Singapore's Energy Transition: Path Dependency and Physical Limits

Timothy Robinson

1. Introduction

Singapore has become one of the most successful nations on earth. However, the government that built modern Singapore is highly interventionist. Against this political backdrop of central planning, energy becomes a qualitatively different challenge because of physical limitations. Due to climate and geography, Singapore cannot produce enough energy to meet domestic demands, so they rely heavily on imports. This highlights the structural limitations of Singapore's central planning model. This energy dependence also means that Singapore's energy sector is inherently sensitive to geopolitical and economic risks that cannot be controlled. Any green energy goals are bounded by this precarious energy situation. Even *if* these challenges are overcome, an expensive path dependency has been created whereby significant investment is needed to move away from natural gas and realise a cleaner energy supply. The future of green energy in Singapore becomes a question of trade-offs. A fine balance of reliability, affordability, and sustainability will need to be met. And the central planning that created modern Singapore will need to adapt if change is to be realised. I will start this essay by placing my argument in its historical context and then detail why energy demonstrates the structural limits of the Singapore model. I'll then say how this affects aspects of the Green Plan, arguing that imports and path dependency creates risks and vulnerabilities to any Green ambitions. I'll conclude by discussing the need to balance competing priorities.

2. The Singapore model of economic development

Since gaining independence in 1965, Singapore has grown to become an immensely successful country and city-state. As can be seen in Figure 1 below, economic prosperity has grown immensely since independence. With an enviable gross domestic product (GDP) per capita of USD 90,674 in 2024, Singapore ranks among the most economically prosperous nations on earth. The Financial Times describes New York, London, and Singapore as 'the hallowed trinity of financial and banking excellence' (Kyriakou, 2024). This description reflects Singapore's importance to the interconnected economy that we all inhabit. Beyond the somewhat crude measurements of GDP and economic indicators, quality of life is also high in this peaceful nation. Life expectancy is now at 83.5 years, approximately 91% of households are owner-occupied (Department of Statistics Singapore, 2025), and crime rates are low (Dancel, 2025).

A key factor in this success is the politico-economic model that Singapore has adopted. In the *Cambridge Journal of Economics*, W. G. Huff points out that 'Economic planning has played a very significant role in the development of Singapore' (Huff, 1995:736). He 'elaborates the concept of a Singapore model of economic development' (Huff, 1995:735), arguing that 'the Singapore model featured a strongly interventionist government and planning' (Huff, 1995:735-736). This is a broad claim, but voting statistics lend credence to this description. Singapore is nominally democratic, but the People's Action Party (PAP) 'has been in power since Singapore was granted self-rule by the British in 1959' (Walden, 2025).

Figure 1: Singapore's annual Gross Domestic Product per capita, 1960 – 2024. All values are quoted in USD. Figure adapted from data reported by the World Bank (World Bank, n.d.).

The reality may be far more nuanced than the picture drawn by this one statistic of continued PAP power. The minutiae of Singapore's political system is beyond the scope of this paper. However, a six-decade dominance of any one party seems unthinkable in democratic Britain or Australia. Owing to such power, Singapore has been described as a 'corporate state that is mainly run by PAP technocrats' (Huff, 1995:748). Milton Friedman described Lee Kuan Yew (LKY), Singapore's first prime minister, as a 'benevolent dictator' (Huff, 1995:753). This moniker may have been given to LKY somewhat rhetorically, but it points to one of the key characteristics at the heart of Singapore's political and economic life. Economic prosperity, high living standards, and national peace have been achieved, but government intervention and control is the norm.

3. Energy in Singapore: constraints and green evolution

I emphasise this control that government can and does wield because it is central to any discussion around energy in Singapore, a sector which cannot be entirely planned through government intervention. Whilst Singapore's politico-economic model has clearly been successful at driving economic growth and social cohesion, energy is a qualitatively different challenge. It is different because of the physical preconditions that are necessary for energy production. There are physical limitations to Singapore's ability to control its domestic energy production because it does not have access to the physical resources that are necessary for sufficient domestic energy production. Geography has been a central factor in the story of Singapore's success. 'The Straits of Malacca and Singapore is one of the most important shipping waterways in the world

from both an economic and a strategic perspective' (Qu and Meng, 2012:258). However, the energy ambitions of the Republic are heavily constrained, essentially dictated by, severely limited access to land and natural resources.

