

SINGAPORE COUNTRY REPORT

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1. Background

Singapore is a small island-state in Southeast Asia, located along the Strait of Malacca between Malaysia and Indonesia. It is the most urbanised and industrialised country in the Association of Southeast Asian Nations (ASEAN), with a per capita gross domestic product (GDP) of \$52,200 (in constant 2010 US\$) in 2015. Singapore submitted its Intended Nationally Determined Contributions (INDC) to the Secretariat of the United Nations Framework Convention on Climate Change on 3 July 2015 (NCCS, 2015) and has signed off to the Paris Agreement as of 22 April 2016 (Ministry of Foreign Affairs, 2016). Singapore's INDC highlights its intentions to reduce its emissions intensity by 36% from 2005 levels by 2030. In addition to emissions intensity targets, Singapore also intends to stabilise emissions with the aim of peaking around 2030. Under the Copenhagen Accord, Singapore also has a voluntary target of reducing carbon dioxide (CO₂) emissions by 7%–11% below Business-As-Usual (BAU) scenario levels in 2020 (NCCS, 2012), which will be increased to 16% if there is a global agreement on climate change.

2. Singapore's Policy Initiatives

The Inter-Ministerial Committee on Climate Change was created in 2007 to facilitate a whole-of-government approach to addressing climate change-related issues. Chaired by Teo Chee Hean, Deputy Prime Minister and Co-ordinating Minister for National Security and Minister of Home Affairs, the committee was attended by the ministers for the environment and water resources, finance, foreign affairs, national development, trade and industry, as well as transport, to provide an overarching strategic planning for Singapore's mitigation efforts.

Switching to cleaner fuels, energy efficiency improvements and the promotion of alternative sources of energy were highlighted as the main tenets of Singapore's mitigation policies. These policies were developed as part of the country's national policy framework to support its multipronged objectives of achieving economic competitiveness, energy security, and environmental sustainability (Ministry of Trade and Industry, 2007) all at the same time.

2.1. Fuel Switch

Singapore started switching from oil to natural gas as a source for power generation in the early 2000s. Today, natural gas remains a key component of the country's power generation mix. Imports into Singapore increased by 2.4% in 2016 and, in 2017, natural gas represented 95.2% of the fuel mix for electricity generation in Singapore (Energy Market Authority, 2018). Petroleum products, coal, and others accounted for the remaining 0.7%, 1.2%, and 2.9%, respectively (Energy Market Authority, 2018). In a consultation paper released by the Energy Market Authority in 2015, natural gas is expected to remain dominant in Singapore's power sector in the foreseeable future.

To expand the country's import capability and sourcing options for liquefied natural gas (LNG), Singapore has already commenced commercial operations with its newly constructed LNG terminal in May 2013. This currently has a throughput capacity of 6 million tons per year (Boon, 2013) and 9 million metric tons per annum (Mtpa) thereafter in 2017 with a fourth storage tank to be constructed. The current aims are to increase the targeted annual capacity to 11 Mtpa by 2018 (Veras, 2016).

2.2. Promoting Solar Energy

Singapore has been active in promoting solar energy as the only alternative renewable source of energy to meet its needs. Although solar technology is not subsidised, there is policy support for the deployment of solar resources in the form of removal of non-market barriers; system support in terms of facilitating system integration of the intermittency of solar energy without compromising grid stability; and continued support for research, development, and demonstration efforts aimed at reducing costs and improving efficiency of solar modules. As part of the policy objective of accelerating the scale of solar deployment in Singapore, the Housing and Development Board (HDB) awarded in 2015 a public tender for the installation and management of 76 megawatt-peak (MWp) of solar photovoltaic (PV) panels under the SolarNova programme (HDB, 2015a). The SolarNova programme, led by the Economic Development Board (EDB), is a government-

led programme that aims to promote solar deployment through aggregating solar demand across the public sector (Ministry of Trade and Industry, 2014). The EDB and the Public Utilities Board have also partnered to install floating PV platforms in reservoirs (Channel News Asia, 2015). Future initiatives will involve the installation of solar-ready roofs on all HDB flats with at least 400 square metres of open roof space, with the HDB committing to install at least 220 MWp of solar panels at about 5,500 HDB flats by 2020 (HDB, 2017). Beyond these forms of support, Singapore also has a national target of deploying 350 MWp of solar PV by 2020 and extending the share of solar PV to 8% of the country's peak electricity demand by 2030 (NCCS, 2016a).

In 2010, Singapore had explored the nuclear option with a nuclear energy pre-feasibility study. The results of the study, which was confirmed in a 2012 statement from the Ministry of Trade and Industry, was that nuclear energy was not suitable for deployment, given that the high risks associated with the dense urban population of Singapore outweigh the benefits (Ministry of Trade and Industry, 2012). However, Singapore will continue to monitor technological developments and may revisit the option in the future. In the meantime, it shall cooperate with international and regional players to actively tackle issues regarding nuclear safety and emergency planning.

2.3. Energy Efficiency Improvements

Energy efficiency is another integral part of Singapore's mitigation effort. An inter-agency Energy Efficiency Programme Office, led by the National Environment Agency and the Energy Market Authority, was established in May 2007 to help promote and facilitate the adoption of energy efficiency across sectors in Singapore (Energy Efficiency Programme Office, 2013a). Across the nation, energy efficiency improvements are promoted through a plethora of standards and regulations, public awareness, and messaging as well as the adoption of more efficient appliance stock.

