adopts a Whole-of-Government approach in developing and implementing policies and frameworks. Various ministries and public agencies will be consulted to ensure multiple perspectives are considered and well-rounded solutions are conceptualized. In addition, Singapore strongly encourages Public-Private Partnerships to leverage on innovative, nascent technologies with some funding support from the government.
- Digital Tools for the Energy Transition: With advancement in digital tools and technologies, there is huge potential for these technologies to be integrated into energy systems and support the energy transition. Advanced data analytics and remote monitoring systems have been widely used to predict solar generation and track the conditions of panels. A digital twin of the power grid allows for more holistic and detailed planning of grid infrastructure to suit future energy requirements in Singapore. Other solutions include analytics of sensor data to identify gaps in energy efficiency as well as self-learning, predictive intelligent systems that will monitor ambient conditions and occupancy rates to optimize energy usage in buildings.
- Market Reforms and Demand Management: Besides diversification of energy sources, it is also necessary to consider and encourage active demand management to increase security and resilience of energy systems. While demand response schemes have been introduced to businesses since 2022 and recently expanded to include households, greater efforts are required to incentivize consumers to participate in such schemes. In addition, with the proliferation of solar PV, energy storage solutions and electric vehicles, these consumers should have an avenue to sell excess electricity back to the grid. A review of the current market structure and market operations may be necessary as new business models and technologies are introduced.

5. ALIGNING NATIONAL ENERGY PLANS WITH EMERGING TRENDS

Singapore's forward-looking energy policies and plans, including the Four Switches framework, the Singapore Green Plan 2030, and the Long-Term Low-Emissions Development Strategy (LEDS), already address many of the trends highlighted in the report. However, continuous improvement and adaptation are essential:

- Charting Ambitious Deep Decarbonization Pathways: While Singapore has set commendable emissions reduction targets, exploring more aggressive decarbonization pathways is essential for achieving long-term climate goals. This involves evaluating the feasibility and potential of carbon capture, utilization, and storage (CCUS) technologies, particularly in hard-to-abate sectors.
- Embedding Circular Economy Principles: Integrating circular economy principles into energy planning can enhance resource efficiency and minimize environmental impact. This involves promoting the reuse and recycling of solar panels, wind turbine blades, and batteries, reducing waste and recovering valuable materials.

- Strengthening International Collaboration on Clean Energy Technologies: Actively participating in international research and development collaborations, particularly in areas like green hydrogen production, advanced energy storage, and next-generation renewable energy technologies, can accelerate innovation and bring down costs. Singapore's strategic position as a global hub for innovation and technology can be leveraged to attract international partnerships and investments in these cutting-edge areas.

6. ENSURING AND MEASURING A JUST AND RESILIENT ENERGY TRANSITION

A just and resilient energy transition is essential to maintain social equity and economic stability. Singapore must ensure that the benefits of the energy transition are shared broadly across all segments of society:

- Affordability and Accessibility:
    - Energy Affordability Index: In 2022, energy expenses accounted for 5% of total household expenses in Singapore. The country can continue tracking energy costs as a proportion of household income for different income groups to ensure that energy remains affordable for all.
    - Subsidy Programs: Since 2012, the government has been providing U-Save rebates to low- and middle-income households to help with cost of living and cope with the rising utility bills. Existing subsidy programs, such as the Public Utilities Board's (PUB) "Home Energy Efficiency" program aims to assist low-income households by providing grants for energy-efficient appliances. Continuous evaluation is necessary to assess the effectiveness in reducing energy poverty.

- Employment and Economic Development:
    - Green Jobs Creation: The International Renewable Energy Agency (IRENA) projects that the renewable energy in Singapore will create over 30,000 jobs by 2030. Monitoring job quality, wage levels, and career advancement opportunities is essential to ensure that these jobs provide a living wage and growth potential.
    - Skills Development and Training: Evaluate the reach and impact of workforce training and reskilling programs designed to equip workers with the skills needed for the clean energy transition. In 2023, the Singapore government formed the Green Skills Committee to identify new jobs and skills required for the energy transition and prepare a roadmap for developing and upskilling the workforce.

- Community Engagement and Public Perception:
    - Community Engagement: In 2022, the Ministry of Sustainability and Environment launched the Partners for Environment Forum to discuss key environmental issues with its 3P partners which consisted of People, Private and Public sectors. As part of the annual Climate Action Week, members of the public can participate in learning journeys and guided tours, and attend workshops to learn more about the environment and sustainability.
    - Public Perception Surveys: A 2022 survey by the EMA revealed that about 73% of Singaporeans support the government's decarbonisation efforts. Moving forward, conducting regular surveys to gauge public sentiment, concerns, and levels of support for energy transition policies can help address any concerns proactively.
    - Awareness and education: In this age of social media, private companies and public agencies are turning to social media platforms to expand their outreach and engage the younger generation. The Energy Market Authority has launched a series of YouTube videos to explain various components and concepts of the energy system in a simple and easily relatable manner.

7. CRAFTING A SUSTAINABLE AND RESILIENT ENERGY FUTURE FOR SINGAPORE

Singapore's journey towards a sustainable and secure energy future is guided by a comprehensive and adaptive strategy that aligns closely with the insights from the 2024 World Energy Trilemma Report. By strategically addressing energy security through diversification, enhancing energy equity through targeted support and efficiency programs, and driving environmental sustainability through innovative clean energy technologies, Singapore is well-positioned to navigate the complexities of the energy trilemma.

WORLD ENERGY COUNCIL

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