Whilst technology advances are always possible, Singapore is 'a tiny metropolis that lacks natural resources or the capacity to develop significant traditional renewable energy' (Rui Loh and Bellam, 2024:2). Firstly, there is 'no native energy resources of fossil fuels…and scarcity of land' (Kit Khoong and Bellam, 2024:1). Solar is abundant, with an 'average annual solar irradiation of about 1,580 kWh/m^2' (NCCS, 2025). However, wind power is unfeasible because 'commercial wind turbines operate at wind speeds of around above 4.5m/s but the average wind speed in Singapore is only about 2m/s' (NCCS, 2025). Similarly, 'hydroelectric power cannot be harnessed, as Singapore does not have a river system with fast flowing water throughout the year' (NCCS, 2025). This means that, due to climate and geography, Singapore cannot legislate its way into abundant energy production. Put simply, energy production is physically constrained in ways that modern social and economic problems are not, and the creation of abundant energy from nothing remains the purview of science fiction.

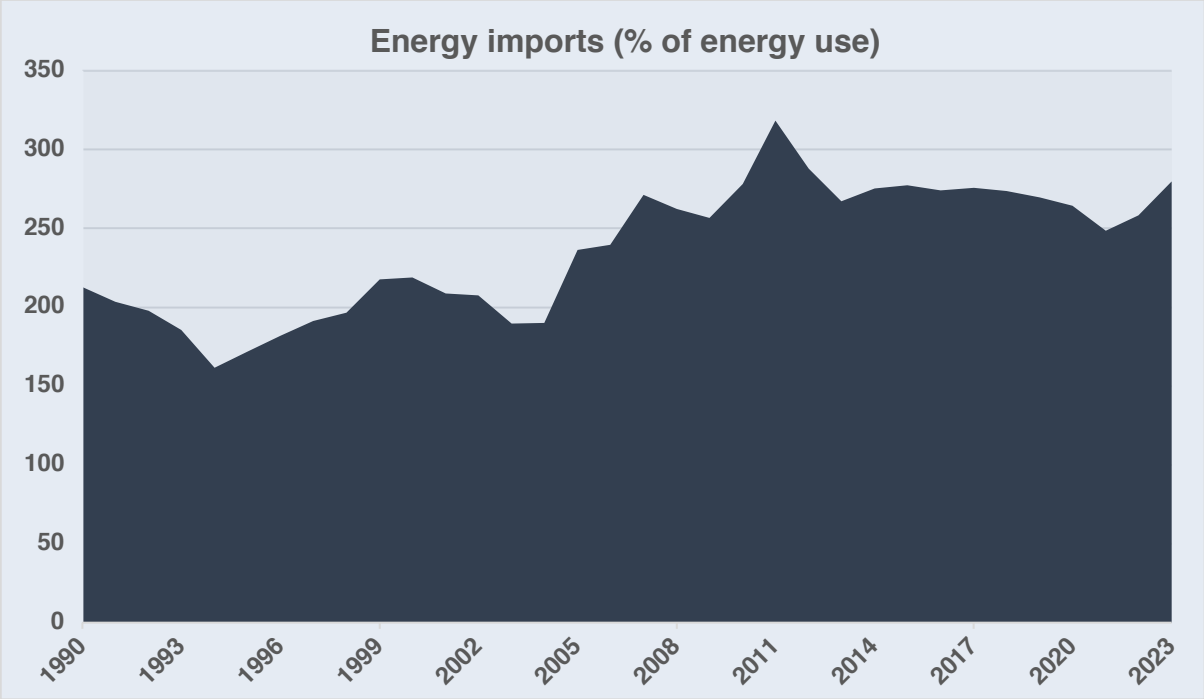

Figure 2: Singapore's annual energy imports, 1990 – 2023. Imports are represented here as a percentage of energy use. Figure adapted from data reported by the World Bank (2025).