Households

Households account for about one-sixth of the electricity consumed in Singapore (NCCS, 2016b) and are, thus, a key sector for energy efficiency policies. The Mandatory Energy Labelling Scheme (MELS) and Minimum Energy Performance Standards (MEPS) are two pillars of residential energy efficiency policies. The MELS, introduced in 2008, imposes compulsory display of energy labels on relevant household appliances. This requirement was imposed on all registrable air conditioners and refrigerators, as well as smaller appliances such as television sets, clothes dryers, and lighting. MELS serves to inform consumers and help them identify, and thereby purchase, more energy-efficient

appliances. MEPS is a supply-side policy that complements MELS by prohibiting the sale of appliance models that do not meet the minimum specified energy efficiency levels. They help consumers avoid being locked into using inefficient appliances with high operating costs and encourage suppliers to import more energy-efficient appliances as innovation progresses over time. Both MELS and MEPS are constantly evaluated and revised to ensure policy efficacy and efficiency.

In addition to MELS and MEPS, various public messaging campaigns aimed at targeting behavioural change in households were also introduced. These initiatives target both the initial purchasing decision as well as behaviour at the consumption stage. For example, the Life Cycle Calculator improves consumer awareness during the purchasing stage, while the Home Energy Auditor motivates energy efficiency behavioural change when consuming electricity at home. Recent public messaging campaigns have also begun targeting residential interior design with the Resource Efficiency Guide for New Home Owners.

Since the early 2010s, the relevant ministries are studying the feasibility and cost-benefit of utilising smart home technologies, such as the home energy management systems, to reduce residential energy consumption. Residents in the Yuhua estate in the west of Singapore will be the first as a pilot estate to experience such technologies, where smart features will be progressively implemented until 2018 (HDB, 2015b). Subsequently, the rollout of full retail contestability, where residential consumers can choose their own electricity supplier in the second half of 2018 (Tang See Kit, 2018), could provide further support for conservation efforts should consumers become more aware of their own electricity load profiles (Loi, Owen, and Ke, 2017).

Transport

Energy efficiency in the transport sector is governed by three complementary policy objectives: (i) reducing private transport (ii) promoting public transport ridership, and (iii) promoting non-motorised transport.

The Vehicle Quota System regulates the growth of vehicle population in Singapore. Under this system, anyone who wishes to register or buy a new vehicle in Singapore must first obtain a certificate of entitlement, which represents a right to vehicle ownership for 10 years (Land Transport Authority, 2014a). In view of the land constraints on road expansion, the annual vehicle population growth rate has decreased to 0% effectively from February 2018 onwards (Land Transport Authority, 2017a). Since 2012, the Fuel Economy Labelling Scheme has mandated fuel economy labels to be affixed to vehicles at the point of sale. This was complemented by the Carbon Emissions-based Vehicle

Scheme, introduced in 2013 (Land Transport Authority, n.d.), and was in place until December 2017. This scheme qualified all new cars and imported used cars with low carbon emissions of less than or equal to 135 g carbon emissions per kilometre (CO_2/km) for vehicle tax rebates of S\$5,000–S\$30,000. Cars with high carbon emissions of more than 185g CO_2/km also incurred a corresponding registration surcharge between S\$5,000 and S\$20,000. Taxis were imposed higher surcharges to adopt lower emission models for their fleet (Land Transport Authority, 2015). This scheme was replaced in January 2018 by the new Vehicular Emissions Label, which offers rebates and surcharges based on the worst-performing pollutant out of five. These charges range from S\$30,000 (rebates) to S\$30,000 (surcharge), depending on the band category in which the new car or taxi is being purchased (Land Transport Authority, 2017b).

Public transport is the most energy-efficient mode of travel. Under the Land Transport Masterplan, Singapore targets to achieve a 75% public transport modal share during peak hours by 2030, up from 66% in 2014. In a nutshell, the promotion of public transport ridership is achieved by ensuring the efficiency and reliability of public transport services. In addition to constantly upgrading and expanding the current fleet of public transport vehicles, actions were also taken to expand existing metro lines and outreach. Mandatory give-way operations also ensure bus priority on the roads. The Park & Ride scheme was also initiated to ensure a seamless switch between private and public transport.

The government will create more connections through the construction of two new rail lines and three new extensions. By 2030, the rail network would have doubled from the existing 178 km in 2013 to about 360 km, and 8 in 10 homes would be located within a 10-minute walk from a train station. Public buses would connect commuters to even more places, with new bus routes added to the bus network. Singapore is adding about 80 new bus services under the Bus Service Enhancement Programme.

To improve the overall experience of commuters, especially in the first and last miles of their journeys, the government will also build more than 200 km of sheltered walkways. More integrated transport hubs will also be built to enable commuters to switch between different types of transport easily, with convenient access to retail, dining, and other lifestyle services. Cycling and walking are also encouraged through public messaging campaigns. Specifically, the intra-town cycling programme launched by the Land Transport Authority promotes cycling through designated specialised road cycling paths. The island-wide cycling path network will eventually be well over 700 km in length. In addition, the electric vehicle pilot car-sharing programme is in progress, which will see the introduction of possibly 1,000 electric vehicles and charging infrastructure by (2020) to promote their use (Land Transport Authority, 2014b).