Here, the Singapore model that led to the nation's immense prosperity comes up against physical reality. This tension highlights the limits of planning. The control exerted over early independent Singapore cannot be applied to domestic energy production. And LKY's form of "benevolent dictatorship" cannot overcome *physical barriers which represent a structural limitation to planning and development*. Physical constraints place limitations on Singapore's ability to control their own

energy sector. So, ultimately, their energy planning options are severely limited because of climate and geography. This affects any shift towards sustainability because the sustainability goals and ambitions that Singapore can realistically achieve are limited by the physical constraints of an island that must import much of its energy. No amount of planning can avoid this reality. (As shown in Figure 2 above, imports are significant, peaking at 318% of domestic energy use in 2011.) The Green Plan is how these limitations show up in sustainability policy. The effect of Singapore's climate and geography on sustainable development will become more concrete when we look at several of the key targets within Singapore's Green Plan.

The Singapore Green Plan 2030 is a national strategy to help Singapore move towards the United Nation's Sustainable Development Goals (SDGs). This strategy is built upon five key pillars, areas of development that Singapore will focus on: city in nature, energy reset, sustainable living, green economy, and resilient future (Singapore Green Plan, 2025a). As part of the energy reset, Singapore will focus on green energy, greener infrastructure and buildings, sustainable towns and districts, cleaner-energy vehicles, sustainable aviation, and sustainable maritime (Singapore Green Plan, 2025b). For our purposes, the development of green energy is the most crucial part of the Green Plan because it is where the tensions and limits of the Singapore model become clear. Singapore's government may wield significant power and succeed in legislating greener buildings and cleaner vehicles, but as discussed earlier, energy production represents a fundamentally different challenge.

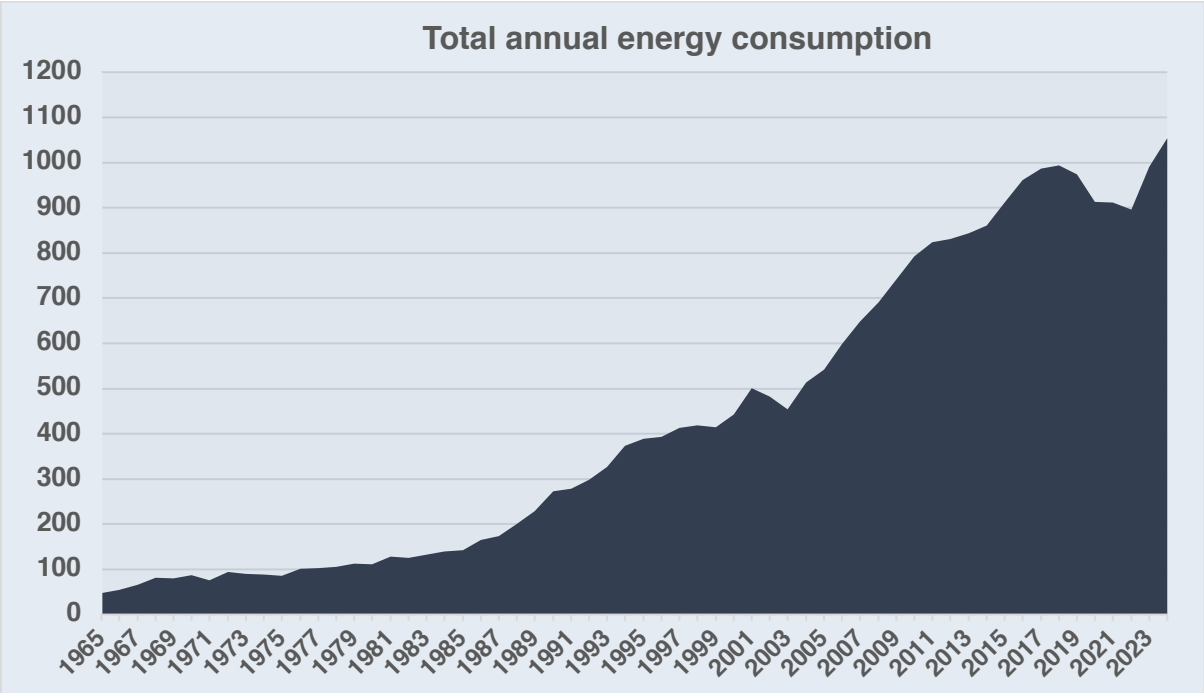

Figure 3: Total annual energy consumption in Singapore, 1965 – 2024. All values quoted in terawatt-hours (TWh). Figure adapted from data reported by Hannah Ritchie and Pablo Rosado of Our World in Data (2025).

One of the key green energy targets that Singapore has identified is an increase in 'solar energy deployment to at least 2 GWp' (Singapore Green Plan, 2025b) by 2030. To be

clear, 2 GWp *is* a considerable amount of solar energy. However, it accounts for only a small fraction of total energy use in Singapore. This solar energy production does not meet Singaporean demands, and there is a significant gap between this domestic green energy production and local energy demands. 2 GWp of energy will be expected to fulfill 'around 3% of…2030 projected electricity demand and generate enough electricity to meet the annual electricity needs of around 350,000 households' (Singapore Green Plan, 2025b). Whilst this is an admirable achievement, with a current population of ~6.1 million (Department of Statistics Singapore, 2025), there is a significant energy shortfall. Furthermore, this is ~3% of *electricity* demand, *total energy* demand is much higher. As detailed in Figure 3 and 4, electricity is a small fraction of total energy demand. In other words, there is significant gap between supply and demand. Even with a well-executed plan, Singapore cannot close this gap through domestic energy production because of the physical barriers discussed earlier.

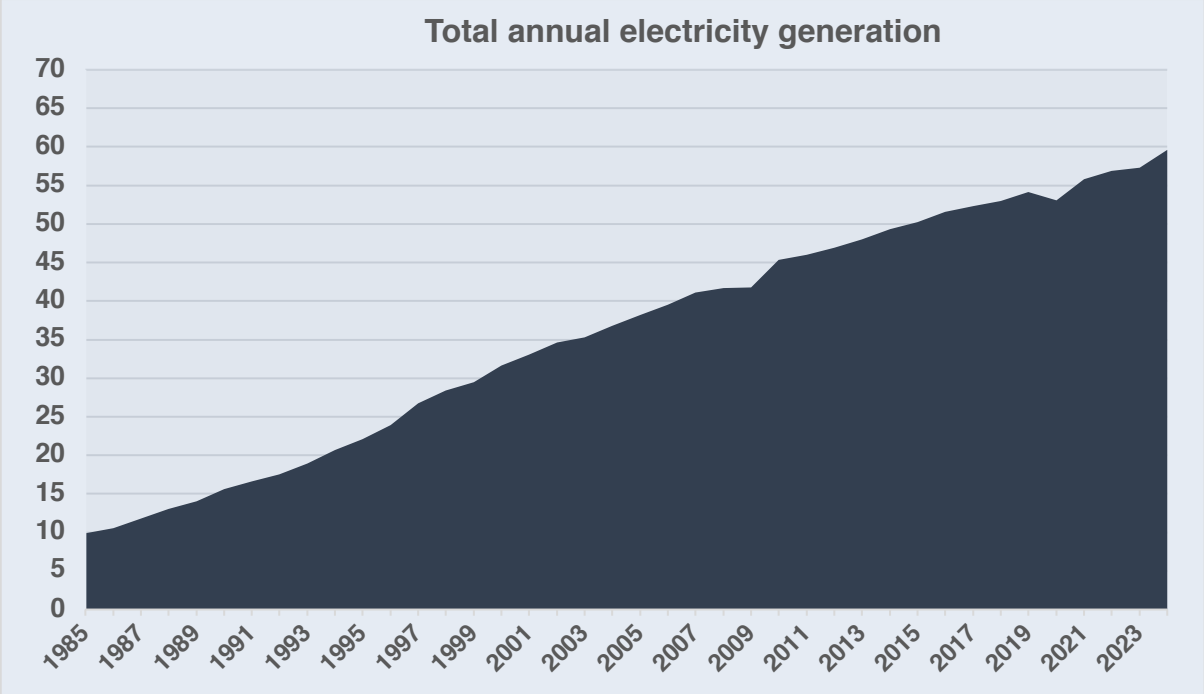

Figure 4: Total annual electricity generation in Singapore, 1985 – 2024. All values quoted in terawatt-hours (TWh). Even at peak usage in 2024, electricity accounted for only ~5.7% of total energy consumption. Figure adapted from data reported by Hannah Ritchie and Pablo Rosado of Our World in Data (2025).