Buildings

At the design stage, energy efficiency in buildings is governed by the Building and Construction Authority (BCA) of Singapore's Green Mark Scheme. Launched in January 2005 to promote environment sustainability in the construction and real estate sectors, the Green Mark Scheme targets environment-friendly designs in buildings, with a focus on energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green features focusing on landlord's contributions in 'going green' (E2 Singapore, 2016). Since April 2008, all new buildings and existing buildings undergoing major retrofitting works with a gross floor area above 2,000 square metres must meet Green Mark certified standards. The BCA Green Mark Scheme promotes the adoption of green building technologies and reduces the use of electricity in the commercial sector via efficiency improvements and conservation. Buildings exceeding the minimum requirements are also awarded higher accreditations, such as the Platinum Green Mark, which serves to promote exceptional performance. Technical and financial support mechanisms are also provided to motivate continued energy efficiency upgrades. The Building Energy Efficiency Roadmap, published jointly by the National Climate Change Secretariat and the National Research Foundation in 2014, evaluates existing energy efficiency technologies for buildings, hence, providing technical expertise in the area. Various financial support mechanisms, such as Green Mark Incentive Scheme for Existing Buildings and Premises and the Building Retrofit Energy Efficiency Financing scheme, are available to provide co-financing for retrofitting and energy efficiency upgrades. The target is for at least 80% of the buildings in Singapore to achieve BCA Green Mark certified rating by 2030 (BCA, 2013). The most recent updates for the Green Mark Assessment Criteria are in 2016 for residential buildings (BCA, 2016), and an ongoing pilot for non-residential buildings (BCA, 2017).

Since a 2012 survey by the Development Authority of Singapore revealed that the 10 largest data centre operators in Singapore consumed as much energy as 130,000 households, data centres became a key sector for policymakers. Data centres have been included in the BCA Green Mark Scheme since 2012. A similar technology roadmap has been prepared for data centres, which highlights strong growth prospects for improving energy efficiency in the sector. This was in line with estimates from the 2012 survey which posited that there is an energy efficiency potential of 20%. The Development Authority of Singapore also launched a new Green Data Centre Innovation Programme aimed at promoting innovative technological approaches to improving energy efficiency in data centres.

Since 2006, the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) initiative has placed the public sector at the front of building energy efficiency. Under the PSTLES, all existing public sector buildings must meet a minimum Gold Mark rating, as determined by the type of building. Moreover, the Guaranteed Energy Savings Performance (GESp) contracts initiative was introduced to ensure reaping the expected energy savings. Under the GESp contract structure, the public sector agency is expected to engage an accredited energy services company to carry out an energy audit, implement the relevant energy efficiency measures, and guarantee annual energy savings over a 3- to 5-year contract period (E2 Singapore, n.d.). The efficacy of this initiative could be proved with the average electricity savings of 15% across 14 projects by March 2015 (E2 Singapore, 2015a), contributing to annual monetary savings of S\$6 million.

Industry

The industry-focused Energy Efficiency National Partnership is a voluntary programme which started in 2010 that helps companies put in place energy management systems and implement projects to improve energy efficiency. Mandatory energy management requirements for energy-intensive companies in the industry sector were later introduced in April 2013 under the Energy Conservation Act. Energy-intensive companies consuming more than 15 GWh (electricity) or 54 terajoules (fuel or steam) each year are required to appoint an energy manager, monitor and report energy use and greenhouse gas emissions, and submit energy efficiency improvement plans (National Environment Agency, 2014). Beside legislation enforcing mandatory energy management practices, policies were also introduced to incentivise energy efficiency investments. The ESCO (energy services company) Accreditation Scheme supports the Energy Conservation Act by ensuring professionalism in energy-related services. As of mid-2018, 29 qualified energy services specialists are from 19 accredited ESCOs.

Incentives and grants, such as the Design for Efficiency Scheme, Energy Efficiency Improvement Assistance Scheme, and the Grant for Energy Efficiency Technologies, were also put in place as co-financing schemes to reduce initial costs of energy efficiency upgrades. The One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology is another example of a tax incentive to encourage energy efficiency upgrades in industries (E2 Singapore, 2015b). Knowledge-sharing is also promoted through industry-focused seminars and provision of energy management training and resources.

3. Modelling Assumptions

3.1. Power Generation Sector

For the BAU scenario, the generation efficiency of combined-cycle gas turbine plants is assumed to improve from 50.5% in 2015 to 52% in 2040, registering an increase of 2.9% due to progression towards a competitive electricity market. Single-cycle thermal plants are expected to improve marginally as well from 34.7% to 42% in 2040. The use of solar generation capacity is assumed to grow from 3% in 2015 to around 9% of aggregate demand for electricity in 2040, as part of public efforts towards promoting renewable energies.

With respect to Alternative Policy Scenario (APS2), which considers greater potential for efficiency in the power generation sector, combined-cycle gas turbine plants will reach 60% efficiency by 2040, whilst single-cycle thermal plants could reach 45%. APS3 allows for the share of solar to reach 30% of Singapore total electricity needs in 2040.

3.2. Transport Sector

The demand for gasoline, natural gas, and diesel for Singapore's road vehicles is assumed to be dependent primarily on vehicle growth. Consistent with vehicle quota targets set by the Land Transport Authority, vehicle growth would remain at 0.25% from 2015 to 2017, before going down to 0% from 2018 thereafter for the BAU scenario. Electricity demand for the mass rapid transit system is mainly driven by the expected expansion of railway length, which will increase from around 200 km in 2015 to 344 km by 2040, an annual average growth rate (AAGR) of 2.2% per year. APS1 is like the BAU scenario here, as no further vehicle growth reductions or railway efficiency improvements have been assumed.

3.3. Residential Sector

In the BAU scenario, electricity demand growth is assumed to follow an AAGR of 6.9% from 2015 to 2040. Electricity demand growth can be further reduced to an AAGR of 6.7% in APS1. Demand for natural gas and oil products remains like the BAU scenario.

3.4. Commercial Sector

In the BAU scenario, electricity demand is assumed to slow down at an AAGR of 0.8% from 2015 to 2040, which will eventually end up below the baseline econometric forecasts in 2040. APS1 will lead to a further reduction in AAGR for electricity demand to -0.9%. No reduction is expected from natural gas and oil consumption.

3.5. Industry/Petrochemicals Sector

For industry, the BAU scenario assumes that natural gas, electricity, diesel, kerosene, residual fuel oil, as well as refinery gas demand will grow at an AAGR of 1.2% in 2015–2040. The demand growth will slow further to 1% in APS1, which is also 10% below econometric estimates in 2040. The BAU scenario and APS1 remain similar for the other fuels in the industry sector.

The production of ethylene is supposedly tied to policy targets to grow linearly to reach 6 million tons per year by 2020, which translates to 22.2 Mtoe of naphtha produced (EDB, 2012) in the BAU scenario. Naphtha is used as an intermediary fuel to produce petrochemicals mainly stockpiled for exports from Singapore to other countries. Here, we assume that naphtha demand remains constant at 6,099.53 Mtoe on the observation that production figures remain like 2008, having just recovered from a large decline after the financial recession.

4. Outlook Results

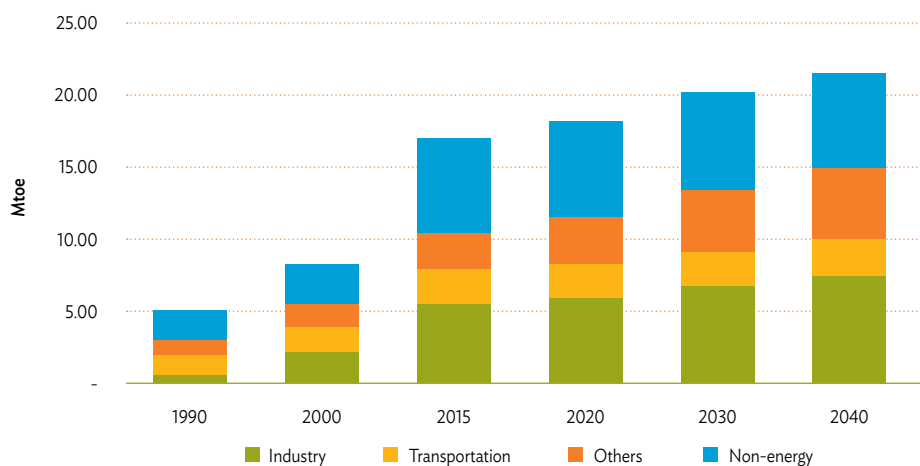
4.1. Business-As-Usual Scenario

4.1.1. Final energy consumption

Singapore's total final energy consumption (TFEC) grew at an annual rate of 5%, from 5.01 Mtoe in 1990 to 17.07 Mtoe in 2015. During the same period, oil was the dominant energy source, with 3.8 Mtoe and 11.59 Mtoe consumed in 1990 and 2015, respectively. About 38.8% of the country's final energy is consumed for non-energy uses in 2015, particularly as feedstock for petrochemical production. In 1990, 27.1% of the TFEC was used in the transport sector although its share declined by almost 50%, reaching around 13.8% only in 2015.

Under the BAU scenario, the TFEC is projected to grow by 0.9% a year between 2015 and 2040. The petrochemical sector is expected to remain stagnant in terms of growth (Figure 15.1). The industry sector's consumption will increase on average by 1.2% per year. The transport sector is projected to grow by 0.3% per year while the 'others' (residential and commercial) sector is projected to grow by 2.7% per year.

Figure 15.1: Final Energy Consumption by Sector, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Under the BAU scenario, industry and non-energy consumption will be dominant in the TFEC. By the end of 2040, non-energy share in the TFEC will decline to 30.9% while the industry sector's share will increase from 32.7% in 2015 to around 34.7% in 2040.

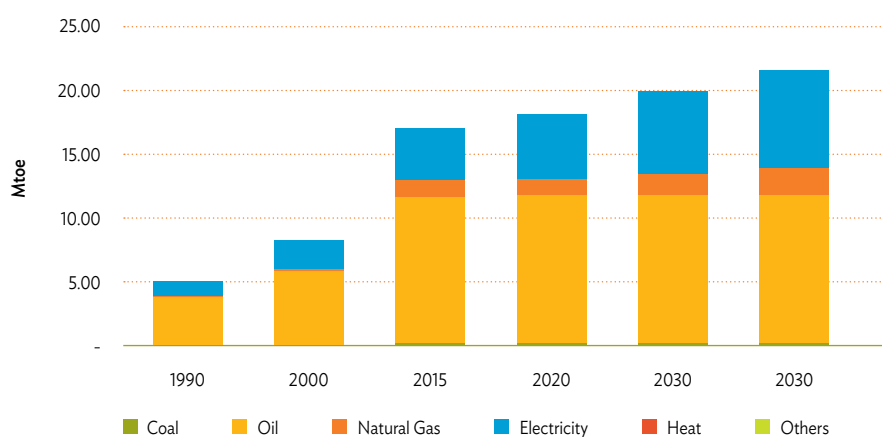
The transport sector's share in the TFEC in 2015–2040 is expected to decrease to 11.7% from its 27.1% share in 1990. This decrease stems from the country's national policies advocating for more efficient automobile technology and the promotion of public transport as the main means of transportation. In addition, the Certificate of Entitlement quotas are also expected to remain effective in curbing vehicle growth.