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4. Energy imports and path dependency

The most immediate result of this shortfall in domestic energy production is the continued reliance on energy imports. Much of Singapore's energy must be imported (Rui Loh and Bellam, 2024:2), and Singapore intends to 'tap green energy sources from the ASEAN region and beyond' (Singapore Green Plan, 2025c). So they are accounting for this shortfall and are explicitly planning to meet demand through continued imports. This is not *necessarily* a problem. The need to import energy is widely acknowledged, and Singapore has long enjoyed a reliable imported energy supply, as is evident from the data represented in Figure 2. However, due to heavy

imports, Singapore's energy sector is inherently sensitive to geopolitical and economic shocks that affect the price of fossil fuels and renewables. Singapore consistently imports well above 100% of its energy demand, see Figure 2, and this energy excess would help mitigate these risks. However, the implicit risks that are a natural consequence of continued energy dependence leave Singapore's energy sector highly vulnerable - and this needs to be explicitly acknowledged during any discussion of a green energy transition. These risks leave Singapore's sustainability goals vulnerable because it cannot completely control its own renewable energy supply, and *its green energy goals are susceptible to the same geopolitical and economic risks that haunt its energy supply*. So whilst the green energy goals articulated as a key part of Singapore's energy reset may be achieved, Singapore's longer-term green energy ambitions will always be bounded by this energy dependence. A dependence that cannot be legislated away by an interventionist government.

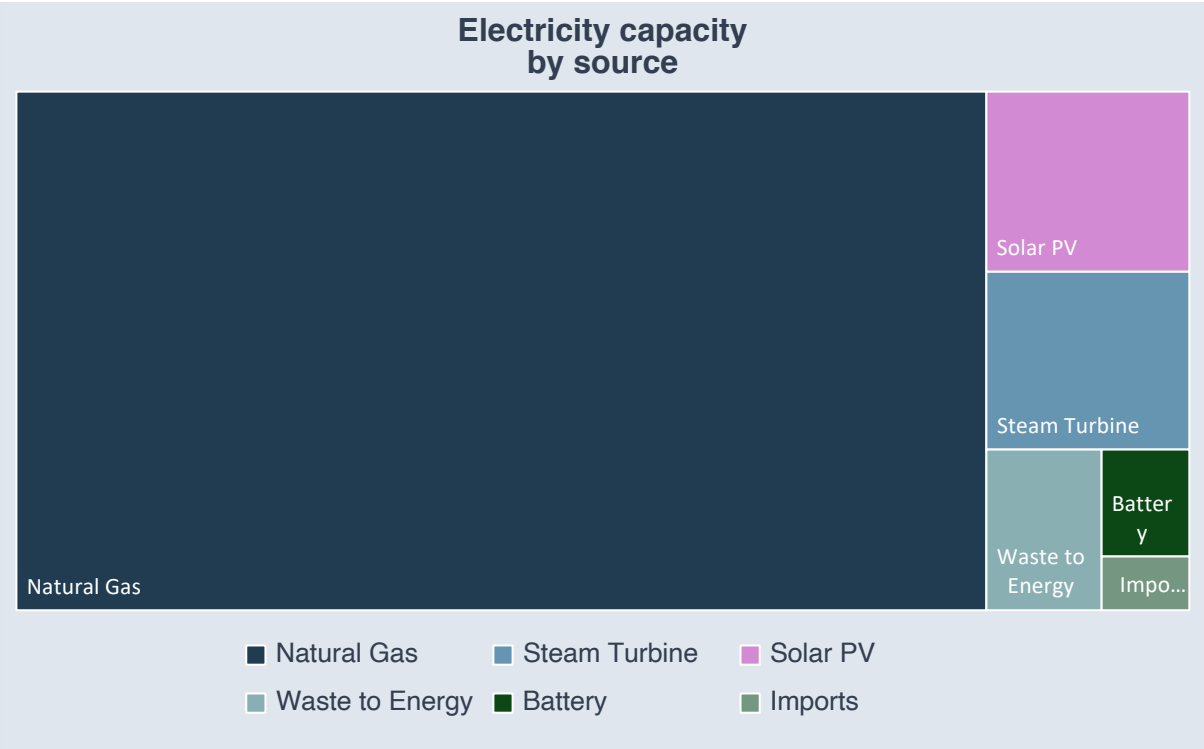

Figure 5: Singapore's electricity generation capacity by technology type in 2023. Whilst the capacity for solar has grown, the majority of capacity is still sourced from natural gas. Figure adapted from data reported by Courtney Weatherby of the Stimson Center (2024).