By fuel type, natural gas experienced the fastest growth in 1990–2015 at an average rate of 12.7% per year. The growth of natural gas was due to the increasing demand in its use mainly in the rapidly expanding industry sector. Also, in 1990–2015, electricity consumption grew at an average annual rate of 5.1%.

Under the BAU scenario, the demand for natural gas is expected to continue expanding but at a slower average growth of 2% per year until 2040. Meanwhile, electricity demand will be growing at an average rate of 2.5% per year.

Oil is still expected to play a major role in the country's TFEC. For the past 2 decades, that is, from 1990 to 2015, the share of oil fell from 76.1% to around 67.9%. Under the BAU scenario, oil's share to the TFEC will fall to 64.1% in 2020 before falling further to 54.3% in 2040. This decline is mainly due to the high growth in natural gas use, which will increase from its share of 7.3% in 2015 to 9.5% in 2040. Meanwhile, the share of electricity in the TFEC will increase to around 27.7% starting 2020 before rising further to 35.5% until 2040. Figure 15.2 shows the final energy consumption by fuel.

Figure 15.2: Final Energy Consumption by Fuel Type, BAU (1990–2040)

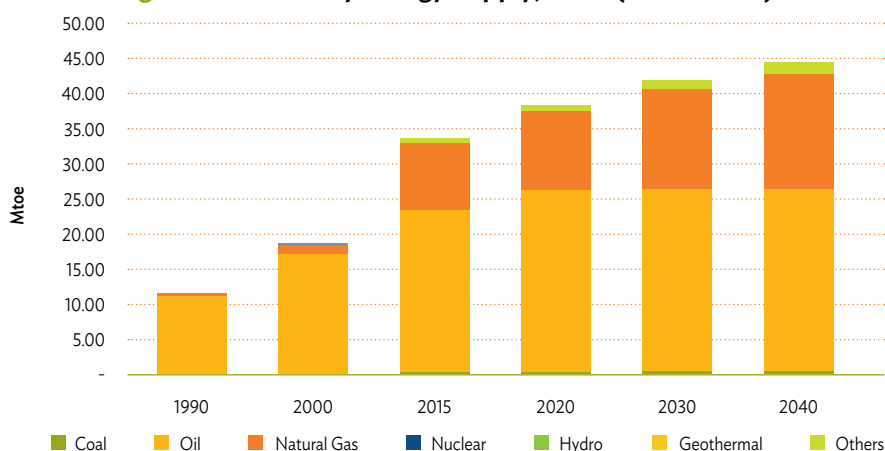


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.1.2. Primary energy supply

Total primary energy supply (TPES) grew by 4.4% per year, from 11.53 Mtoe in 1990 to 33.63 Mtoe in 2015. Singapore's dominant source of energy in 1990 was oil, and its supply increased by 2.9% yearly from 11.44 Mtoe in 1990 to 23.15 Mtoe in 2015. Following the construction of pipelines for gas-fired power plants – the first of which sourced gas from Malaysia in 1991 – and two more recent pipelines from Indonesia, the share of natural gas consequently increased. Natural gas consumption increased rapidly from 0.4 Mtoe in 1992 to 9.39 Mtoe in 2015.

Figure 15.3: Primary Energy Supply, BAU (1990–2040)

BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Primary energy supply in the BAU scenario is projected to grow by 1.1% per year during 2015–2040 (Figure 15.3). Amongst the energy sources, solar energy is expected to grow the fastest at 3.9% a year, followed by biomass (2.5% per year) and natural gas (2.2% per year). Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

Singapore's net generation capacity has already increased by more than 2,000 megawatts (MW) or about 20% of current installed capacity with more efficient combined-cycle gas turbines (Ministry of Trade and Industry, 2013). Nevertheless, oil is expected to remain the primary energy source, accounting for 58.2% of primary energy supply in 2040, followed by natural gas at 36.4%.

4.1.3. Power generation

Electricity generation grew by 4.8% per year from 15.7 terawatt-hours (TWh) to 50.41 TWh in 1990–2015. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 28% of electricity generation in Singapore in 2001, grew rapidly to supply 95% of Singapore's electricity in 2015. Thermal power generation from fuel oil was around 0.35 TWh in 2015. In the same period, biomass and solar took up a small proportion of the mix, totalling around 3.1%.

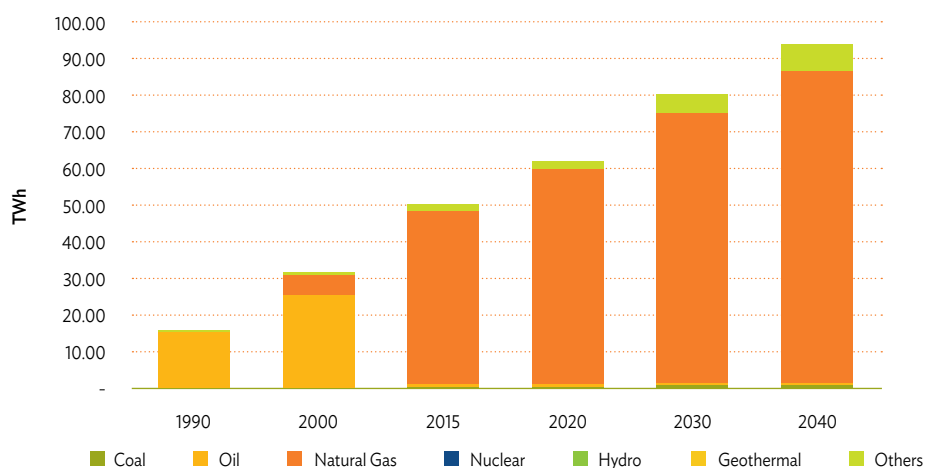
In the BAU scenario, power generation is projected to increase at 2.5% per year as well, reaching 94.54 TWh in 2040. By type of fuel, generation from others, which comprise biomass and solar power, will have the fastest growth at an average rate of almost 6.6%

per year. Power generation of others is expected to increase its share from a minimal share of 3.1% in 2015 to 8.1% in 2040. Coal started to be utilised in 2013 as a substitute for hydrogen and carbon monoxide as feedstock for the energy and petrochemical sectors. It is projected to grow only marginally at 2.5% per year.

After 2015, at least 90% of the country's power generation mix will come from natural gas under the BAU scenario. Its share of the generation mix will gradually decline over time – from 95.0% in 2015 to 90.5% in 2040 – as more solar power is utilised. On the other hand, the share of oil will decline to 0.2% over the same period.

The average thermal efficiency of Singapore's fossil-fuelled power plants was around 30.3% in 1990 and improved to 49.5% in 2015 as more natural gas-fired power plants operated. In the BAU scenario, the thermal efficiency of fossil plants is expected to improve further to around 50.9% in 2040. That of natural gas plants will be 52% in 2040, and that of oil, 42%.

Figure 15.4: Electricity Generation, BAU (1990–2040)

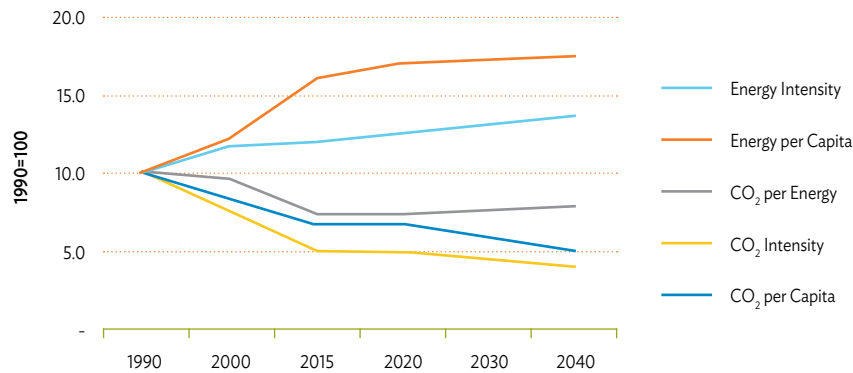


BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

4.1.4. Energy indicators

Primary energy intensity, which is computed as the ratio of primary energy supply over GDP, is expected to decrease. Similarly, final energy intensity of Singapore (ratio of final energy consumption over GDP) will also be declining in 2015–2040. This decrease in energy intensity indicates that Singapore is moving towards a highly economically productive country; that is, less energy will be used to produce each unit of output. Energy and CO₂ per capita increases as population growth is expected to remain lower than fossil fuel demand growth (Figure 15.5).

Figure 15.5: Energy Indicators, BAU (1990–2040)

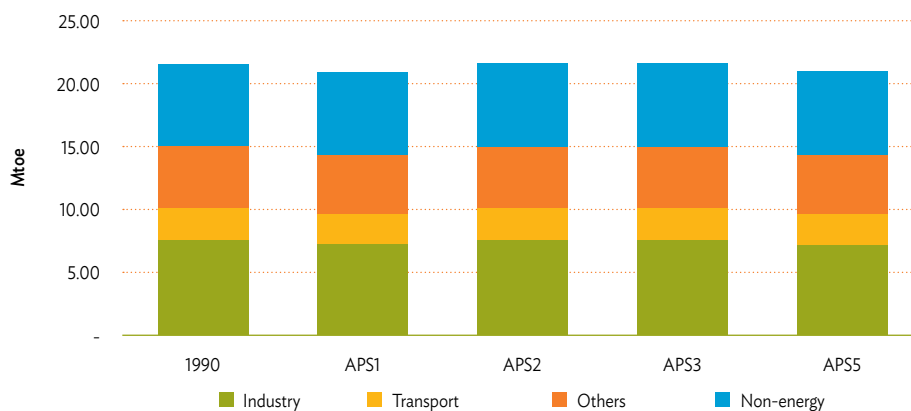
BAU = Business-As-Usual, CO₂ = carbon dioxide.

Source: Author's calculation.