The final challenge to Singapore's green energy shift is its path dependency. Even *if* clean energy can be imported reliably and affordably, it often needs to be converted into a usable form for the final user. As detailed in Figure 5 above, the current capacity for electricity generation in Singapore is heavily reliant on natural gas. This implies a path-dependency, and breaking free from this reliance on fossil fuels will require significant investment. That is, to meet net-zero targets, Singapore 'will require major changes and buildout of new power generation and transmission infrastructure' (Weatherby, 2024). So even with ready access to renewables, the capacity of Singapore's power grid still needs to be expanded so that renewables can be converted

into electricity. This technology upgrade, which is necessary for the shift towards a cleaner domestic energy supply, will be expensive. This immense financial cost of the energy reset, an unavoidable consequence of path-dependency, further complicates an already difficult challenge. Energy dependence, an inherent quality of Singapore's climate and geography, poses significant threats and risks. These threats and risks are compounded by the need to invest heavily in order to upgrade an energy system that must adapt to modern renewables technology. These compounding problems lead to questions of trade-offs. I will now end this paper by summarising my argument and commenting on the need to balance competing priorities amidst such trade-offs.

5. Competing priorities and conclusion

We have seen how Singapore is physically constrained by geography and climate, so it cannot produce much of its own energy. Even with ambitious domestic solar production targets, domestic supply is a small fraction of total energy demand. To close this significant shortfall, Singapore is reliant on energy imports, and often imports well above its annual usage. Singapore will long face this precarious and uncertain energy reality. These risks have been successfully managed in the past, but it means that Singapore's energy sector is inherently vulnerable to factors outside their control. Then, even *if* clean energy can be imported, Singapore is highly path dependent, and relies on natural gas for much of its electricity. Significant investment in technology and infrastructure is therefore needed to transform their supply from fossil fuels to renewables.

The final conclusion we can draw from this is that green energy goals may be jeopardised unless the transition, a challenge exacerbated by competing properties, is managed carefully. A reliable and affordable energy supply must be secured for continued prosperity, and Singapore will not wilfully plunge itself into darkness to meet emissions targets. However, the energy supply must also become sustainable. These are not *necessarily* competing goals, but in Singapore's context, the shift towards clean energy is particularly challenging because of an energy supply that is inherently vulnerable. So the Green Plan could be considered ambitious and forward-thinking. However, parts of the Green Plan could also be characterised as an expensive and uncertain investment that ignores Singapore's inherent vulnerabilities as a small city-state with very little natural resources. Both interpretations are plausible, and the challenge for Singapore's energy sector will be to balance priorities so that its forward-thinking goals are not swallowed by uncertainty and financial bloat, risks and vulnerabilities that could easily jeopardise sustainability goals.

Perhaps the most interesting question that comes from this line of argument is *how will Singapore's political elite react to its limited ability to exert control over its green energy ambitions*? Lee Kuan Yew played a large role in creating a government that has been successful in building admirable prosperity. However, there are limits to such government intervention. They are now forced to cede ultimate control of their sustainability goals to other nation states that may or may not sell renewable energy to Singapore at a reasonable price. In several decades, with renewable supply routes and excess green energy firmly secured, this may be a moot problem. However, right now, Singapore's evolving energy sector is in a precarious position. To a political elite that is accustomed to central planning, this vulnerability may represent a real threat. They cannot plan their way out of energy dependence, but are committed to a cleaner, greener energy supply that is sufficient to meet demand. This challenge to the innate

nature of Singaporean politics is one of the key issues that may stall Singapore's move to green energy. I started this paper by highlighting the interventionist nature of the Singapore model. Whilst this model has been successful in creating prosperity and peace, navigating a precarious and evolving energy sector requires a different approach. No amount of force or negotiation can create energy from nothing. This character change is a more subtle challenge, but it also needs to be embraced alongside the energy transition.

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