4.2. Energy Saving and CO₂ Reduction Potential

4.2.1. Final energy consumption

The TFEC under APS1 is projected to increase by 0.8% from 2015 to 2040. Like the BAU scenario, the non-energy sector grows at 0% per year. The 'others' (residential and commercial) sector grows at 2.5%; this is followed by the industry sector at 1.0% and the transport sector at 0.3%. APS2 and APS3 do not include energy conservation policies for end-demand and, hence, are like the BAU scenario. APS5, a combination of all APS, will have the same final energy consumption as that of APS1 (Figure 15.6).

Figure 15.6: Final Energy Consumption by Sector, BAU and APS

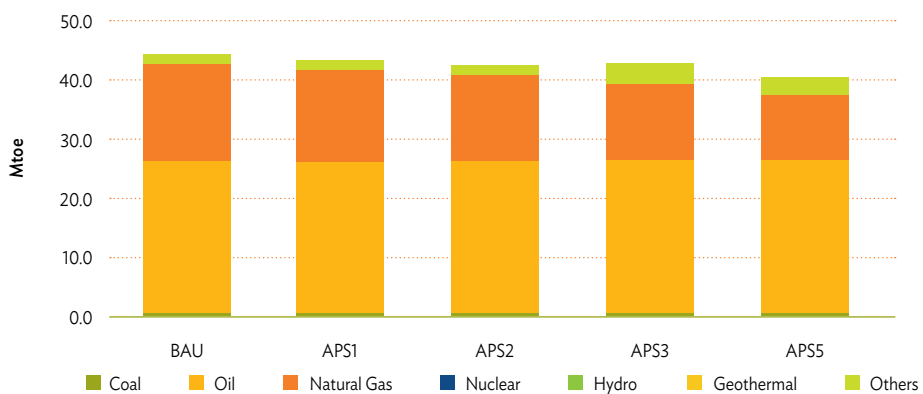
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.2.2. Primary energy supply

Results from APS2 show that the primary energy supply for 2015–2040 will increase at an average annual rate of 0.9%, a 1.89 Mtoe decrease from the BAU scenario (Figure 15.7) in 2040. This translates to a reduction of 4.2% from the BAU scenario in 2040. APS1 and APS3 will help lower primary energy supply by 1.01 Mtoe and 1.5 Mtoe, respectively, in 2040. This illustrates that policies targeting end-user energy efficiency and renewables still play only a secondary role to power generation efficiency policies in reducing primary energy supply.

Figure 15.7: Total Primary Energy Supply by Fuel Type, BAU and APSs

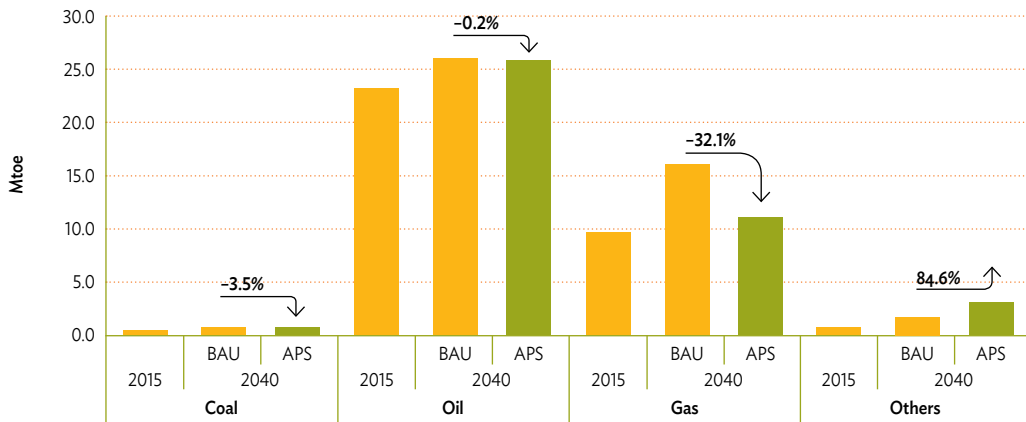


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Most of the reduction in primary energy supply will come from natural gas at 1.89 Mtoe, which is a drop of 11.7% from the BAU scenario (Figure 15.8). Oil falls only by 0.14% as it is limited by the already-declining the BAU scenario consumption for power generation, as well as the large consumption in petrochemical non-energy use. Biomass consumption will remain relatively constant, whereas solar power progresses significantly but is still small in magnitude. Hence, this leads to increased consumption of others by 84.6%.

Figure 15.8: Primary Energy Supply by Fuel Type, BAU and APS5 (2015 and 2040)



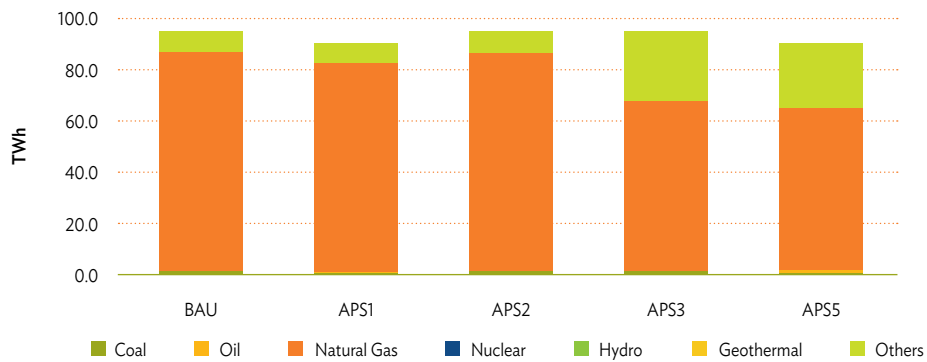
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.2.3. Power generation

Results from APS1 and APS5 show decreased electricity generation, registering a drop of 4.4 TWh or 4.7% from the BAU scenario. APS2 and APS3 assume the same generation as the BAU scenario since these do not have energy-saving measures (Figure 15.9).

Figure 15.9: Electricity Generation, BAU and APSs



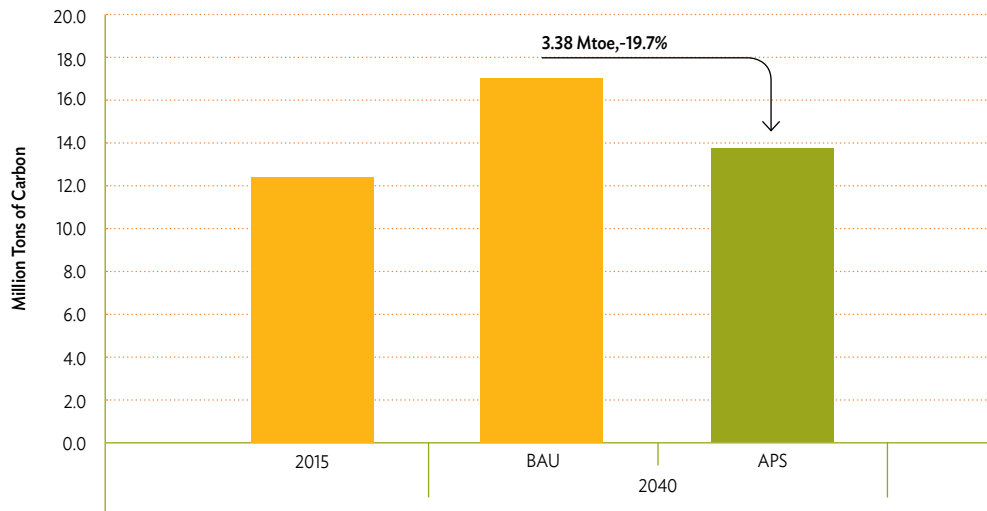
APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

4.2.4. CO₂ reduction potential

Under the BAU scenario, CO₂ emissions from energy demand are projected to increase at an average annual rate of 1.3%, from 12.4 Mt-C in 2015 to around 17.2 Mt-C in 2040 (Figure 15.10).

Figure 15.10: CO₂ Emissions from Energy Supply, BAU and APS5 (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

CO₂ emissions reduction potential comes mainly from improvements in thermal efficiency for power generation (APS2), with savings of 1.21 Mt-C in 2040, equivalent to a 7.1% decrease from the BAU scenario. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with APS1 registering emissions reduction of 0.59 Mt-C in the same period (a 3.4% reduction from the BAU scenario). Increased use of solar power offers large emissions reduction of 2 Mt-C (a 11.7% reduction from BAU). Overall, APS5 will contribute to emissions reduction of 3.38 Mt-C, which is a 19.7% reduction from the BAU scenario. Under this scenario, carbon emissions will increase at an AAGR of 0.4% from 2015 to 2040, compared with 1.3% under the BAU scenario.

5. Implications and Policy Recommendations

The Singapore government has been progressively implementing new strategies to help incentivise and advocate the adoption of clean energy technologies and conservation behaviour amongst industries and households. These programmes include several funding schemes, including the Clean Development Mechanism, Documentation Grant that help provide companies with financial assistance to engage carbon consultancy services, and Grant for Energy Efficient Technologies to help encourage industry investments in energy-efficient equipment or technologies (Energy Efficiency Programme Office, 2013b). Zero-Capex (Capital Expenditure) or similar commercial contracts can also be actively promoted to increase the involvement of energy service companies to help conserve energy.

Solar adoption, an electric vehicle car-sharing programme, as well as smart technologies pave the way to further reduce carbon in industries and households in the future. There is also an initiative to improve the petrochemical industry's energy efficiency and competitiveness by way of a 'heat-integration' plan (Lim, 2013).

Singapore has also taken measures to ensure that its energy needs are diversified across more countries for energy imports rather than depending on gas pipeline flows from Malaysia and Indonesia as Singapore transits towards using more natural gas to power its electricity needs. Currently, Singapore plans to increase LNG import storage facilities, and is appointing one or two companies to import LNG for Singapore in the short-term future. Coal use for co-generation, as well as the greater adoption of solar energy, shows efforts made towards fuel mix diversification.

As shown in the forecast results for the BAU scenario with 2015 as the base year, Singapore is already on track to meet its projected 2020 targets of hitting 77.2 million tons of MT-CO₂, (NCCS, 2016c) where estimations show the potential to go as low as 13.42 Mt-C or approximately 50 million tons of MT-CO₂ if much greater efforts are taken to reduce emissions.

Despite the limitations posed by its small size and the paucity of renewable energy sources, Singapore's long-term commitment to building a sustainable city will ensure that the efforts of using energy efficiently and in an environmentally viable manner will continue to receive broad support.

Notes

APS 1 to APS5 are results from an academic exercise and should not be taken to reflect Singapore's national position for climate policies.

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